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Høgskulen på Vestlandet

MASTER'S THESIS

Assessing the Impact of Simulator and Real Vessel Training at the Royal Norwegian Naval Academy

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Western Norway University of Applied Sciences

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02.06.2023

I confirm that the work is self-prepared and that references/source references to all sources used in the work are provided, cf. Regulation relating to academic studies and examinations at the Western Norway University of Applied Sciences (HVL), § 12-1.

II

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Abstract

Simulators play a significant role in maritime education, widely utilised worldwide by maritime institutions. The International Maritime Organization (IMO) highly recommends and even mandates their use in certain cases. There are numerous studies to assess the efficacy of simulators. Real-world vessel training is a requirement set by the IMO. Many schools face the challenge of limited access to actual vessels. To acquire the certificates, students must still complete the necessary sea service during or after graduation. There is a need for research on the effectiveness of real-world navigation training tailored explicitly to nautical students.

The Royal Norwegian Navy (RNoNA) has been utilizing real-world vessels and simulators for training in practical navigation for decades. This study examines the impact of the combination of simulators and real-world vessels on the knowledge and skill development of nautical students in the RNoNA. The research project explores the optimal approach for training students in practical navigation. It addresses specific questions regarding the justification of resources invested, the adequacy of simulator training alone, and ways to enhance the utilization of simulators and real-world training in the RNoNA. The study employs a systematic literature review, qualitative surveys, and semi-structured interviews.

Findings reveal that the combination of simulator sessions and real-world training provides a solid foundation for students' future roles in the Navy. The study also shows that simulators cannot fully replicate certain aspects. Although the practical navigation training at the RNoNA is of high quality, improvements in platform utilization are needed. For instance, recommendations include prioritizing extensive training in a simulated environment early in the semesters and introducing real-life platforms later for more efficient utilization.

This study highlights the importance of enhancing the learning experience for nautical students through the effective utilization of simulators and real-world training.

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List of abbreviations

Abbreviation	Definition
AIS	Automatic Identification System
AMVER	Automated Mutual-Assistance Vessel Rescue
ARPA	Automatic Radar Plotting Aid
CAPA	Computer-Aided Performance Assessment
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
CPA	Closest point of approach
DR	Dead reckoning
EBL	Electronic Bearing Line
ECDIS	Electronic Chart Display and Information System
ECTS	European Credit Transfer and Accumulation System
EDA	Electrodermal Activity
ELT	Experiential Learning Theory
ETA	Estimated Time of Arrival
FHS	Forsvarets Høyskole
FOG	Fibre Optical Gyroscope
GNSS	Global Navigation Satellite System
GPS	Global Position System
HVAC	Heating, Ventilation, and Air Conditioning
HVL	Høgskulen på Vestlandet
IALA	The International Association of Marine Aids to Navigation and Lighthouse Authorities
IBS	Integrated Bridge System
IMO	International Maritime Organization
INCSEA	Incidents at Sea
INS	Inertial Navigation System
MET	Maritime Education and Training
MPN	Military Practical Navigation
NAVWAR	Navigation Warfare
OOW	Officer of the Watch
OSC	On Scene Coordinator
RADAR	Radio Detection and Ranging
RNoN	Royal Norwegian Navy
RNoNA	Royal Norwegian Naval Academy
SEG	Serious Educational Games
SOP	Standard Operating Procedure
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TA	Thematic Analysis
TCPA	Time to closest point of approach
VDR	Voyage Data Recorder

1. Introduction

This study aims to examine how the use of simulators and real vessels impacts the knowledge and skill development of nautical students at the Royal Norwegian Naval Academy (RNoNA). The research methodology involves a combination of literature review, interviews, and paper surveys, with participants including navigators and nautical students.

The project's background introduces the use of simulators and school vessels as educational tools. Then the purpose of this research, the research question, and the structure of the study will be outlined.

1.1 Background

At the RNoNA, it is taught and trained far beyond national and international requirements in terms of navigation in practice (Brandal, 2016). The purpose of the training is that the students should be able to be cleared officers of the watch (OOW) shortly after graduation (Brandal, 2016). The Navy has used real-life platforms and simulators for decades as part of the training.

I work as an instructor at the RNoNA, where some of my tasks involve training and assessing cadets, hereby referred to as students, in Military Practical Navigation (MPN) through simulations and real-life scenarios on school vessels. MPN aims to equip students with the ability to navigate safely when advanced aids, like Global Navigation Satellite System (GNSS) and radio detection and ranging (RADAR), are not available. The students learn to use tools like stopwatches, trip meters, and compass bearings to navigate in fairways outside the usual routes, which may have limited sea marks. They are also trained to navigate in all weather conditions. I am enthusiastic about instructing students in their training and development, which is why I am researching ways to improve our training methods and my role as an instructor through my thesis.

RNoN has been utilizing M/S Kvarven and M/S Nordnes as school vessels since 2010. These fast aluminium-hulled water jet vessels from Alutech are 16.4m long and can reach a velocity potential of up to 40 knots. They are equipped with an Integrated Bridge System (IBS) like the one found on Norwegian frigates and corvettes (Skipsrevyen, 2022). Kvarven and Nordnes are used for navigation training purposes. The RNoNA possesses modern K-Sim simulators, including a one-to-one simulator for certain vessels in the fleet. Integrating theoretical education, practical simulator exercises, and real-world training can potentially achieve learning outcomes (Morley & Jamil, 2021). It is worth noting that operating vessels for nautical training can be expensive and demanding for both instructors and students. Additionally, the study program for nautical students underwent a reform in 2017, which reduced the duration of the program without compromising its content. As a result, the Navy shortened the program from 3 ½ years to three years, devoting one year to leadership and military subjects exclusively. This means that only two years are left for actual nautical training. A new review of the 2017 reform is underway to assess the entire program arrangement.

Numerous academic studies have been conducted on simulator-based maritime education, covering training, learning, and assessment (Sellberg, 2017; Sellberg, 2018; Hontvedt & Øvergård, 2020). Simulators are commonly used as a training tool in nautical institutions, and the International Maritime Organization (IMO) recommends their use in training or as a component of training, as per the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) guidelines (IMO, 2017). The IMO has released Model Course 6.10, which focuses on training simulator trainers and assessors. Its purpose is to establish consistency in simulator-based training for maritime operations (IMO, 2012), ensuring a standard framework for executing simulator training and education. Simulators offer instructors numerous opportunities to create the ideal scenario, whether it involves practising a single task or a complex scenario. Instructors can provide a thorough and timely briefing, monitor and guide their students, pause the scenario, and analyse audio and visual recordings of the session. Additionally, instructors need not worry about the safety concerns of instructing in a real-life scenario.

To summarize, there are various requirements and guidelines set by IMO through the STCW and requirements from the Navy that involve exams at the naval academy and steps towards becoming an OOW after graduation. Academic studies have also been conducted on simulator usage, including how to efficiently use the platform and how instructors can improve learning outcomes. However, there is limited research on the effectiveness of real-world navigation training for nautical students. Therefore, there is a need for research to analyse the impact of real-life navigation training and compare it to the effects of simulator training.

1.2 Purpose and research questions

This thesis evaluates the effectiveness of using simulators and real-world platforms by the RNoNA to train nautical students in practical navigation. The aim is to determine if there is room for improvement in the Navy's training methods.

To accomplish this objective, this thesis addresses the following questions:

1. ***Does the practical experience gained from real-world navigation training justify the resources invested in nautical students at the RNoNA?***
2. ***Can simulator training alone fulfil the requirements set by the STCW and provide adequate and efficient practical navigation training for nautical students in the RNoNA?***
3. ***How can the RNoNA enhance utilization of simulators and real-world navigation training?***

The following section will present the structure of the thesis.

1.3 Structure of the Thesis

Chapter 1 presents the project's background, highlighting the utilization of simulators and school vessels as educational tools. It presents the purpose of the research and introduces the research question that will guide the study. Finally, the structure of the study is outlined, providing a clear overview of its organization.

Chapter 2 introduces general MET literature, focusing on the program at the RNoNA. It provides a comprehensive explanation of the MPN program, including details about the simulator and simulator sessions and information about the school vessels and the procedures followed during real-life training sessions. Additionally, it covers the requirements outlined by the STCW and the Navy`s requirements. Furthermore, the chapter introduces various learning theories relevant to the field of MET.

Chapter 3 presents the research methods used in this thesis. The overall methodology is presented, followed by a detailed description of the procedure during the systematic literature review, qualitative surveys, and semi-structured interviews. Finally, the data analysis procedure is explained.

Chapter 4 presents the results gathered from the research. Chapter 4.1 presents the key findings from the systematic literature review in table format. Chapter 4.2 presents a summarized version of the data from the qualitative survey. Chapter 4.3 presents a summarized version of the data from the semi-structured interviews. The key findings are presented with overview figures.

Chapter 5 integrates the findings from the systematic literature review and discusses the main themes that emerged from the analysis of both interviews and surveys. The research methodology is examined to assess whether the research aim has been achieved and whether the results can be considered valid.

Chapter 6 revisits the research questions and concludes the research. Lastly, future possibilities for research are presented.

2. Theory

This chapter introduces general MET literature, focusing on the program at the RNoNA. It provides a comprehensive explanation of the MPN program, including details about the simulator and simulator sessions and information about the school vessels and the procedures followed during real-life training sessions. Additionally, it covers the requirements outlined by the STCW and the Navy`s requirements. Furthermore, the chapter introduces various learning theories relevant to the field of MET.

2.1 Maritime Education and Training in accordance with STCW

The STCW Convention of 1978, as amended, has set universal competence standards for seafarers. These standards encompass the needs for training, certification, and watchkeeping.

In 1995 and 2010, the convention underwent revisions and updates, which led to the establishment of a framework for the global training and education of mariners. This training is required to meet specific minimum criteria. All marine officers in charge of navigating vessels must possess the minimum competency stipulated in these regulations (IMO, 2017).

According to the convention, seafarers must possess specific competencies, knowledge, understanding, and proficiency. Additionally, appropriate methods must be used to demonstrate these competencies and specific criteria must be met to evaluate a seafarer's competence (IMO, 2017). For instance, to show competency in maintaining a safe navigational watch at the operational level under table A-II/1 Function: Navigation, one can undergo examination and assessment through one or more of the following:

1. Approved in-service experience.

2. Approved ship training experience.

3. Approved simulator training where appropriate.

4. Approved laboratory equipment training (IMO, 2017).

The STCW code mandates (ARPA) and (ECDIS) training as the only necessary simulator training requirements. All other requirements mentioned in the code are recommended to be completed on a simulator or alternative platform (IMO, 2017). The mandatory training requirements in nautical bachelor programs are defined in the STCW code, table A-II/1 and A-II/2.

The bachelor's degree in military studies, specialized in leadership, naval power, and military navigation from the RNoNA, fulfils the requirements of STCW A-II/1 and A-II/2. This program is designed for nautical officers in the Navy. However, to obtain a deck officer certificate, graduates must complete 12 months of systematic training onboard a vessel, as mandated by The Norwegian Maritime Directorate (Sdir, 2023).

The following section will present more detailed information about the study program and education in RNoNA.

2.2 The study programme for the nautical students at RNoNA

At the RNoNA, nautical students enrol in a study program called Military Studies with a focus on leadership, naval power, and military navigation. Upon completion, students earn a bachelor's degree in military studies with a specialization in nautical science. Throughout their education, they will gain knowledge and skills in navigation, bridge watching, and the management and execution of maritime operations in both open sea and coastal zones (Forsvaret, 2023). This program fulfils the requirements of the Norwegian Maritime Authority for obtaining certificates up to the level of Master Mariner (D1).

This program spans over three years with six semesters and 180 European Credit Transfer and Accumulation System (ECTS). The first two semesters of the program focus on developing leadership skills, military methods, and naval power, all geared towards shaping a well-rounded military officer (Forsvaret, 2023). During the summer following the second semester, students start navigation training with real life-vessel exercise West Coast and take an ECDIS course (IMO Model 1.27). This is the first time they will experience practical navigation, focusing on learning the roles of the assistant, helmsman, and navigator. In the third semester, students begin their nautical professional education.

Table 1 provides an overview of selected RNoNA courses involving simulators and real vessel training platforms. All courses are not listed in the table, and the inclusion of simulator and real vessel training may vary based on specific requirements and curriculum updates.

Table 1: Overview of courses involving simulator and real vessel training platforms at the RNoNA.

Course Name	Semester	Classroom	On Vessel	Simulator
Military navigational watch	3	✓		✓
Military Navigation 1	3	✓		✓
Military Practical Navigation 3	3	✓	✓	✓
Navigation systems 1	4	✓	✓	
Military Navigation 2	4	✓		✓
Military Practical Navigation 4	4	✓	✓	✓
Military Navigation 3	5	✓		✓
Military Practical Navigation 5	5	✓	✓	✓
Military Practical Navigation 6	6	✓	✓	

In the third semester, students gain essential maritime knowledge and develop an understanding of various subjects, including naval military technology, military navigational watch, meteorology and oceanography, military navigation, and practical navigation.

The Military Navigational Watch course at the Royal Norwegian Naval Academy meets Navy standards and STCW code requirements (Forsvaret, 2023). Students gain knowledge in:

- Forces in ship handling
- Vessel manoeuvrability in different conditions.
- Mooring, anchoring, and towing equipment.

- Sailing routes, administration, pilotage, reporting, and monitoring.
- Search and Rescue, collision, grounding, and stranding procedures.
- Incidents at Sea (INCSEA) agreement and Automated Mutual-Assistance Vessel Rescue (AMVER) (Forsvaret, 2023).

The course includes classroom, group presentations, and simulator exercises, supporting the (MPN) curriculum.

Military Navigation 1 is a theoretical course that fulfils Navy and STCW code requirements (Forsvaret, 2023). It covers:

- Determining ship position using landmarks and navigational aids.
- Chartwork, accounting for wind, tides, currents, and speed.
- Utilizing navigation charts, publications, and information for safe navigation.
- Proficiency in using ECDIS and optical telegraphing.
- Determining position through terrestrial observations and map skills.
- Assessing the accuracy, detecting errors, and employing corrective methods.
- Understanding compass errors, Earth's shape, and geodetic data.
- Knowledge of the IALA system, seamarks, and navigational aids.
- Familiarity with relevant professional tools (Forsvaret, 2023).

The course combines classroom learning with group presentations and is coordinated with real vessel Exercise West Coast, ECDIS course, MPN 3, and MPN 4

Military Practical Navigation 3 is a comprehensive course that teaches practical navigation techniques using manual positioning optical control. It is designed to familiarize students with practical navigation in the Navy. MPN employs a hands-on approach, integrating theory from other related subjects with practical demonstrations and exercises on board school vessels and in navigation simulators. The course complies with STCW codes A-II/1 and A-II/2 and B-I/12, covering navigation at the operational and management levels, ship operation control, and care of persons on board. The course description is based on the IMO model course 7.03 Officer in Charge of a Navigational Watch, Appendix (Forsvaret 2023). This course is the basis for the student's practical navigation training.

Upon completion, students will know basic practical navigation principles in the Navy, including navigation phases, Navy course notations, optical turn, control, and positioning methods, methods for controlling measured speed and gyro faults, maritime words and expressions, Navy's bridge procedures, seamarks and nautical chart symbols, traffic at sea, basic seamanship, and the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs). They will also learn about using simulators, ECDIS, and the basic use of the K-Bridge bridge system (Forsvaret, 2023).

After the course, students will be able to:

- Apply optical turn, control, and position methods.
- Verify sensor performance.
- Assume roles in the bridge team onboard school vessels.
- Understand common maritime terms.
- Perform time, velocity, and distance calculations, and use a stopwatch for navigation.
- Use an electronic logbook.
- Reflect on professional practice and adjust under supervision (Forsvaret, 2023).

The course comprises theoretical lessons; simulator exercises every other week, and practical exercises on board the school's vessels. Students will have two evenings, one weekend, and two weeks dedicated to practical education on the vessels throughout the semester.

Table 2 provides an overview of the hours spent on the simulator and real vessel training platforms in MPN during semester 3.

Table 2: Overview of hours spent on the two platforms in MPN during semester 3

Total hours spent on navigational training semester 3	
Simulator	School vessels
24 hours	128 hours

During the fourth semester, students develop a more advanced understanding of navigational systems, radar navigation, military operations, and tactics, building upon the knowledge gained in semester three.

Navigation Systems 1 meets Navy requirements and complies with STCW codes A-II/1 and A-II/2, covering operational and management-level navigation (Forsvaret, 2023). After completing the course, students will have knowledge of radar theory, ARPA, geodesy, navigation equipment, history of navigation systems, traditional navigational aids, satellite-based navigation systems (including ECDIS and AIS), and land-based navigational systems (Forsvaret, 2023).

The course combines classroom instruction with practical learning on school vessels, including lab exercises on the ship's bridge system. It is coordinated with Naval Military Technology 1 and 2, MPN 4, and Military Navigation Watch.

Military Navigation 2 is a theoretical course that satisfies the Navy's navigation needs and complies with STCW codes A-II/1 and A-II/2, covering operational and management-level navigation (Forsvaret, 2023). After completing the course, students will have knowledge of voyage planning tools and methods, using electronic aids for position determination, sailing routes, interpreting meteorological instruments, radar navigation methods, and relative/true movements between vessels (Forsvaret, 2023).

The course includes classroom education, group presentations, and simulator-based lab exercises, and is coordinated with Exercise West Coast, the ECDIS course, MPN 3, and MPN 4. It supports both MPN 4 and MPN 5.

Military Practical Navigation 4 is a continuation of MPN 3, with a shift towards radar control. While optical control was the focus earlier this semester, the use of radar is emphasized. During the previous semester, students were not allowed to use the radar. However, they are not allowed to look outside the window this time. To simulate this scenario in the simulator, the visibility is restricted by fog, while on school vessels, a curtain covers the students' view outside. However, the other positions onboard have an unobstructed view.

The course complies with the requirements of the STCW codes A-II/1 and A-II/2 and B-I/12. It covers the STCW functions: navigation at the operational level, controlling the operation of the ship and care of persons on board at the operational level, as well as navigation at the management level. The course description is based on the IMO model course 7.03 Officer in Charge of a Navigational Watch, Appendix (Forsvaret 2023). Upon completion, the student will have equivalent knowledge and skills to those taught in MPN 3, specifically in the application of radar technology.

This course blends theoretical concepts, simulator exercises every alternate week, and practical exercises conducted on the school vessels. The students are provided with practical education on the school vessels for two evenings, one weekend, and one week this semester.

Table 3 provides an overview of the hours spent on the simulator and real vessel training platforms in MPN during semester 4.

Table 3: Overview of hours spent on the two platforms in MPN during semester 4

Total hours spent on navigational training semester 4	
Simulator	School vessels
24 hours	73,5 hours

During the fifth semester, students expand upon the knowledge gained in the previous semester by delving deeper into navigational systems, stability calculations, maritime law, and the integration of optical and radar navigation. Additionally, they also focus on joint military operations.

Military Navigation 3 is a theoretical course that meets the Navy's requirements for effectively planning and executing overseas voyages. It complies with the requirements of the STCW codes A-II/1 and A-II/2 and covers the STCW functions: navigation at the operational and management levels (Forsvaret, 2023). After completing the course, the student has knowledge about:

- Central themes, theories, issues, processes, tools, and methods within overseas voyages with astronomical navigation
- Using celestial bodies to determine and deploy a ship’s position in ECDIS.
- Overseas voyages with astronomical navigation, its history, traditions, uniqueness, and place in the Navy (Forsvaret, 2023).

The course combines classroom lectures, planetarium demonstrations, simulator lab exercises, and group presentations.

In Military Practical Navigation 5, students will build upon the knowledge gained in MPN 3 and 4. This semester, they will learn to integrate optical and radar control in their navigation. The course emphasizes the practical application of these skills, with most exercises taking place after sunset or in a simulated night environment. This challenge requires students to navigate using lights and beacons, applying the techniques learned in MPN 3 and 4. The course complies with the requirements of the STCW codes A-II/1 and A-II/2 and B-I/12. It covers the STCW functions: navigation at the operational level, controlling the operation of the ship and care of persons on board at the operational level, and navigation at the management level. The course description is based on the IMO model course 7.03 Officer in Charge of a Navigational Watch, Appendix (Forsvaret, 2023). After completing the course, the student can combine the knowledge and skills taught in MPN 3 and 4.

The course includes theoretical sessions, simulator exercises every other week, and hands-on training on the school's vessels. In addition, practical education sessions onboard are conducted for two evenings, one weekend, and one week.

Table 4 provides an overview of the hours spent on the simulator and real vessel training platforms in MPN during semester 5.

Table 4: Overview of hours spent on the two platforms in MPN during semester 5

Total hours spent on navigational training semester 5	
Simulator	School vessels
24 hours	79 hours

During the 6th semester, students learn about the operation and maintenance of naval vessels—military loading, unloading, and stowage on the operational and management levels. Military Practical Navigation 6 introduces students to the OOW's responsibilities in the Navy. Additionally, students will be required to submit their bachelor's thesis.

The final practical navigation course at the naval academy is Military Practical Navigation 6. It builds upon previous semesters and focuses on integrating optical and radar control with GPS input. Students learn high-speed craft navigation techniques that meet both civilian and Navy standards. The curriculum includes theoretical and practical components, with exercises conducted on school vessels. Upon completion, students gain knowledge of practical navigation, electronic positioning, optical and radar control in the Navy, and high-speed craft operations (Forsvaret, 2023). They develop skills in optical turn, control, and position methods, sensor performance verification, and using the K-bridge navigation system. Students also learn to assess traffic situations, make informed choices as navigators, and organize bridge teams for safe voyages (Forsvaret, 2023).

By the end of the course, students are prepared to participate in bridge teams on high-speed vessels, pursue OOW certification, and reflect on their professional practice (Forsvaret, 2023). The course includes theoretical and practical components conducted on school vessels, providing hands-on learning experiences (Forsvaret, 2023). Additionally, students can obtain a high-speed certificate that meets Norwegian maritime authority standards (Forsvaret, 2023).

Table 5 provides an overview of the hours spent on the simulator and real vessel training platforms in MPN during semester 6.

Table 5: Overview of hours spent on the two platforms in MPN during semester 6

Total hours spent on navigational training semester 6	
Simulator	School vessels
0	42 hours

Table 6 provides an overview of the hours spent on the simulator and real vessel training platforms in MPN during semesters 3-6.

Table 6: Overview of total hours spent on the two platforms in MPN during semesters 3-6

Total hours spent on navigational training semester 3-6	
Simulator	School vessels
72	322.5 hours

According to the data presented in Table 6, students spend 72 hours on simulator training and 322.5 hours on real vessel training in MPN throughout the semesters. This indicates a significant emphasis on real vessel training, providing students with extensive practical experience and the opportunity to apply their navigation skills in real-world scenarios.

The longer duration of real vessel training likely contributes to a more comprehensive understanding and practical proficiency in navigating actual vessels. However, it is important to consider each platform's specific training objectives and effectiveness when assessing the significance of the time difference.

The following subsection will present more detailed information about the requirements from the Navy.

2.2.1 Requirements from the Navy.

According to the requirements from the Navy regarding practical navigation, the navigators must pass three practical exams during their time as a student at the naval academy. To become an OOW on the Navy`s vessel, graduated students follow the 12 months of systematic training onboard the vessel as required by The Norwegian Maritime Directorate (NavKomp, 2023). To qualify for Navy clearance, candidates must adhere to a rigorous model and demonstrate proficiency at various levels of competence. This model includes assessment in a high-risk simulation environment and practical assessment conducted on their own vessel. To ensure objectivity, external sensors are utilized to evaluate both the simulated scenarios and practical evaluations. Due to confidentiality reasons, I cannot provide detailed information on the exams or competency levels involved in the high-risk scenario and the practical assessment. However, I will provide a brief overview to help readers better understand the expectations placed on Navy navigators.

At the Naval Academy, students take the final practical exam in military navigation after they are finished with Military Practical Navigation 5. This exam assesses the student's abilities in all the practical courses they have taken. It requires them to demonstrate their knowledge, skills, and competence in manual positioning, optical and radar control, using speeds between 18-24 knots. The exam takes around 2 hours and is graded from A to F (NavKomp, 2022). During the exam, the student must utilize appropriate methods to achieve situational awareness in various challenging situations. The purpose of the exam is to evaluate the student's overall comprehension. Students will be navigating manually with the help of optical and radar control. Radar primarily serves as a support tool for monitoring traffic to prevent collisions and groundings. Safety and efficiency must be prioritized when planning the voyage using navigation principles. Optical principles must be applied to avoid hazards on every leg (NavKomp, 2022).

The students must accurately navigate using optical principles to determine their position during their training. They are also expected to assess the safety of their position and avoid any potential danger areas. If they need to change their planned route, they should evaluate their manoeuvre room. Additionally, the students must be able to determine the accuracy of their bearings, position, and measured speed. They need to know how to avoid any hazards that may come their way. Finally, they must be able to assess traffic and manoeuvre in compliance with COLREGs.

Effective communication during navigation is crucial, particularly for the bridge team to identify and rectify any errors. To achieve this, the navigator must follow a structured approach throughout the navigation process, follow procedures, and execute drills accurately. Clear and concise communication of the navigator's intentions is essential to ensure that other bridge team members understand the navigator's plans (NavKomp, 2022). Students must comprehend how the accuracy of their instruments affects navigation precision. To illustrate this, they must identify gyro errors and measure speed. In the Navy, calculating the Estimated Time of Arrival (ETA) is crucial to ensure a vessel arrives at a designated location on time. Navigators must be skilled in ETA calculations (NavKomp, 2022).

Once the simulated scenario is completed, the students must undertake an oral task related to the COLREGs.

After graduation, navigators undergo thorough training to ensure they have the necessary knowledge and skills to navigate their vessel type in challenging conditions. This training includes complex, high-risk scenarios in simulated environments and practical evaluation onboard their vessel. The simulated scenarios allow the navigator to demonstrate their capability to handle challenging scenarios while engaged in military operations on their vessel type. In these scenarios, there may be a decrease in the accuracy of navigation input due to simulated technical difficulties, as well as Navigation Warfare (NAVWAR). The navigator may encounter steering issues and other technical malfunctions on board while dealing with external and internal factors. The navigator must be able to manage operational, navigational, and human factors to master these scenarios successfully.

During the practical evaluations, navigators will demonstrate their familiarity with their vessel type, ability to manage various types of onboard faults, and capability to conduct military operations.

The following subsection will present more detailed information about the school vessels and how the navigational exercises are conducted onboard.

2.2.2 RNoNA School Vessels and training phases

At the RNoNA, vessels are utilized for navigation training, with designated roles for the navigator, assistant, and helmsman, all operated by nautical students. The instructor/master also has a position on the ship, as shown in Figure 1.

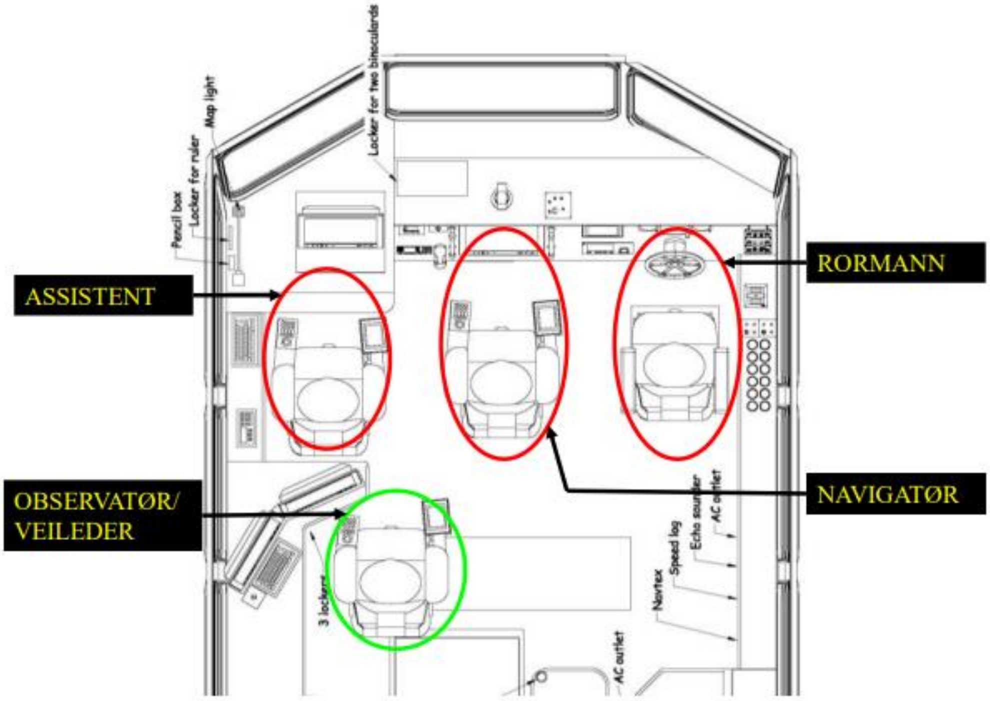

Figure 1: From a bird's eye view, bridge design and positions on the school vessels. (Bolstad, 2018)

A permanent crew does not operate the vessels. Instead, RNoNA personnel serve as the Master and instructors, while the chief engineer rotates among various engineers in the Navy. Additionally, conscript shipmates are responsible for day-to-day duties on the vessels. For voyages lasting longer than one day, the typical crew consists of one Master, one instructor, one chief engineer, and one conscript, along with a team of 4-5 nautical students. Figure 2 shows the school vessel Nordnes.

Figure 2: School vessel Nordnes (Brandal, 2016)

The navigator leads the bridge team and plans the route using ECDIS, following principles from Navy regulations. When planning a sailing route, it is important to include a heading point, turn point, and safety principles for navigating hazardous waters and avoiding shallows and rocks. The navigator should utilize these navigation principles to ensure the vessel stays on the course or safely navigates outside the course line to clear other vessel traffic. While sailing, the navigator must frequently look out the window to confirm the vessel's position and identify other vessels or objects in the water. The navigator should limit the time looking at the ECDIS and instead rely on the assistant for map information and chart work.

The assistant reads the map and manages the chart work as the navigator plans the route. The assistant verbally relays crucial information such as heading points, turn points, and potential hazards in the waters. The assistant accurately plots the vessel's position on the map by receiving compass bearings or radar distances from the navigator. While some tasks are predetermined, such as notifying the navigator two minutes before a turn, the assistant collaborates with the navigator on other tasks. Additionally, the assistant functions as a lookout to always ensure safety.

The primary responsibilities of the helmsman include steering the designated course and keeping the speed as instructed by the navigator. Furthermore, the helmsman also serves as a lookout.

Students first receive a practice order containing all the necessary details to conduct practical navigation exercises. They then plan their routes in accordance with Navy standards. After planning, the students review their plan with the instructor, preferably the same instructor who will oversee the exercise. The student receives feedback and instructions on improving the plan during this review. Once the student has improved the plan, the student is ready to sail (Sulen, 2017). On an evening sailing aboard the school vessel, the RNoNA instructor makes a trip to Haakonsvern Naval base to collect the vessel and sail it to RNoNA. The instructor spends about two hours on this operation. Once at the RNoNA, the students gather on board and commence the navigation exercise with a briefing. The briefing covers several topics such as safety, program objectives, weather and wave forecasts, astronomical data, tides, a detailed description of the operational area, communication, bridge status, vessel status, port information, and comments from the master. Following the briefing, students man the roles on board the vessels, as shown in Figure 1. An average evening involves 5-6 hours of navigation practice in the vicinity of Bergen with one instructor and 3-4 students. Each student has a turn in each role and will receive individual feedback highlighting their strengths and areas for improvement based on their performance as a navigator. Later that night, when the vessels are docked, there is a debriefing session to discuss the exercise goals. All students present their experiences and focus on what they, other students, and the instructor can learn from the session (Sulen, 2017). The weekend and week-long sailing structure are the same, with navigation exercises conducted from morning to night.

As a military navigator, one must consider various operational, navigational, and human factors. The navigational factors comprise four main components with multiple sub-components, such as knowledge about charts, sensors and systems, the use of helmsman or autopilot, and different control modes. These factors, along with human factors and the requirements of a military operation, make military navigation a complex task. However, with MPN, there is an intention to gradually develop navigational and human factors through exercise goals and theoretical courses (Sulen, 2017). Figure 3 shows the fundamental factors for military navigation.

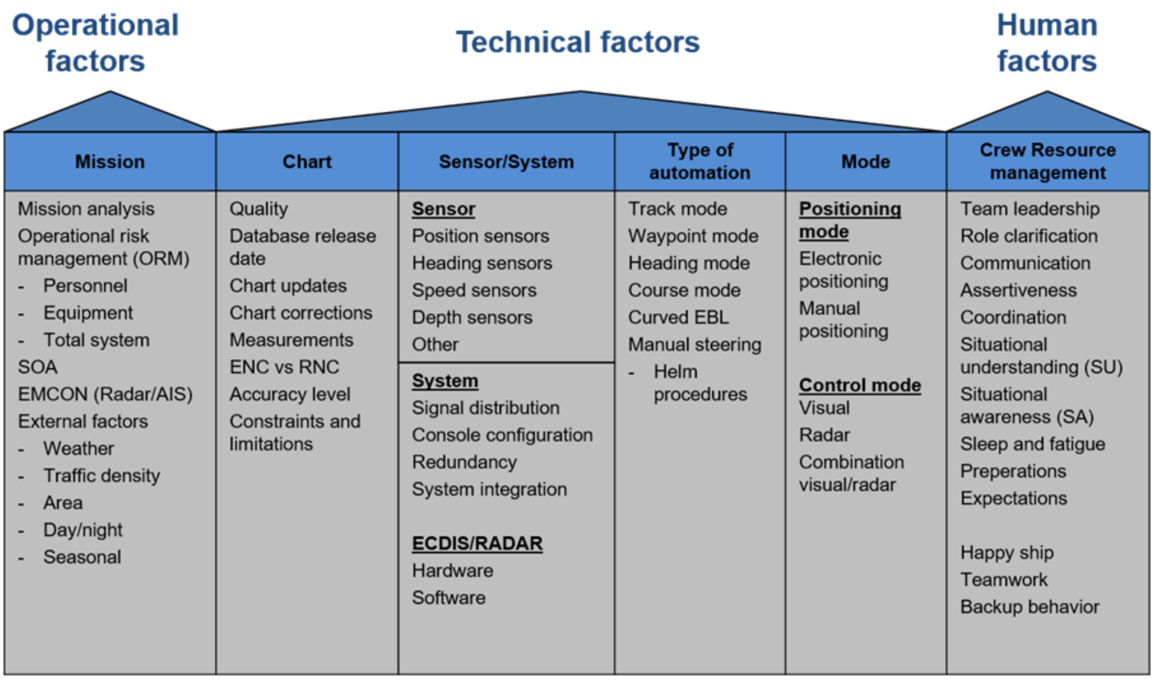

Figure 3: Fundamental factors for military navigation (NavKomp, 2023)

In the RNoN, navigation is divided into four phases, a crucial component of the standard operating procedure (SOP). The phases provide a systematic approach to managing the complexities of military navigation. During their education at RNoNA, students learn to build their phases from scratch until they resemble Figure 4. The length of each phase varies depending on the vessel's velocity and the leg's length. For instance, if a ship moves at 8 knots and the leg is 0.8 nautical miles long, the bridge team has 6 minutes to complete all four phases. However, if the vessel travels at 16 knots on the same leg, the bridge team will only have 3 minutes to complete the phases. Figure 4 illustrates the four phases of navigation.

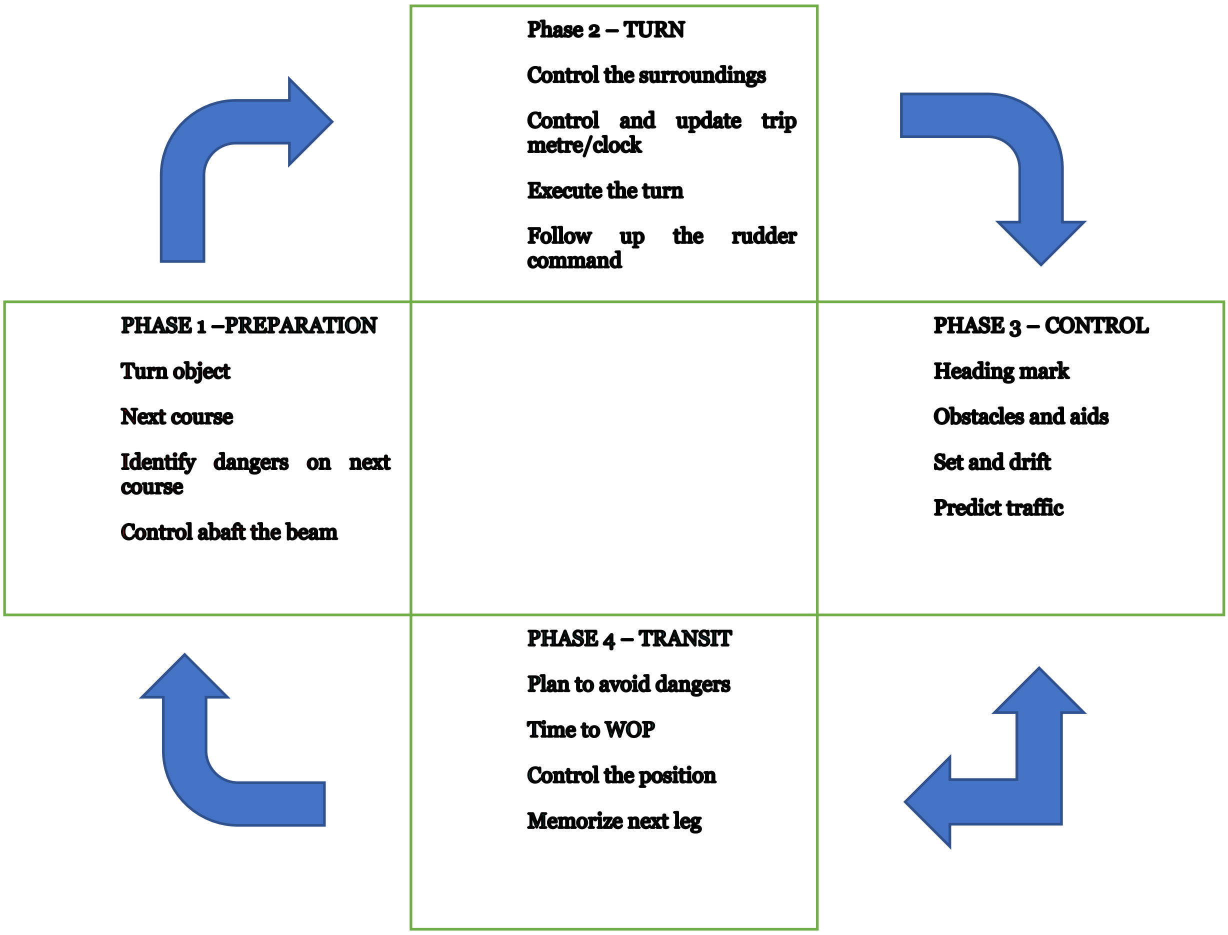

Figure 4: The four phases of navigation (NavKomp, 2023)

Before making a turn, preparing properly during Phase 1 is essential. The navigator should gather all necessary information to ensure a successful turn.

During phase 2, the actual turn, the navigator must ensure that the turn is done in the correct location. The navigator should also check the surroundings, use a stopwatch and trip meter to control the turn and monitor the rudder angle. If the vessel has deviated from the planned route before the turn, the navigator should try to use the turn to get back on track.

Once a turn is completed, the navigator enters phase 3, the control phase. During this phase, the navigator must observe the surrounding environment and ensure the vessel is on the course line. Additionally, the navigator needs to predict the set and drift, identify any obstacles or aids to navigation, and anticipate any potential traffic.

Phase 4 is the last; during this phase, the navigator will calculate the time to the next wheel-over point. The navigator will frequently verify and update the vessel's position using terrestrial principles. The navigator will also continuously verify the navigation sensor's performance. The navigator plans to avoid dangers in this phase (Sulen, 2017). Figure 5 provides an overview of the phases.

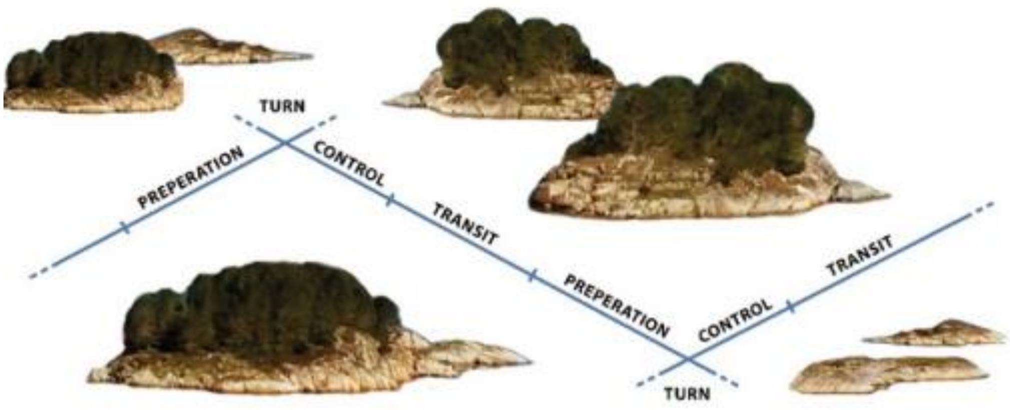

Figure 5: Overview phases of navigation (Hareide, 2020)

The following subsection will present more detailed information about the simulators and how the simulated navigational exercises are conducted.

2.2.3 RNoNA Bridge Simulators and training phases

Maritime education and training institutions commonly use simulators as their main platform (Nazir et al., 2019). The process of maritime simulation-based training is normally divided into three phases. First, there is a briefing that outlines the objectives and expected outcomes of the session. Second, the simulation occurs, during which the students take on officers' roles in an instructional context while the instructor observes and monitors their progress. Finally, the session concludes with a debrief, which involves studying and reflecting on the events during the simulation. This step is critical for effective training (IMO, 2012). Retrospective feedback and evaluation benefit students by allowing them to learn from past experiences and prepare for future scenarios. A three-phase structure that includes analysing what happened, identifying what could have been done differently, and summarizing the lessons learned and identified is recommended (Sellberg et al. 2018).

The RNoNA utilizes K-Sim simulators to provide training for its nautical students. The ship-handling simulator is a high-fidelity simulation system featuring seven bridges, including one large bridge, one high-speed craft simulator, and five small bridges. Additionally, a control room and an auditorium can be used for briefings, instructions, and debriefings. Each bridge is equipped with navigation and communication systems and provides an authentic representation of the maritime surroundings. Figure 6 provides a view of one of the small bridges.

Figure 6: RNoNA ship-handling simulator small bridge

As shown in Figure 7, the control room is equipped with several instructor stations, network structures, server systems, computer hardware, and communication systems necessary to run simulations for all bridges, individually and simultaneously (Mjelde, 2013). The instructor can observe the students' activities via cameras and microphones inside the bridges, thanks to the monitor system in the control room. Additionally, there are screens that replicate the students' environmental views, a 3D presentation of the vessel, and slave monitors for ECDIS, RADAR, and CONNING.

Figure 7: RNoNA ship-handling simulator control room, instructor station.

During simulator sessions, there are typically two instructors organizing the session. Students receive an exercise brief in the auditorium, presenting them with the objectives and principles they will be practising. They are then divided into simulators, with a team size of three to four students per simulator. Depending on the class size, three to five simulators may be used. The instructors then assess and instruct the students accordingly. The exercise is conducted with students covering positions and roles as they would on school vessels Figure 1. After an hour, there is a short break, and students rotate positions. Once the exercise is completed, students gather back in the auditorium for a debrief.

The students have six simulator sessions each semester, except for the sixth semester when they only use the school vessels. These sessions last for four hours each.

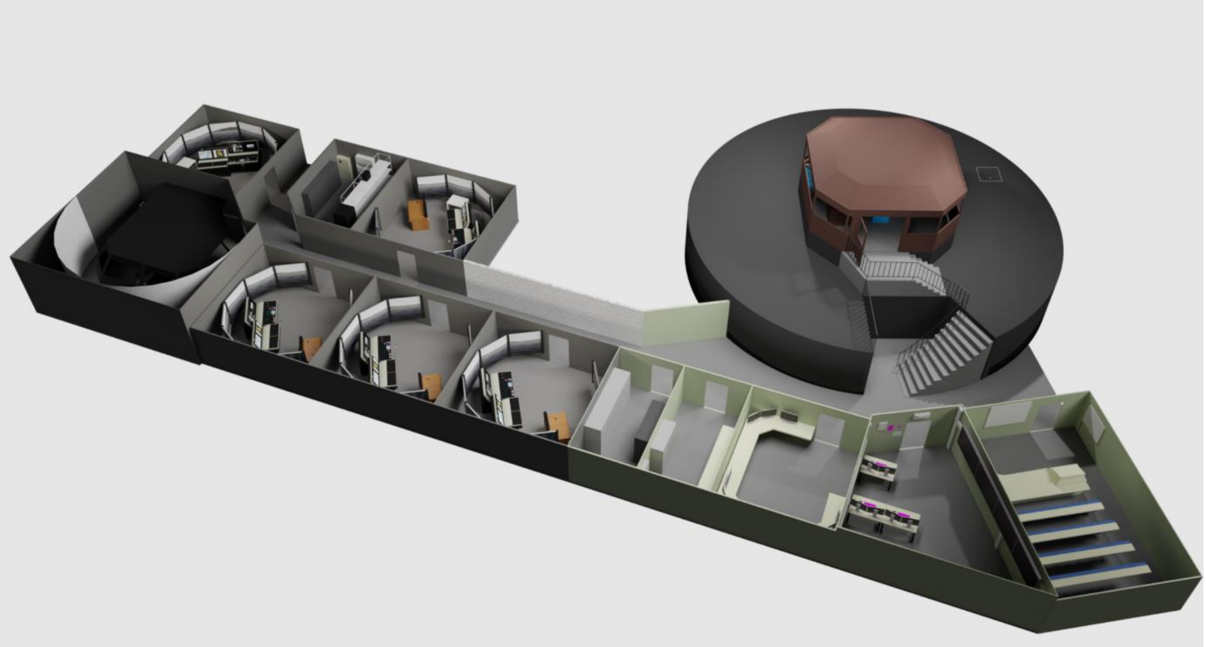

Figure 8: RNoNA ship-handling simulator facility layout

The following subsection presents literature on the topics of fidelity and immersion.

2.2.3.1 Fidelity and Immersion in simulator-based Training

The term fidelity is used in various fields and is defined by the Oxford Dictionary as "the degree of exactness with which something is copied or reproduced " (Fidelity n.d.). In the context of simulator training, it is assumed that fidelity is important. In the case of maritime simulator training, fidelity can be defined as the extent to which the virtual environment in the simulator resembles the real-world platform. Fidelity can be categorized as either high or low based on the simulators' level of immersion and complexity (Rehmann et al. 1995).

According to Alessi (1988), it is beneficial to begin training on low-fidelity simulators and gradually expose individuals to more complex high-fidelity simulators once they have attained a certain level of proficiency. Brydges et al., (2010) conducted a study comparing students' performance using low-fidelity simulators versus high-fidelity simulators. They also observed a third group of students who initially learned isolated skills in a low-fidelity environment and progressed to mid-fidelity before training on integrated skills using high-fidelity simulators. The results showed that the group that gradually transitioned from low- to high-fidelity simulators had the best performance. Additionally, the study found that high-fidelity simulators were most effective in training integrated sets of skills.

Hamstra et al., (2014) state that a simulator's fidelity can vary significantly between different areas. As a result, the term is not specific enough and often used to describe various concepts. They also note that fidelity is commonly associated with how closely a simulation replicates physical appearance rather than how effectively it facilitates learning or mimics a real-world experience (Hamstra et al., 2014).

Hontvedt & Øvergård, (2020) supports that the term fidelity is not precise enough. Their literature review found that the term could refer to either the immersion level of the physical or technical environment or the immersion level of the simulation itself. As a solution, they proposed a framework for designing simulator training that considers the necessary level of fidelity based on training objectives and assessments. This framework is based on three central approaches:

One approach prioritizes technical fidelity, which means ensuring physical and functional accuracy. Another approach focuses on psychological fidelity, which involves creating environments that encourage problem-solving strategies, mental models, and emotions. Lastly, they emphasize interactional fidelity, which aims to recreate precise coordination and collaboration within a team (Hontvedt & Øvergård, 2020).

In certain training simulations, it is crucial to have high technical fidelity for effective learning. This means the simulator must provide a consistent and realistic feeling that responds to the tasks. However, what matters most is how suitable the scenario is for achieving the training objective rather than how well the simulator matches its characteristics. For instance, some training scenarios, such as a complex navigation exercise, may require an immersive world that accurately replicates the surroundings and movements (Hontvedt & Øvergård, 2020).

To achieve high psychological fidelity, scenarios should challenge and broaden the participants' mental models. Such scenarios can also aid in productive debriefings and reflection sessions, allowing participants to link their experiences with relevant concepts (Hontvedt & Øvergård, 2020).

Based on this research, it can be concluded that fidelity plays a critical role in immersing students in a simulation.

Immersion is defined as a "deep mental involvement in something" (Immersion n.d.). It refers to the level of engagement an individual experiences in a specific task or situation. In video games, immersion refers to the extent to which a player is fully engaged and absorbed in the game. Brown and Cairns (2004) categorized immersion into three stages: engagement, engrossment, and total immersion. These stages are separated by barriers that players must overcome to progress to the next level of immersion. Ermi and Mäyrä (2005) further support the concept of immersion and break it down into three components: sensory immersion, challenge-based immersion, and imaginative immersion.

Engagement has two barriers: access and investment. The player's preference determines access, which is their initial obstacle. If they do not enjoy the type of game, they will not try it. If they like it, they will invest time and effort to focus on it. Their focus and engagement will gradually increase as they spend more time and effort playing the game (Cheng & Annetta, 2015).

As players become more invested in a game, they enter an engrossment stage. However, there are two barriers they must overcome to reach this stage. Firstly, their awareness of their physical surroundings and environment decreases as their emotional attachment to the game increases. Once they are fully engrossed, the game becomes the primary focus of their attention, to the extent that they are less aware of the real world. The game will directly impact their emotions, and they may feel emotionally drained when they stop playing (Cheng & Annetta, 2015).

Total immersion in a game is when the player feels like they are living inside the game. At this point, the player has lost their self-awareness, and it is almost as if their consciousness has been transported from reality into the game world. The player becomes completely invested in the in-game characters and their situations, feeling empathy towards them. This detachment from reality makes the player feel like the game is all that matters (Cheng & Annetta, 2015).

Cheng and Annetta (2015) suggest that serious educational games (SEGs) can be a valuable tool for learning, as players can learn while fully immersed in the game. However, the authors caution that students may become too absorbed in the game and overlook the educational material. Thus, the instructor or teacher's role is crucial in guiding the learning process effectively.

For a simulation to be effective in training students, they must be able to relate it to the real world. The level of immersion can be described as how realistic the experience feels. Fidelity refers to how the simulation is presented technically, psychologically, and in terms of interaction. Immersion is how much the student "buys into" the simulation. Of course, the highest levels of fidelity and immersion are achieved in the real world, as it is the most authentic experience.

The following section presents literature on training, learning, and assessing in a simulated environment and on real-life platforms.

2.3 Training, learning, and assessing in a simulated environment and on real-life platforms.

Charlott Sellberg has conducted several studies regarding the use of simulators, with a review and qualitative synthesis of the use of simulators in maritime education and training, focusing on bridge operations during navigation training and assessment (Sellberg, 2017). Research studies have been conducted by her on the teaching approach of instructors, from briefing to debriefing, which addresses the ways to enhance learning using simulators (Sellberg & Lundin, 2017; Sellberg, 2018).

Through her research, she discovered that simulators effectively train technical and non-technical skills. However, the optimal use of simulators requires competent instructors (Sellberg, 2017). Sellberg and Lundin's (2017) study also revealed that simulators enable instructors to employ diverse strategies to emphasize different aspects in various scenarios (Sellberg & Lundin, 2017). The instructor can adjust the scenario's complexity based on the student's response and has the option to stop it altogether. Sellberg et al. (2018) suggest that the simulator alone is insufficient for learning. Still, it can be a valuable tool if combined with an instructor who can supervise and provide feedback. The simulator also allows for playback during debriefing, providing a chance to correct the student's actions and guide them towards the desired outcome (Sellberg, 2018). Sellberg et al. (2018) conducted a study that revealed the importance of spending time at sea to gain first-hand experience working on a ship. This experience cannot be replicated through simulations alone. The study concluded that novice learners should not rely solely on simulator-based training but instead engage in onboard practice as well. However, this study states on board practices, not a vessel intended solely for navigation like M/S Kvarven and M/S Nordnes.

Research has also been conducted on how simulator exercises can be further improved. In a study by Mallam et al., (2019), the possibilities of using Virtual Reality, Augmented Reality, and Mixed Reality in maritime training and education were explored. The study revealed that this technology could offer new educational prospects, but it can currently only serve as a supplement. Further research is required to better understand the potential benefits and drawbacks of these tools, both in maritime education and planning for maritime operations

(Mallam et al., 2019). According to Lean et al. (2021), simulations offer the opportunity to expand the range of practice for students by presenting scenarios that may not be available in real-world settings.

A bachelor thesis researched nautical students at the RNoNA, measuring their electrodermal activity (EDA). The study involved measuring EDA in simulators and real-world training on school vessels. EDA refers to skin conductivity and provides insights into stress levels. The results revealed that participants experienced higher average EDA values during real-world training on school vessels than in the simulator. This indicates higher stress levels while sailing on school vessels compared to simulator training (Gade-Lundlie & Timberlid, 2018). According to Gade-Lundlie and Timberlid, there is a significant distinction between sailing in virtual and real environments. Their thesis suggests that simulator training alone cannot replace navigation education on school vessels. They argue that real-world experience is crucial for stress training and that actions in the physical world have real consequences. The study required students to collect EDA measurements independently, and only five complete measurements were obtained. As a result, the researcher doubts the reliability of the study's conclusions. Nonetheless, the thesis emphasizes the significance of utilizing real-life vessels in educating nautical students at RNoNA.

The following section will present RNoNA's educational approach and relevant learning theories such as constructivism learning theory, Kolb's experiential learning theory, and co-curricular learning.

2.4 Learning theories

The RNoNA applies the same educational approach for military practical navigation as it does in its leadership courses. Since 2000, this education model has been used for practical navigation (Sulen, 2017). RNoNA's education philosophy revolves around a positive outlook, acknowledging individuals' unique characteristics and wills. RNoNA also believes that individuals strive to contribute to a larger context, and when given challenges that they can overcome, they are motivated to seek and conquer new challenges (Olsen, & Espevik, 2009). Positive environments amplify good traits, while negative ones amplify bad traits. Individuals will develop their knowledge and skills based on their environment. Humans have an important and influential role in developing, organising, and implementing knowledge. Their prior experiences, interests, and dedication all create a new understanding of reality (Olsen, & Espevik, 2009).

Instructors must assess their students' skills and knowledge about the curriculum and their approach to reality. To help students understand the exercise goals, instructors should provide an image of the goals in a familiar context. This will increase students' commitment and understanding of the exercise (Olsen, & Espevik, 2009).

Students' Military Practical Navigation training progress is influenced by the balance between their previous and new experiences. According to RNoNA, learning involves stepping out of one's comfort zone and entering an unfamiliar and uncertain situation. In MPN, this translates to moving away from familiar methods and trying new ones yet to be mastered. Building trust between the instructor, environment, and students is crucial in encouraging students to take on new methods, conquer their fear of failure, and learn new skills (Olsen, & Espevik, 2009.; Sulen, 2017). Figure 9 shows the bridge of trust.

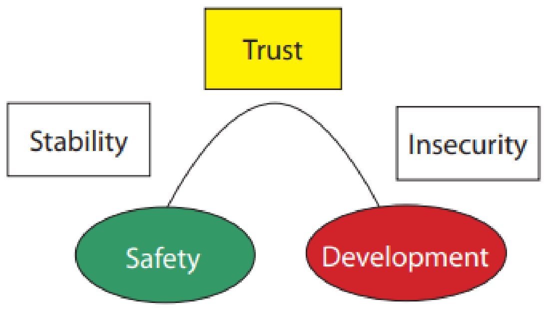

Figure 9: Bridge of trust (Olsen & Espevik, 2009).

The social environment plays a crucial role in enhancing learning. When students venture into new arenas and experiment with different methods while being observed, trust becomes vital between everyone involved, the students, peers, and instructors (Olsen, & Espevik, 2009). Collaborative learning leads to social interaction among students and creates opportunities for a better comprehension of the subject. Everyone perceives and evaluates situations differently. Therefore, discussing and striving for a mutual understanding can improve the learning outcome significantly (Olsen, & Espevik, 2009).

Constructivism learning theory suggests that learners will create their understanding and knowledge by being exposed to and reflecting on new situations. As we encounter new situations, we connect them to our past experiences and either consider them irrelevant or allow them to change how we evaluate the situation. Learners construct their knowledge in this process (Bada, 2015). Encouraging learners to ask questions, exposing them to challenges, and reflecting on experiences are important for improving their understanding. The instructor should adjust the difficulty of challenges to an appropriate level, allowing learners to use new challenges as building blocks in the learning process (Bada, 2015). According to Bada (2015), constructive learning involves two crucial concepts: learners create new knowledge based on what they already know, and learning is an active process. For constructivist learning to be effective, the environment must allow active learning. Bada (2015) identifies four key characteristics that must be present in a constructivist learning environment for this to be possible:

1) Knowledge is shared between both teachers and students.

2) Teachers and students share the authority.

3) The teacher’s role is to facilitate and help the students learn.

4) The learning groups consist of small numbers of students with unique abilities.

In 1996, Honebein outlined seven objectives for what a constructivist learning environment should provide:

1) Experience with the knowledge construction process.

2) Provide experience in and appreciation for multiple perspectives

3) Embed learning in realistic and relevant contexts

4) Encourage ownership and a voice in the learning process

5) Embed learning in the social experience

6) Encourage the use of multiple modes of representation,

7)Encourage self-awareness of the knowledge construction process (Honebein, 1996, p. 11).

Bada (2015) suggests that Constructivist teaching is based on understanding the human brain and the learning process. Caine & Caine (1991) have proposed twelve principles of brain-based learning. These principles include the following points:

1. The brain can process multiple tasks simultaneously.

2. The entire body is engaged during the learning process.

3. The desire to seek meaning is innate.

4. The search for meaning happens through pattern recognition.

5. Emotions play a crucial role in pattern recognition.

6. The brain processes both parts and wholes simultaneously.

7. Learning involves paying attention and having peripheral perception.

8. Conscious and unconscious processes are involved in the learning process.

9. Our brain has two memory systems: spatial memory and rote learning.

10. We tend to remember things better when they are embedded in natural, spatial memory.

11. Learning is enhanced by challenges and inhibited by threats.

12. Every brain is unique (Caine and Caine, 1991).

Experiential Learning Theory (ELT) is a framework for experiential educators to enhance learning and development. It recognizes the importance of experience in the learning process, which can lead to a complete understanding of the subject matter. This theory is based on the idea that learning is a holistic process and that all learning involves re-learning, leading to knowledge creation (Kolb et al., 2014).

The ELT learning cycle is a well-known concept, describing the learning process as a repetitive circle. First, learners experience the world through their senses. Next, they reflect on these experiences, considering what they mean. The third step is to connect the experience and reflections to established theories or experiences, referred to as abstract conceptualisation by Kolb & Kolb. Finally, learners use active experimentation to assess their concepts and see if outcomes differ (Kolb & Kolb, 2017).

According to Kolb & Kolb (2017), the educator role profile is helpful for educators who teach learners with ELT. This profile outlines four common roles that educators may play:

• The Facilitator Role: This involves assisting learners in connecting their individual experiences and reflecting on them.

• The Subject Expert Role: Educators should ensure learners can grasp the concepts from their experiences and reflections.

• The Standard-Setter/Evaluator Role: Educators should demonstrate to learners what they must master to determine if their active experimentation is within the requirements.

• The Coaching Role: Educators must guide learners on how to apply their knowledge to achieve their objectives. These roles are not bound to the educator; both learners and educators can develop the flexibility to use all roles and styles to create an even more powerful and effective process of teaching and learning (Kolb & Kolb, 2017)

Co-curricular activities and learning experiences are supplementary to the regular curriculum. These activities are usually voluntary. Examples of co-curricular activities include sports and student organizations (Stirling & Kerr, 2015). Research shows that co-curricular activities can enhance students' academic performance and intellectual involvement. In higher education, these activities occur alongside curricular activities, providing opportunities for students to benefit from both. Teachers can facilitate "purposive co-curricular participation" by creating programs that allow students to apply Kolb's ELT and improve their curricular performance (Stirling & Kerr, 2015). To ensure successful learning, it is necessary to establish specific learning objectives for students to achieve through the program. A portfolio can be created for students to reflect on and conceptualize their co-curricular experiences, as suggested by (Stirling & Kerr, 2015).

3. Methodology

In this chapter, the research methods used in this thesis will be presented. The overall methodology will be presented, followed by a detailed description of each method.

3.1 Methodology description

The research questions focus on the impact the combination of simulators and real-life vessels has on the learning experience for nautical students, specifically in exploring how these platforms can be used more efficiently to enhance knowledge and skills acquisition.

Qualitative research involves collecting subjective data from individuals in their natural environment to investigate their opinions and behaviours. This type of research utilizes various methods to gain insights into human experiences and perspectives. (Christensen et al., 2015). Qualitative data refers to data that is expressed in the form of words, like human activities, beliefs, and ideas. This descriptive data type can offer valuable insights into a phenomenon (Walliman, 2022). Qualitative data can be gathered from sources such as literary texts and interview transcripts. The researcher conducted a systematic literature review, qualitative surveys, and semi-structured interviews in this study.

A systematic literature review provides qualitative data in the form of findings from previous researchers. A literature review is normally used for setting up the baseline for a research project. However, a structured literature review with qualitative data analysis can provide a great deal of historical and present data (Walliman, 2022). When analysing texts of other researchers, there are different approaches one can use. Depending on what the aim of the research is. Thematic qualitative text analysis was chosen for this project. The initial literature review discovered that numerous academic studies had been conducted on the use of simulators and their usage. By analysing these studies qualitatively, it is possible to gain insight into how simulators impact knowledge acquisition for nautical students. However, there is limited reliable research available on the use of real-world training for nautical students.

A qualitative survey in the form of a questionnaire was found appropriate for the study. Surveys allow for the measurement of individuals' attitudes, activities, opinions, and beliefs (Christensen et al., 2015). The survey population comprised graduated nautical students from the last year and the current graduate class at the RNoNA. This demographic was selected to gather students' perspectives and beliefs on how the simulator and real-world platform are utilized.

The RNoNA has a team of experienced instructors who have been training cadets for up to two decades through simulators and real-life platforms. Each instructor has their own area of expertise. Some of them excel in simulator training, while others in real-life training. To ensure that the questionnaires used on the students were valid, these experts were asked for guidance in formulating the questions. Additionally, the researcher conducted semi-structured interviews with five instructors to gain their perspectives and insights. However, it was acknowledged that these experts might be biased due to their proximity to the research topic, and this was taken into consideration during the research process (Christensen et al., 2015).

According to Leedy & Ormond (2021), certain research inquiries require us to delve deeper and gain a comprehensive understanding of the phenomenon being studied rather than just scratching the surface. Therefore, a qualitative analysis that combines a systematic literature review and qualitative surveys and interviews was chosen to investigate the research question. Using multiple qualitative research methods, also known as triangulation, is a technique recommended by (Christensen et al.,2015) to gain a comprehensive understanding of the subject under study.

The following section will provide more detailed information about the research procedure and how the research methods were conducted.

3.2 Procedure

3.2.1 Literature review

The literature is gathered from various sources, including Høgskulen på Vestlandet (HVL) Library Oria, Google Scholar, Forsvarets Høyskole (FHS) Brage, FHS library, and studies recommended by my supervisor. I applied strict inclusion criteria, limiting my search to peer-reviewed research or published theses, in English or Norwegian, with full-text availability. Table 7 shows the inclusion criteria for the systematic literature review.

Table 7: Inclusion criteria for the systematic literature review

Included
• Peer-reviewed research or published theses • English or Norwegian • Full text available.

Once the inclusion criteria were made, I formulated search strings to find external data on the use of school vessels for training nautical students or officers. Despite trying various strings, I could not find any information beyond the RNoNA regarding this topic.

Table 8 presents the databases containing the final search strings and their respective results. The literature search provided a total of 137 publications. Upon reviewing these, many articles were deemed irrelevant after skimming the abstract, or they were not available as open access. Other articles required a thorough reading before being classified as relevant. There were also instances of duplicate articles found between Oria and Google Scholar, and in such cases, Oria was selected as the database for that publication.

Table 8: Literature overview table

Database	Search string	Result	Exclusion	Results after Exclusion
HVL Oria	Title contains: Simulator Any field contains: maritime OR nautical AND education AND assessment	86	70	16
Google Scholar	All in title: Simulator training OR assessment AND maritime OR Nautical	53	50	3
FHS Brage	Title: simulator Any field contains: skolefartøy	1	0	1
Total		137	117	20

After conducting a thorough database search, I identified twenty relevant articles. Overall, my systematic literature review regarding the use of simulators and real-life vessels includes these twenty articles. To supplement this literature, I also reviewed references from these articles and consulted with my supervisor to gather additional relevant literature. In total, the thesis includes fifty-eight references.

3.2.2. Qualitative Surveys

Measuring individuals' attitudes, activities, opinions, and beliefs is possible through surveys (Christensen et al., 2015). After reviewing "The Online Survey as a Qualitative Tool" by Braun et al. (2021), the questionnaires for the survey were finalized. They are available in Appendix C.

Qualitative surveys involve open-ended questions focused on a single topic, allowing participants to respond in their own words instead of choosing from pre-defined options (Braun et al., 2021). This approach gives researchers access to participants' ideas and beliefs, enabling them to extract valuable insights. Collecting data through qualitative surveys is quick and easy. Still, it is essential that questions are designed carefully to get responses that are relevant to the problem at hand, as it is not possible to clarify individual responses (Braun et al., 2021). When designing a qualitative survey, there are two main question types: topic-based and demographic. To answer the research questions, a topic-based question design was chosen. When designing good qualitative questions, it is important to have open, short, and clear questions. To increase the reliability of the survey, it is important to define the question being asked (Braun et al.,2021).

The survey questions were formulated based on the research questions and ideas provided by instructors at the RNoNA. To ensure clarity, a person unfamiliar with the topic read the questions and provided feedback, refining some questions. Additionally, a consent form was created in accordance with guidelines from the Norwegian Agency for Shared Services.

Conducting pilot studies is crucial in ensuring the quality of surveys (Hilton, 2017; Braun et al., 2021). Typically, 5% to 20% of the expected sample size is used for pilot testing (Braun et al., 2021). Four second-year students from the RNoNA were selected as the pilot group for this survey. These students had eight months of experience using simulators and operating vessels, making them suitable representatives of the sample population. Three pilot surveys were completed, and adjustments were made to improve the survey based on the feedback received.

After obtaining approval from the Norwegian Agency for Shared Services and the Norwegian Defence Research Board, approximately forty surveys were distributed to current students at the Naval Academy and graduates in the Navy via email. The survey aimed to gather feedback from nautical students and graduates regarding their experiences with simulators and real-life platforms and their opinions on their current utilization. The survey population were all in their twenties. The students had two months left of their program at the time of the survey, while the graduates had nine months of professional experience in the Navy. Both male and female individuals were included in the survey population. It is generally a clever idea to put in more effort to get survey respondents to participate, as this tends to increase response rates (Walliman, 2022). Although I believed the topic would capture the participants' interest, I understood that conducting a qualitative survey could be challenging for a busy population. Therefore, I talked with a large part of the population, informing them of the project before distributing the survey, as it is important to get a good response to ensure reliability (Walliman, 2022). Since the email responses were received before the respondents were anonymized, the researcher has control over the quality of the responses, which ensures the reliability and validity of the data (Walliman, 2022).

The data collection took place during March and April of 2023.

3.2.3 Interviews

Organizing and distributing a survey is a straightforward process. However, even qualitative surveys have limitations in terms of flexibility for obtaining necessary information through follow-up questions. Interviews are a highly versatile tool that can be employed in various scenarios (Walliman, 2022). There are three commonly used interview types:

The structured interview form consists of standardized questions, typically in a closed format.

An unstructured interview is a flexible form that typically follows a guide but allows the interviewer to go deeper into more interesting aspects by going back and forth.

A semi-structured interview combines structured and unstructured forms using standardized and open-ended questions. It allows researchers to address qualitative issues flexibly (Walliman, 2022).

For this thesis, semi-structured interviews were found appropriate. To prepare for these interviews, an interview guide was created. The guide was created based on the survey questions used on the nautical students and qualitative interview strategies recommended by the sociology department at Harvard University. The guide emphasizes the importance of asking simple questions and encouraging interviewees to provide detailed and satisfying responses (Harvard, 2023). Additionally, a consent form in compliance with the guidelines set by the Norwegian Agency for Shared Services was created.

The interview aims to gather insight from instructors regarding their perspectives and experiences using both simulators and real-life platforms for training. Participants were selected based on their proficiency and familiarity with simulator-based and real-life training. To conduct a semi-structured interview, the interviewer must have the necessary skills and expertise (Leedy & Ormond, 2021). Before conducting the interviews, the researcher conducted a literature review. As the researcher had no prior experience conducting academic interviews, a decision was made to evaluate the interview guide on an instructor at RNoNA who has similar experience and background as the research participants. Conducting a pilot interview can be useful in recognising any weaknesses in the interview questions (Leedy & Ormond, 2021) and helps the interviewer become more familiar with the interview topic (Harvard, 2023). During the pilot, it was discovered that it is preferable to ask questions in English while allowing the interviewee to respond in Norwegian. Additionally, the pilot was transcribed and coded to gain practical experience with the transcribing and coding process.

Following the necessary approval from the Norwegian Agency for Shared Services and the Norwegian Defence Research Board, five semi-structured interviews were conducted at the researcher's office in RNoNA. The interviewees were all male, aged 35-62 years, with considerable experience (4-25 years) working as instructors. The interviews lasted 22-51 minutes, with a median duration of 31 minutes. The interviews were recorded and transcribed for further analysis. To enhance the accuracy of the interviews, the researcher conducted member checking (Leedy & Ormond, 2021). This involved requesting participants to review the transcripts. The transcripts were labelled with codes instead of the interviewees' names and stored on a separate computer to ensure anonymity. Data collection took place in March/April 2023, and the complete interview guide is available in Appendix A.

The following section will provide more detailed information about the data analysis procedure.

3.3 Data analysis

Content analysis involves analysing various forms of text, media, and live situations. This analytical approach applies to both primary and secondary sources (Walliman, 2022). Originally designed as a quantitative method, the approach can also serve as a qualitative method to provide structure to qualitative data through thematic analysis (TA) (Walliman, 2022). TA can help researchers gain insight into study participants' experiences, viewpoints, and perspectives (Clarke & Braun, 2017). Unlike other methods, TA is not limited by a specific theoretical framework (Braun & Clarke, 2006). The process of TA involves six steps:

1. Familiarize yourself with the data, read it, and know it.

2. Make the initial codes based on the data.

3. Search for themes, and group the codes into suitable themes.

4. Review the themes, go over the themes and ensure that they represent the data.

5. Define and name the themes.

6. Produce the report, and write the narrative (Braun & Clarke, 2006).

TA was chosen as the method for the collected data from the literature review, qualitative surveys, and semi-structured interviews. Braun and Clarke's (2006) framework has been followed during this study, providing a clear and practical framework for thematic analysis.

The literature review was the first and last step in the analysis; interviews were the second data set that was analysed, and then the surveys were analysed before doing the systematic literature review to refresh my knowledge on the topic. The process was quite similar for all three datatypes. Therefore, I will only describe the process from the semi-structured interviews. First, the researcher had to transcribe the interviews, and then I needed to understand the data set better. This was done by (1) reading all the transcripts multiple times. Then the first codes were created based on the entire data set. The researcher decided to search for codes at the semantic level, meaning that the researcher only searches for what the data says explicitly (Braun & Clarke, 2006). The first codes included: students, improvements, training in a simulator, connecting simulators and real-life platforms, learning and instructors. After this, more codes were assigned to the initial codes; for example, combining school vessels and simulators as a learning enhancer for the students was a frequent theme, and it is relevant to this research. After this, I used the literature by (Hjelmervik et al., 2018; Hontvedt & Arnseth, 2013; IMO, 2012; Sellberg & Lundin, 2017; Sellberg & Lundin, M, 2018; Sellberg et al. 2018) to interpret the data. This included but was not restricted to searching for how motivated the instructors are, how updated they are academic, their thoughts about the student's learning opportunities, how well prepared they are as instructors and their general thoughts about both simulators and school vessels as an educational platform. The research questions:

1. ***Does the practical experience gained from real-world navigation training justify the resources invested in nautical students at the RNoNA?***
2. ***Can simulator training alone fulfil the requirements set by the STCW and provide adequate and efficient practical navigation training for nautical students in the RNoNA?***
3. ***How can the RNoNA enhance utilization of simulators and real-world navigation training?***

Thematic analysis can be separated by either having an inductive or deductive approach (Braun & Clarke 2006). This research analysis had a deductive approach, meaning the research questions drove it, supported by the interview guide and literature by Hjelmevik, Hontvedt & Arneseth, IMO and Sellberg & Lundin. The different codes were then thematised back towards the interview guide to have a presentable structure when comparing the responses from the students and instructors. Table 9 presents the main themes.

Table 9: Main themes

Theme	Topic
Theme1	MPN and the connection to other subjects
Theme 2	The instructor as a learning facilitator
Theme 3	The student as a learning participant
Theme 4	Learning outcomes from the two platforms
Theme 5	Combining school vessels and simulators as a learning enhancer for students
Theme 6	Improving the usage of simulators and real-world navigation training

The thematic map displayed in Figure 10 shows the correlation between codes and themes. The primary theme is centred around the learning outcome from the two platforms, and it encompasses three subthemes: simulator, combination, and real-life platform. These subthemes are further connected to several codes, with some linked to just one subtheme and others linked to multiple subthemes. Delve qualitative data analysis software was used to manage the dataset.

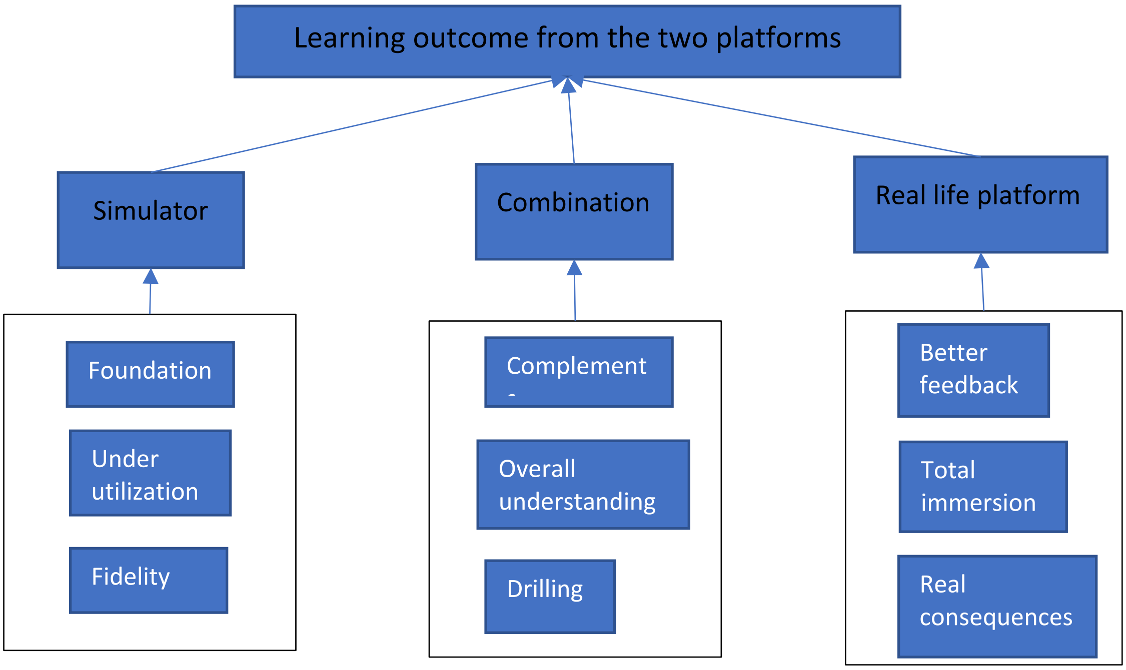

Figure 10: Thematic map, theme 4

4. Results

This chapter presents the results gathered from the research. As described in the methodology chapter, three different methods have been used to collect data. Chapter 4.1 presents the key findings from the systematic literature review in table format. Chapter 4.2 presents the data from the qualitative survey in a summarized version. The key findings are presented with overview figures. Chapter 4.3 presents the data from the semi-structured interviews in a summarized version. The key findings are also presented with overview figures.

4.1 Results from systematic literature review

The systematic literature resulted in twenty publications. The main findings are presented in Table 10. The publications are sorted by author in alphabetical order.

Table 10: Overview of systematic literature review

Reference	**Title**	**Main Findings**
(De Oliveira et al., 2022)	Systematic Literature Review on the Fidelity of Maritime Simulator Training	• Literature favours full mission simulators and high fidelity to avoid distracting trainees with inconsistencies and inaccurate representations. • However, there is little evidence of the real impact of each fidelity feature on the trainee’s performance or whether this also applies to novice mariners. • Low-fidelity simulators can also be as useful as full-mission simulators.
(Ernstsen, & Nazir, 2020)	Performance assessment in full-scale simulators – A case of maritime pilotage operations	• Computer-aided performance assessment (CAPA) s technical dimension could reliably reproduce a performance score and is considered an improvement compared to the conventional assessment group in this study. • It was also found that the conventional assessment methods did not reproduce reliable and valid assessment scores across all dimensions
(Gade-Lundlie & Timerlid, 2018)	Stress i navigasjon – stressforskjell i simulator og skolefartøy –	• The experiment results indicate that the students experience a higher stress level as navigators on board the school vessels than in a simulator. • The results suggest that navigation training in a simulator cannot replace navigation training on board school vessels. • The results emphasize the importance of training navigation in simulators and school vessels.
(Hindmarsh et al., 2014)	Work to make simulation work: 'Realism', instructional correction, and the body in training	• Participants often draw distinctions between the simulation and ‘real-life situations, particularly while giving a reason for corrections. • When attending to disparities between the simulator and the real world, tutors and learners must progress and continue the instruction. • Instructors must create a ‘suspension of belief’, where students are encouraged to work as if the students are in the real world.

		• While the simulator is chronically insufficient, the tutor does significant interactional work to make the simulation work
(Hjelmervik et al., 2018)	Simulator training for maritime complex tasks: an experimental study	• If students are exposed to complex scenarios too early in their training, their performance will be lower compared to scenarios with a gradual increment of difficulty level. • Combining training with both homogeneous and heterogeneous ocean currents can contribute to improved training outcomes for the nautical students in the case of docking operations. • Increasing the functional fidelity of the simulation during training improved participants' performance during complex tasks, compared to training with the highest fidelity from the beginning.
(Hontvedt, & Arnseth, 2013).	On the bridge to learn: Analysing the social organization of nautical instruction in a ship simulator	• Social construction of context is closely related to learning opportunities. • Structuring interactions by enacting professional roles and responding to a simulated activity context affects student learning opportunities. • Managing a credible role-play takes much effort and may conflict with other training objectives, such as instruction or asking for help. • The ship simulator has a clear potential for learning, but the simulation far exceeds the simulator
(Hontvedt, 2015).	Professional vision in simulated environments — Examining professional maritime pilots' performance of work tasks in a full-mission ship simulator	• Simulators may facilitate environments for professional action. However, the analysis results suggest that the simulator's technological aspects are fundamentally connected to instructional design. • Successful simulator training involves considering whether the degree of fidelity meets the requirements of the situated work tasks and learning objectives. This involves considering the nature of the professionals' particular expertise
(Hontvedt & Øvergård, 2020)	Simulations at Work —a Framework for Configuring Simulation Fidelity with Training Objectives	• The Study identifies three types of simulator fidelities that might be useful from a trainer's perspective: technical, psychological, and interactional fidelity. • The study shows how the fidelity of the simulation relates to the level of expertise targeted in training. • Conceptualisations of simulator fidelity may help in the creation of reliable simulated environments for building professional expertise
(IMO, 2012)	IMO model course 6.10 Train the simulator trainer and assessor	• The simulator instructor is: 1. A facilitator, 2. A Dedicated teacher, 3. A Manager, 4. Flexible and Adaptable, 5. A Learning organizer, 6. A Guide, 7. A Motivator, 8. An evaluator, 9. A native psychologist • A good simulator system is wasted if it is supported by a bad instructor, and a good instructor can produce great learning outcomes from a simple simulator. • The simulation level must be at the right level • The simulation session consists of 4 main components: briefing, planning, simulation exercise and debriefing.

(Jamil & Bhuiyan, 2021).	Deep learning elements in maritime simulation programmes: a pedagogical exploration of learner experiences	• Maritime education and training for seafarers are highly profession-focused and skills-oriented. Thus, the learning objectives for traditional maritime simulation sessions must combine skills and knowledge-related outcomes. • Carefully designed preparatory tasks for attending maritime simulation activities that benefit students and faculty members. • This can help students gain essential prior knowledge and study skills, prepare useful queries and strategies to apply in simulation exercises, and, after all, attend the sessions as informed and active participants
(Juszkiewicz, & Żukowska, 2023)	The Use of the K-Sim Polaris Simulator in the Process of Automatic Assessment of Navigator Competence in the Aspect of Anticollision Activities	• Kongsberg has provided an automatic evaluation program in its K-Sim simulator, which, in its current form, is useful and effective but could still be improved. • Proper preparation of an automatic evaluation sheet requires precise parameter selection, proper limits and weights adjustment, and the creation of links and relations between tested quantities. • Simulator Exercise Assessment (SEA) can support the instructor in the competency assessment process, providing objectivity. • SEA can help the instructor focus more on the assessment of non-measurable elements (e.g., navigator's behaviour, relations with other members of the watch, communication skills, logical thinking, etc.) • It provides information on the outcome of the simulation in the form of a printed final report
(Kim, Te et al., 2020)	The continuum of simulator-based maritime training and education	• Learning occurs through the active role played by the trainees in the simulation and is supported by the instructors. • Utilization of simulators comes through effective assessment techniques which rely heavily on simulator instructors. • It takes time to develop, adjust, and improve exercise content and quality in a full mission simulator
(Nazir et al., 2019).	Maritime simulator training across Europe: a comparative study	• Even though some of the simulator training practices in Europe appear to be performed similarly due to comparable proceedings, the implementations of these proceedings can create dissimilarities
(Sellberg, 2017).	Simulators in bridge operations training and assessment: a systematic review and qualitative synthesis	• There are more questions than answers about the use of simulators in bridge operation training • Simulators are useful for training both procedural and non-technical skills • Need for skilled instruction during training
(Sellberg, 2017)	Representing and enacting movement: The body as an instructional resource in a simulator-based environment.	• The results suggest that the coordination of representational states, bodily conduct, and talk are used to fill in missing aspects of the real world in the simulator environment • Inconsistencies between the simulator and the real world should be seen as instructional recourses, but they must be addressed in instruction to avoid pitfalls in training • The study contributes to the work that considers how instructors and students attend to matters of realism during instructional sequences, highlighting the need for competent

		and fastidious instructors to closely monitor and facilitate the students through exercises in the simulator
(Sellberg & Lundin, 2017).	Demonstrating professional intersubjectivity: The instructor's work in simulator-based learning environments.	• Simulators allow the instructor to use different approaches to highlight distinct aspects in various situations • Developing the students' professional vision goes beyond teaching them to see and interpret it is also a matter of teaching them actions • The instructor scaffolds the students in carrying out their learning tasks • When students' knowledge and skills develop, it is possible to remove some of these scaffolding practices
(Sellberg, & Lundin, 2018)	Tasks and instructions on the simulated bridge	• The development of professional knowledge is co-constructed by the students and the instructor: by relying on a mutual orientation toward the technology at hand, the assessment criteria of the task, as well as the instructors' expert knowledge in developing the students' understanding. • Instructions in the simulator environment greatly rely on being in this particular socio-material context.
(Sellberg, 2018).	From briefing, through scenario, to debriefing: the maritime instructor's work during simulator-based training	• How the instructor organises and facilitates the learning activities before, in and after action is crucial. • The simulator environment provides the instructor with the tools to monitor, correct and assess the student towards desired learning outcomes • Video-based debriefing could be useful to address learning objectives by providing stable and accountable records that give a detailed assessment and open up for discussion and reflection.
(Sellberg, et al., 2018).	Learning to navigate: the centrality of instructions and assessments for developing students' professional competencies in simulator-based training	• Simulator-based training should not replace time at sea • Time spent at sea might be critical to get first-hand experiences of work on board a ship that simulations cannot offer • Systematic professional guidance and feedback are critical to making simulator-based learning activities relevant to the wide range of tasks involved in manoeuvring seagoing vessels • Instructional support is important throughout training (from briefing through scenarios to debriefing)
(Wahl, 2020)	Expanding the concept of simulator fidelity: the use of technology and collaborative activities in training maritime officers	• An exact replication of a bridge is not always needed to realise training goals. Computer technology should be regarded as an essential but not the only tool in creating the necessary level of fidelity. • Level of fidelity is enhanced by training tasks that are based on real events and that mirror bridge officers' daily work. • Learning quality is enhanced when course participants share their stories and give each other feedback independent of formal rank. • The instructor has a key role in creating a high overall level of fidelity that goes beyond being a system operator. Enabling interaction among trainees and creating life-like collaborative activities using simulator technology requires the trainer to act more like a facilitator than an instructor both during simulator exercises and debriefings

The following section will present the data from the qualitative survey.

4.2 Results from qualitative surveys

On March 28th, surveys were distributed to all participants, with approximately two times twenty surveys sent out to students. The exact number of students invited to the study will not be disclosed for confidential reasons. Participants had until April 21st to complete the survey before the researcher began the analysis process. Of the graduated students, seven responded. They were from all Navy squadrons except one, while fourteen current students responded. The research process, including recruiting and follow-up, took approximately 45 hours.

The following subsection presents the responses about how students experienced the connection between the curriculum in navigational systems, navigation, COLREGs, and MPN.

Does the curriculum in nautical subjects support military practical navigation?

When asked if they experienced a connection between the curriculum in navigational systems, navigation, the rules of the sea, and military practical navigation, all the graduated students replied that the curriculum in the nautical subjects supports military practical navigation effectively. Most current students reported that using simulators and real-life platforms in MPN enabled them to see the theoretical courses in a practical setting. Graduate one is quoted as:

> *I believe that the curriculum in other courses supports simulator training and training with the school vessels in a way that enables me as a cadet to gain a broader professional competence and understanding of MPN and the exercise of the rules of the sea. It creates a greater system understanding and increases my ability to utilize the vessel in a better and safer way. In addition, you get the theory in military navigation, navigation systems and bridge watch, and you get to test this in practice to a greater extent in MPN. Both in the simulator and on the school vessels*

However, students three and four shared different beliefs, as they perceived the curriculum in the other nautical courses as more focused on STCW-related topics and did not see them as supporting MPN. Student three replied that:

> *Military navigation did not support MPN so much, as it mostly covered sailing on the open seas and the calculations behind the methods of doing this. Navigational systems other than ECDIS were not used actively during our real-life training during MPN. It*

was not until our last weekend sailing with Nordnes/Kvarven that the theories in navigational systems were tied to the practical use in MPN. This is a shame because an earlier practical introduction to these systems would have provided us with added value in both subjects.

In contrast to the graduated students, many current students replied that they could have received more education regarding COLREGs. However, there are split opinions among the students here. The graduates and current students highlighted each semester's focus areas: optical, radar and optical with radar. This allowed them to focus on learning one thing at a time.

Semester 4, the radar semester, is where the students believe that the curriculum supports MPN to the highest degree. Student five replied:

> *From the start of the third semester, where you start with MPN, the courses are experienced as support subjects to understand the totality of navigation and how to work on a Navy vessel. This is especially evident during the "radar semester", semester 4, where almost all subjects revolve around how radar works, theoretically, theoretically-practically, to be further implemented in practical navigation in simulators and on school vessels. I am convinced that this is an effective way to do it." After graduation, we will become part of a bridge team and ensure safe navigation. Then you need to know about the possibilities and limitations the navigation systems give you. One must have a theoretical insight into how to take tidal differences into account, as well as be able to plan for longer overseas voyages or how propeller/rudder arrangement affects the vessel's properties to and from the quay.*

Figure 11 presents the key findings on how the curriculum in other nautical subjects at the RNoNA supports military practical navigation.

Does the curriculum in nautical subjects support military practical navigation?

The curriculum in the nautical subjects supports military practical navigation in a good way.

The use of simulators and real-life platforms in MPN enabled them to see the theoretical courses in a practical setting.

Semester four is experienced as the most holistic semester.

Some students did not experience the connection and felt that the curriculum in other courses where mostly STCW related courses.

Half of the current students requested a more thorough review of COLREGs.

Figure 11: Key findings from does the curriculum support MPN?

The following subsection presents the responses regarding how students experienced learning outcomes from the two platforms.

Learning outcome

When asked to compare the two learning platforms and determine which provides the greatest learning outcome, the students and graduates were unanimous in their opinion that the real-life platform offers the best overall learning outcome. However, most students and graduates also acknowledged that both platforms are valuable and complement each other.

The students and graduates highlighted the simulator as an arena where they can practice specific exercises, create certain situations, and focus on exercise goals. Some students even took the initiative to learn how to operate the simulator without an instructor, and they expressed high satisfaction with the simulator and its possibilities. Student one replied:

> *We also received a voluntary offer of K-Bridge start-up courses so we could train on our own. There is too little time to learn everything and maintain skills with four-hour sessions every other week in the schedule. Self-training in the afternoons and weekends has paid great dividends, even if the instructor is absent.*

Several students and graduates highlight that the simulator is a good platform to train without a safety organization. Students can train alone and in teams with each other. The simulator also provides the opportunity to review and analyse the voyage thoroughly. Several students support the statement that the four-hour sessions every fortnight are insufficient to learn and maintain their skills. Student three replied:

> *The simulator exercises are very good too, but there are only 3 hours every other week, which I consider too little. We would benefit more from the simulator sessions if they were more frequent, as it would have led to continuity and an ever-increasing progression."*

Many students and graduates also report that if they underperform in the simulator, it is easy to attribute it to the simulator, either the fidelity or "bugs". Student eleven said, "*There is a much better learning outcome on the school vessels since there are consequences if one were to do something wrong. So, I find simulator exercises to be good but lacking because you know it is not "real"*. Student nine replied that it is easier to train onboard the school vessels because the difficulty level is higher in some of the simulator exercises compared to the real world, where it was a natural and dynamic difficulty level.

The responses indicate that the students and graduates experience more realism in a real environment because they can relate to other actual vessels and not simulated situations controlled from a control room. Graduate one is quoted: *"When you are out with the school vessels, you feel an extra sense of responsibility, and you are responsible for safety."* Graduate five replied:

> *I would say that I have gotten the most out of sailing, navigating, and training on the school vessels! When I reflect on my own learning and experience from the Naval Academy with regard to practical navigation, it is the school vessels that have created the best learning.*

These opinions are supported by the other replies, as real emotions, holistic experience, better feedback, and real consequences are recurring responses. Graduate six summarizes the responses with this quote:

> *Nevertheless, the foundation you build in a simulator to learn the basic principles provides a much better prerequisite for solving emerging situations out at sea. So, the connection between the simulator and practice out at sea is essential.*

When asked about their experience achieving the learning goals in the two platforms, the responses were ambivalent. Some students expressed that the platform itself does not matter much. However, they also mentioned that striving for the goals on both platforms was beneficial. Some students and graduates stated that the simulator was preferable because it allowed them to follow a pre-designed scenario or practice at their convenience later. On the other hand, some respondents mentioned that achieving the goals was easier in a real-life platform as they had sufficient time as navigators to focus on them, and the instructors would remind them of the goals. In contrast, the simulator sessions were often too short to achieve the learning goals fully, or they forgot about them.

Figure 12 presents the key findings on the learning outcome from the two platforms.

Learning outcome from the two platforms

Real-life platform will by far provide the best total learning outcome.
A four-hour session in simulator every fortnight is not enough learn and maintain skills.
Potential real consequences enhance the learning.
In the simulator students can train without an instructor present
The simulator provides the opportunity to have a thorough review of the voyage.
If students underperform in the simulator they can attribute it to the fidelity, or "bugs".
The combination of simulator and practice at sea is essential.

Figure 12: Key findings from the learning outcome of the two platforms

The following subsection presents the responses regarding how students experience the instructor's feedback.

Feedback from instructors

When asked about their perception of the quality of feedback received from sessions in the two different platforms, most students and graduates expressed high satisfaction with the quality of feedback received from sessions on the school vessels. The feedback was deemed appropriate, and the discussions between the students and instructors helped clarify the reasons and outcomes of specific situations, thus enhancing the learning experience. However, some students noted that the feedback varied depending on the instructors, including length, structure, and quality differences. In some cases, instructors focused more on areas for improvement rather than acknowledging what the students did well. Student thirteen provided the following response:

> *The quality of feedback from mentors/instructors tends to be good and constructive. However, there are individual differences, and my experience is that the main emphasis on the feedback deals with what you have done wrong/badly and little focus on what you have achieved. This can be demotivating. But overall, the quality of the feedback provided is good.*

Student ten shares the same opinion:

> *Feedback on board is particularly good, and the fact that it is taken as soon as possible after a completion helps to highlight the learning moments one must focus on while it is still sitting in the fingers. However, there is sometimes considerable variation in how the feedback is given, the structure and level of detail of it, which varies from supervisor to supervisor, which gives the impression that there is no set template for elements that should be included in the feedback.*

The students and graduates expressed dissatisfaction with the perceived quality after a simulator session. They found that there were limited instructors available, and the feedback provided after a simulator session was generic. Many students did not feel that this feedback applied to their specific performance, leading them to disregard it. However, several students mentioned receiving comprehensive and personalized feedback from their fellow students after a simulator session. Graduate two says: *"The quality of the feedback is better on board because we always have one instructor that follows us. The simulator can be as good as real life if we had one instructor for each student navigator".*

In contrast, the students and graduates emphasized that the feedback they received after a session with the school vessels was much more utilised. This feedback was perceived as individualized and held more significance for the students. Furthermore, during the navigational exercises, the students could navigate again a few hours later or the next day, allowing them to focus on the feedback and the exercise goals. Graduate six expressed:

As simulator sessions often had two-week intervals, it became difficult to remember what you set as improvement goals for the next session as there are also many other things going on in a busy school schedule. When sailing with the school vessels, this gap was only a few hours and a maximum of one day for longer voyages. This meant that it was easier to practice what you received feedback on last time due to the time between sessions.

Figure 13 presents the key findings on feedback from instructors.

Feedback from instructors

Very pleased with the quality of feedback received from a session with the school vessels.
Some students reported that the feedback varied depending on the instructors.
Not pleased with the quality of feedback received from a session in the simulator.
Few instructors available during simulator sessions.
Feedback after a simulator session is perceived as generic and discarded by many students.
It is difficult to use feedback effectively due to the long intervals between simulation sessions.
Longer navigational exercises allow the students to utilize the feedback a rapidly.

Figure 13: Key findings on feedback from instructors

The following subsection presents the responses regarding how students experience realism in the simulator.

Fidelity and Immersion in the Simulator

When asked how they experienced the realism in the simulator compared to onboard the school vessels, the students and graduates replied that there was a high degree of technical fidelity. Student one replied:

I find the simulator very realistic as I have sailed the same areas in the simulator as in real life. You can also change the weather conditions in the simulator to match reality. But it should be said that some parts of the simulator feel very artificial. You experience very well pre-programmed vessels, which will not react to your actions, and which make the whole at times artificial.

Several of the responses indicate that the scenarios in the simulator fail to create a good sense of psychological fidelity, particularly in terms of how other vessels behave compared to the real world. Many respondents emphasize the lack of depth perception as a significant limitation regarding the simulator's realism. Additionally, respondents highlight that the radar functionality in the simulator is unrealistically accurate.

Several respondents acknowledge that the simulator offers a realistic and authentic way to train principles and methods. They also express that it lacks the immersive experience of training holistically with the benefits of real-world experiences to connect emotions and learning. According to their perspective, they feel "too relaxed" in the simulator. Graduate seven provided the following response:

> *The realism in the simulator is enough to conduct drill training effectively. On the other hand, I would say that there is a huge realism gap between voyages and simulator sessions. I feel that while the simulator was useful for building navigation skills using drilling. However, it's the voyages with school vessels that have given me the experiences to fall back on in challenging situations during my process towards becoming an OOW in the Navy.*

Figure 14 presents the key findings on how the students perceive realism in the simulator.

Fidelity and Immersion in the simulator

A high degree of technical fidelity in the simulator.
The scenarios fail to create a good psychological fidelity.
Lack of depth perception as a major drawback for the simulator.
The radar is unrealistic good in the simulator.
Simulator offers a realistic and authentic way to train principles and methods.
It does not provide an immersive enough experience to train holistic.

Figure 14: Key findings on fidelity and Immersion in the simulator

The following subsection presents the responses regarding students' motivation and preparations.

Students' Motivation and preparations

When asked how much time they spend preparing for the two different platforms, most students and graduates replied that they spend up to half an hour preparing for the scheduled simulator exercises. This includes reading the practice order, reviewing the area of operations, and some students also mentioned reviewing the feedback from the last session. Student eight replied: "Before *the simulator, I made very few preparations, I usually forget to look through the route, and if it is a longer route, you do not know which part you are sailing*." Student four replied:

> *Before a simulator session, I often quickly review the route and practice objectives, spending a maximum of 10 minutes on this. Before sailing with the school vessels, I spend several hours, depending on whether it is evening sailing, weekend sailing or practice. The time spent can be anything from 1-2 hours on a nav brief. 2-8 hours of route planning.*

Other aspects that the respondents mentioned are that they spend more time studying the maps and preparing for challenging areas before a real-life exercise. Graduate seven summarizes the planning before exercises:

> *I spent considerably more time planning before sailing in real life compared to sailing in the simulator. In the simulator, we mostly used pre-planned routes, and there was no need to spend time making navigation briefs, planning routes, etc.*

Several students mentioned that if they had more time during their working hours, they would have spent more time preparing for the simulator sessions. Half of the respondents said they were equally motivated when asked about their motivation for the two different platforms. One student was not motivated by either of them, while the rest were more motivated by sailing with the school vessels. All respondents highlighted that navigating on the school vessels was more fun. The students also mentioned that their motivation was affected by the total workload. Many were not motivated to prepare for a voyage with the school vessels if they had a high total workload. However, once they were onboard and had started the navigational exercise, the platform was perceived as an escape from the busy school life, allowing them to focus on one thing for a few days. Student ten replied:

There is no hiding the fact that, at times, it feels like an extra burden to sail with the school vessels, but there is also no doubt that this aspect of the education gives more flavour and acts as the main motivating factor. It is a break from everything else while also feeling like the most directed and relevant to future service and is the very foundation for our professional future.

Graduate 4 replied: *"Simulator is better than regular school, but sailing with school vessels is fun. It is rewarding to navigate with skilled instructors in the same area that we will navigate in later in our career."* The respondents also highlighted the feedback they received after a session with the school vessels as a motivating factor. The school vessels appear to provide the students with a better return on interest. Student three replied: "Sailing on the school vessels is associated with great learning, but more wear and tear on the crew." Other motivational factors for some students were who the instructor was, as the instructor could be perceived as a motivator or demotivator. Student 12 highlights that mistakes on the school vessels can have potential consequences, which is a motivational factor to be well-prepared and alert when navigating.

Figure 15 presents the key findings on the student's motivation and preparations.

Students motivation and preparations

Student spend more time preparing for sailing on the school vessels compared to the simulator.

If the students had more time in during their working hours, they would have spent more time preparing for the simulator sessions.

Half of the students are equally motivated for both platforms. However, all students find real world training to be more exiting.

The feedback after real life exercises is a motivational factor for some students

Preparations to real life exercises can be perceived as a burden with extra workload. However, this burden is forgotten when the exercise starts.

Figure 15: Key findings on the student's motivation and preparations

The following subsection presents the student's responses regarding how the RNoNA can improve their usage of simulators and real-world navigation training.

Students' opinions on how to improve the use of simulators and real-life platforms.

When asked if there is anything else they would like to add about how the RNoNA can improve its usage of simulators and real-world navigation training, the respondents had several suggestions. Almost all respondents requested more frequent simulator sessions and more instructors available during these sessions. Graduate one replied: *"There is too little time available for MPN. Throughout a semester, we have about 7-8 simulator sessions where you navigate approx. 30 min of each of these sessions".* Student three replied:

> *I gained a higher percentage of knowledge and skills from sailing on school vessels because of the many other challenges in addition to navigation it represents. Where the simulator provides specific training for navigation, sailing with the school vessels requires much more regarding preparations, performance and debriefs. The instructors are more present than in the simulator. This leads to a certain pressure which stimulates my performance in a more efficient way than in the simulator. It also gives the instructors a fuller picture of the cadets in training, which provides the foundation for a more holistic feedback session. If the instructor-to-cadet ratio were the same in the simulator and while sailing with the school vessels, the percentage learned during the simulator exercise would increase. However, the real-life consequences in play while sailing with school vessels keep everybody on their toes and provide a greater sense of commitment from the cadets. This is the main reason that sailing on school vessels always will be better for the acquisition of knowledge and skills for nautical students in the RNoNA.*

Several students and graduates replied that providing the students with only the area of operations and not a pre-planned route before the simulator sessions could improve the simulator sessions because it would force them to prepare more. However, as a prerequisite, more time must be available for preparations.

Student one mentions that the opportunity that the class received to learn how to start, run and stop the simulator should have been mandatory and not optional:

> *With such a hectic schedule as we have had, and the simulator sessions only being every two weeks, I think it is not enough to sustain individual skills. After we learned how to run the simulator, I experienced an increased activity among everyone in the class to*

help navigate in the simulator in the evenings and weekends. More people in the class wish they had the tutorial and were not dependent on anyone who had it.

Graduate five said that if the students could spend a few days onboard real Navy vessels as a part of MPN, this could broaden their navigational horizon.

Several students and all graduates highlight that the MPN-6 weekend exercise was the exercise that provided the best learning during their education. Using the words of graduate seven:

"Looking into the possibility of introducing elements from the exercise earlier in the MPN courses. The more holistic focus on the operation of the vessel and assignment solution led me to think more about other things than just the technical navigation".

Furthermore, several students and graduates highlight that the combination of simulator sessions and real-world training is unique and provides them with a solid foundation to become future OOWs in the Navy. The graduates emphasize that using real-world platforms has provided them with a holistic experience in navigation. Graduate one replied*: "The school vessels provide important experience and must not cease to be used in training students as navigators."*

Figure 16 presents the key findings on the student's opinions on how the RNoNA can improve the usage of simulators and real-world navigation training.

How to improve the use simulators and real life platforms

Have more frequent simulator sessions.
Have more instructors available for the simulator exercises.
Make the students plan their own routes prior to simulator sessions.
Provide more time for preparing for simulator sessions.
Make it mandatory for the students to learn how to run the simulator.
Make it possible to spend a few days on navy vessels.
Implement elements from MPN 6 already in MPN 3.

Figure 16: Key findings on how to improve the use of simulators and real-life platforms.

The following subsection presents the graduates' responses regarding how the simulators and school vessels have prepared them for service in the Navy.

Preparing students for service in the Navy

When asked how the simulators and school vessels have prepared them for service in the Navy, the graduates all replied that the simulator had given them a solid foundation in methods, principal training, and drilling procedures. The graduates now using K-Bridge onboard highlight that being familiar with the navigational systems onboard was a great advantage when they started. Some graduates reported that they would have benefited from more navigational planning. Graduate six replied:

> *The simulator has certainly been important for learning basic navigation principles and putting them together with practice. The lack of planning training is where I have the biggest "gaps" when working in the Navy. I would have liked more planning training in MPN before the simulator sessions.*

The graduates replied that the real-life platforms were essential for them to be at the level that the Navy requires when they graduate. Graduate five replied: "*The school vessels have provided a much more holistic understanding and often what I perceive as my foundation stone."* While graduate seven added: *"I notice that I have a more robust navigational technical foundation than navigators on board my vessel with education from civilian schools where they have not received the same practical navigation trainin*g." Graduate six added:

> *Sailing with vessels has been a major contributor to knowing how movement in the vessel and responsibility affect the navigator during sailing and has certainly tested my simultaneous capacity better than the simulator. Communication, much noise on board, fatigue and emerging hazards/aids have certainly provided me with a picture of what working on naval vessels is like.*

The graduates from larger vessels added that the school vessels do not give a good perspective on navigating a larger vessel and that it would be nice to have some experience with this from the simulator. Graduate one added:

> *I really feel that both the simulator and the use of the school vessels have provided great transfer value. This makes it easier to familiarise yourself with the navigation on board and the systems used. The fact that we are used to all modes (optical night, radar control, optical with radar support, and fully integrated system) means that I bring with*

me experience from all the modes so that I can build on it in the Navy. I know that when I was a student at the Naval Academy, it was heavy and sometimes boring, but it is only when you put everything together, which you do in the Navy, it provides great value when navigating and operating the vessel as an OOW.

The graduates also added that conducting exercises with the school vessels takes time. However, in retrospect, they value the experience the platform provided. The graduates also stated that they could connect “the dots” after starting their process of becoming an OOW.

Figure 17 presents the key findings on how the simulators and school vessels have prepared the graduates for service in the Navy.

Preparing students for service in the Navy

Simulator provides a solid foundation in methods, principal training, and drilling procedures.

The graduates with K-Bridge onboard had an advantage as they were already familiar with the navigational systems onboard.

Graduates reported that they would have benefited from more navigational planning.

Real-life platforms were essential for graduates to be at the level that the navy requires when they graduate.

Graduates from larger vessels added that it would be nice to have some experience with navigating larger vessels from the simulator.

Figure 17: Key findings on preparing students for service in the Navy.

The following section will present the data from the semi-structured interviews.

4.3 Results from semi-structured interviews

The interviews were conducted at the author’s office at the RNoNA from 29th March to 3 April 2023. A total of five interviews were conducted with consenting participants. The total recording time was 3 hours. The research time used to attain these results was approximately 50 hours. This includes transcribing the interviews. The results present a summary of the interviews with translated quotes.

The following subsection presents the responses regarding how the instructors experience the connection between the curriculum in navigational systems, navigation, COLREGs, and MPN.

Does the curriculum in nautical subjects support military practical navigation?

When asked if they experience a connection between the curriculum in navigational systems, navigation, the rules of the sea, and MPN, all the instructors stated that the curriculum in the nautical subjects supports MPN. They reported that using simulators and real-life platforms supports theoretical education by allowing students to try the theory in practice. Instructor two said: *"An advantage with the use of both simulators and real-life platforms as an amplifier for learning is that it gives the student the opportunity to try theory in practice"*.

Some instructors stated that this provides a deeper understanding of navigation and maritime operations. They highlighted a deeper understanding of navigation systems regarding software and hardware, including system redundancy. Instructor three mentioned a challenge with using real-life platforms as an amplifier for theoretical education: various instructors are conducting practical instructions, and not all of them may be up to date with the theoretical curriculum. Instructor three highlights the RNoNA`s educational model and that it is based on the trust bridge, as described in the theory chapter. Several instructors mention that this combination of theory and practice focusing on positive feedback amplifies student learning.

One challenge with the subject of military practical navigation is that no textbook is available, and the execution of the subject is based on the curriculum and orders. However, there is a work in progress to make a textbook for military practical navigation. Instructor four said:

> *«The philosophy is that we teach the cadets in the classroom, then we practice in the simulator, then we practice on our vessels afterwards to anchor the knowledge. Then we go back to the classroom to build on this new knowledge. However, I am not sure if we are doing it efficiently enough».*

Instructor four states that the subjects support military practical navigation, but not to a satisfactory extent. The instructor believes that the students need more in-depth knowledge in several areas. One probable reason for this is that, in some cases, the students are introduced to many elements at once when sailing on school vessels without readily available solutions. According to instructor four, some graduate students often do not know how to use basic ECDIS functions, *«when this happens, we have failed as instructors»*. A trend observed from the interviews is that although the instructors believe that the curriculum supports practical navigation, several feel that the connection between theoretical and practical navigation needs to be addressed and improved. They also suggest that instructors would benefit from staying updated on the theoretical curriculum. This could potentially be addressed by the textbook currently in progress.

Figure 18 presents the key findings on how the curriculum in other nautical subjects at the RNoNA support MPN.

Does the curriculum in nautical subjects support military practical navigation?

The curriculum in the nautical subjects supports military practical navigation.

The use of simulators and real-life platforms allows the students to try the theory in practice.

The use of real-life platforms provides a deeper understanding for both navigation and maritime operations.

There are multiple instructors conducting the practical instructions, all the instructors may not be up to date with the theoretical curriculum.

There is no textbook available in the subject military practical navigation.

There is a potential to connect military practical navigation and the curriculum further.

Instructors could benefit from staying updated on the curriculum.

Figure 18: Key findings does the curriculum in nautical subjects support military practical navigation?

The following subsection presents the instructor's responses regarding their motivation.

Instructor's motivation

When asked about their motivation for the two different platforms, the interviewees all said that they were highly motivated to instruct in both simulators and onboard the school vessels instructor four is quoted as:

> *"For me, the most important thing is the students and the student's learning. I enjoy seeing the students learn, which gives me great pleasure in my job. And that is probably one of the main motivational factors for me. If I do it in a simulator or on board does not matter."*

The instructors mentioned that they were motivated by the learning opportunities that the combination of simulators and real-life platforms provides, ranging from training simple tasks in a simulator to tackling more complex real-life scenarios in challenging weather conditions.

However, most of the instructors expressed that, on a personal level, they were more motivated to sail on a real-life vessel for various reasons. Several instructors mentioned that conducting simulator drills could become monotonous, leading to fatigue and reduced commitment. One way to counter this, as suggested by an instructor, is to alternate the areas where drills are conducted. Instructors did not experience the same level of fatigue and lack of commitment when conducting drills in the same area on school vessels. Additionally, instructors mentioned they were motivated by the heightened awareness required on real-life platforms, as safety aspects often necessitate intervention to avoid potential groundings. This helps them maintain and develop their practical navigation skills more than in the simulator. A challenge with using simulators for more complex exercises was getting the students and instructors in the correct mindset over time. While it is possible, it requires improved scenarios and the introduction of the appropriate mindset. This is not an issue on a real-life platform in the actual world. The instructors stated that the simulator used at RNoNA is an amazing tool but has some limitations, such as training radar navigation, including how to tune the radar and how clutter realistically affects radar performance. The visual appearance of the simulator also has some artificial aspects. All instructors agreed that the highest motivation was experienced when the students successfully mastered their tasks, regardless of the platform used.

Figure 19 presents the key findings on the instructors' motivation.

Instructors' motivation

- Highly motivated for instructing in both simulators and onboard the school vessels.
- On a personal level most, instructors were more motivated to sail onboard real-life vessels.
- Real life platforms require more from the instructor's awareness.
- Highest motivational factor when the students master their task.
- Simulator drills can be experienced as monotonous.
- Immersion in the scenario can be a challenge.
- Instructors can experience tiredness and a decrease in commitment during long simulator exercises.

Figure 19: Key findings on the instructor's motivation

The following subsection presents the instructor's responses regarding their preparations.

Instructors' preparation

When asked about their preparation time on the two different platforms, the instructors mentioned that the time they spent preparing as an instructor for an isolated exercise to be conducted was the same. Instructor four provided a specific response:

> *There is a given exercise to be conducted, and it is the same documentation we have in advance, regardless of whether our training environment is the simulator or on board the vessels. It will require the same of my preparation for the student.*

However, when the training environment is on a real-life platform, the students are responsible for creating their routes, which must be assessed by the instructor before they are allowed to sail on them. This process requires more time. It allows the instructor to evaluate the students' route planning, provide feedback, and teach appropriate techniques for different waters. As a result, the instructor becomes more familiar with the planned route of the student.

Some instructors mentioned that they are more mentally prepared when sailing on the school vessels, not just for their role as an instructor but also in terms of preparing for pre-planned options or addressing safety considerations. Other aspects of preparation with real-life platforms are passage planning, replenishment, and weather conditions. However, these responsibilities fall under the exercise leader and vessel commander rather than solely the role of the instructor. One instructor shared from his experience as an exercise leader that it was easier to reuse the same plans for the next exercise in the simulator compared to planning exercises with school vessels. The instructors mentioned that for simple exercises, the simulator requires the least time-consuming preparations to achieve a good learning outcome. However, instructor four states that for more complex scenarios, considering the current capabilities of the simulator and the resources available to provide an authentic scenario, the use of school vessels is the least time-consuming option. Figure 20 presents the key findings on the instructors' preparations.

Instructor's preparations

No difference in time preparing as an instructor regarding an isolated exercise.
Route assessment prior to real world training provides an additional arena for training.
Instructors are more mentally prepared for real life training.
For simple exercises simulators are more time efficient regarding preparations in total.
For complex exercises real world training is more efficient regarding preparations in total.

Figure 20: Key findings on the instructor's preparations

The following subsection presents the responses regarding how the instructors experience the learning outcome from the two platforms.

Learning outcome from the two platforms?

When asked to compare the two learning platforms and determine which provides the greatest learning outcome, the instructors were clear that the real-life platform surpasses the simulator in terms of overall learning outcome. They emphasized that everything learned in the simulator can be learned on a real-life platform. Learning on a real-life platform is superior when combining different navigation techniques and placing them in context. The instructors emphasized that these skills are learned naturally on a real-life platform as they are applied in an unpredictable environment. When the instructors were asked to be more specific about the benefits of a real-world platform, instructor five said: *"You do not receive the same overall understanding in the simulator compared to a real-life platform; there is something unique with a platform that is affected by the surroundings and having to interact with other vessels".* Instructor two emphasised that he was more committed to the students when instructing on the school vessels, that it was easier to maintain a higher degree of awareness in the real world, and that every action in the real world can have a real consequence. Instructor four said:

> *It is possible to create a close-to real-world scenario in the simulator, it has been done in our simulator, and we have received outstanding feedback. However, this requires much planning and is resource-demanding to conduct in real time".*

However, all the instructors stated that it is more complex than simply declaring one platform as better than the other. The instructors' opinion is that the two platforms complement each other. The simulator is an efficient platform for learning new techniques, drills, and procedures. It offers the ability to pause scenarios, engage in in-depth discussions about specific situations as they arise, repeat drills with identical parameters, and allows students to review recordings of their performance. In other words, it is a valuable tool for acquiring methods and skills at an early stage.

Once these methods are well-learned in a simulated environment, the knowledge and skills can be applied on a real-life platform to enhance overall understanding. However, to optimize available resources, students must have a solid understanding of the fundamentals acquired from the simulated environment.

The instructors emphasized that the simulator offers better reliability and availability than a real vessel, as it does not require the same level of maintenance. They highlighted that the simulator is accessible regardless of real-world weather conditions.

Instructors expressed that combining simulators and real-life platforms is crucial for developing Navy officers. However, they also stressed the importance of using these platforms wisely, with a clear vision of how and when to utilize them. They acknowledged that it is possible to achieve unsatisfactory results by using both platforms improperly but also emphasized that when used effectively, the combination can lead to excellent outcomes.

When asked about the hypothetical question of whether it would be possible to develop Navy officers of the same quality without the real-life platforms, Instructor four believed that it is theoretically possible but would require additional resources for the simulator department, redevelopment of scenarios, dedicated staff to operate the scenarios, and increased demands on the instructors.

Figure 21 presents the key findings on the instructors’ opinions regarding learning outcomes provided by the two platforms.

Learning outcome from the two platforms

Real-life platform will by far provide the best total learning outcome.

Real-life platform where it will happen naturally, and the environment world is unpredictable. more complex than to say that one platform is better than the other.

The two platforms complement each other.

The simulator is a more efficient platform to learn new techniques, drills, and procedures.

It is possible to create a close to real world scenario in the simulator,

The combination of simulators and real-life platforms is essential to develop navy officers for the Navy

It will be difficult to develop navy officers of the same quality without the real-life platforms.

Figure 21: Key findings from the learning outcome of the two platforms

The following subsection presents the instructors' own belief in their competence.

Instructors' competence

When the instructors were asked if they felt that they were up to date with the curriculum to conduct teaching in MPN effectively, they all replied that they could teach it efficiently. However, some instructors added that they had their specialities and were not experts in all subjects. They mentioned that finding support from colleagues or reference manuals to guide the students was easy. The instructors also emphasized that they had the potential to learn more and were constantly acquiring new knowledge from other instructors, students, and literature. Figure 22 presents the key findings on the instructors' belief in their competence.

Instructors competence

The instructors believe that they can teach and instruct in a good and efficient manner.
The instructors have their own specialities and are not experts on all subjects.
It is easy to get support from colleagues or manuals if needed.
The instructors have a focus to constantly self-improve.

Figure 22: Key findings from the instructor's competence

The following subsection presents the instructors' opinions regarding the adequacy of education in meeting the future requirements of the Navy.

The current education and future Navy requirements?

When asked if the current education is adequate regarding future Navy requirements, all instructors emphasised that Navy navigators are trained to navigate in all conditions with restricted or no navigational input. They must be able to navigate when the world does not work as it should. Instructor five said:

> *I believe that the education is adequate today. Both present and future Navy officers must be able to sail without GNSS, and they must be able to sail in restricted visibility at a speed that is required in the Navy. When we train and educate them like this, they should be able to handle NAVWAR challenges.*

Several instructors highlighted the importance of maintaining a high level of training in practical navigation, both for freshly graduated students and for ongoing practice in terrestrial navigation.

Some instructors were uncertain if the education was adequate in all areas. They mentioned that feedback from the Navy indicated that fewer navigators were being cleared as OOW or that the clearing process was taking more time. There could be multiple reasons for this, such as changes in the clearance process following the Helge Ingstad accident. Instructor one expressed the opinion that students should have a deeper understanding of navigating when the systems are unavailable and preventive measures to protect the systems from NAVWAR.

An observation made by several instructors that correlate with the Navy's feedback is that the students are not receptive to anything besides practical navigation when navigating. According to instructor four, this is a consequence of their training, making them extremely skilled in navigating. Still, several students lose the ability to relate to anything else: *"We damage the students by narrowing them too closely to the navigational subject, which is educationally wise. However, we must repair this damage by broadening their horizons afterwards so they can be used for other things than just navigating."* Instructor four is also clear that this issue must be addressed. A solution that the interviewees mentioned were to streamline the education with a clearer thread to ensure a deeper understanding of combining navigation and other aspects of maritime operations.

Figure 23 presents the key findings on the instructors' opinions regarding the adequacy of education in meeting future Navy requirements.

Current education and future Navy requirements

Navy navigators are trained to navigate in all conditions with restricted or no navigational input.

The training enables graduates to handle NAVWAR challenges.

Some of the instructors were uncertain if the education was adequate in all areas

Students should know how to protect the systems from NAVWAR.

Several students are not receptive of other aspects of maritime operations besides navigation when they are navigating.

Figure 23: Key findings current education and future Navy requirements

The following subsection presents the instructors' opinions on how using simulators and real-life vessels affects the acquisition of knowledge and skills for nautical students at the RNoNA.

Combining simulators and real-life vessels for nautical students at the RNoNA?

When asked if they would like to add anything about how simulators and real-life vessels affect the acquisition of knowledge and skills for nautical students at the RNoNA, the instructors emphasized the importance of combining simulated training and sailing on real-life platforms. This mix of training ensures that students can develop a deeper understanding of navigating a vessel. Instructor two highlighted the necessity for Navy navigators to be capable of sailing in unfamiliar and challenging waters without a Pilot Exemption Certificate or a pilot onboard, both in peacetime and during times of war. Therefore, they need to receive proper education and training on real-life platforms. Instructor four stated:

> *The navigators are reaching completely different levels with the use of simulators compared to when we did not have the simulator, which is also logical from a theoretical point of view. What I believe is unfortunate is that we have so much to do that we can't take the time to do things as thoroughly as they could have been done.*

Furthermore, the instructors emphasize that they would have needed significantly more time and resources to train the students sufficiently without the simulator. Other instructors support this notion by emphasizing that the simulator plays a vital role in training basic elements on an accessible platform.

The instructors also highlight the real consequences of using a real-life platform. For instance, if a student arrives late for planned refuelling, they may risk not receiving fuel, and these real-world consequences have the potential to enhance the learning experience.

The instructors stress the importance of purposeful training, regardless of the platform used. Instructor one stated:

> *Everyone can go in the simulator and sail, go out again and say that they have had a good day in the simulator. However, the learning outcome will be drastically reduced without a specific purpose. This applies to both platforms; therefore, training with a purpose, having a proper brief, conducting the exercise, and debriefing the experience are important. If the instructors and students do not do this, they waste valuable time.*

Instructor one added that he often observed students and other users at the simulator's training without a proper purpose.

Figure 24 presents the key findings on the instructors' opinions about how the use of simulators and real-life vessels affects the acquisition of knowledge and skills for nautical students at the RNoNA.

Combining simulators and real life platforms

- Important to ensure that the students get a deeper understanding of navigating a vessel.
- Navigators are reaching completely different levels.
- The RNoNA do not have the time to do things, as thoroughly as they could have been done.
- Without the simulator they would have spent a lot more time and resources to train the students at a proper level.
- Instructors highlight the real consequences as a learning enhancer when using a real-life platform.
- It is important to train purposefully, regardless of platform.
- If there is not a specific purpose the learning outcome will be drastically reduced.

Figure 24: Key findings combining simulators and real-life platforms.

The following subsection presents the instructors' opinions on how the RNoNA can improve its usage of simulators and real-world navigation training.

How can *the RNoNA improve its usage of simulators and real-world navigation training?*

When asked if there is anything else they would like to add about how the RNoNA can improve its usage of simulators and real-world navigation training, the instructors mentioned several factors. They highlight that while the current vessels are good, they are not optimal for learning and rest. Suggestions were made for larger vessels with improved sleeping facilities, better heating, ventilation, and air conditioning (HVAC), and reduced noise levels onboard. This would help alleviate student fatigue and contribute to a better learning outcome. It is also noted that larger vessels would accommodate more students at once, allow for better rotation, and reduce the number of exercises needed to train all the students. Navigating larger vessels in the training phase could provide a stronger foundation for handling larger Navy vessels in the future. Another suggestion is incorporating larger vessel models in the simulator, as only the Nordnes model is currently used for practical navigation. Using larger platforms in the simulation would enhance students' understanding and readiness for navigating larger vessels. Instructor five expressed this viewpoint: *"With a larger vessel, the students have to make* *different considerations regarding Closest point of approach/Time to closest point of approach (CPA)/(TCPA), stopping distance and passing through narrow straits."*

Another suggestion mentioned by instructor three is to implement a self-study package for the simulator. This package would ensure that all students receive a minimum exposure to various scenarios throughout their time as students. It would outline how and how many times different exercises should be conducted. By working systematically in groups and maintaining continuity each semester with this package, the student's performance could be significantly improved. Instructor three stated, "We know from experience that groups with a lot of self-study time in the simulator perform significantly better overall in exams compared to groups with little self-study time." The instructor further proposed formalizing this package by requiring a signature at the end of each exercise, allowing students and instructors to track their progress. This approach would help build the students' experience base and provide a solid foundation for real-world exercises.

The simulator and school vessel utilize K-Bridge and K-Radar, the same Integrated Bridge System (IBS) found on the Frigates and Corvettes. Another suggestion is to acquire bridge systems for other vessels so that students can familiarize themselves with these systems before graduating.

Some instructors emphasized the importance of all instructors gaining a deeper understanding of simulator usage and the possibilities it offers. They suggested revising various simulator scenarios to ensure high quality and following a standardized scenario-building setup. This setup would include using consistent colours for specific routes, such as assigning a colour for ferry routes. Instructors can provide a more consistent and effective learning experience by adhering to a standard scenario-creation procedure. This initiative has already begun, and the feedback from students and participating instructors has been positive. However, instructor four said:

> *Many teachers and instructors are not interested in reworking their scenarios, and people often do what they are required to do and what they believe is fun to do. Sadly, most people do not like to rework and document simulator scenarios. I see certain subjects and some courses that are not documented properly.*

Furthermore, he stated that if everything, from simple exercises to complex scenarios, is well-documented with proper descriptions and built using a standardized setup, it will be easier for everyone to execute them efficiently. The students should also have access to these scenarios to practice independently.

Another improvement suggestion that emerged during the interviews was to modify the setup within each semester. This would involve using the simulator more purposefully by conducting isolated lab exercises and drilling these exercises. Once the isolated lab exercises have been sufficiently practised, they can be combined to create larger, more complex scenarios in the simulator. Finally, the students would train on real-life platforms. This approach would differ from current usage, where real-life platform and simulator training are conducted simultaneously. However, it would be crucial to start re-drilling in the simulator early enough to prepare for the final exam adequately. Additionally, within each semester, the students should be given tasks beyond navigation, allowing them to experience other aspects of maritime operations.

The idea of a textbook was raised again, suggesting that it could serve as a common reference.

It was mentioned that the students have simulator exercises every second week. Two instructors are available to oversee the exercises and provide feedback to potentially five bridges (groups) during these exercises. However, there is a concern about limited opportunities for one-on-one feedback. The feedback is more general, and the students are primarily responsible for their feedback within their respective sailing groups. Having more instructors available during these sessions could significantly improve the quality of feedback and help establish better relationships between the students and instructors for real-life training.

Figure 24 presents the key findings on the instructors' opinions about how the RNoNA can improve its usage of simulators and real-world navigation training.

How to improve the use simulators and real life platforms

New vessels with improved HVAC and improved sleeping facilities.
Improve the structure of simulator training.
Train the students with larger vessels in the simulator
Implement self-study package for use in the simulator.
Implement textbook.
Have more instructors available for the simulator exercises.

Figure 25: Key findings on how to improve the use of simulators and real-life platforms.

5. Discussion

This chapter will integrate the findings from the systematic literature review and discuss the main themes that emerged from the analysis of both interviews and surveys. The research methodology will be examined to assess whether the research aim has been achieved and whether the results can be considered valid.

5.1 Methodology discussion

The qualitative methods chosen for the research have pros and cons. The systematic literature review was effective in identifying documented practices in the use of simulators, providing a solid foundation of qualitative data.

The semi-structured interviews proved valuable in gathering information from the instructors. Their expertise in instructing, particularly in real-life platforms where limited literature was available, contributed to collecting valid data on using real-life platforms. The semi-structured interviews allowed for follow-up questions, which proved beneficial as interesting perspectives and insights emerged during the interviews. Although there were some unique responses from the interviewees, the overall trends were consistent, and a high percentage of the instructors working at the RNoNA were interviewed, enhancing the validity of the findings.

The qualitative surveys effectively gathered information from the students, and the student's experiences using both simulators and real-life platforms are considered important for the validity of the thesis. The survey was distributed to the students after completing all their MPN training, ensuring they had sufficient experience while still allowing the researcher enough time to collect and analyse the data. This enhanced the reliability of the data. However, the interviews had to be conducted before the survey results were available, and it may have been beneficial to have the students' responses available during the interviews with the instructors. Additionally, asking follow-up questions based on some of the student responses could have been advantageous, as they provided valuable insights.

The data gathered in this thesis has high validity. The instructors at the RNoNA can be considered experts in instructing maritime students, and the students and graduates have first-hand experience in receiving Maritime Education and Training (MET). Therefore, the collected data holds significant value. The instructors interviewed represent a large portion of the total population of instructors at the RNoNA. Approximately half of the student and graduate population responded to the survey. As a result, the dataset can be regarded as representative of the opinions of instructors and students regarding the use of simulators and real-life navigation for nautical students at the RNoNA.

Especially among the students and graduates, most of them mentioned similar positive and negative factors. It is assumed that the respondents have not collaborated, further reinforcing the validity of the data. The research aim has been achieved.

The following section will present the discussion of the main themes.

5.2 Results discussion

The systematic literature review identified several aspects regarding maritime simulation-based training. These aspects include how fidelity affects learners in a simulation (De Oliveira et al., 2022; Hindmarsh et al., 2014; Hjelmervik et al., 2018; Hontvedt & Arnseth, 2013; Hontvedt, 2015; Hontvedt & Øvergård, 2020; Wahl, 2020), how simulations should be conducted, and how instructors should facilitate learning (IMO, 2012; Kim, Te et al., 2020; Sellberg, 2017; Sellberg & Lundin, 2017; Sellberg, & Lundin, 2018; Sellberg, 2018). Moreover, how instructors can use CAPA (Computer-Assisted Personalized Assessment) to assess students (Ernstsen & Nazir, 2020; Juszkiewicz & Żukowska, 2023) and how maritime simulator training is conducted across Europe (Nazir et al., 2019).

The results suggest that practical navigation at the RNoNA is good. However, there is room for improvement in the utilization of both platforms.

The first theme discusses MPN and its connection to other nautical subjects.

(1) MPN and the connection to other nautical subjects

When asked about the connection between MPN and other subjects. Instructors, graduates, and most students acknowledged a connection and that other nautical subjects support MPN. However, students three and four held different beliefs, as they perceived the curriculum of other nautical courses to be more focused on STCW (Standards of Training, Certification, and Watchkeeping) requirements and less supportive of MPN. It is important to note that MPN and STCW are not contradictory; in fact, they are complementary, as MPN follows STCW A-II/1, A-II/2, and B-12 (Forsvaret, 2023).

Upon reviewing the study program's curriculum and the STCW requirements, it becomes apparent that there is a clear connection between all nautical subjects, including MPN, and the alignment with STCW. A recurring theme from the interviews is that while instructors believe the curriculum supports practical navigation, many feel there is a need to address and improve the connection between theoretical and practical navigation. This will be further discussed under the theme of improvements.

The next theme presents the discussion regarding the instructor as a learning facilitator.

(2) The instructor as a learning facilitator

The instructor is crucial in creating an effective maritime simulated learning environment (IMO, 2012). In such an environment where learners can be exposed to new situations, instructors must encourage and motivate the learners (Bada, 2015). All the instructors expressed high motivation when instructing the students, regardless of the platform. However, it was noted that instructors were more motivated when working on the real-life platform. When asked about their motivation, the instructors also mentioned the challenges and limitations of the simulators.

The instructors stated they were well-prepared to instruct the students, regardless of the platform. However, they acknowledged that real-life platforms require more planning, especially regarding passage planning. It is worth noting an interesting point raised by instructor four: that creating an authentic scenario with the currently available resources requires more time and planning when using the simulator compared to real-life vessels. While only one instructor mentioned this viewpoint, Wahl (2020) highlights the instructor's pivotal role in achieving high fidelity in simulation. Thus, despite the simulator's high technical fidelity, creating high psychological fidelity in the simulator requires more time and resources from the instructors compared to preparing for a real-life exercise. This observation is further supported by Kim, Te et al. (2020), who emphasize the time required to develop and improve simulator exercises.

During the interviews, instructor two mentioned that it was easier to reuse the plans for the simulator exercises than on the real-world platform. However, instructor four's comment about the insufficient documentation of several scenarios suggests room for improvement in the RNoNA's preparations for simulator exercises.

All the instructors expressed confidence in their ability to teach MPN effectively and acknowledged that they learned from the students. This aligns with the feedback from the students, who perceived the instructors as competent and providing valuable feedback. However, there is a notable difference in the feedback received on the school vessels compared to the simulator. According to the survey responses, one can argue that the instructors create a state-of-the-art constructive learning environment onboard the vessels, where students engage in experiential learning following Kolb's Experiential Learning Theory (ELT). The RNoNA learning philosophy also appears to align with Kolb's theories.

Student thirteen, mentioned that the feedback primarily focuses on highlighting what the student did wrong, which contradicts the RNoNA learning philosophy. While this opinion represents a single student's perspective and does not reflect the main trends in the responses, it is still valuable and should be considered.

The students generally expressed dissatisfaction with the feedback received in the simulator. Despite the RNoNA's adherence to the principles outlined in the IMO model course 6.10, which includes two instructors and distinct simulation phases (briefing, planning, simulation, and debriefing) (IMO, 2012), students reported that the feedback was perceived as generic, leading them to disregard it. There could be several reasons for this perception. It could result from comparing the simulator feedback to the high-quality feedback received on the vessels, where instructors constantly monitor the students. It is also possible that the simulator is underutilized, with insufficient instructors available to adequately monitor the students or that the instructors must improve the execution of the simulation. As the role of instructors in facilitating learning is crucial throughout the simulation process (Sellberg, 2018), having one instructor available per bridge could enhance the quality of feedback.

The next theme presents the discussion regarding the student as a learning participant.

(3) The student as a learning participant

Experiential Learning is based on the belief that learning is a comprehensive process, where all learning is re-learning, leading to knowledge creation (Kolb et al., 2014). Consequently, preparation plays a crucial role in the learning process. The students generally indicated that they engaged in minimal preparation before simulator exercises and invested significant effort in preparing for real-world exercises. Jamil & Bhuiyan (2021) discovered that preparatory tasks before maritime simulation exercises could enhance learning outcomes. This suggests that there is potential for greater learning outcomes by incorporating more preparation before simulator exercises. However, the students mentioned that the reason for their limited preparation before simulator exercises was the overall workload across the curriculum. This is an important consideration for instructors when designing preparatory tasks, considering the students' workload, and balancing it appropriately.

Half of the students expressed greater motivation for sailing on the real-life platform. It is crucial for students to encounter challenges and reflect on their experiences to enhance their understanding. Instructors play a vital role in tailoring the difficulty of these challenges to an appropriate level, allowing learners to use them as building blocks in the learning process (Bada, 2015). By presenting appropriate challenges, motivation can also be increased. Adjusting challenges is generally easier in the simulator compared to the real world.

Another factor that can influence students' motivation is the fidelity of the simulator (De Oliveira et al., 2022). According to the student’s responses, the simulator demonstrates high technical fidelity. However, several replies indicate that the scenarios lack sufficient psychological fidelity. The fidelity level must align with the simulation requirements and learning objectives (Hontvedt, 2015). The instructor is vital in establishing a high-fidelity level by creating lifelike situations (Wahl, 2020). The students noted that the scenarios often fall short of producing realistic situations.

The next theme presents the discussion regarding learning outcomes from the two platforms.

(4) Learning outcomes from the two platforms

The survey and interview data suggest that the real-life platform provides the best learning outcome. However, it is important to note that the responses also indicate that comparing the two platforms is more complex than determining one platform to be superior. Both platforms have their strengths and complement each other. The instructors emphasize the importance of a solid understanding of the basics in the simulated maritime environment to optimize resource efficiency. The literature also supports the notion that exposing students to overly complex scenarios too early can result in lower performance compared to gradually increasing complexity (Hjelmervik et al., 2018). In this context, one can argue that the real-world platform presents the most complex scenarios for the students. The student's first encounter with MPN is during Exercise West Coast, where they utilize the vessels Kvarven and Nordnes. Introducing students to the real world in Exercise West Coast without prior lab exercises and simulator training may potentially hinder the overall learning outcome in MPN. Therefore, it is suggested to begin with lab and simulator exercises and gradually expose the students to the real world once they have acquired a solid foundation of knowledge and skills.

Instructor four believes developing Navy officers of the same quality is possible without using real-life platforms. Still, he acknowledges that achieving this would require significantly more resources than the RNoNA currently has. While this may be a theoretical possibility, Sellberg et al. (2018) found that time at sea plays a crucial role in gaining experiences that simulators cannot provide. The responses from surveys and interviews indicate that the simulator is effective for learning new procedures, but the real world offers a holistic learning environment where emotions relate to learning. This aligns with the educational philosophy of the RNoNA (Olsen, & Espevik, 2009), principles of brain-based learning (Caine & Cain, 1991), and experiential learning (Kolb & Kolb, 2017).

It can be concluded that the school vessels provide the best overall learning outcome. However, the simulator serves as a foundation for learning. This is supported by Hjelmervik et al. (2018), who recommend exposing students to simple scenarios and building a foundation before introducing them to increasingly complex environments.

The responses from students and graduates also suggest that the simulator is underutilized. Issues identified include infrequent sessions, insufficient psychological fidelity in the scenarios, and a need for more available instructors during simulator sessions. These factors can hinder the learning outcome from simulator sessions and consequently reduce the overall learning outcome. The next theme discusses combining the two platforms to enhance learning.

(5) Combining school vessels and simulators as a learning enhancer for students

Data from interviews and surveys indicate that combining maritime simulation education with real-life navigation is crucial for training Navy navigators who can confidently sail in unfamiliar and challenging waters without relying on a pilot onboard. The graduates mentioned that they could connect the dots and understand the significance of their training after graduation. They acknowledged that using both platforms, simulation and real-life navigation, had contributed to an improved performance towards becoming an OOW.

As previously mentioned, Navy navigators must be able to navigate without GPS. The findings suggest that first-hand experience with this type of navigation in real-world scenarios can be invaluable in enhancing students' performance and preparedness for their roles in the Navy.

Instructor four, who has experience in educating cadets both before and after the introduction of high-fidelity simulators in the Navy, emphasizes that using simulators has significantly elevated the proficiency of navigators compared to when only vessels were utilized. Simulators are essential for training fundamental elements in a readily accessible platform. However, as indicated by the results, it is crucial to integrate and utilize both platforms purposefully.

By viewing the real world as a complex environment encompassing technical, psychological, and interactional fidelity, as defined by Hontvedt and Øvergård (2020), the combination of simulator and real-life training can be considered a best practice in practical education for maritime students. However, the students must be trained in low-fidelity, simple environments to master the basic elements. Subsequently, complexity and fidelity should gradually increase as students gain more experience and knowledge in the field. This progressive approach is well-documented in the literature on MET (De Oliveira et al., 2022; Hjelmervik et al., 2018; IMO, 2012; Sellberg & Lundin, 2017; Wahl, 2020) as well as in learning literature (Bada, 2015; Honebein, 1996; Caine and Caine, 1991; Kolb & Kolb, 2017; Morley & Jamil, 2021).

The last theme discusses how the RNoNA can enhance its utilization of simulators and real-world navigation training.

(6) Improving the usage of simulators and real-world navigation training

The results provided several suggestions for improving the usage of the real-world platform, particularly regarding simulators. This section will discuss potential measures that the RNoNA can implement without considering the feasibility in terms of resources.

One obvious initiative is to increase the frequency of simulator sessions. Learning is a repetitive cycle (Kolb & Kolb, 2017), and currently, the students are not receiving enough repetitions in the simulator. By increasing the frequency of simulator sessions, students would have more opportunities to strengthen their foundation and enhance their overall learning outcome.

The survey results indicate that students desire more practice and are willing to invest additional time in practising. To support the students in this aspect, the RNoNA could make the simulator more accessible after working hours. Providing this opportunity can foster a sense of ownership in the learning process (Stirling & Kerr, 2015). Additionally, as suggested by instructor three, the RNoNA could introduce a co-curricular portfolio that allows students to train at their convenience. This purposeful co-curricular portfolio can enhance curricular performance (Stirling & Kerr, 2015).

Instructor four highlighted the importance of improving the scenarios and scaffolding the students to enhance their immersion in the simulation. The students mentioned that when they underperform in the simulator, it is easy to attribute it to the simulation itself, which is also supported by the findings of Hindmarsh et al. (2014). Therefore, the instructors must create scenarios and simulations that immerse the students. This notion is further supported by Hontvedt 2015; Sellberg, 2017; Wahl, 2020). It is worth noting that a potential challenge at the RNoNA, compared to other nautical institutions, is that all students already have experience navigating in the real world. This may require additional efforts to make the scenarios immersive enough.

The instructors emphasized that while the vessels are good, they are not optimized for learning and rest. They suggested that the vessels should have been slightly larger, with improved sleeping facilities, better HVAC systems, and reduced noise onboard. Larger vessels could offer several advantages, such as providing better rest for the students during exercises, giving them experience navigating larger vessels, and enhancing their ability to conduct good seamanship. However, it is worth noting that none of the students mentioned the size of the vessels or fatigue during exercises as issues. Some graduates even mentioned fatigue as a positive aspect. Nonetheless, it is important to acknowledge that fatigue can still be a factor on larger platforms, and the experience of navigating larger vessels with fewer weather restrictions could be beneficial.

The instructors are considering the use of larger vessels in the simulator. Introducing a larger platform could give the students a better foundation and understanding of navigating larger vessels in the future. This suggestion aligns with the feedback from graduates who had professional experience on larger vessels and felt that their time at the naval academy needed more exposure to such situations. It is a valuable suggestion that could allow all students to experience how navigators on larger vessels perceive different scenarios.

Another improvement suggestion that emerged during the interviews was to revise the setup within the semesters by utilizing the simulator more purposefully. This would involve conducting isolated lab exercises in the simulator, drilling these exercises repeatedly and, once the students have gained sufficient proficiency, integrating the different exercises into larger and more complex scenarios in the simulator. Finally, the students would receive training on the real-life platform.

Implementing this suggestion is likely the easiest and most effective way to enhance the training process. Currently, students are being exposed to the complexity of the real-life platform too early, without a solid foundation to utilize the platform effectively. Research has shown that introducing complex scenarios too early can lower total learning outcomes (Hjelmervik et al., 2018). Furthermore, it can be assumed that there is a gap between the student's existing knowledge and the desired learning outcomes early in the study program, making it challenging to foster effective knowledge sharing between students and instructors and hindering the development of a constructivist learning environment. As mentioned by instructor four, some students may lack in-depth knowledge in certain areas, and one probable reason for this could be the introduction of multiple elements simultaneously. This issue can be addressed and mitigated by implementing the proposed revision to the setup.

Graduate five suggested incorporating a few days onboard a real Navy vessel as part of the MPN program would greatly enhance the students' navigational perspective. The RNoNA should consider this suggestion a mandatory component for all students. There are several benefits to this approach. Research by Sellberg et al. (2018) indicates that spending time at sea provides invaluable first-hand experience of working onboard vessels. It also offers students a more comprehensive understanding of the types of vessels they may want to serve on after graduation.

The systematic literature review also revealed the potential for using computer-aided performance assessment (CAPA) to evaluate student performance. CAPA has been shown to generate reliable scores when assessing student performance (Ernstsen & Nazir, 2020). Specifically, the K-Sim CAPA, which can be utilized at the RNoNA, has proven to be a valuable tool in supporting instructors during student assessments (Juszkiewicz & Żukowska, 2023). While it requires careful setup and preparation of the evaluation sheet, when implemented correctly, students can also use it to receive feedback when training on their own.

6. Conclusion:

This chapter revisits the research questions and concludes the conducted research while suggesting potential avenues for future research. The study has contributed to the field of MET, particularly in utilizing the combination of simulators and real-life platforms for practical navigation training of students. Although the study was conducted on students at the RNoNA, the results are supported by relevant MET literature and can be extrapolated and applied in a broader context. The study emphasizes the limitations and possibilities of utilizing real-world vessels and simulators and how they can complement each other to achieve better outcomes for nautical students. To accomplish this objective, this thesis addresses the following questions:

1. ***Does the practical experience gained from real-world navigation training justify the resources invested in nautical students at the RNoNA?***

The data from interviews and surveys show that despite the ability to practice everything in a simulated environment, the practical experience gained from real-world navigation training is highly beneficial for the students. It offers a holistic learning experience where they can connect knowledge and skills to develop competence. Additionally, the students report higher motivation, better feedback, and increased alertness when training in the real world, which is supported by the existing learning literature. The combination of simulator sessions and real-world training is unique and provides the students with a solid foundation to become future

OOWs in the Navy.

Another important aspect that supports the use of real vessels is that the instructors must maintain their navigating skills at a high level, and they can provide the students with credible demonstrations of how to navigate in the real world.

2. ***Can simulator training alone fulfil the requirements set by the STCW and provide adequate and efficient practical navigation training for nautical students in the RNoNA?***

The mandatory training requirements in nautical bachelor programs are defined in the STCW code, specifically in tables A-II/1 and A-II/2. These requirements can all be fulfilled through simulation training. The simulator alone can provide adequate and efficient practical navigation training for nautical students at the RNoNA. However, it would require additional resources for the simulator department at the RNoNA. Even if the simulator department received more resources, the overall learning outcome would likely be reduced if simulation training were the sole form of practical navigation training for the students. This statement is supported by data from surveys and interviews that suggest the real-world platform provides the best overall learning outcome, and most importantly, the two platforms complement each other. While the simulator offers a technically realistic experience where students can practice and enhance their skills, there are certain aspects that the simulator cannot replace. The survey revealed that the real world gives students a sense of responsibility due to real consequences, triggering real emotions and providing a more holistic learning environment. Additionally, having one instructor who constantly monitors the students can provide better instructions and feedback.

Therefore, relying solely on simulation training would likely reduce the efficiency of the training and result in lower navigation proficiency among the graduates. Consequently, increasing the resources needed for the graduates to become cleared OOW in the Navy.

3. ***How can the RNoNA enhance utilization of simulators and real-world navigation training?***

The practical navigation training at the RNoNA is of high quality, as it must to for the students to meet the requirements for Navy navigators. However, the study revealed several areas where the utilization of platforms could be improved. The RNoNA could consider revising the setup within the semesters to prioritize extensive drilling in a simulated environment and introduce real-life platforms later. Combined with an increase in the frequency of simulated sessions would give students more time to practice and reinforce fundamental elements.

To enhance the learning process, the RNoNA could make the simulator more accessible outside of regular working hours. This would foster a sense of ownership among the students. Additionally, introducing a co-curricular portfolio would allow students to train at their convenience, further supporting their learning.

Incorporating CAPA as an evaluation tool could provide instructors with an additional means of assessing student performance. It could also serve as a valuable feedback mechanism for students, particularly when they engage in self-directed training after hours.

Improving the scenarios in the simulator is crucial to increase the psychological fidelity and immersion of the students. This aligns with the findings that suggest enhanced scenarios lead to better learning outcomes.

Introducing a larger vessel in the simulator would give students a better foundation and understanding of navigating larger vessels in the future. This exposure to larger vessel navigation would be valuable for their development.

Investing in larger real-world vessels also brings several advantages. It would give students better rest during exercises, offer experience navigating larger vessels, and enhance their overall seamanship skills.

Furthermore, incorporating a mandatory component of spending a few days onboard a real Navy vessel for all nautical students would greatly enhance the students' navigational perspective. This approach has several benefits, including providing invaluable first-hand experience of working onboard vessels and offering students a more comprehensive understanding of the types of vessels they may choose to serve on after graduation.

In summary, the thesis supports existing knowledge about the utilization of simulators and contributes to a clearer understanding of the benefits of real-life navigation training. Future studies could delve further into platform utilization, specifically the impact of implementing a co-curricular portfolio, the benefits of using larger vessels in the simulator, and spending time onboard Navy vessels.

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Appendices

Appendix A: Interview Guide

Introduction and opening questions:

- ✓ **Thank the respondent for participating.**
- ✓ **Informing about the consent form**
- ✓ **Signature of the consent form**
- ✓ **How old are you?**
- ✓ **When did you start working at the Naval Academy, and what is your background before you started working here?**

Interview Questions

1. **Do you experience a connection between the curriculum in navigational systems, navigation, the rules of the sea, and military practical navigation**

2. **How motivated are you to sail on the school vessels? How motivated are you to sail in the simulator?**

3. **How much time do you spend preparing for sailing on the school vessels? And how much time do you spend preparing for sailing in a simulator?**

4. **Which of the two platforms do you think provides the greatest learning outcome, and why?**
5. **Do you feel that you are up to date according to the current requirements and curriculum to be able to execute MPN teaching in a good way?**

6. **What are your thoughts about the current education in practical navigation with regards to the future Navy needs?**

7. **Is there anything else you would like to add about how *the use of simulators and real-life vessels affect the acquisition of knowledge and skills for nautical students in the RNoNA*?**

8. **Is there anything else you would like to add about how *the RNoNA can improve their usage of simulator and real-world navigation training?***

Once again thank the object for participating.

Appendix B: Informed Consent Form Interview

Are you interested in taking part in the research project

Is real-life training on school vessels an efficient use of resources when training nautical students in practical navigation?

Purpose of the project

You are invited to participate in a research project where the main purpose is to investigate if real-life training on school vessels is an efficient use of resources when training nautical students in practical navigation. And what will be the best-suited way to train the students in practical navigation?

This is a master thesis.

Which institution is responsible for the research project?

Western Norway University of Applied Sciences is responsible for the project (data controller).

Why are you being asked to participate?

As an instructor at the Royal Norwegian Naval Academy, you are in the target group for this thesis, therefore you have been selected to participate. A total of 5 persons have been asked to participate in this study.

What does participation involve for you?

If you chose to take part in the project, this will involve that you will be interviewed. The interview will take approx. 45 minutes. The interview includes questions about your experience with the use of simulators and real-life vessels as an instructor in the RNoNA.

Your answers will be recorded ».

Participation is voluntary

Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified here and we will process your personal data in accordance with data protection legislation (the GDPR).

- I will replace your name and contact details with a code. The list of names, contact details and respective codes will be stored separately from the rest of the collected data», I will store the data on a separate computer, locked away.
- Your answers will be shared with teachers at the Royal Norwegian Naval Academy and Meric Karahalil at Western Norway University of Applied Sciences.
- These individuals will have access to collected data that has been de-identified)
- Participants will not be recognizable in publications.

What will happen to your personal data at the end of the research project?

The planned end date of the project is 02.06.2023 at the end of the project all personal data will be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and

send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with Western Norway University of Applied Sciences, The Data Protection Services of Sikt – Norwegian Agency for Shared Services in Education and Research has assessed that the processing of personal data in this project meets requirements in data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- Western Norway University of Applied Sciences via Meric Karahalil, meric.karahalil@hvl.no, +47 46234763
- Our Data Protection Officer: Trine Anikken Larsen

If you have questions about how data protection has been assessed in this project by Sikt, contact:

email: (personverntjenester@sikt.no) or by telephone: +47 73 98 40 40.

Yours sincerely,

Project Leader	Student
Meric Karahalil	Nils Eivind Skaar

Consent form

I have received and understood information about the project: Is real-life training on school vessels an efficient use of resources when training nautical students in practical navigation? And have been given the opportunity to ask questions. I give consent:

☐ to participate in a paper-based survey

I give consent for my personal data to be processed until the end of the project.

(Signed by participant, date)

Appendix C: Survey Questions

Questionnaires to the survey participants.

1. Do you experience a connection between the curriculum in navigational systems, navigation, the rules of the sea, and military practical navigation?
2. How do you experience the learning outcome in the simulator? How do you experience the learning outcome on board the school vessels?

For each session in the MPN, there are specific practice goals to be implemented.

3. How do you feel it is to achieve the practice goals in the simulator? How do you feel it is to achieve the exercise goals on board the school vessels?

For each session in MPN, you will receive feedback from the instructor.

4. How do you perceive the quality of the feedback from instructors on board the school vessels? How do you perceive the quality of the feedback from instructors in the simulator?

5. How do you experience the realism in the simulator compared to being on board the school vessels?

For each session in MPN, you will receive feedback from the instructor.

6. How do you manage to use feedback from a session on the school vessels compared to feedback after a simulator session?
7. How motivated are you to sail on the school vessels? How motivated are you to sail in the simulator?
8. How much time do you spend preparing for sailing on the school vessels? And how much time do you spend preparing for sailing in a simulator?

Exclusive question to graduated cadets, who are now in service

How do you feel that the school vessels and simulators have prepared you for service aboard Navy vessels? Please elaborate on the pros and cons of the different platforms.

Seamanship is in this questionnaire defined as knowledge of mastering the use of larger and smaller vessels and it includes several subjects and skills. Among these are navigation, maritime law, meteorology, shipping, communication, firefighting, sea distress, rescue, etc.).

9. How has sailing on school vessels made you better at exercising good seamanship? How has sailing in a simulator made you better at good seamanship?
10. Which of the two platforms do you think provides the greatest learning outcome, and why?
11. Is there anything else you would like to add about how *the use of simulators and real-life vessels affect the acquisition of knowledge and skills for nautical students in the RNoNA*?
12. Is there anything else you would like to add about how *the RNoNA can improve their usage of simulator and real-world navigation training?*

13. Are you a current student, or a graduated student?

Appendix D: Informed Consent Form Survey

Are you interested in taking part in the research project

Is real-life training on school vessels an efficient use of resources when training nautical students in practical navigation?

Purpose of the project
You are invited to participate in a research project where the main purpose is to investigate if real-life training on school vessels is an efficient use of resources when training nautical students in practical navigation. And what will be the best-suited way to train the students in practical navigation?

This is a master thesis.

Which institution is responsible for the research project?

Western Norway University of Applied Sciences is responsible for the project (data controller).

Why are you being asked to participate?

As a student or former student at the Royal Norwegian Naval Academy, you are in the target group for this thesis, therefore you have been selected to participate. A total of 40 persons have been asked to participate in this study.

What does participation involve for you?

If you chose to take part in the project, this will involve that you fill a paper-based survey. It will take approx. 45 minutes. The survey includes questions about your experience with the use of simulators and real-life vessels as a nautical student in the RNoNA?

Your answers will be recorded electronically».

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified here and we will process your personal data in accordance with data protection legislation (the GDPR).

- I will replace your name and contact details with a code. The list of names, contact details and respective codes will be stored separately from the rest of the collected data», I will store the data on a separate computer, locked away.
- Your answers will be shared with teachers at the Royal Norwegian Naval Academy and Meric Karahalil at Western Norway University of Applied Sciences.
- These individuals will have access to collected data that has been de-identified)

Participants will not be recognizable in publications.

What will happen to your personal data at the end of the research project?

The planned end date of the project is 02.06.2023 at the end of the project all personal data will be deleted.

Your rights

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- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

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- Western Norway University of Applied Sciences via Meric Karahalil, meric.karahalil@hvl.no, +47 46234763
- Our Data Protection Officer: Trine Anikken Larsen

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- email: (personverntjenester@sikt.no) or by telephone: +47 73 98 40 40.

Yours sincerely,

Project Leader	Student
Meric Karahalil	Nils Eivind Skaar

Consent form

I have received and understood information about the project: Is real-life training on school vessels an efficient use of resources when training nautical students in practical navigation? And have been given the opportunity to ask questions. I give consent:

☐ to participate in a paper-based survey

I give consent for my personal data to be processed until the end of the project.

(Signed by participant, date)

Appendix E: NSD Approval Letter

Meldeskjema /Is real-life training on school vessels an efficient use of resources when... / Vurdering

Referansenummer
234707

Vurderingstype
Standard

Dato
27.03.2023

Prosjekttittel
Is real-life training on school vessels an efficient use of resources when training nautical students in practical navigation? Master Thesis

Behandlingsansvarlig institusjon
Høgskulen på Vestlandet / Fakultet for økonomi og samfunnsvitskap / Institutt for maritime studium

Prosjektansvarlig
Meric Karahalil

Student
Nils Eivind Skaar

Prosjektperiode
04.01.2023
-
02.06.2023

Kategorier personopplysninger
Alminnelige

Lovlig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)
Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 02.06.2023.

Meldeskjema

Kommentar
OM VURDERINGENSikt har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen avpersonopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

FØLG DIN INSTITUSJONS RETNINGSLINJERVi har vurdert at du har lovlig grunnlag til å behandle personopplysningene, men husk at det er institusjonen du er ansatt/student vedsom avgjør hvilke databehandlere du kan bruke og hvordan du må lagre og sikre data i ditt prosjekt. Husk å bruke

leverandører som din institusjon har avtale med (f.eks. ved skylagring, nettspørreskjema, videosamtale el.)
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved åoppdatere meldeskjemaet. Se våre nettsider om hvilke endringer du må melde: https://sikt.no/melde-endringar-i-meldeskjema

OPPFØLGING AV PROSJEKTET
Vi vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Appendix F: Norwegian Defence Research Board Approval Letter

FORSVARET
Forsvarets høgskole

Vår saksbehandler	**Vår dato**	**Vår referanse**
Audun Benjamin Bengtson, aubengtson@mil.no +47 FHS/FAGSTAB/SEK FOU ADM	2023-04-12	2023/015289-002/FORSVARET/ 910
	Tidligere dato	**Tidligere referanse**

Til
Nils Eivind Skaar

Kopi til

Tillatelse til å innhente opplysninger i og om Forsvaret til forskningsformål

1 Bakgrunn

Forsvarets høgskole (FHS) har mottatt din søknad av 9. mars 2023 om tillatelse til å innhente opplysninger i og om Forsvaret til forskningsformål. Prosjektet det skal innhentes data til er en masteroppgave, og følgende problemstillinger er oppgitt: «In what way or to what extent does the use of simulators and real-life vessels affect the acquisition of knowledge and skills for nautical students in the RNoNA?». Det skal gjennomføres intervju med og sendes ut spørreskjema til avgangskullet Sjømilitær Navigasjon ved FHS SKSK, [redacted] personer, fjorårets avgangskull, [redacted] personer, samt 5 instruktører ved KNM Tordenskjold Navkomp.

2 Drøfting

Vurdering av søknader om tillatelse til å innhente opplysninger i og om Forsvaret til forskningsformål er regulert av *Bestemmelse om utlevering av personopplysninger til forskning og gjennomføring av spørreundersøkelser*, fastsatt av sjef HR-avdelingen i Forsvarsstaben 1. mai 2018.
I henhold til punkt 2.3 og 2.4 i denne bestemmelsen er det en forskningsnemnd oppnevnt av sjef FHS som har myndighet til å behandle søknader om tillatelse til datainnsamling i Forsvaret. Kriterier og rettsgrunnlag som skal legges til grunn for vurderingen er omtalt i punkt 4.1 og 4.2.

Forskningsnemnda har vurdert din søknad som tilfredsstillende i henhold til gjeldende krav.

3 Vedtak

Søknad om tillatelse til å innhente opplysninger i og om Forsvaret til forskningsformål innvilges. Tillatelsen gjelder til prosjektslutt 2. juni 2023.

4 Vilkår for tillatelsen

Det er kun gitt tillatelse til innhenting av det datamaterialet som fremgår av søknaden. Data hentet fra Forsvaret skal ikke benyttes til andre formål enn den aktuelle masteroppgaven. Ved prosjektslutt skal alle data hentet fra Forsvaret slettes. Det skal sendes sluttmelding til FHS vedlagt masteroppgaven. Sluttemelding sendes til fhs.datautlevering@mil.no

Postadresse	**Besøksadresse**	**Sivil telefon/telefaks**	**Epost/ Internett**	**Vedlegg**
Postboks 800 Postmottak 2617 Lillehammer Norge	Oslo mil/Akershus 0015 OSLO Norge	/ **Militær telefon/telefaks** 99/0500 3699	postmottak@mil.no www.forsvaret.no **Organisasjonsnummer** NO 986 105 174 MVA	

Sven Gabriel Holtsmark

Leder forskningsnemnda

Dokumentet er elektronisk godkjent, og har derfor ikke håndskreven signatur.