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Enhancing the transfer effect of learning with ship simulators

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Abstract

This thesis explores the enhancement of the transfer effect of learning in maritime education through the utilization of simulators for ship handling instruction and training. The work focuses on the experiences of experienced deck officers as they adapt to a new innovative propulsion system. This learning process, particularly for experienced deck officers adapting to new, innovative propulsion systems, involves the partial abandonment or modification of previously learned knowledge and methods in favor of acquiring new navigation skills. This phenomenon is explored in this study through the lens of 'unlearning', which refers to the active process of identifying and discarding or updating established routines, habits, or knowledge that are no longer effective or may interfere with performance in a new context, such as handling a vessel with an azimuth propulsion system. Simulator training is examined as a method to create realistic and safe environments that promote the practice of various operational scenarios and can facilitate this complex learning and unlearning process. The importance of carefully designed simulator training is emphasized through the formulation of learning objectives, the design of assignments, the facilitation of discussions, the stimulation of student motivation, and the definition of instructor roles. Empirical evidence presented in this study indicates that simulators are crucial in enhancing the transfer effect of learning, which in turn promotes higher safety standards, improved energy efficiency, and the advancement of environmentally sustainable practices in vessel operations. The study presents theoretical perspectives and practical recommendations aimed at developing simulator-based training models in maritime education.

Language: English
Key Words: Learning, unlearning, simulator, transfer effect of learning

EXAMENSARBETE

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Abstrakt

Detta examensarbete undersöker förbättringen av överföringseffekten av lärande inom sjöfartsutbildning genom att använda simulatorer för undervisning och träning i fartygshantering. Arbetet fokuserar på erfarenheterna hos erfarna däcksofficerare när de anpassar sig till ett nytt innovativt framdrivningssystem. Denna inlärningsprocess, särskilt för erfarna däcksofficerare som anpassar sig till nya, innovativa framdrivningssystem, innebär att delvis överge eller modifiera tidigare inlärda kunskaper och metoder till förmån för att förvärva nya navigationsfärdigheter. Detta fenomen utforskas i denna studie genom linsen av 'avlärning' ('unlearning'), vilket hänvisar till den aktiva processen att identifiera och kassera eller uppdatera etablerade rutiner, vanor eller kunskaper som inte längre är effektiva eller kan störa prestanda i en ny kontext, såsom hantering av ett fartyg med ett azimutframdrivningssystem. Simulatorträning undersöks som en metod för att skapa realistiska och säkra miljöer som främjar övning av olika operativa scenarier och kan underlätta denna komplexa inlärnings- och avlärningsprocess. Betydelsen av noggrant utformad simulatorträning betonas genom formuleringen av lärandemål, utformningen av uppgifter, faciliteringen av diskussioner, stimuleringen av studentmotivation och definitionen av instruktörsroller. Empiriska bevis som presenteras i denna studie visar att simulatorer är avgörande för att förstärka överföringseffekten av lärande, vilket i sin tur främjar högre säkerhetsstandarder, förbättrad energieffektivitet och främjandet av miljömässigt hållbara metoder i fartygsoperationer. Studien presenterar teoretiska perspektiv och praktiska rekommendationer som syftar till att utveckla simulatorbaserade utbildningsmodeller inom sjöfartsutbildning.

Språk: Engelska
Nyckelord: Learning, unlearning, simulator, transfer effect of learning

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Tiivistelmä

Tämä opinnäytetyö tutkii oppimisen siirtovaikutuksen parantamista merenkulun koulutuksessa hyödyntämällä simulaattoreita aluksenkäsittelyopetuksessa ja -koulutuksessa. Työ keskittyy kokeneiden kansiupseerien kokemuksiin heidän sopeutuessaan heille uuteen innovatiiviseen propulsiojärjestelmään. Tämä oppimisprosessi, erityisesti kokeneille kansiupseereille, jotka sopeutuvat uusiin, innovatiivisiin propulsiojärjestelmiin, sisältää aiemmin opittujen tietojen ja menetelmien osittaisen hylkäämisen tai muokkaamisen uusien navigointitaitojen omaksumisen hyväksi.

Tätä ilmiötä tarkastellaan tässä tutkimuksessa 'unlearningin' (poisoppimisen) näkökulmasta. 'Unlearning' viittaa aktiiviseen prosessiin, jossa tunnistetaan ja hylätään tai päivitetään vakiintuneita rutiineja, tapoja tai tietoja, jotka eivät ole enää tehokkaita tai jotka saattavat häiritä suorituskykyä uudessa kontekstissa.

Simulaattorikoulutusta tarkastellaan menetelmänä luoda realistisia ja turvallisia ympäristöjä, jotka edistävät erilaisten operatiivisten skenaarioiden harjoittelua ja voivat helpottaa tätä monimutkaista oppimis- ja poisoppimis-prosessia. Huolellisesti suunnitellun simulaattorikoulutuksen merkitystä korostetaan oppimistavoitteiden muotoilun, tehtävien suunnittelun, keskustelujen ohjaamisen, opiskelijoiden motivaation stimuloinnin ja ohjaajan roolien määrittelyn avulla.

Tässä tutkimuksessa esitetty empiirinen näyttö osoittaa, että simulaattorit ovat ratkaisevia oppimisen siirtovaikutuksen parantamisessa, mikä puolestaan edistää korkeampia turvallisuusstandardeja, parannettua energiatehokkuutta ja ympäristöystävällisten toimintatapojen edistämistä alustoiminnassa. Tutkimus esittelee teoreettisia näkökulmia ja käytännön suosituksia, joilla pyritään kehittämään simulaattoripohjaisia koulutusmalleja merenkulun koulutuksessa.

Kieli: Englanti
Avainsanat: Learning, unlearning, simulator, transfer effect of learning

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1 Introduction

Maritime Education and Training (MET) is a multifaceted and constantly evolving field aimed at ensuring the competency and safety of maritime professionals in the global maritime industry. MET systems are complex entities involving several interconnected stakeholders such as training institutions, shipping companies, authorities, and labor organizations. One of the most significant features of modern maritime education is the widespread utilization of simulators.

The rapid technological advancements in maritime transportation, particularly the introduction of innovative propulsion systems like azimuth thrusters, present unique challenges for experienced seafarers. While extensive prior experience is invaluable, skills and intuitions developed with conventional vessel handling techniques may, in some instances, interfere with the effective operation of vessels equipped with novel systems. This phenomenon, where existing knowledge or skills hinder the acquisition or application of new ones, is sometimes referred to as negative transfer of learning. It also highlights the necessity of 'unlearning' – a process distinct from mere forgetting, involving the conscious identification and active modification or discarding of established, but now inappropriate, behaviors, procedures, or mental models. This study investigates the role of simulator-based training in facilitating this complex process of adapting to new technology, focusing on how it supports both the learning of new skills and the unlearning of potentially interfering prior knowledge.

Ship simulators offer a valuable environment for practicing new technology and related skills in this context. They enable the creation and practice of realistic and safe operational scenarios, which is critical for adopting new and complex systems. Different types of simulators are used in maritime education, such as desktop simulators, full-mission bridges, VR simulators, and cloud-based solutions. Full-mission simulators are particularly known for their high physical and social fidelity and suitability for all STCW training requirements, as well as for practicing Non-Technical Skills (NTS) and teamwork. Advantages of simulators also include the ability to adjust the learning pace and task complexity, support for motivation and higher-order learning. Challenges, on the other hand, include acquisition and maintenance costs and the need for qualified instructor personnel. (Karahalil, Lützhöft,

& Scanlan, 2024; Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019). To achieve training objectives, it is important to properly configure simulator fidelity. Simulator training is often seen as a separate, highly structured learning event, with briefing and debriefing as essential components. Debriefings have been identified as important promoters of professional learning.

The importance of carefully designed simulator training is central to enhancing the transfer effect. This includes formulating clear learning objectives, designing effective tasks, facilitating guided discussions, stimulating student motivation, and defining the roles of the instructor. The role of the simulator instructor is indeed critical for the transfer of learning. Their expertise (knowledge, theoretical knowledge), skills (practical skills, technical proficiency), and personal qualities (communication skills, motivation, positive attitude) significantly influence the learning process. The instructors' expertise is also utilized in designing simulator training scenarios.

In academic research, simulator-based training and assessment in the maritime sector have traditionally focused strongly on human factors (such as Crew Resource Management, CRM; Bridge Resource Management, BRM; Engine Room Management, ERM) and maintaining industry standards. Prominent research topics have included resource management, academic performance, simulator training, and authentic assessment (Wiig, Sellberg, & Solberg, 2023). However, the concept of learning itself has received less explicit and scientific attention in research before the last decade, and the field has relied more on "folk pedagogy" – that is, implicit assumptions about learning that often lack a strong theoretical basis. In recent years, however, there has been growing interest in the scientific study of learning activities empirically.

This thesis is situated within this new research direction. The goal of this study is to investigate and better understand the transfer effect of learning in simulator-based maritime education, with a particular focus on the experiences of experienced deck officers in adopting a new propulsion system where unlearning plays a central role. The research examines how simulators, structured practice within them, and the role of the instructor can enhance the transfer of new skills from the simulator environment to practical ship handling onboard.

The thesis presents theoretical perspectives on the transfer effect of learning and unlearning in the context of maritime education and utilizes empirical evidence regarding the importance of simulators. At the end of the study, practical recommendations are presented for developing simulator-based training models in the maritime sector. The empirical evidence from the study supports the view that simulators are crucial in strengthening the transfer effect of learning, which directly contributes to higher safety standards, improved energy efficiency, and environmentally sustainable practices in shipping. The work thus aims to deepen the understanding of learning processes in MET and offer concrete suggestions for improving training.

1.1 Research question and related aspects.

To navigate the complexities of modern ship handling operations, effective training is more important than ever. One of the key challenges in all maritime education is ensuring that what is learned in the classroom or simulator can be successfully applied in real-world situations. This process, known as the transfer of learning, lies at the heart of this master's thesis.

The central research question guiding this study is: "How can the transfer effect of learning be enhanced by using simulators in ship handling instruction and training?"

This question originates from a strong interest in the concept of learning transfer and its practical relevance. Learning transfer refers to the ability to apply knowledge and skills acquired in one context to new and different situations. It is a fundamental element of effective education and training. This study is particularly inspired by the potential of simulator-based instruction to connect theoretical understanding with real-world maritime operations.

Simulator-based instruction offers a promising bridge between theoretical knowledge and practical application. This study explores how such training environments can be designed and used to strengthen the transfer of learning, contributing to safer and more efficient maritime operations. operations.

A significant challenge in learning new ship handling techniques involves the need to question and sometimes let go of established practices. This process, known as unlearning, becomes especially important when mariners adopt new technologies or systems. The thesis explores how unlearning influences the transfer of learning and how educational design can support this essential process. (Bonchek, 2016).

By exploring how simulators can improve the transfer of learning, this research aims to support the development of more effective training programs. These programs are intended to enhance professional competence and promote safety, energy efficiency, and environmental responsibility in maritime operations. The study also seeks to identify the most effective methods to ensure that skills acquired in simulators are successfully applied in real-world ship handling scenarios.

The thesis will evaluate current simulator training practices, highlight areas where improvements are needed, and propose practical solutions. It will consider cognitive, psychological, and technical factors that influence learning transfer, offering a comprehensive perspective on the educational process. This research is particularly relevant at a time when the maritime industry is experiencing rapid technological change and human factors continue to play a major role in maritime incidents.

The theoretical foundation of the study is based on Robert E. Haskell's book *Transfer of Learning: Cognition, Instruction, and Reasoning* (2001). Haskell defines learning transfer as the application or adaptation of past or current learning to similar or new situations. He emphasizes that transfer is not just a learning technique but a way of thinking and understanding. His work provides insights into how transfer can be encouraged in both educational settings and everyday life. (Haskell, 2001).

The thesis also outlines general principles for the use of high-fidelity full mission ship bridge simulators. The simulator platform used in this study is the Wärtsilä NT5000, which features a dedicated passenger ship model equipped with azimuth propulsion and a full-scale ship bridge simulator.

1.2 Research methods

In this thesis, the data collection process is anchored in two fundamental methodologies: literature review and semi-structured survey. The literature review serves as a foundational element, providing a comprehensive overview of existing knowledge and theoretical frameworks relevant to the thesis topic.

The research material was analyzed in a theory-based manner, utilizing content analysis. The material collected from the interviews was transcribed and analyzed by themes, which were based on the theories of learning, unlearning, and the transfer effect. The analysis looked for recurring themes, similarities, and differences in the respondents' experiences, as well as the factors that, according to the respondents, promoted or hindered the transfer effect of learning from simulator training to real-world situations.

The semi-structured survey in this thesis was particularly useful for gathering experiences from ship navigating officers. This method merges the predefined questions of a structured survey with the conversational freedom of unstructured formats, allowing for a detailed exploration of specific topics while also uncovering new, relevant themes. This approach enriches the data with diverse insights, capturing the complex realities of navigating officers’ experiences. Although the flexibility of the semi-structured survey can lead to data variability, complicating comparative analysis, the method’s effectiveness relies on the interviewer’s ability to elicit comprehensive responses without bias. Despite the considerable investment required for conducting and analyzing this survey, it is an essential method for obtaining profound contextual understanding that more rigid methodologies might overlook.

Online tools were used in the research process to enhance data management and analysis. Copilot was used to manage research tasks, summarize the literature review, and promote collaboration. Notebook LM, on the other hand, served as a key tool for combining and structuring notes, references, and research results. These tools made it possible to conduct an extensive literature review and ensured that the research process remained up to date with the latest technological developments in academic research.

The integration of these two methods enables a robust and multifaceted approach to data collection. The literature review guides the development of the research framework and hypotheses, while the survey contributes empirical data that is vital for the analysis and conclusions of the thesis. Together, they form a cohesive research strategy that combines the strengths of both theoretical and empirical investigation, ensuring a comprehensive exploration of the research question. This dual approach not only enriches the thesis but also enhances its credibility and scholarly contribution.

1.3 Validity of the research

In authoring this thesis on improving the transfer effect of learning through simulators in ship handling instruction and training, several validity and reliability concerns have been identified and addressed.

Subjectivity in assessment, where trainees might overestimate their abilities and trainers may assess performance based on subjective standards, has been mitigated by incorporating multiple evaluation methods such as simulator-based training, introspective self-assessment, and traditional interviews, alongside establishing clear and objective performance criteria (Gough & Madill, 2012). Sampling bias, which can challenge the generalizability of results if the sample is not representative, has been addressed by ensuring a diverse and representative sample of ship deck officers stratified by experience level and type of vessels operated (Simkus, 2023). The lack of standardization in qualitative interviews and surveys, which can lead to inconsistencies, has been tackled by developing a standardized questionnaire with clear, concise, and unambiguous questions, pretested with a small group to identify and rectify issues before the full survey (Levitt, et al., 2018). The fidelity and validity of simulators—critical for ensuring the transferability of learning—are often maintained through the use of high-fidelity simulators that closely replicate real-world conditions. However, the relationship between simulator fidelity and training effectiveness is not straightforward; it is complex and highly context-dependent, influenced by factors such as training objectives and learner experience. (Hontvedt & Øvergård, 2019).

By addressing these validity concerns, this thesis aims to enhance the reliability and generalizability of the research findings, contributing to the improvement of ship handling training programs.

1.4 Reliability of the research

A significant concern in this research is the consistency of assessments, as the subjective nature of evaluations can lead to variability in results, with trainees potentially overestimating their abilities and trainers assessing performance based on personal standards. To address this, multiple evaluation methods, including simulator-based training, introspective self-assessment, and traditional interviews, are crucial, alongside establishing clear and objective performance criteria to minimize subjectivity (Gough & Madill, 2012). Sampling bias also presents a challenge, as an unrepresentative participant sample can compromise the generalizability of results. Ensuring a diverse and representative sample of ship deck officers, stratified by experience level and types of vessels operated, is essential (Simkus, 2023). The lack of standardization in qualitative interviews and surveys can lead to inconsistencies, as qualitative methods are often more flexible and less structured, posing challenges for maintaining consistency and comparability of responses. Developing a standardized questionnaire with clear, concise, and unambiguous questions, and pretesting it with a small group of participants to identify and address issues before the actual survey, is crucial for ensuring data quality and validity (Fowler, 2013).

By resolving these reliability issues, the research seeks to improve the trustworthiness and relevance of its findings, thereby aiding in the enhancement of ship handling training programs.

2 Literature review

The objective of this literature review is to assess how the use of simulators in Maritime Education and Training (MET) benefits the development of unlearning, the acquisition of new knowledge and skills, and the transfer of learned knowledge and skills. The review's scope is limited to analyzing available written sources that address simulator-based training in the maritime field and its connection to these three areas of learning. (Karahalil, Lützhöft, & Scanlan, 2024; Kim, et al., 2021).

This literature review is based on scientific articles, conference publications, and other materials that discuss maritime education and the use of simulators. The sources are from reputable publications in the fields of maritime affairs and educational science. The review includes up-to-date publications as well as foundational texts addressing the underlying theories of the field.

Simulators have long been a traditional part of Maritime Education and Training (MET). They are a key tool in learning new skills in the maritime industry, as they provide a safe and risk-free environment to acquire technical, procedural, and operational skills. The fidelity of simulators aims to replicate the real working environment, and high fidelity is thought to improve learning outcomes. Students often find themselves more motivated and enjoy immersive simulator training more compared to traditional methods. (Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019). Simulators provide a controlled environment for practicing complex and critical situations, enhancing understanding, and facilitating the learning of new operational methods. Various types of simulators are available, including desktop simulators, full-mission simulators, and VR simulators. Each type has its own unique strengths and weaknesses. (Kim, et al., 2021).

Unlearning is necessary when previously learned knowledge or skills are outdated or incorrect. Simulators can facilitate unlearning by creating situations where old assumptions or ways of working no longer function. In a safe simulation environment, students can identify their misconceptions without real-world consequences and reflect on their actions. Simulation exercises can generate cognitive dissonance between what was previously learned and what is observed in the simulation, which can motivate a re-evaluation of one's beliefs and new learning.

Transfer of learning is a central goal in maritime education, as the skills acquired during training should effectively be applied in real-world working environments. This transfer can occur in both near and far contexts, depending on the similarity between the learning and application environments. Educational research emphasizes the importance of contextual similarity for successful transfer. Therefore, simulation scenarios in Maritime Education and Training (MET) should be designed to be functionally consistent with actual work situations. Theoretical frameworks such as situated learning support this approach by highlighting how authentic, context-rich environments enhance the applicability of learned skills. (Hajian, 2019).

Scenario design is a critical factor in promoting the transfer of learning. Effective simulator training requires clear learning objectives and realistic, authentic, and credible scenarios. While it is important that simulators reflect real-world conditions, high technical realism alone does not necessarily guarantee effective learning outcomes (Harrington, Sellberg, & Lindwall, 2025). The role of the instructor is also significant in supporting the transfer of learning, as their experience and pedagogical expertise are key to designing successful and contextually relevant scenarios (Harrington, Sellberg, & Lindwall, 2025). Furthermore, debriefing, which refers to the post-exercise feedback discussion, is an essential part of the learning process. It provides students with the opportunity to connect theory to practice and reflect on their experiences, thereby deepening their understanding. (Sellberg, Lindwall, & Rystedt, 2021).

The analysis of simulator-based MET research has highlighted key themes such as managing resources, academic performance, simulator training, and authentic assessment. Resource management (BRM/MRM) has been a central topic, and research has aimed to determine if current training and assessment practices meet safety objectives. The theme of academic performance has focused on measuring performance and licensing students. The theme of authentic assessment emphasizes the development of valid and reliable assessment methods. (Wiig, Sellberg, & Solberg, 2023).

Research has shown that the concept of learning itself has been underrepresented in the literature on maritime simulator training, particularly prior to 2012. The focus during that period was primarily on learning outcomes rather than the learning process. In more recent years, there has been a noticeable shift, with growing interest in empirically investigating learning activities within simulator environments. (Wiig, Sellberg, & Solberg, 2023).

Different sources support the idea that simulators are a valuable tool in maritime education for learning new skills and questioning old ones, (Kim, et al., 2021; Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019). However, they emphasize different aspects in achieving the transfer of learning. Some sources highlight the importance of realism (Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019), while others emphasize functional similarity and the quality of scenario design (Harrington, Sellberg, & Lindwall, 2025). Critically evaluating, it can be stated that high technical realism alone does not necessarily guarantee good transfer, but pedagogical choices, such as scenario design and the instructor's actions, have a greater impact. Social realism, i.e., the trainee-instructor interaction, is also important for learning. (Kim, et al., 2021).

There are several challenges associated with the use of simulators, including high acquisition and maintenance costs (Kim, et al., 2021; Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019). Emerging technologies such as virtual reality (VR) and cloud-based simulators offer promising potential, but their effective integration into maritime education and training requires further empirical research (Kim, et al., 2021). The COVID-19 pandemic has also presented significant challenges to simulator-based training, while simultaneously accelerating the adoption of digital technologies in the maritime education sector (Kim, et al., 2021). Looking ahead, it is important to strike a balance between different forms of learning and to develop systematic approaches to scenario design (Harrington, Sellberg, & Lindwall, 2025). Integrating motivated goal achievement into simulator training plays a crucial role in enhancing learner engagement and performance (Karahalil, Lützhöft, & Scanlan, 2024).

Simulators are an effective tool in maritime education, as they support new learning by providing a safe and controlled environment for practicing skills (Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019). They enable the questioning of outdated knowledge and skills and promote the transfer of learned knowledge and skills to the real working environment. Key factors in optimizing transfer are functional similarity, careful scenario design, instructor support, and effective reflection. (Kim, et al., 2021).

A review of the existing literature highlights that, despite widespread acknowledgment of the advantages offered by simulators, there remains a pressing need for ongoing investigation—particularly into how learning unfolds, how knowledge and skills are transferred, and how emerging technologies can be effectively leveraged. Future studies should prioritize the refinement of educational frameworks and the integration of established learning theories into maritime simulator training to uphold and enhance instructional quality. Incorporating the viewpoints of diverse stakeholders within the maritime education ecosystem is essential. (Schinas, 2023; Wiig, Sellberg, & Solberg, 2023).

3 Simulator

In this thesis, the term simulator refers to the hardware that creates the simulation. Simulators can be complex and comprehensive, such as full-scale ship simulators that replicate the real working environment, including a detailed visual environment, realistic sound, and even simulation of ship movement. On the other hand, simulators can be simpler, such as partial task simulators that focus on specific tasks, like practicing radar observations. The choice of simulator depends on the training objectives and available resources.

Term simulation refers to a representation of conditions that closely resemble a real or operational environment. Simulations can be used to create a safe and effective environment for practicing and testing skills. They can be modified into different scenarios designed for specific purposes, such as a realistic port approach or a situation where two or more ships meet at close range. For example, a ship simulator can create a scenario where a ship encounters an unforeseen navigational situation, and the crew must act quickly and efficiently to ensure the ship's safety. (Council, 1996, p. 37).

The theoretical basis for using simulators in training lies in the ability to transfer learned skills from one context to another. Because no two situations are identical, the improvement of an individual's skills with each repetition of similar tasks demonstrates the effectiveness of this principle. Even though the training environment does not fully correspond to the real operational environment, each practice session strengthens and refines learned skills, enabling their utilization in authentic situations later on. This principle of transfer forms the foundation of all formal training programs, which operate on the assumption that skills and knowledge acquired in the classroom are applicable outside of it.

Simulator training supports this assumption by providing a realistic and controlled environment where learners can practice and enhance their skills. This approach ensures a smooth transition from theoretical knowledge to practical application, thereby reinforcing the principle of skills transfer. Simulators enable the creation of scenarios comparable to real situations in a safe environment, where mistakes can be made and learned from without risks. Simulators also allow for repetition and rewinding of scenarios, facilitating the analysis and learning from errors. With simulators, multiple tasks can be practiced simultaneously, and their prioritization can be learned, which is essential in navigation. (Council, 1996, p. 38).

Simulators have become a foundational tool in maritime training, where they are widely used to support the development of professional competencies and ensure operational safety (Kim, et al., 2021). While their use is particularly prominent in the maritime sector, recent research has also explored how curriculum design and institutional practices influence their effectiveness in educational settings (Karahalil, Lützhöft, & Scanlan, 2024). Maritime Education and Training (MET) has traditionally combined theoretical instruction with hands-on experience at sea. Thanks to the convenience of simulators, an increasing amount of practical training takes place in bridge and engine room simulators. (Kim, et al., 2021).

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) permits the use of simulators that comply with Section A-I/12 to substitute for onboard training, provided they meet specific performance and assessment standards (IMO, 2011). The primary objective of simulators is to replicate real-world working environments as closely as possible (Kim, et al., 2021). High fidelity, which refers to the degree of realism in the simulation, is believed to enhance learning outcomes. Moreover, students often report greater motivation and engagement during simulator-based training compared to more traditional instructional methods. (Harrington, Sellberg, & Lindwall, 2025; Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019).

Simulators offer a structured setting where learners can rehearse intricate and high-stakes scenarios, thereby deepening their comprehension and supporting the acquisition of new operational procedures. One of the primary goals of maritime simulator training is to ensure that the competencies developed during training are effectively applied in real-life maritime contexts. Unlike traditional on-the-job training, simulators eliminate many of their constraints by providing a secure and cost-efficient platform for skill development. Within this environment, learners are free to experiment, make errors, and gain insights from those experiences without facing actual operational risks (Hajian, 2019).

Maritime Education and Training (MET) employs a variety of simulator technologies to support practical learning. The use of tools such as full mission bridge simulators, cloud-based platforms, and virtual reality (VR) systems has become increasingly common in recent years, offering flexible and immersive training environments that complement traditional sea-based experience. (Kim, et al., 2021).

Among the types of simulators used in MET are desktop simulators, full mission simulators, cloud-based simulators, and VR-based systems. Desktop simulators are computer-based tools that replicate navigational scenarios and are designed to run on standard computers, making them accessible and cost-effective. (Narayanasamy, Wong, Fung, & Rai, 2006). Full mission simulators (FMS) replicate the entire bridge environment of a ship, offering high-fidelity, immersive training experiences in a controlled setting (Skjong, Rindarøy, Kyllingstad, Æsøy, & E, 2017). Cloud-based simulators, which became more prevalent during the COVID-19 pandemic, allow users to access training remotely via the internet, offering flexibility and scalability. VR simulators use headsets and interactive devices to create immersive 3D environments, enabling users to engage with realistic or hypothetical maritime scenarios. (Skjong, Rindarøy, Kyllingstad, Æsøy, & E, 2017).

Fidelity is a concept that describes the degree of realism of a simulator or simulations. It can be classified into different dimensions, such as physical fidelity and functional fidelity. Physical fidelity refers to the simulator's appearance, sounds, and feel compared to the operating environment. Functional fidelity refers to how well the simulator replicates the behavior of real operations. Technical fidelity combines physical and functional fidelity. (Karahalil, Lützhöft, & Scanlan, 2024). Other dimensions of fidelity include behavioral fidelity (the similarity of tasks performed), psychological fidelity (the extent to which tasks resemble those to be learned), and social or interactional fidelity (the nature of collaborative activities involved) (Harrington, Sellberg, & Lindwall, 2025; Kim, et al., 2021).

3.1 Motivations for simulator aided ship handling training

Simulation training has become an integral component of maritime education due to its unique combination of realism and safety. Simulators create a virtual environment that convincingly replicates the operation and navigation of a vessel under various conditions.

This allows students to practice practical skills and decision-making without posing real risks to themselves, the vessel, or the environment.

Simulators enable the reproduction of numerous scenarios that would be impossible or too hazardous to conduct in reality. For instance, high-risk operations such as navigating narrow channels or responding to emergencies can be safely practiced and analyzed in the simulator. This provides students with the opportunity to build their confidence and skills in a controlled manner, free from the fear of making errors with significant consequences.

Practical training on a training ship inherently involves limitations. A licensed officer must constantly supervise students' actions and intervene in situations where the safety of the vessel is at risk. This can limit students' independent decision-making and slow down the learning process. In a simulator, students have the freedom to try different solutions and learn from their mistakes, which enhances their problem-solving abilities and capacity to perform under pressure.

By offering a realistic and controlled environment, simulators ensure a seamless transition from theoretical knowledge to practical application, thereby reinforcing the principle of skill transfer. The flexibility to modify simulations into various scenarios allows for comprehensive training that prepares maritime professionals for the challenges of real-world operations. (Council, 1996, pp. 52-53).

Simulation-based training presents significant benefits within educational frameworks, particularly in maritime operations. Unlike the constraints of real-life sea operations, where opportunities for practice and skill reinforcement are limited and not easily repeatable, simulators offer flexibility. Instructors can conclude a training scenario once objectives are met or repeat it until trainees fully comprehend the lesson. Onboard training, which may span weeks or months, often cannot be repeated frequently due to logistical constraints. Consequently, simulation enhances the learning experience by ensuring a more efficient and effective transfer of knowledge, which is essential for preparing individuals for the complex and dynamic nature of maritime operations.

One of the key advantages of simulator-based training is the ability to record and playback scenarios. This function provides a comprehensive approach to scenario analysis, vital for post-scenario review, allowing for thorough evaluation and debriefing. Educationally, it allows instructors to permit errors and mishaps as valuable teaching moments. Trainees can retrospectively assess their actions, distinguishing between correct and incorrect decisions, and understanding the consequences of their actions after the exercise.

From an assessment perspective, the recording and playback function provides a verifiable record of performance, offering an objective basis for evaluation. This feature is particularly beneficial when a candidate disputes an assessor's judgment, thereby reducing the potential for subjective bias in licensing assessments. This approach ensures a robust and transparent assessment process, enhancing the credibility of simulator-based training programs. (Council, 1996, p. 53).

Simulator-based training offers exceptional adaptability, enabling the structured organization of instructional scenarios tailored to the educational team's preferences or the training curriculum's specifications. These simulation environments facilitate the incorporation of innovative pedagogical methods, thereby expediting the learning process, enhancing retention, and building resilience to stress. This approach aligns with contemporary educational paradigms and provides a flexible yet systematic framework for learner development.

Deck officers are tasked with prioritizing the most critical duties from a multitude of responsibilities, necessitating continuous decision-making across various scenarios. Traditionally, the training for novice officers was segmented, with separate instruction, practice, and evaluation of individual skills. However, simulator-based training has transformed this method by integrating theoretical knowledge with practical application, allowing officers to manage and prioritize multiple tasks concurrently. This training method not only enhances skill acquisition but also improves decision-making regarding task prioritization, thereby elevating overall operational effectiveness.

Equipped with the ability to repeat training exercises and document performance through recording and playback, simulators provide a secure environment for mariners to train on new equipment. This advancement not only boosts safety but also ensures thorough understanding and proficiency in handling modern maritime technology. Simulation-based training is crucial for preparing individuals for real-world scenarios, fostering a culture of continuous learning and adaptation to technological advancements within the maritime industry.

Simulator-based training facilitates peer interactions and assessments, fostering an environment where mariners, often isolated in their duties, can engage in collaborative learning. Given the solitary nature of maritime operations, where masters and pilots may operate for extended periods without peer review, simulator facilities offer a unique opportunity for skill enhancement, the adoption of new techniques, and the refinement of expertise. This collaborative setting promotes constructive critique of established practices, encouraging continuous improvement and safety in maritime operations.

In maritime industry training, enhancing performance is a primary objective, and achieving cost-efficiency is equally vital. Simulators present a more economical option than actual ships, both in terms of building and operating them. This cost benefit allows for broader and more accessible transition training compared to training conducted on commercial vessels. Although it is challenging to accurately measure the financial advantages of simulators over real ships, the practical constraints of onboard training—such as safety concerns, rigid operational requirements, and demanding schedules—emphasize the value of simulation-based education. Today, ongoing training is a standard expectation in the shipping industry, representing a clear departure from outdated practices. However, some shipping companies remain reluctant to invest in simulator-based training when it is not mandated by regulations. (Council, 1996, pp. 53-54).

3.2 Scenarios, three commonly used types of them

Scenarios are typically constructed utilizing one of three distinct data categories: hypothetical, empirical, or a composite of both. Hypothetical data is derived from conjectural conditions, serving as a foundation for theoretical analysis and model validation. Empirical data, on the other hand, is gathered from actual observations or experiments, providing a solid basis for case studies and practical applications. The hybrid approach merges these two, harnessing the predictive power of hypothetical models with the grounding influence of real-world data, to offer a more comprehensive perspective. This synthesis facilitates a robust framework for scenario development, enhancing the reliability of projections and strategic planning in scholarly research. (Council, 1996, p. 103).

3.2.1 Hypothetical (generic) scenario

In maritime education, hypothetical (generic) scenarios implemented in simulators refer to artificially created training exercises. These scenarios do not rely on real ports, vessels, routes, or navigational information. Their primary goal is to focus attention on specific learning objectives and provide students with new and unpredictable situations.

For instance, in hypothetical scenarios, the fundamental characteristics of a vessel can be altered, such as the propeller system or the ship's draught. This allows for the intentional simplification of exercises or, conversely, the emphasis of a particular function or characteristic. Thus, the simulator can be used flexibly for practicing various skills, such as ship handling, resource management, and working through specific problem scenarios. A significant advantage of hypothetical scenarios is their ability to eliminate the potential influence of previously learned knowledge. This helps in revealing a student's actual performance and reactions in novel situations. When a simulation is conducted on a familiar route, a student's potential weaknesses may not necessarily surface. In contrast, a hypothetical scenario challenges the student to apply their existing knowledge and skills in a completely new and potentially unexpected environment. This is particularly valuable in learning the principles of route planning and managing various situations encountered along a route.

Although hypothetical scenarios offer flexibility, their creation also involves challenges. It is essential that the simulation environment is sufficiently realistic and includes the necessary details to achieve the training objectives and provide students with relevant stimuli. Furthermore, gathering and processing the necessary information for the simulation can be time-consuming, especially if all normally available reference information needs to be simulated. Finally, it is critical to ensure that the created hypothetical scenario is logical and consistent.

Hypothetical scenarios offer significant flexibility and are simple to create and modify, making them useful in basic training and learning new concepts. However, it is important to be aware that their lack of realism can potentially lead to misleading perceptions, as noted in our previous discussion. Therefore, the use of hypothetical scenarios should always be considered in relation to the set training objectives and the required level of fidelity. (Council, 1996, p. 104).

3.2.2 Real-world scenario

Real-world scenarios form an essential part of simulator training, as they utilize authentic navigation data, such as accurate port charts, real waterways, and up-to-date environmental conditions. In these scenarios, the ships used in the simulation are modeled with extreme precision, aiming to correspond as authentically as possible to the characteristics and performance of real vessels. The aim of this is to ensure that the training experience reflects actual maritime conditions as closely as possible, giving students a realistic feel for the ship's behavior in a specific operating environment. For this reason, real-world scenarios are particularly valuable in training experienced seafarers, such as captains and ship's crews, for new types of vessels or unfamiliar routes.

The key advantage of real-world scenarios is their high level of realism, which creates a credible and engaging experience of operating a ship in a simulated environment. This enables excellent learning efficiency, especially in deepening professional skills and preparing students to face real-world work situations. However, it should be noted that developing and validating such scenarios is significantly more resource-intensive and requires profound expertise. Real-world scenarios can be less flexible in nature when tailoring them to meet specific training needs compared to hypothetical alternatives.

Simulator fidelity is a crucial factor in ensuring the effectiveness of training scenarios that aim to reflect real-world conditions. It refers to how accurately a simulator replicates the actual environment. Fidelity is categorized into two types: physical fidelity, which includes the simulator’s visual appearance, sounds, and tactile features, and functional fidelity, which pertains to how well the simulator’s operations and responses mirror those of real systems. While high physical fidelity has traditionally been considered beneficial, recent research highlights that functional fidelity plays a more significant role in supporting the transfer of skills to real-life work settings. (Renganayagalu, Mallam, Nazir, Ernsten, & Haavardtun, 2019).

The expertise of experienced instructors is critical in designing successful real-world scenarios. Their in-depth understanding of real maritime practices ensures that the scenarios are not only authentic but also relevant to the potential challenges of the students' future work and environments. Scenarios based on real events may also require students to have a more developed understanding of overall contexts, such as traffic planning and management. (Harrington, Sellberg, & Lindwall, 2025).

It is important to avoid overwhelming simulation scenarios with unnecessary or overly complex elements, as this can elevate student stress and potentially hinder the learning process. In this regard, the concept of functional congruence becomes particularly relevant. This concept highlights the need to align the realism of the simulation environment with the specific educational goals of the training. The key is to design scenarios in which learners' actions are directly and meaningfully linked to the intended learning outcomes, ensuring that the training remains focused and effective. (Harrington, Sellberg, & Lindwall, 2025).

Real-world scenarios are indispensably valuable in developing and transferring professional skills to practical working life, as they offer significant contextual similarity (Hajian, 2019) and enable experiential learning. However, their design requires careful consideration of resource needs, scenario flexibility, and their functional congruence with the set learning objectives. (Harrington, Sellberg, & Lindwall, 2025).

3.2.3 Hybrid scenario

Hybrid scenarios form a flexible and effective approach to simulator training, as they combine real-world data and hypothetical elements. Thanks to this combination, it is possible to utilize the best aspects of both realistic and adaptable scenarios. In practice, this can mean, for example, that a simulation is based on a real port and its charts, but hypothetical weather conditions are added, or traffic situations are modified to meet specific training needs.

Hybrid scenarios offer several significant advantages. They provide experienced seafarers with a realistic and often familiar environment, which facilitates engagement with learning. Instructors can adapt scenarios precisely to defined training objectives by incorporating hypothetical challenges, faults, or exceptional situations. Because hybrid scenarios are partly based on real data, their verification is often more straightforward than that of completely hypothetical scenarios. Hybrid scenarios are excellent for both supporting learning and assessing competence. Hypothetical elements can be added and changed, preventing the utilization of pre-learned answers in assessment situations. However, it is important to note that the design and implementation of hybrid scenarios require careful planning and the expertise of instructors. The aim is to create scenarios that are on the one hand sufficiently realistic and on the other hand meet the training or assessment requirements.

The principle of functional congruence is emphasized in hybrid scenarios. They enable the precise targeting of learning objectives, as hypothetical elements can be used to create the exact challenges through which specific skills or competencies are desired to be developed or assessed. Instructors must therefore ensure that students' actions in the simulation – regardless of whether they concern real or hypothetical elements – are in a direct and meaningful connection with the learning objectives of the scenario. (Harrington, Sellberg, & Lindwall, 2025).

Hybrid scenarios offer a versatile and effective tool for maritime simulator training. They combine the possibilities of reality and customization, thus supporting both realistic practice and targeted skill development and assessment. Successful utilization, however, requires careful planning and an understanding of the significance of functional congruence. (Harrington, Sellberg, & Lindwall, 2025).

Effective scenario design plays a vital role in maximizing the transfer of learning during maritime simulator training for ship handling. Different types of scenarios are employed to meet a range of training objectives, each offering unique strengths and limitations depending on the desired level of realism and instructional focus. To clarify their function within simulator-based education, the following table (Table 1: Different Types of Scenarios) outlines the most commonly used scenario types, along with their descriptions, benefits, and associated challenges.

Table 1: Different types of scenarios

Scenario type	Description	Advantages	Disadvantages
Hypothetical (generic)	A completely fictional scenario that is not based on real locations, ships, or conditions.	Flexibility: The scenario can be freely modified to meet specific training needs. Simplicity: Easy and quick to create and modify. Suitable for practicing basic skills and learning new concepts.	Lack of Realism: Does not provide a realistic picture of real conditions, which can lead to misleading perceptions and incorrect learning.
Real-world	The scenario utilizes genuine navigation data, and the ship's characteristics correspond to real ships. It can simulate, for example, a specific port, fairway, or sea area with real weather and traffic conditions.	Realism: Offers a realistic and believable experience of the ship's operation in a specific environment. Learning Efficiency: Excellent for honing skills and preparing for real situations.	Complexity: Requires a lot of resources and expertise to create and validate. Lack of Flexibility: More difficult to tailor to specific training needs compared to hypothetical scenarios.
Hybrid	Combines real-world data and hypothetical elements. For instance, the scenario may be based on a real port, but fictional weather conditions or traffic situations have been added based on the training needs.	Realism and Flexibility: Offers both a realistic environment and the possibility of customization. Ease of Validation: Easier to validate than a fully real-world-based scenario. Suitability for Assessment: Excellent for both training and assessment purposes, as hypothetical elements can be added and modified as needed.	Demanding: Designing and implementing hybrid scenarios require careful planning and expertise to ensure both realism and the fulfillment of relevant training/assessment needs.

4 Learning theories

Learning theories are fundamental constructs that explain the mechanisms through which learning occurs, encompassing the assimilation, processing, and retention of knowledge. These theories explore the cognitive, emotional, and environmental factors that influence learning, as well as the role of prior experiences in shaping comprehension and memory. (Seel, 2012). They provide a foundation for designing instructional strategies that are tailored to optimize individual learning processes, thereby enhancing educational outcomes (Harasim, 2017). Furthermore, learning theories investigate the motivations behind learning and the conditions that either facilitate or hinder it. By understanding these theories, educators can develop more effective teaching methodologies that address the diverse needs of learners, ensuring that educational practices are both inclusive and impactful. (Seel, 2012).

A thorough understanding of learning theories is essential for promoting the transfer of learning, which refers to the ability to apply knowledge and skills acquired in one context to new and varied situations. These theories provide valuable insights that help educators design instructional strategies aimed at supporting this transfer. Such strategies enable learners to connect theoretical knowledge with practical application. As a result, learning environments become more effective in fostering retention and real-world use of knowledge, enhancing learners' problem-solving abilities, adaptability, and overall competence in both professional and personal settings.

4.1 Behavioral learning theories

Behavioral learning theories emerged in the early twentieth century as psychologists sought to transform psychology into a more scientific discipline by focusing on measurable and quantifiable phenomena. Behaviorists posited that understanding human behavior necessitates examining environmental influences, such as associations, reinforcements, and punishments, rather than internal cognitive processes (Kwon & Silva, 2020). Ivan Pavlov's theory of classical conditioning demonstrates how learning can occur through the association of stimuli. In this process, a neutral stimulus becomes linked with a naturally occurring one, eventually triggering a learned response. Pavlov illustrated this with his experiments involving dogs, where the sound of a bell, initially neutral, was repeatedly paired with the presentation of food. Over time, the dogs began to salivate in response to the bell alone. In contrast, B.F. Skinner's operant conditioning theory emphasizes learning through consequences. According to this model, behaviors followed by rewards are more likely to be repeated, while those followed by negative outcomes are less likely to recur. Skinner argued that classical conditioning could not fully explain all forms of learning, particularly those involving voluntary behavior. Both theories highlight the role of environmental factors in shaping behavior, aligning with the behaviorist perspective that learning is driven by external stimuli and responses. (Cherry, 2024; Skinner, 2014, p. 59).

Behavioral learning theories can be applied to simulator-aided ship handling training through various strategies. Classical conditioning can be utilized by using simulators to create associations between specific signals, such as alarms, and corresponding actions, like emergency maneuvers. Repeated exposure to these scenarios helps learners develop automatic responses to these signals. Operativity can be implemented by establishing a system of rewards and penalties within the simulator environment. For instance, successful docking maneuvers could earn points, while collisions might result in point deductions, thereby reinforcing desired behaviors. Varied reinforcement schedules can be employed to maintain learner engagement, providing immediate feedback for basic tasks and delayed rewards for more complex maneuvers. Behavioral modeling can also be incorporated by including scenarios where learners observe expert ship handlers performing tasks and then replicate those actions, reinforcing learning through imitation. These strategies, grounded in behavioral learning theories, can significantly enhance simulator-based training in ship handling.

4.2 Cognitive learning theories

Cognitive learning theories highlight the importance of mental activities in the learning process, emphasizing how individuals absorb, retain, and apply knowledge. These theories examine how elements such as focus, emotional state, and distractions, along with environmental influences like cultural norms and physical settings, shape how people think and learn. A well-known example is Piaget’s theory of cognitive development, which describes four distinct stages through which children’s thinking evolves. In the sensorimotor stage, infants explore the world through sensory experiences. The preoperational stage introduces symbolic thinking and imaginative play. During the concrete operational stage, children begin to apply logical reasoning to concrete situations. Finally, the formal operational stage allows for abstract and hypothetical thinking. These developmental phases demonstrate how children’s cognitive abilities expand as they mature and interact with their surroundings. (Cherry, 2024; Piaget & Cook, 1952).

Cognitive learning theories emphasize several key aspects in simulator-aided ship handling training. By designing simulator scenarios that require trainees to focus on specific tasks, their attention and concentration are significantly improved, which is crucial for successful learning. Repetitive and varied scenarios can help trainees retain information and improve their memory of ship handling procedures, thereby reinforcing learning through practice. Incorporating real-time feedback and debriefing sessions allows trainees to process and understand their actions and decisions during simulations, facilitating deeper comprehension and information processing. Creating complex, real-world scenarios that challenge trainees to apply their knowledge and develop problem-solving strategies can further enhance their cognitive skills and prepare them for real-life situations. These approaches leverage cognitive processes to make simulator training more impactful and improve learning outcomes.

4.3 Constructivist learning theories

Learning is often viewed as an active process in which individuals build their understanding through experience and interaction. This perspective is heavily influenced by the work of Lev Vygotsky, whose sociocultural theory highlights the significance of social engagement in cognitive development. Two key concepts in this theory are the "more knowledgeable other" and the "zone of proximal development." The more knowledgeable other refers to a person, such as a teacher, adult, or peer, who possesses greater expertise and can provide guidance to the learner. The zone of proximal development includes tasks that a learner is not yet able to complete independently but can accomplish with suitable support. As learners gain experience, they gradually become capable of performing these tasks on their own, thereby expanding their abilities over time. These concepts are central to constructivist learning theories, which emphasize the influence of social and contextual factors on how knowledge is acquired. (Cherry, 2024; Vygotsky, 1978).

Constructivist learning theories enhance simulator-aided ship handling training by focusing on active engagement, collaboration, real-world context, and feedback. Learners interact with the simulator, making decisions and solving problems in real time, which helps them build their own understanding of ship handling. Simulators support group exercises where learners collaborate, share insights, and learn from each other’s experiences, reflecting the importance of social interaction. They also offer a realistic environment where learners can apply theoretical knowledge to practical scenarios, enhancing their learning through hands-on experience. Immediate feedback from the simulator allows learners to reflect on their actions and outcomes, fostering deeper understanding and continuous improvement. This approach has been shown to be effective in promoting skill acquisition and knowledge transfer in simulation environments. It ensures that learners are actively involved in their learning process, bridging the gap between theory and practice. (Dutta & Louis, 2025).

4.4 Experiential learning theories

David A. Kolb's Experiential Learning Theory (ELT) offers a comprehensive framework for understanding how individuals acquire and apply knowledge through direct experience. Rooted in the philosophical and psychological traditions of John Dewey, Kurt Lewin, and Jean Piaget, Kolb's model emphasizes the dynamic and cyclical nature of learning. Rather than viewing learning as a linear process or a static outcome, ELT conceptualizes it as a continuous, recursive cycle that integrates experience, reflection, conceptualization, and experimentation. (Morris, 2020).

At the heart of Kolb's theory lies a four-stage learning cycle. The process begins with a concrete experience, where the learner engages in a specific activity or situation. This is followed by reflective observation, during which the learner considers the experience from multiple perspectives. The next stage, abstract conceptualization, involves forming generalizations or theories based on the reflections. Finally, the learner enters the stage of active experimentation, applying the newly formed concepts to the world to test their validity and utility. This cycle is not rigidly sequential; rather, it is iterative and adaptable, allowing learners to enter at any point and move through the stages in a manner that suits their context and learning style. (Kolb & Kolb, 2006).

Kolb's theory is grounded in six foundational principles that underscore the complexity and richness of experiential learning. Learning is understood as a process rather than a product, emphasizing the importance of continuous engagement and development. It is also seen as a process of relearning, where learners revisit and refine their understanding through repeated cycles of experience and reflection. Emotional engagement is considered essential, as learning often involves navigating tensions between different modes of adaptation, such as feeling versus thinking or acting versus reflecting. The theory also promotes a holistic view of learning, recognizing the interplay between cognitive, emotional, and behavioral dimensions. Furthermore, learning is shaped by the interaction between the individual and their environment, highlighting the contextual and situational nature of knowledge construction. Finally, ELT is firmly rooted in constructivist epistemology, which posits that knowledge is actively constructed through the interplay of personal and social experiences. (Chan, 2022).

A key contribution of Kolb’s work is the identification of learning styles that correspond to different preferences within the learning cycle. These styles are derived from two continua: the processing continuum, which ranges from active experimentation to reflective observation, and the perception continuum, which spans concrete experience to abstract conceptualization. The intersection of these continua yields four distinct learning styles. Diverging learners excel in imaginative ability and prefer to observe rather than act, often approaching problems from multiple perspectives. Assimilating learners favor logical reasoning and theoretical models, preferring structured explanations over practical application. Converging learners are adept at problem-solving and the practical application of ideas, often excelling in technical tasks. Accommodating learners rely on intuition and hands-on experience, often learning through trial and error. These styles are not fixed traits but rather adaptive tendencies that can shift depending on the learning context and task demands. (McLeod, 2025).

The practical implications of ELT are far-reaching. In educational settings, the model has been used to design curricula that foster active engagement, critical reflection, and applied learning. In professional development and organizational training, ELT provides a framework for experiential fieldwork, reflective practice, and continuous improvement. Despite its widespread application, the theory has also faced critiques, particularly regarding its limited attention to sociocultural factors and the ambiguity surrounding the concept of “experience.” Scholars such as Morris (2019) have proposed revisions that incorporate more contextually rich experiences and critical reflection, thereby enhancing the model’s relevance and applicability in diverse learning environments.

Kolb’s Experiential Learning Theory offers a robust and flexible model for understanding the multifaceted nature of learning through experience. Its emphasis on the cyclical, holistic, and constructivist dimensions of learning provides valuable insights for educators, trainers, and learners alike. Although ongoing refinements continue to address its limitations, the core principles of ELT remain foundational in the field of experiential education.

4.5 Challenges with learning theories

The implementation of simulator-aided ship handling learning and training presents several significant challenges, particularly when integrating various learning theories into teaching methods. From a behavioral learning perspective, ensuring that the simulator scenarios provide consistent and immediate feedback is crucial for reinforcing desired behaviors and discouraging errors. This requires well designed simulations that accurately replicate real-world conditions and provide appropriate reinforcements and punishments. Cognitive learning theories highlight the importance of attention, memory, and information processing, necessitating that simulators offer scenarios that engage learners' cognitive faculties and provide opportunities for reflection and problem-solving. This can be challenging as it requires creating complex, realistic scenarios that stimulate critical thinking and allow for the application of theoretical knowledge (Radović, Hummel, & Vermeulen, 2021). Constructivist learning theories emphasize the role of social interaction and active participation in learning, which can be difficult to replicate in a simulated environment (Liangshi, 2025). Instructors must facilitate collaborative exercises and ensure that learners can construct their knowledge through hands-on experiences and peer interactions. Integrating these diverse theoretical approaches within a simulator-based training program requires careful planning and ongoing adjustments to ensure that all facets of learning are thoroughly addressed. (Radović, Hummel, & Vermeulen, 2021).

5 Learning methodologies

A learning model is a framework or theory that describes how individuals acquire, process, and retain knowledge and skills. It describes the mental and physical processes involved in learning and offers strategies to engage these processes successfully. Learning models help educators design instructional methods that align with how people learn best, ensuring that the learning process is efficient and effective.

Lecture-based learning remains a cornerstone of traditional education, where instructors deliver content directly to students, often in a classroom setting. This approach facilitates the effective distribution of knowledge, exemplified in university economics lectures where instructors use visual aids like slides to highlight important concepts and actively involve students through interactive questioning and discussions. (Reuell, 2019).

Problem-based learning (PBL) emphasizes engaging students in addressing authentic, multifaceted challenges, thereby promoting analytical reasoning and the practical use of academic concepts. In medical education, for instance, learners might collaboratively assess a clinical scenario, drawing on their theoretical understanding to propose diagnostic and therapeutic approaches. This interactive method not only reinforces their medical knowledge but also sharpens their ability to plan and make clinical decisions in real-world contexts. (Trullas, Blay, Sarri, & Pujol, 2022).

Collaborative learning prioritizes interaction among peers and cooperative engagement in group tasks, which significantly contributes to the development of communication and teamwork competencies. For example, in a history class, students might be assigned different facets of a historical event to investigate individually, later combining their insights into a cohesive group presentation. This method not only deepens their understanding of the subject matter but also enhances their ability to articulate ideas, negotiate meaning, and work effectively within a team. Research has demonstrated that collaborative learning environments, particularly those that encourage peer-to-peer dialogue and shared responsibility, lead to improved group cohesion, greater perceived efficacy, and more productive argumentation styles. These environments also reduce discomfort in group settings and foster a stronger orientation toward teamwork. Furthermore, studies have shown that the effectiveness of collaborative learning depends on how it is structured and facilitated, with peer-driven approaches often yielding better outcomes than instructor-led ones. Overall, collaborative learning has been found to be most effective when it supports both cognitive and social processes essential for meaningful group engagement. (Nokes-Malach, Richey, & Gadgil, 2015; Tedla & Chen, 2025).

The flipped classroom model introduces content at home through videos or readings, reserving class time for interactive activities that deepen understanding. In the context of secondary education, mathematics instructors may employ a flipped classroom methodology, wherein students are tasked with viewing video lectures pertaining to algebraic equations as preparatory homework. Subsequently, the in-class period is dedicated to the application of this pre-acquired knowledge through a series of problem-solving exercises. This pedagogical approach optimizes the utilization of classroom time for enhancing practical mathematical proficiency. (Setren, Greenberg, Moore, & Yankovich, 2021).

Gamification incorporates game elements into the learning process to increase engagement and motivation. In the domain of language acquisition, educators are increasingly incorporating interactive digital platforms that incentivize student engagement through the allocation of points and badges upon the completion of exercises and active participation in linguistic games. This gamification approach is posited to enhance motivation and reinforce learning by leveraging the innate human propensity for competition and achievement. Empirical studies suggest that such systems may facilitate higher levels of participation and improved retention of language concepts when compared to traditional pedagogical methods. (Mediavilla, Andrade, Gonzalez, & Martin, 2024).

Blended learning combines online digital media with traditional face-to-face instruction, offering a flexible and comprehensive educational experience. In the context of modern business education, a hybrid instructional model is proposed, wherein asynchronous online modules serve as the foundational pedagogical approach, allowing students to assimilate knowledge at a self-directed pace. This is complemented by synchronous, in-person workshops which are instrumental in facilitating the practical application of theoretical concepts. Through this dual-faceted approach, incorporating case studies and collaborative activities, the educational experience is enriched, fostering a comprehensive understanding of business principles. (Han, 2023).

The effectiveness of maritime simulator training, particularly in enhancing the transfer effect of learning, relies not only on creating realistic and challenging scenarios, but also on the selection and application of pedagogical teaching methodologies. Learning models and methods offer a theoretical framework for how individuals acquire, process, and retain knowledge and skills. Understanding the principles of different teaching methods is crucial for designing effective curricula and training experiences, especially in simulator-based environments aimed at improving the transfer of learning to practice. These methods can support in various ways both the acquisition of new skills and knowledge (learning) as well as potentially the conscious discarding or modification of previous habits or knowledge that are not applicable in a new context (unlearning).

The following table (Table 2: Learning methodologies) compiles a summary of some teaching methodologies relevant to simulator-based maritime training that can potentially support the enhancement of the transfer effect of learning. The table briefly presents the basic ideas of each method and how it can be utilized to increase the effectiveness of training. Table provides clear description of the characteristics of these methodologies and how they can be utilized or what their challenges are in training.

Table 2: Learning methodologies

Teaching Method	Description	Benefits	Challenges
Lecture-based teaching	Transferring theoretical knowledge into lecture format.	Efficient way to convey large amounts of information in a short time.	It can be passive and lead to little information assimilation and application.
Problem-based learning	Students solve real-world problems in groups.	Promotes critical thinking, problem-solving skills, and collaboration skills.	Requires careful planning and guidance.
Experiential learning	Learning through practical experience and reflection.	Effective way to learn practical skills and apply theory to practice.	It can be time-consuming and resource intensive.
Gamification	Utilizing game elements in the learning process.	Increases learning motivation and commitment.	Requires careful planning to ensure that gamification supports learning goals.
Flipped learning	Learning material is studied in advance, and the classroom focuses on application and discussion.	Promotes active learning and deeper information assimilation.	Requires students to work independently and can be challenging to implement with large groups.
Collaborative learning	Learning together with others.	Promotes interaction, teamwork skills and peer learning.	It can be challenging to ensure everyone's participation and equal work.

5.1 The impact of different learning methodologies on unlearning

Unlearning, the process of letting go of outdated or incorrect knowledge and replacing it with new, accurate information, is a crucial aspect of effective learning. Various teaching methodologies can significantly influence this process, either facilitating or hindering unlearning.

Traditional lecture-based learning, while effective for disseminating large amounts of information, often fails to challenge existing knowledge structures. This passive approach can make it difficult for learners to discard outdated or incorrect information, as students are not actively engaged in questioning and replacing their prior understandings. McWilliam 2008 highlights that lecture-based learning tends to reinforce existing beliefs rather than encouraging critical reflection, which is essential for unlearning (McWilliam, 2008).

Problem-based learning (PBL) promotes active engagement and critical thinking, both of which are essential for the process of unlearning. By encouraging learners to apply new knowledge to solve real-world problems, PBL helps replace outdated or incorrect information with accurate, experience-based understanding. It fosters a dynamic educational environment where students are motivated to question their existing beliefs and adapt to new insights. This approach supports unlearning by enabling learners to critically reassess and revise their prior knowledge in light of new experiences and information. (Pepper, 2015).

Collaborative learning also plays a significant role in unlearning. By fostering peer interaction and teamwork, collaborative learning allows students to challenge each other's assumptions and collectively build new knowledge. This social aspect of learning is crucial for unlearning, as it encourages learners to reconsider and revise their understanding based on feedback from their peers. Paolini (2015) notes that collaborative learning environments enhance the unlearning process by promoting active dialogue and mutual support among learners. (Paolini, 2015).

Spaced repetition and retrieval practice are highly effective methodologies for facilitating unlearning. Spaced repetition involves reviewing information at regular intervals, which helps strengthen memory and reduce the retention of outdated information. This continuous reinforcement of new knowledge weakens old, incorrect information, making it easier for learners to replace it. Retrieval practice, which requires learners to actively recall information, further supports unlearning by reinforcing new knowledge and making it more accessible. These methodologies emphasize active participation and continuous reinforcement, which are crucial for effective unlearning.

Methodologies that promote active engagement, critical thinking, and continuous reinforcement are more effective in facilitating unlearning. By creating dynamic learning environments that challenge existing knowledge structures and encourage the adoption of new information, educators can support learners in the unlearning process, enabling them to adapt to new information and continuously evolve their understanding.

5.2 Challenges in simulator aided ship handling training

In simulator-aided ship handling training, various learning methodologies present unique challenges and potential problems. Lecture-based learning, while effective for delivering theoretical knowledge, often struggles to engage students actively. The passive nature of lectures can lead to reduced retention and application of knowledge in practical scenarios. The lack of hands-on experience in a lecture setting may hinder the development of critical ship handling skills.

Problem-based learning (PBL) emphasizes real-world problem-solving but can be challenging to implement effectively in simulator training. The complexity of maritime scenarios requires well-designed problems that accurately reflect real-life situations. Inadequate problem design can lead to confusion and frustration among trainees. Moreover, the collaborative aspect of PBL may be difficult to manage in a simulator environment, where individual performance is often the focus.

Collaborative learning fosters teamwork and communication skills, essential for ship handling. However, it can be challenging to ensure equal participation and contribution from all trainees. Dominant personalities may overshadow quieter individuals, leading to an imbalance in learning opportunities. Coordinating group activities within a simulator can be logistically complex, requiring careful planning and facilitation.

The flipped classroom model, which involves pre-class preparation and in-class activities, can enhance engagement and understanding. However, it relies heavily on students' self-discipline and motivation to complete pre-class assignments. Inconsistent preparation can result in uneven knowledge levels among trainees, complicating in-class activities. Furthermore, the effectiveness of in-class activities depends on the quality of the pre-class materials and the instructor's ability to facilitate interactive learning.

Experiential learning, which emphasizes hands-on experience, is highly beneficial in simulator training. However, it requires significant resources and time to create realistic and varied scenarios. The fidelity of the simulator and the realism of the scenarios are crucial for effective learning. Inadequate simulation quality can lead to a disconnect between training and real-world application, reducing the overall effectiveness of the training program.

Utilizing elements related to gaming in learning, known as gamification, can enhance students' motivation and engagement. However, it may also lead to an overemphasis on competition rather than collaboration. The design of gamified elements must balance fun and educational value to avoid trivializing the training content. It is important to note that not all trainees may respond positively to gamification, and it may not suit all learning styles.

Blended learning combines online and face-to-face instruction, offering flexibility and a comprehensive learning experience. However, it requires careful integration of both components to ensure a cohesive learning journey. Technical issues with online platforms can disrupt the learning process, and the lack of immediate feedback in online modules may hinder progress. Furthermore, the transition between online and in-person activities must be seamless to maintain continuity in learning.

While each learning methodology offers distinct advantages, their implementation in simulator-aided ship handling training must be carefully managed to address potential challenges and maximize their effectiveness. Balancing theoretical knowledge with practical application, ensuring active participation, and maintaining high-quality simulation experiences are key to successful training outcomes.

6 Unlearning

The concept of unlearning is increasingly recognized as essential for understanding how professionals and organizations adapt to rapidly evolving operational environments. Unlike passive forgetting, unlearning is an intentional and active effort to discard outdated knowledge, behaviors, or routines that no longer serve their intended purpose. This process is especially critical in professional environments where established practices can become liabilities in the face of innovation. Unlearning enables individuals and organizations to break free from cognitive and procedural inertia, making room for new ways of thinking and acting that align with current demands. (Klammer, Grisold, Nguyen, & Hsu, 2024).

The distinction between unlearning and forgetting is crucial. Forgetting is often involuntary and unconscious, whereas unlearning requires conscious recognition that certain knowledge or habits are no longer effective. This recognition is typically triggered by disruptions such as technological advancements, organizational restructuring, or performance failures. In these moments, the limitations of existing mental models become apparent, prompting a reassessment of what should be retained and what must be relinquished. The process of unlearning is not linear. It involves cycles of reflection, experimentation, and reinforcement, often supported by structured learning environments. (Klammer & Gueldenberg, 2019).

The theoretical foundations of unlearning are rooted in cognitive psychology, organizational learning theory, and knowledge management. From a cognitive perspective, unlearning involves the suppression or replacement of prior knowledge that conflicts with new information. Organizational learning theory positions unlearning as a necessary counterbalance to learning, preventing the entrenchment of outdated routines, and enabling continuous improvement. In the realm of knowledge management, unlearning is seen as a mechanism for maintaining the relevance and utility of organizational knowledge assets. A common theme that emerges across these perspectives is that unlearning is essential for adaptation in complex and dynamic environments. (Klammer, Grisold, Nguyen, & Hsu, 2024).

Despite its importance, unlearning is not without challenges. Individuals often exhibit cognitive rigidity, clinging to familiar practices even when they are no longer effective. Organizational cultures may reinforce this rigidity by discouraging dissent or innovation, thereby creating environments where unlearning is difficult to initiate. Moreover, the ambiguity surrounding what should be unlearned can lead to confusion and resistance. These challenges highlight the need for deliberate strategies to facilitate unlearning, including leadership support, psychological safety, and opportunities for experiential learning. (Klammer & Gueldenberg, 2019).

One domain where unlearning is particularly salient is maritime operations. As vessels become increasingly equipped with advanced propulsion technologies such as azimuth thrusters, experienced deck officers must adapt to fundamentally different control dynamics. Their intuitive responses, shaped by years of operating conventional propulsion systems, may not only be ineffective but potentially hazardous in the new context. This phenomenon, known as negative transfer, illustrates how ingrained habits can interfere with the acquisition of new skills. To address this, simulator-based training environments have become essential tools. These simulators provide a safe and controlled setting where officers can confront the limitations of their prior knowledge, experiment with new techniques, and gradually internalize the operational logic of modern systems. (Sharma & Lenka, 2021).

Unlearning is not merely the absence of learning but a strategic process that enables transformation. It requires courage, reflection, and support, both at the individual and organizational levels. As the pace of change continues to accelerate, the capacity to unlearn outdated knowledge will become increasingly critical for sustaining performance, fostering innovation, and ensuring safety in high-stakes environments. Future research should continue to explore the mechanisms and conditions that facilitate effective unlearning, particularly in fields where the cost of failure is high and the margin for error is narrow. (Klammer, Grisold, Nguyen, & Hsu, 2024).

6.1 The effect of unlearning on the transfer effect of the learned

In simulator-aided ship handling training, the concept of "unlearning" plays a crucial role in the transfer effect of learning. A major factor influencing unlearning in this context is the deeply embedded nature of past experiences and habits. Experienced mariners often rely on long-established routines and methods that have served them well in the past. However, these routines may not align with modern best practices or the capabilities of advanced simulation technologies. The challenge lies in encouraging trainees to let go of these familiar but potentially outdated approaches and embrace new, more efficient methods. To facilitate the transition from outdated methods to more effective practices, it is crucial to consciously underscore the deficiencies of traditional approaches. This involves illustrating the benefits of contemporary techniques through engaging and realistic simulation scenarios, helping trainees clearly perceive the practical advantages of adopting new methods, which aids in a smoother and more persuasive shift in their learning process. (Otto, et al., 2024).

A key factor is the mental confusion that occurs when new information conflicts with established beliefs and knowledge. Trainees may experience discomfort and resistance when confronted with evidence that challenges their established understanding of ship handling, which can hinder the unlearning process and, consequently, the transfer of new skills and knowledge. To effectively manage cognitive dissonance in training programs, it is essential to offer clear, evidence-based explanations that help reconcile conflicting information. Fostering a supportive learning environment that promotes open-mindedness and adaptability is crucial. This approach ensures that trainees are more receptive to new ideas and methods, facilitating a smoother transition from old to new practices. By addressing cognitive dissonance in this manner, training programs can enhance the overall learning experience and improve the retention and application of new knowledge (Otto, et al., 2024).

The role of feedback in the unlearning process cannot be overstated. Immediate and constructive feedback helps trainees recognize and correct their mistakes, reinforcing the unlearning of incorrect practices. In simulator-aided training, high-quality feedback mechanisms are essential for guiding trainees through the unlearning process. This includes not only identifying errors but also explaining the underlying reasons and offering practical alternatives. Cultivating an environment that prioritizes ongoing development, and education enables trainers to help trainees discard ineffective habits and embrace optimal practices. This continuous improvement in culture encourages learners to consistently refine their skills and knowledge, making it easier to transition away from outdated methods. By promoting such a dynamic and progressive learning atmosphere, trainers can effectively guide trainees towards adopting the most effective and up-to-date techniques. The emotional and psychological aspects of unlearning must be considered. Unlearning can be a challenging and sometimes unsettling experience, as it involves questioning one’s competence, adapting to new ways of thinking, and acting. Trainers must be sensitive to these emotional dynamics and provide the necessary support to help trainees navigate this transition. This approach involves gradually increasing learners’ confidence by breaking down the learning process into manageable steps, acknowledging and celebrating their achievements along the way. Establishing an environment where trainees feel secure to experiment and make mistakes without fear of judgment encourages risk-taking and innovation, which are essential for effective learning and growth (Otto, et al., 2024).

6.2 The impact of incomplete unlearning process

A poor or incomplete unlearning process can significantly hinder the ability to acquire new information and skills, leading to several serious drawbacks. Without unlearning, individuals are likely to cling to outdated beliefs and practices, resulting in cognitive biases such as confirmation bias. This inflexibility hinders their ability to embrace new information that challenges their current understanding, thus impeding innovation and adaptability. (Finch, Bhroin, & Krüger, 2023). When old, ineffective habits and knowledge are not discarded, they can interfere with the acquisition of new skills. The overlap of concepts can cause confusion and hinder the efficiency of learning processes, making it difficult to integrate new ideas seamlessly. (Kearney & Gonzalvez, 2022).

In a rapidly changing environment, the unlearning outdated methods can result in a lack of adaptability. Continuous learning and adaptation are crucial in fields like technology and maritime operations, where failure to do so can have particularly detrimental effects (Klein, 2008). Failure to unlearn can lead to professional and personal stagnation. Individuals may find themselves unable to progress or innovate, leading to obsolescence in their skills and knowledge. This can negatively impact career growth and personal development (Klein, 2008). Clinging to outdated knowledge can impair decision-making processes. Individuals may rely on obsolete information to make decisions, leading to suboptimal outcomes and potentially harmful consequences (Bonchek, 2016).

When unlearning is not properly addressed, the transfer of learning from one context to another becomes challenging. Old habits and knowledge can interfere with the application of new skills in different situations, reducing the effectiveness of training programs. (Klein, 2008).

A poor or undone unlearning process can lead to cognitive rigidity, ineffective learning, reduced adaptability, stagnation, poor decision-making, and decreased transfer of learning, all of which can severely impact both personal and professional growth.

7 Transfer of learning

The phenomenon in which an individual or team applies what they have learned beyond the immediate learning event is known as learning transfer. This process involves more than simply acquiring knowledge; it encompasses the ability to apply acquired knowledge, skills, attitudes, and understanding in new and often complex contexts. Learning transfer is a foundational goal of education and training, as it reflects the learner's capacity to adapt and perform in real-world situations. (Meilin, 2024).

Historically, this process has also been referred to as training transfer, particularly in structured instructional settings. However, the term learning transfer is now more widely used, reflecting the broader range of learning experiences that occur outside traditional training programs. These include informal and non-traditional methods such as workplace learning, mentoring, and self-directed inquiry, all of which contribute to the transfer of knowledge and skills across diverse professional and organizational contexts. (Meilin, 2024).

Understanding learning transfer as a process reveals its inherent complexity. It is influenced by a variety of factors, including individual characteristics such as motivation, prior experience, and cognitive flexibility, as well as external factors like organizational support, workplace culture, and the design of the learning experience. The degree of similarity between the learning environment and the application context—often described in terms of near or far transfer—also plays a significant role in determining the success of transfer outcomes. (Meilin, 2024).

Recent theoretical frameworks, such as the Experience Generalization Theory and Transformation Theory, emphasize that the depth of understanding and the ability to recognize relationships between knowledge elements are critical for successful transfer. These theories suggest that learners who can generalize principles and understand the structure of knowledge are more likely to apply what they have learned in new and varied contexts. (Meilin, 2024).

Use of simulators is particularly important in ship handling training, as it allows for the application of theoretical knowledge and practical skills in a variety of real-world situations, often under pressure. Effective transfer of learning in this context means that trainees can take what they have learned in the simulator and apply it seamlessly to actual ship handling scenarios.

Ship handling is an example of such a task, where theoretical knowledge and practical skills must be successfully combined. Simulators provide a safe and effective environment for practicing these skills before moving on to real situations.

One of the primary challenges in achieving effective transfer is overcoming cognitive biases and rigidities that can impede the acceptance of new information. Learners often struggle to apply what they have learned in one context to a different, unfamiliar situation. This difficulty arises because the cognitive processes involved in learning are highly context dependent. For instance, a trainee who excels in a controlled simulator environment may find it challenging to apply the same principles in the unpredictable conditions in reality. (Lobato & Hohensee, 2021).

Effective transfer of learning in simulator-aided ship handling training requires instructional practices that encourage active engagement, reflection, and the application of knowledge in varied contexts. Techniques such as Problem-based learning, collaborative projects, and experiential learning are particularly effective in promoting transfer. These methods help trainees to see the relevance of their knowledge in different situations and to develop the cognitive flexibility needed to apply their skills broadly. Moreover, offering prompt and helpful feedback is essential for assisting trainees in identifying and rectifying their errors, thus strengthening the application of their learning. (Hernandez, Lundström, Favela, McChesney, & Arnrich, 2020).

The transfer effect of learning is a critical aspect of education that ensures learners can apply their acquired knowledge and skills in diverse contexts. In simulator-aided ship handling training, addressing the challenges associated with cognitive biases and rigidities, and employing instructional strategies that promote active engagement and reflection, are essential for enhancing the transfer of learning. By creating a learning environment that encourages ongoing enhancement and flexibility, instructors can enhance the efficiency of education and the capability of learners to utilize their practical real-life maritime operations. (Dutta & Louis, 2025).

7.1 Theoretical models of transfer effect

The theoretical models of transfer effect in the context of simulator-aided ship handling training are essential frameworks that guide the design and implementation of educational simulations. These models form the basis for understanding how skills and knowledge gained in a simulated environment can be successfully applied to real-world scenarios. The importance of these models lies in their ability to predict and enhance the transferability of competencies, ensuring that the training is not only effective within the simulator but also translates into improved performance in actual ship handling. This is crucial for successful learning outcomes as it directly impacts the safety and efficiency of maritime operations. By leveraging these models, educators can make training programs to bridge the gap between theory and practice, fostering a more competent and prepared workforce capable of meeting the demands of modern maritime challenges. Theoretical models of transfer effect thus serve as a cornerstone for developing robust and impactful simulator training programs that contribute to the advancement of maritime education and the industry at large.

7.1.1 Formal discipline model of transfer

The formal discipline approach to transfer, rooted in ancient and classical educational theory, posited that training in disciplines like geometry, mathematics, or Latin inherently enabled the mind to transfer learned skills to everyday reasoning and performance. This theory assumed that the internal logic of these disciplines mirrored our cognitive structures and environmental patterns, thus facilitating transfer. However, research has consistently shown that this approach is ineffective. Learning Latin, for instance, does not generalize to learning other languages, and courses in logic do not inherently teach people how to think. Despite the persistence of critical thinking programs that assume general thinking skills can be taught; evidence indicates that learning remains context specific. The failure of the formal discipline model underscores that transfer cannot be assumed as an automatic outcome of teaching any subject. Nonetheless, the question of its potential validity and utility in certain contexts remains open for further exploration. (Haskell, 2001, pp. 79-80).

The implementation of the formal discipline model of transfer in simulator-assisted ship handling training is a topic of considerable interest in maritime education. This model, which posits that mental discipline developed through rigorous training in one area can transfer to other areas, aligns well with the structured and repetitive nature of simulator-based training. Training in simulator provides a controlled environment where trainees can repeatedly practice and refine their skills, thereby enhancing their cognitive and procedural abilities. Recent research indicates that incorporating active learning techniques into simulator training enhances educational outcomes by involving students in both practical and cognitive tasks. (Kim, et al., 2021; Wiig, Sellberg, & Solberg, 2023).

The formal discipline model of transfer can be effectively implemented in simulator-assisted ship handling training. The structured, repetitive, and immersive nature of simulator training aligns well with the principles of this model, fostering the development of transferable cognitive and procedural skills.

7.1.2 Identical elements model

The identical elements model is a key concept within the broader framework of the transfer of learning. This model underscores the principle that the efficacy of learning transfer is significantly enhanced when there are shared elements between the contexts of learning and application.

Charles Judd’s classic research in 1908 challenged the identical elements model by demonstrating that transfer occurs not only through identical elements but also by understanding abstract general principles. Judd’s experiments with children throwing darts at underwater targets revealed that those instructed on the principle of light refraction performed better than those who practiced without such instruction. This finding suggests that transfer is more abstract and involves cognitive processes, such as metacognitive strategies, rather than just concrete similarities. Judd’s model emphasizes the importance of the learner’s internal understanding and motivation, making it a precursor to modern cognitive and metacognitive approaches to transfer, which recognize the role of indirect processes in facilitating far transfer. (Haskell, 2001, p. 81).

In simulator-aided ship handling training, achieving the Identical elements model type transfer effect necessitates a comprehensive strategy. The core principle of this model is that the transfer of skills from the training environment to the real-world context is optimized when both environments share common elements. High-fidelity simulators, which closely replicate the actual work environment, are instrumental in this process. They provide realistic and immersive experience, allowing for the development of technical, procedural, and operational skills without the risks associated with on-the-job training. Moreover, incorporating a comprehensive curriculum that includes training time, teaching of general principles, addressing students' needs, and providing timely feedback can significantly enhance the learning experience. Systematic training needs analysis, coupled with qualified instructors, ensures that the training is both effective and relevant to the students' future roles.

7.1.3 General principle model

The general principle model of transfer, as defined by Robert E. Haskell, posits that the transfer of learning is a multifaceted process that extends beyond the mere application of instructional techniques or methods of learning. Instead, it is conceptualized as a cognitive framework that encompasses a way of thinking and knowing, which is integral to the adaptation and application of knowledge to new situations. Haskell's model is articulated through eleven principles that outline how the transfer of learning can be successfully facilitated both within educational settings and in everyday life contexts. These principles serve as a foundation for educators and learners alike to foster a deeper understanding and implementation of transfer, emphasizing its role as a critical element in the cognitive processes of reasoning and problem-solving. The model underscores the significance of transfer of learning as a dynamic and essential component of educational practices, challenging the traditional views that often limit their scope to specific domains or curricular methods. (Haskell, 2001, p. 81).

Within simulator-based ship handling training, achieving a general principle model type transfer can be enhanced by employing a blend of pedagogical strategies. These include the use of high-fidelity simulators that provide realistic scenarios for practice, which is crucial for bridging the gap between theory and practical application. Integrating a variety of scenarios that cover a wide range of conditions and challenges can help trainees develop adaptable skills. Furthermore, incorporating feedback mechanisms, where trainees receive immediate and detailed feedback on their performance, can significantly improve learning outcomes. The use of virtual reality and cloud-based simulators is predicted to become more prevalent, offering remote and scalable training options. These methods, combined with the expertise of skilled instructors who can tailor the training to the individual needs of the trainees, form a comprehensive approach to maritime education that aligns with industry standards and prepares seafarers for the complexities of modern ship handling. (Kim, et al., 2021).

7.1.4 Stimulus generalization model

The stimulus generalization model is rooted in behaviorist laboratory research, particularly Pavlov's classical conditioning paradigm. It explains how a non-reinforced response can be evoked by a stimulus similar to an original conditioned stimulus. This model is fundamental in understanding transfer, as it provides the physiological basis for how identical elements enable generalization. Despite its theoretical significance, the model has limited practical application in instructional settings. Researchers focused on basic research are more likely to investigate the underlying processes of transfer, aiming to formalize these processes separately from the broader concept of the transfer of learning. (Haskell, 2001, pp. 81-82).

Achieving the stimulus generalization model type transfer effect in simulator-aided ship handling training involves several key strategies that enhance the transfer of skills from the simulated environment to real-world scenarios. One effective approach is the use of high-fidelity simulators that accurately replicate the dynamics of actual ship handling, providing a realistic training experience. Recent studies suggest that integrating active learning methods into simulator training significantly improves educational results by engaging students in both hands-on and mental activities. Moreover, including diverse scenarios and environmental conditions in training can equip trainees to handle a variety of real-world situations, expanding their experience and improving their capacity to apply learned skills in different settings. (Dutta & Louis, 2025).

Structured debriefing sessions after simulator exercises are crucial for reinforcing learning and addressing any misconceptions. These sessions enable trainees to evaluate their performance, gain feedback, and grasp how to implement their skills in various situations (Kim, et al., 2021). Integrating cognitive and behavioral learning theories into the training curriculum can help in understanding and applying skills in various contexts.

Ongoing assessment and feedback mechanisms ensure that the training is effective and that trainees are able to generalize the skills learned on different ships and conditions. Assessing the effectiveness of blended learning through empirical research has demonstrated that ongoing evaluation and feedback are crucial for enabling trainees to apply their skills in various contexts (Marougkas, Troussas, Krouska, & & Sgouropoulou, 2023).

7.1.5 The cognitive information-processing model

The cognitive information-processing model has evolved significantly over time, with its roots in applied instructional education and behaviorist research, later incorporating cognitive psychology. Historically, cognitive psychology did not focus on transfer, but recent decades have seen a renewed interest in understanding the mechanisms underlying this process. Central to contemporary cognitive psychology is schema research, which posits that information is organized and processed through hypothetical cognitive structures called schemata. These structures facilitate the assimilation and interpretation of new information based on pre-existing knowledge. Early schema research, although not explicitly focused on transfer, laid the groundwork for understanding how previous learning influences new situations. Modern theoretical approaches to schema transfer include isomorphic relations, artificial intelligence computations, metaphorical and analogical reasoning, and exemplification. The cognitive model addresses similarity through schemata and strategy-transfer, where previous learning and strategies are applied to new information, although it does not fully explain the cognitive recognition of similarity or rule application. (Haskell, 2001, pp. 82-83).

To achieve a cognitive information-processing model type transfer effect in simulator-aided ship handling training, it is essential to employ methods that enhance the processing speed and attentional control of trainees. Research suggests that employing multi-site, longitudinal, and actively controlled study designs can be effective. Understanding the cognitive mechanisms affected by processing speed training across the lifespan can maximize the effectiveness of cognitive training for broad transfer to everyday life outcomes. Theoretical models also indicate that transfer of training can occur at several levels of abstraction, and general knowledge can be a byproduct of learning, which is crucial for tasks like ship handling that require complex cognitive skills. Moreover, recent findings suggest that extended dual-task training can reliably transfer to new dual-task situations, which could be particularly relevant for the dynamic and multifaceted nature of ship handling. Therefore, a combination of these methods, tailored to the specific cognitive demands of ship handling, would be the most effective approach for achieving the desired transfer effect in training.

7.1.6 The metacognition model

The metacognition model is a cognitive approach that facilitates transfer through self-monitoring strategies. This model involves learners asking self-reflective questions about their learning process, which helps them transfer these strategies across different tasks or learning domains. Although metacognitive research is not strictly part of cognitive psychology, it aligns closely with educational strategies. The approach focuses on general strategies that promote transfer, even though it does not fully explain the cognitive processes underlying transfer. Despite this, discovering how to promote transfer remains crucial for instructional purposes. (Haskell, 2001, p. 83).

To achieve the metacognition model type transfer effect in simulator-aided ship handling training, it is essential to focus on methods that enhance metacognitive skills transferable to a variety of learning tasks. Research suggests that hybrid training, which combines metacognitive skills with cognitive strategies, supports both near and far transfer of these skills. This approach can be particularly effective in the context of simulator training, where the complexity of tasks requires learners to apply and adapt their skills in dynamic scenarios. Professional development for instructors in metacognitive instruction is crucial, as it equips them with the necessary tools to facilitate higher-order thinking and self-regulated learning among trainees. Implementing metacognitive strategies, such as planning, monitoring, and reflecting, can further improve learning outcomes and ensure that trainees not only acquire technical skills but also develop the ability to evaluate and adjust their learning strategies in real-time.

7.1.7 The instructional model

The educational concept of transfer of learning has experienced a significant paradigm shift, moving from an applied instructional concept to a cognitive and metacognitive mechanism. Historically, educational research did not utilize cognitive research findings, but since 1979, there has been a growing awareness and integration of these data. This shift has both positive and negative aspects. Positively, it has led to a more research-based understanding of the cognitive processes underlying transfer, moving away from the ineffective exhortation to "teach for transfer." Negatively, pure cognitive research has overshadowed the applied instructional approach. To address this, findings from both paradigms need to be integrated into a new theoretical base for an instructional model of transfer, ensuring cognitive validity while maintaining practical applicability. (Haskell, 2001, pp. 83-84).

The transfer of learning is a multidimensional process that can be explained with various theoretical models. These models do not merely describe the mechanisms of transfer; they also provide essential frameworks for designing effective training, particularly in simulator environments aimed at bridging the gap between theory and practice.

Different transfer theories, such as the theory of identical elements, which emphasizes the similarity between learning and application contexts, the low and high road theory, which distinguishes between reflexive and conscious, abstraction-based transfer, the analogy and abstraction theory, which examines the identification and application of general principles and situated learning, which highlights learning occurring within authentic, social contexts offer diverse perspectives on the factors that promote or hinder the transfer of knowledge and skills from one context to another. These models help us understand how learning transfers and how training should be structured to achieve the desired positive transfer (desired transfer), i.e., the ability to use skills and knowledge in genuine problem-solving situations. Understanding these models is a cornerstone for developing robust and impactful simulator training programs that contribute to maritime safety and efficiency.

The following table (Table 3: Theoretical models of transfer effect) compiles key theoretical models of the transfer of learning that are particularly relevant in the context of ship handling simulator training. The table presents the core ideas of each model and provides examples of their application in simulator training. By consulting this table, the reader will gain a deeper understanding of how different theories explain the transfer of learning and how these principles can be utilized to optimize training effectiveness and maximize the real benefits of simulator training in practical work.

Table 3: Theoretical models of transfer effect

Model	Core Idea	Example of Simulator Training
Formal discipline model	Certain subjects, such as mathematics and logic, develop general thinking skills that are transferable to other situations.	Simulator training improves students' ability to solve problems and make decisions under pressure, which can also be beneficial in real-life situations.
Identical elements model	Transfer of learning is most effective when the training and application environments are as similar as possible.	The simulator practices the same steering movements and techniques used on a real ship.
General principle model	General principles and concepts are transferable to new situations, even if the details change.	Navigation principles learned in the simulator are applicable in different ship handling situations. Weather, other traffic, sea state etc.
Stimulus generalization model	Learning generalizes to stimuli that are similar to the original stimulus.	Reactions to emergencies practiced in the simulator can also generalize real-life emergencies.
Cognitive information-processing model	The transfer of learning depends on how information is processed and stored in memory.	Simulator training improves information processing speed and attention control, which is also beneficial in real-life tasks.
Metacognition model	Awareness of one's own learning processes and strategies promotes the transfer of learning.	In simulator training, students can practice evaluating and developing their own ways of working.
Instructional model	Teaching methods and strategies can affect the transfer of learning.	Simulator training uses a variety of teaching methods that support the transfer of learning, such as practical exercises, simulations, and feedback.

In the context of simulator-aided ship handling training, the most effective instructional methods are those that closely replicate real-world conditions and challenges seafarers may face. This includes the use of advanced simulators that offer a variety of scenarios, from navigating through narrow channels to dealing with adverse weather conditions. These simulators should comply with performance standards to ensure quality training. Integrating bridge and engine room simulators can enhance the realism of the training, providing a more comprehensive learning experience. The role of the instructor is also crucial; they must be adept at adjusting scenarios to match the competence level of the trainees, ensuring that the simulation is perceived as realistic and beneficial for learning. Incorporating hands-on activities, such as managing cargo and ballast operations, enhances the transfer of learning by allowing trainees to apply simulator-acquired skills to actual ship handling scenarios. This practical approach ensures that theoretical knowledge is seamlessly translated into real-world competence, thereby greatly enhancing the overall impact of the training, and preparing learners for real-life maritime operations. The continual advancement of technology, including the adoption of virtual reality and cloud-based simulators, is predicted to further enhance maritime education and training in the future.

7.2 Types of transfer

The effects of learning transfer can be classified into various types, each demonstrating how skills and knowledge are applied in different contexts. Near transfer involves using learned abilities in environments that closely resemble the training setting, which ensures ease of application. In near transfer, the same knowledge is applied in similar contexts. For example, ship handling skills and techniques practiced in a simulator transfer directly to handling a real vessel. Near transfer occurs reliably.

In contrast, far transfer applies learned principles to entirely different contexts, showcasing a broader range of skill use. Far transfer concerns the utilization of knowledge in distant and dissimilar contexts. For instance, problem-solving skills learned in a simulator help in resolving unexpected situations on a real vessel. Far transfer rarely occurs reliably. It should be noted that the definition of near and far transfer is intuitive, and there is no precise way to measure how distant or close situations are to each other.

Lateral transfer refers to the generalization of skills across similar scenarios. For example, the ability to navigate in a narrow channel learned in a simulator helps in navigating in other confined spaces. Vertical transfer, on the other hand, involves using specific skills to develop a more comprehensive skill set. Basic ship handling skills practiced in a simulator help in learning more complex handling tasks.

Literal transfer is the straightforward application of an acquired skill to a new task. Navigation rules learned in a simulator are directly applied to real navigation. Figural transfer involves creatively adapting existing knowledge to solve new problems. The ability to anticipate a ship's behavior, learned in a simulator, helps in evaluating risky situations in real life. (Kirwan, 2009, p. 6).

Transfer effects can also be neutral, negative, or positive. Neutral transfer occurs when learning something new does not impact previously acquired knowledge or skills . Negative transfer can hinder learning in new contexts due to interference from old habits. For instance, handling techniques learned with a conventional propulsion system might interfere with adopting an azimuth propulsion system. Negative transfer is problematic in the early stages of learning a new domain, and learners often correct their misconceptions as they gain experience in the field. Conversely, positive transfer enhances the acquisition of new skills or their application in different contexts, as previously learned routines facilitate performance in subsequent tasks. Understanding these types of transfer is crucial for designing effective educational and training programs that maximize the applicability of learned skills across various situations. (Kirwan, 2009, p. 6; Ni, Gathercole, & Norris, 2023).

Underpinning these transfer types are the behavioral and cognitive theoretical frameworks of learning. Behavioral theorists prioritize the observation and quantification of behavior, advocating for the reinforcement of preferred behaviors and the suppression of unfavorable ones. This perspective is particularly pertinent to explaining near and literal transfer, where the direct application of skills is evident. Cognitive theorists, on the other hand, explore the mental processes that underlie behavior, positing that understanding the rationale behind actions is crucial for effective behavior modification. This approach is deemed more effective in explaining the mechanisms of far and figural transfer, where abstract reasoning and conceptual application prevail. Thus, the interplay between these learning theories provides a comprehensive understanding of the dynamics of learning transfer, with each theory offering insights into different aspects of the transfer process. (Shuell, 1992).

The effectiveness of simulator-based maritime training relies not only on the use of realistic scenarios, appropriate teaching methodologies, and theoretical models of learning transfer, but also on a deeper understanding that learning transfer is not a single, uniform process. Instead, it can take various forms depending on the context. The transfer of learning from one situation to another can be categorized into different types, based on factors such as the degree of similarity between the original learning environment and the new application setting. Recognizing these types of transfer is essential for designing training that encourages the intended, positive application of skills in real-world practice.

It is important to distinguish between, for example, near transfer, where learned skills and knowledge are applied in similar situations, and far transfer, where what has been learned is used in new and significantly different situations. For instance, steering skills and techniques practiced in a simulator transfer directly to similar tasks on a real ship (near transfer). In contrast, applying strategic principles of ship handling to manage a completely new type of vessel or situation represents far transfer. Furthermore, it is crucial to recognize that transfer can be either positive, where previous learning helps in acquiring or applying something new, or negative, where previous learning interferes with performance in a new context. While negative transfer can be problematic, especially in the initial stages of learning or "unlearning", training primarily focuses on promoting the desired positive transfer. In designing simulator training, awareness of these different types of transfer helps in targeting exercises and teaching methods to maximize the possibility of positive transfer and minimize negative transfer.

The following table (Table 4: Types of Transfer) presents key forms of learning transfer that are particularly relevant to ship handling simulator training. It outlines the core concepts of each type and provides examples of how they appear in both simulator exercises and real-world maritime operations. This table offers a comprehensive understanding of how different types of transfer are expressed in practice and how they influence learning outcomes in simulator-based training.

Table 4: Types of transfer

Transfer Type	Core Idea	Example of Simulator Training
Near transfer	Learned skills and knowledge transfer easily to similar situations.	Steering skills and techniques practiced in the simulator transfer directly to steering a real ship.
Far transfer	Learned skills and knowledge are applied to new and different situations.	Problem-solving skills learned in the simulator help to solve unexpected situations on a real ship.
Lateral transfer	Learned skills and knowledge generalize to tasks at the same level.	The ability to navigate a narrow channel learned in the simulator helps to navigate in other confined spaces.
Vertical transfer	Learned skills and knowledge form the basis for learning more demanding skills.	Basic steering skills practiced in the simulator help to learn more complex steering tasks.
Literal transfer	The learned skill or knowledge is transferred as is to a new situation.	Navigation rules learned in the simulator are applied directly to real-life navigation.
Figurative transfer	Learned skills and knowledge are creatively applied to new problems.	The ability to anticipate the behavior of a ship learned in the simulator helps to assess risk situations in real life.
Neutral transfer	Learning something new does not affect what has been learned before.	Learning a new navigation system does not affect previously learned maneuvering skills.
Negative transfer	Previously learned things interfere with new learning.	Steering techniques learned with a traditional propulsion system may hinder the adoption of an azimuth propulsion system.
Positive transfer	Previously learned things make it easier to learn or apply new things.	Prior knowledge of working at sea helps working in the simulator as well in reality.

7.3 Factors influencing transfer

Learning transfer is often assumed to be a fundamental outcome of most educational endeavors, with educators aiming for learners to apply acquired knowledge or skills in various contexts. This expectation extends to self-directed learners who also intend to utilize their learning in future scenarios. However, participation in a learning activity alone does not ensure the occurrence of transfer. Barriers can arise before, during, and after the learning experience, such as insufficient foundational knowledge, lack of motivation or confidence, and inadequate post-learning support. Common classroom practices might hinder transfer, particularly when facilitators fail to model, reward, encourage, or provide opportunities for practicing transfer. Facilitators who place the responsibility of achieving transfer solely on learners often see less success. For instance, a facilitator might not demonstrate how skills acquired through simulator-aided ship handling training for professional maritime operations can also be applied to personal navigation tasks, such as planning a recreational sailing trip. Transfer difficulties often occur across different learning environments, such as from school to the workplace, highlighting the importance of integration projects to promote transfer. The transferability of learning processes and outcomes depends on the type of learning—cumulative, assimilative, accommodative, or transformative—and the resulting knowledge. Some suggest abandoning the term "learning transfer" in favor of viewing learning as a process of becoming within transitional boundary crossings, which occur not only between school and work but also in other life stages such as parenthood and retirement. A fundamental barrier to transfer is the oversight of its necessity during both the design and facilitation phases, leading to the erroneous assumption that transfer will occur naturally. (Kaiser, Kaminski, & Foley, 2013, p. 8).

The study of learning transfer encompasses several critical factors that influence its effectiveness. One key factor is the similarity between the original learning context and the target context, with greater similarity facilitating more effective transfer. Abstraction also plays a crucial role, as abstract principles are more easily generalized across different contexts than isolated facts (Brown, Roediger III, & McDaniel, 2014). The concept of contextual interference, originally explored in motor learning, suggests that varying practice conditions—such as interleaving different problem types—can enhance adaptability and promote transfer (Shea & Morgan, 1979). Additionally, metacognitive awareness is essential for effective transfer, as it enables learners to monitor and regulate their learning strategies and apply knowledge appropriately in new situations (Flavell, 1979).

8 Survey research, design, testing, implementation, and analysis of results

The primary objective of this survey research was to present findings on the impact of simulator training on the transfer effect of learning in ship handling. The survey aimed to investigate how effectively simulator exercises enhance ship handling skills and decision-making in real-life scenarios. It also evaluated the challenges posed by abandoning traditional methods in favor of new technologies, such as azimuth thrusters.

Respondents, who are experienced ship deck officers involved in navigation, provided feedback on various aspects of the training. This included the structure of the training, the support provided by instructors, and the realism of the simulators. Respondents suggested improvements to better align simulator training with actual job tasks and promote the transfer effect of learning.

The survey was based on a questionnaire presented to the target respondents, and the analysis of their responses aimed at drawing meaningful conclusions about the effectiveness of simulator-assisted ship handling training and its impact on real-world operations. The survey included 29 questions addressing respondents' work experience, educational background, and experiences with simulator training. These questions were designed to map respondents' perceptions of the usefulness of simulator training, the transfer effect of learning, and the importance of unlearning old habits to learn new control techniques. The survey incorporated multiple-choice questions, open-ended questions, and matrix questions, allowing respondents to share their insights on how simulator training can be modified to ensure the most effective transfer of learned skills to real-world situations.

8.1 Planning and implementing survey questions

The design and implementation of research questions, in conjunction with simulator-assisted ship handling training, required a detailed and systematic approach. The process commenced with the definition of research objectives, which were fundamental in guiding the overall design of the questions. This involved identifying specific areas of interest, including training effectiveness, challenges encountered by trainees, and their overall satisfaction with the training program. Creamailer software was utilized for implementing the questions, receiving responses, and analyzing the data.

The survey questions were carefully crafted in two different languages English and Swedish to receive detailed and pertinent responses from the participants. Within the context of simulator training, the questions centered on the trainees' prior experience with conventional propulsion systems, their experiences during the training, and their ability to apply the acquired skills in reality onboard a ship.

Prior to distributing the survey to the target group, two pilot test surveys were conducted. The questions were presented to a small group consisting of university of applied sciences lecturers and simulator instructors. The purpose of the pilot test surveys was to identify any potential issues with the questions, such as ambiguities or comprehension difficulties, and to make necessary revisions. Feedback obtained from the pilot test surveys helped refine the survey to effectively achieve its objectives.

Once the questions were finalized, the questionnaire was distributed to the target respondents. In this survey research, the target group consisted only of navigating officers involved in the navigation and handling of a passenger ship equipped with azimuth propulsion. An online survey was used as the distribution method.

During the data collection phase, the survey responses were automatically saved to the Creamailer software after the respondents submitted their answers. All respondents answered the Swedish survey. The author of the thesis has added English translations to the appended Swedish response report. The software did not record any personal information about the respondents; instead, they were identified by set of numbers. The responses were interpreted, and conclusions were drawn using the statistical analysis tools and qualitative analysis methods provided by the Creamailer software. At this point, it was decided that the questionnaire and its results would be kept completely anonymous, i.e., all identification possibilities based on names were removed from the questionnaires, results, and summaries.

The final stage of the survey research involved interpreting the results and reporting them clearly and in a structured manner. This included a summary of the most important insights, a discussion on the impact of the findings, and recommendations for future training programs.

8.2 Research participants

The survey focuses on deck officers working on a passenger vessel who are responsible for the navigation and handling of the ship. Their navigation and ship handling tasks, ranging from port maneuvering to archipelago and open sea navigation, differ significantly. Each participant holds a Master Mariner certificate, which qualifies them to navigate and handle the specific type of vessel described in this study. In addition to their theoretical qualifications, they possess substantial experience navigating various types of vessels. All survey participants had several years of experience working on other passenger ships, but they all had short experience on the current vessel due to the ship's age and had little or no prior experience in navigating and handling a passenger ship with an azimuth thruster before the simulator training course.

All survey participants have completed simulator training on navigating and handling a passenger vessel equipped with azimuth propulsion system at the Aboa Mare training center.

8.3 Data collection and methods

The research data was collected through a survey conducted in October 2024 using the Creamailer platform. A total of 5 deck officers who are involved in ship navigation and maneuvering participated in the survey. The survey included questions related to the respondents' work experience, educational background, and experiences with simulator training. The survey aimed to map the respondents' perceptions of the usefulness of simulator training, the transfer effect of learning, and the significance of unlearning in acquiring new steering techniques.

Permission to conduct the survey was requested via email from the ship owner on August 28th, 2024. The email addresses of the mates were verified with the ship, and two mates were contacted by phone to obtain their email addresses.

The questionnaire was published on October 16th, 2024, at 10:00 and closed on October 23rd, 2024, at 11:59. The first response was received on October 16th, 2024, and the last response on October 23rd, 2024. The survey was sent to 24 mates, and 5 responses were received, indicating a low level of participation.

The survey data collected in this thesis was analyzed primarily using theory-based content analysis. Theory-based content analysis, also referred to as directed content analysis, is a qualitative research method that systematically applies existing theoretical frameworks to guide the analysis of textual data. This approach contrasts with conventional content analysis, where categories and themes emerge inductively from the data itself. In theory-based content analysis, the coding process begins with predetermined categories derived from prior research or established theory, allowing the researcher to validate, refine, or extend theoretical constructs within a new empirical context. Hsieh and Shannon (2005) provide a foundational description of this method in their article Three Approaches to Qualitative Content Analysis, where they outline how direct content analysis can enhance the analytical depth and theoretical alignment of qualitative studies. (Hsieh & Shannon, 2005). This method is particularly valuable in applied research settings, where the goal is often to test the applicability of theoretical models in practice-oriented environments.

Method involved transcribing the data gathered from respondents' experiences and views, particularly from open-ended questions and interview-like sections, and analyzing it based on themes. These themes were derived directly from the thesis's theoretical framework, which covered the theories of learning, unlearning, and the transfer effect of learning. The purpose of the analysis was to identify recurring themes, similarities, and differences in the respondents' experiences, and to ascertain which factors, according to the respondents, promoted or hindered the transfer of learning from simulator training to real-world ship handling situations. Supporting the qualitative analysis, descriptive statistical methods were also used to examine the respondents' answers both individually and in groups. Creamailer software was utilized not only for implementing the questions and receiving responses but also for the analysis of the data itself, including support for both statistical and qualitative analysis. This combination of analysis methods provided a versatile and theoretically anchored perspective on the survey data, helping to answer the research question about enhancing the transfer effect of learning through simulator training.

8.4 Survey analysis and findings

This chapter presents the analysis and key findings from the survey study on the impact of simulator training on the transfer effect of learning in ship handling. The concepts of learning, "unlearning," and transfer effect discussed in the theoretical part, as well as theoretical perspectives related to the use of simulators and learning methodologies, provide a solid foundation and explanatory framework for these empirical findings. The fundamental assumption of the thesis, that simulators are crucial in enhancing the transfer effect of learning in maritime education, is confirmed by the survey results, which indicate that simulators are crucial in strengthening the transfer effect. Respondents emphasized the importance of simulator characteristics, such as realism and functional similarity, and the careful design of scenarios for the transfer effect. This aligns directly with the theory section's discussion of different levels of simulator fidelity (physical, functional, technical, behavioural, psychological, and social/interactional) and the importance of functional congruence and scenario design in achieving learning objectives and promoting transfer. The study, which focused on the experience of experienced deck officers moving to a new propulsion system for them, highlighted the central importance of "unlearning", i.e. abandoning old habits and knowledge. The survey results revealed challenges in this unlearning process and showed that previously learned techniques can interfere with new learning. The theoretical part acknowledges the difficulty of unlearning and discusses the consequences of an incomplete unlearning process, as well as the possibility of cognitive dissonance and mental confusion when new information conflicts with old, which can particularly hinder transfer. The teaching methods perceived as effective in the survey, such as practical exercises and simulations, individual feedback, group discussions, and blended methods, are supported by the learning theories in the theoretical part. For example, experiential learning theories emphasize the significance of practical experience and reflection, while constructivist theories highlight the importance of collaboration, social interaction, and the role of feedback in the learning process and constructing new knowledge. The importance of the simulator instructor's role for the transfer effect emerged strongly in the survey, which is fully in line with the theoretical part's emphasis on the instructor's expertise, skills, and personal qualities as central to the learning process and scenario design. Furthermore, respondents' experience that simulator training improved their ship handling skills, decision-making ability, and ability to perform under pressure corresponds to the goals of simulator training and the consequences of the transfer effect discussed in the theoretical part, such as practicing complex and critical situations safely, improving understanding and problem-solving ability, and strengthening performance under pressure.

The survey was completed by five deck officers working on a particular passenger ship equipped with an azimuth propulsion system. Most respondents were chief mates or pilots, possessing significant work experience on the vessel in question (over two years for the majority), as well as several years of experience on other passenger ships. Crucially, none of the respondents had significant prior experience handling a vessel equipped with azimuth propulsion before participating in the specific training for this propulsion system at the Aboa Mare training centre. It is critically important to stress that the small number of respondents (n=5) significantly limits the generalizability of the results to the broader maritime industry. The findings primarily reflect the subjective experiences of this limited group.

8.4.1 Challenges in unlearning previously learned skills.

The transition to utilizing a new type of propulsion system, such as azimuth propulsion, poses particular challenges for experienced deck officers whose ship handling skills are often based on deeply ingrained experience with conventional systems like shaft propellers and rudders. This adaptation process is not solely about learning new skills; it also involves "unlearning," which refers to the active process of identifying and either discarding or updating established routines, habits, or knowledge that are no longer effective or might interfere with performance in a new context, such as handling a vessel with an azimuth propulsion system. Theoretical examination of the transfer of learning has indicated that prior learning can influence new learning not only positively (positive transfer) but also negatively, where previously learned skills interfere with performance in a new context. While negative transfer diminishes with experience, it can be a significant challenge, especially in the early stages of learning. This subsection presents how this challenge related to unlearning specifically manifested in the empirical data collected in this study.

The survey data collected in the study provided clear empirical evidence that the unlearning process was experienced as challenging and that previously learned ship handling skills and techniques indeed interfered with new learning. The survey directly inquired about participants' experiences regarding the challenging nature of this process (Question 8) and how often previous skills interfered with learning to handle a vessel equipped with azimuth propulsion (Question 13). Based on the responses (from five participants for these specific questions), the research confirmed that the negative transfer from prior, deeply ingrained experience poses a significant challenge for experienced deck officers as they transition to using innovative propulsion systems. This implies that they must actively work to override or adapt situations where their established reactions, based on conventional steering systems, are inappropriate or hinder effective operation. The nature of this challenge was illuminated in responses to the open questions (e.g., Question 28, which asked how simulator training could be modified to make the unlearning process clearer). One specific response highlighted that one respondent personally did not want to "unlearn" anything but wished to retain their previous skills with conventional ships, while simultaneously emphasizing the desire to learn new things, which he/she felt was best accomplished through repetition and practice ("more driving in the simulator and then in real life"). This response, while not directly quoted in the provided source excerpts but drawn from the research results discussed in our conversation history, illustrates the deeply ingrained nature of previous skills and how challenging their conscious modification or bypassing can be. It underscores the critical importance of sufficient practice and repetition in enabling this transition.

The theoretical framework aligns with these empirical observations. When new knowledge or skills conflict with old ones, it can lead to uncertainty and potentially hinder the transfer of learning into practice. The process of unlearning also involves psychological and emotional dimensions; it can be uncomfortable and may require questioning one's own competence, making it a challenging endeavour. An incomplete unlearning process can significantly impair the ability to adopt new, more effective ways of working and skills.

The findings of the research discussed, combined with theoretical insights, underscore that effective simulator training must explicitly recognize and address the challenges of unlearning. The survey responses gathered for this study for questions like Question 12 about instructor support and Question 26 about teaching techniques indicated the importance of elements such as instructor support and various teaching methods in this process. Immediate, constructive feedback within the simulator environment is crucial for identifying and correcting incorrect approaches based on old habits, which aids in unlearning and reinforces correct techniques. Furthermore, sufficient, and targeted practice in the simulator is essential for solidifying new skills and bypassing old, interfering routines.

This research has shown that experienced mariners face real and significant challenges when adapting to novel propulsion systems, particularly due to the need to unlearn previously acquired skills. These difficulties arise from deeply ingrained habits and the effects of negative transfer. Addressing them effectively in training requires recognizing the importance of unlearning, ensuring ample opportunities for practice, and providing high-quality, guided feedback.

8.4.2 Importance of simulator realism

The empirical part of the study provided concrete evidence of how different dimensions of simulator realism were perceived as important in the learning process and especially for learning transfer. The study's central assumption, that simulators are crucial for strengthening learning transfer in maritime education and training (MET), was confirmed by the survey results. Respondents emphasized that simulator characteristics, such as realism and functional similarity, as well as carefully designed scenarios, are very important factors for learning to transfer into practice.

The survey directly inquired about the realism of scenarios compared to a real vessel (Question 15, 5 responses) and what improvements in simulators could increase learning transfer (Question 22, 11 responses). Although respondents found simulator scenarios realistic compared to a real vessel, they expressed a clear desire for several improvements to increase realism and thus improve training outcomes.

Concrete features desired by respondents to enhance realism included, among others, virtual reality (VR), digital twins, realistic weather and environmental conditions, controls that accurately replicate the real vessel, integration with the vessel's actual systems and data, adaptive learning systems, and high-quality visualization. These features were believed to increase similarity, especially functional similarity (i.e., replicating the behaviour of real operations), between the simulator experience and the actual work environment. This desire to improve functional similarity is fully aligned with theoretical literature, which often emphasizes the importance of functional realism over mere physical or technical realism for learning transfer.

The concept of simulator realism is multi-dimensional. It includes physical realism (appearance, sounds, feel), functional realism (correspondence of functions to reality), and a combination of these, technical realism. Additionally, there are dimensions related to behavioural, psychological, and social/interactional realism. Traditionally, it has been assumed that high realism maximizes learning transfer (according to the identical elements theory), but research on this connection is contradictory. Many studies and experts, including the simulator instructors interviewed related to this thesis, emphasize that merely high technical realism does not necessarily guarantee good transfer. Instead, pedagogical choices, such as scenario design and the instructor's actions, are more significant.

In this context, the concept of functional congruence emerges, which has been proposed as a better term to describe the core of simulator training effectiveness than just realism, authenticity, and fidelity. Functional congruence means that scenarios should be modelled so that students' actions in the simulation have a direct and meaningful connection to the learning objectives set by the scenario (Tolk, et al., 2023). This requires a balance between a sufficiently realistic environment and clearly defined learning objectives. Not all elements need to be extremely realistic; the realism of certain elements critical to the learning objectives is more important. Experienced simulator instructors emphasized in interviews that the simulator is merely a tool, and its effectiveness depends on how it is used wisely and precisely to achieve specific learning objectives. They also noted that overly complex or unrealistically overloaded scenarios can be frustrating and reduce the benefit of training.

This study found that experienced mariners place high value on simulator realism and features as essential elements for effective learning transfer. Their expressed desire for improvements in realism, as reflected in responses to Questions 18 and 22, highlights the importance of functional realism and congruence. These findings support the theoretical view that the effectiveness of simulator training depends not merely on achieving the highest level of technical or physical realism, but on the simulator’s ability to meaningfully replicate critical real-world tasks and situations in alignment with clearly defined learning objectives. Additionally, the instructor's role in guiding this process is crucial. The significance of simulator realism, therefore, extends beyond visual or physical accuracy; it lies in the simulator's capacity to serve as a practical tool for rehearsing scenarios and tasks that foster skill development and successful transfer to operational practice.

8.4.3 Effective teaching methods

The survey aimed to ascertain which teaching methods and simulator instructor characteristics the respondents considered significant for achieving learning transfer. Furthermore, the questionnaire specifically inquired which teaching method was most helpful in the unlearning process (Question 9) and how the support provided by simulator instructors was perceived in this process (Question 12).

In the survey (Question 25), respondents were asked to evaluate the significance of certain teaching methods for achieving positive learning transfer. These evaluated methods, which the respondents assessed based on their experiences, included individual feedback and supervision, group discussions with colleagues, practical exercises and simulations, theoretical lectures and written material, and mixed teaching combining these. Respondents' views on the significance of the simulator instructor for transfer were explored in Question 27, which assessed the importance of the instructor's knowledge, skills, personal qualities, and attitude. These methods and characteristics presented in the survey were selected based on their relevance from the perspective of effective maritime training and transfer, grounded in the study's background framework and the assumption that certain methods are more effective than others in this context.

The sources underlying the study support the potential significance of the teaching methods presented in the survey. For instance, practical exercises and simulations are known as an effective way to help learners adapt to new situations by providing authentic practice environments. The importance of simulator training in creating safe and realistic practice environments is emphasized in the maritime training literature. Crucially, for effective training, the functional congruence of the simulator with the real environment is particularly important, which is achieved through careful scenario design and teaching methods, not solely technical realism.

Individual feedback and supervision, as well as group discussions, are central elements in many pedagogical models proven effective. For instance, problem-based learning (PBL), communities of practice (CoP), and cognitive apprenticeship emphasize guidance, collaboration, problem-solving, and reflection. In cognitive apprenticeship, an expert (experienced deck officer or instructor) makes their tacit knowledge visible and guides the learner, and feedback is very important in this process. Therefore, post-simulation debriefing with the instructor is a critical part of simulator training. Group discussions and peer assessment are also linked to the idea of communities of practice and can support learning.

The instructor's role emerges strongly as a key factor influencing effectiveness. Instructors do not just transmit information; their task is to guide the learning process, offer support, especially in unlearning, provide constructive feedback, and help learners build their new understanding. Their expertise and ability to utilize it in scenario design and execution are valuable. The survey also highlighted the importance of the instructor's personal qualities and positive attitude.

Theoretical lectures and written material represent more traditional teaching. While they can be part of mixed teaching, effective methods for transfer often lean more towards active, experiential, and contextualized practice that particularly supports skill development and changing old habits. Question 9, which specifically inquired about the teaching method for unlearning, links the concept of effective methods directly to the thesis's central theme, emphasizing that effective teaching in this context also includes the ability to identify and modify old, inappropriate modes of action. The instructor's support in this process (Question 12) underscores the importance of the guide even in the most challenging phases of learning.

This study identified effective teaching methods by combining theoretical insights from various learning theories and pedagogical models, such as situated learning, Cognitive Apprenticeship, and simulator functional congruence, with the practical experiences and perceptions of seasoned mariners. These mariners offered valuable input on which instructional approaches and instructor qualities most effectively support learning and its transfer to real-world practice. This is especially important when acquiring complex new skills, such as operating a vessel with azimuth propulsion, which also involves the process of unlearning previous habits. The survey provided concrete empirical data on the teaching strategies and instructor attributes that were perceived as most beneficial for promoting both transfer and unlearning. These findings made it possible to identify effective methods tailored to the needs of the study's target group while also connecting them to broader educational principles.

8.4.4 Perceived effectiveness of training

The study approached effectiveness primarily through the experiences and perspectives of experienced deck officers, gathered via a structured survey. The main objective was to identify which specific teaching methods, characteristics of simulator exercises, and instructor qualities were perceived by respondents as significantly enhancing the transfer of learning to real-world practice. Effectiveness was also examined in terms of what supported respondents most in the unlearning process, particularly in letting go of outdated or potentially interfering ship handling habits. Instructor support during this transition was a key focus.

Effectiveness was further explored through the survey questionnaire (Appendix 1), which aimed to pinpoint the teaching methods, exercise characteristics, and instructor actions that deck officers considered most valuable for learning the practical skill of handling a vessel with an azimuth propulsion system. Respondents were asked to evaluate these elements from multiple angles to provide a well-rounded understanding of what contributed to successful learning and transfer.

One of the survey questions (Question 23) asked respondents to assess the overall effectiveness of simulator training in improving the transfer of learning to real-life operations, relative to the time invested in training. This provided a general measure of perceived training value.

To gain deeper insights, the survey also examined how simulator training was believed to improve specific skills and performance in actual ship handling. Respondents evaluated the impact of training on their general ship handling abilities (Question 14), decision-making in real situations (Question 24), and performance under work-related pressure (Question 25).

These responses offered a clearer picture of how training outcomes were perceived in critical operational areas.

Teaching methods were evaluated through Question 26, which asked respondents to rate the effectiveness of various instructional techniques in promoting learning transfer. These methods, selected based on established pedagogical theories in maritime education, included individual feedback and supervision, peer discussions and assessments, practical exercises and simulations, theoretical lectures and written materials, and blended learning approaches. Practical exercises and peer interaction emerged as the most valued methods for learning and applying new skills.

The role of the simulator instructor was examined through Question 27, which focused on the importance of different instructor characteristics in supporting learning transfer. These characteristics were grouped into categories such as expertise, technical and practical skills, communication abilities, and overall attitude and behaviour toward learners. This aligns with the theoretical framework that highlights the instructor's role as a facilitator, feedback provider, and source of support throughout the learning process.

The connection between training effectiveness and unlearning was a central theme in the study. Respondents were asked which teaching methods helped them most in unlearning old habits (Question 9), and how they perceived the instructor's support during this process (Question 12). These insights emphasized the importance of helping experienced mariners recognize and adapt outdated behaviours that no longer suited the demands of new propulsion systems, with instructor guidance playing a critical role in this transition.

Effectiveness in this study was defined and evaluated by combining theoretical pedagogical principles such as learning transfer, unlearning, and the functional fidelity of simulators with empirical data and subjective evaluations from experienced seafarers. The respondents' perceptions of improved operational skills, decision-making, and performance under pressure, along with their insights into what contributed most to these improvements, formed the foundation for assessing the effectiveness of the training. Although theoretical models like cognitive apprenticeship and situated learning were not directly referenced in the survey questions, they influenced the design and interpretation of the study.

8.4.5 Suggestions for improvement

The theoretical background of the thesis identifies unlearning as a crucial phenomenon, particularly when experienced deck officers transition to using new, innovative propulsion systems. Routines, habits, and knowledge learned previously may no longer be effective or could even interfere with performance in a new context, making the identification and replacement of old habits necessary. Simulators offer a safe and realistic environment for this process, allowing old habits to be dismantled and new ones built without the consequences of real-world errors. The empirical results of the study support this need by clearly highlighting the requirement to increase practical simulator driving time and the frequency of exercises. In the survey responses, participants felt that learning new skills and letting go of old habits happened best through sufficient repetition. This suggests that to support learning transfer, especially in the context of unlearning, sufficient practice time and the opportunity to repeat critical situations are needed.

Simulators have been found to be crucial for improving learning transfer in maritime education. The theoretical background of the thesis and previous research literature suggest that while emphasis is often placed on the visual and physical fidelity (realism) of simulators, functional congruence or functional correspondence with the real work task is even more important for learning transfer. This means that scenarios should model events in a way that requires the student to perform actions and make decisions that correspond functionally and in terms of content to the tasks required in the real environment, regardless of whether all the details of the simulator look exactly the same as in reality. Scenario design should be systematic and always based on clearly defined learning objectives. Merely simulating technical systems or a realistic environment is not sufficient if it does not support learning objectives. Scenarios should also be tailored to the students' needs and their complexity should be adjustable. The survey study emphasizes the importance of simulators in achieving transfer effect, which implicitly supports that the relevance and functional correspondence of scenarios have been at an adequate level but leaves room for improvement in terms of systematicity and goal-orientation. The survey also inquired about what features were desired in simulators to improve training results.

The role of the simulator instructor is extremely important in promoting learning transfer. The theoretical background of the thesis emphasizes the need for highly competent instructors who not only master the technical system but also understand pedagogy. The instructor should act as a facilitator of the learning process, providing individual feedback and guidance. Group discussions and peer assessment with colleagues are also important learning methods. The empirical results of the survey confirm the instructor's importance; respondents rated the instructor's role as very important in achieving transfer effect. It has been specifically suggested that the presence of an experienced captain with in-depth experience with the vessel type being handled (e.g., pod vessels) on the simulator bridge during exercises would be extremely beneficial. This would increase social fidelity and provide trainees with the opportunity to learn real working methods and cognitive strategies directly from an experienced expert. The instructor's ability to adjust the pace and complexity of the exercise according to the student's level is also pedagogically beneficial in supporting learning.

Since unlearning is a core part of the learning process when transitioning to a new propulsion system, simulator training must actively support this process. The survey inquired how challenging unlearning old habits was and what teaching method helped most with unlearning and how important the instructor's support was in this process. The simulator is an ideal environment for unlearning because it allows for safe experimentation and making mistakes. As a development proposal, it is suggested that training design must explicitly identify and consider the challenges of unlearning, and exercises and guidance should be designed to systematically help students identify and replace old, detrimental habits with new, effective ways. Instructors have a critical role here in providing feedback specifically related to unlearning.

Maximizing the transfer of learning in simulator training requires a comprehensive approach that brings together theoretical insights into learning and unlearning with practical observations from real training environments. The findings of this study, supported by both theoretical frameworks and survey responses, highlight several interconnected areas that contribute to more effective training outcomes.

One important aspect is ensuring that learners have ample opportunities for hands-on simulator practice, with enough repetition to reinforce new skills and support the unlearning of outdated habits. Scenario design also plays a crucial role. Rather than focusing solely on achieving high technical fidelity, scenarios should be aligned with real-world tasks in a way that reflects functional congruence. This means that the actions learners take during training should clearly relate to the skills they need in actual operations, guided by well-defined and learner-centred objectives.

The role of the instructor is equally vital. Instructors must combine deep technical knowledge with strong pedagogical skills to effectively support learners. Their ability to provide timely, individualized feedback and guidance is especially important when learners are working through the challenges of unlearning previous practices. The involvement of experienced professionals, such as captains, in simulator sessions can further enhance the relevance and authenticity of the training experience.

Supporting the unlearning process is not a peripheral concern but a central component of helping experienced mariners adapt to new systems and procedures. Training programs that acknowledge and actively address this process are more likely to succeed in fostering lasting skill development.

By integrating these elements into simulator training, the maritime sector can significantly enhance the effectiveness of its educational programs. This will help ensure that the skills acquired during training are not only retained but also successfully applied in real-world vessel operations. Such improvements contribute to higher safety standards, better energy efficiency, and more environmentally sustainable practices. While the survey results confirm that simulators already play a key role in supporting learning transfer, the targeted enhancements identified in this study offer a clear path toward even greater impact.

9 Conclusion

This Master's thesis aimed to investigate how the transfer effect of learning can be enhanced within maritime education, particularly focusing on the experiences of experienced deck officers adapting to a new, innovative azimuth propulsion system. This adaptation process involved not only acquiring new navigation skills but also the challenging process of unlearning established, previously learned knowledge and methods. The study explored the role of ship simulators in creating realistic and safe environments to facilitate the practice of various operational scenarios during this transition.

The study's empirical evidence, based primarily on a survey answered by five experienced deck officers undergoing this transition, confirmed a key finding: simulators are crucial in strengthening the transfer effect of learning. This enhancement of learning transfer is considered instrumental in promoting higher safety standards, improved energy efficiency, and environmentally sustainable practices in vessel operations.

Experienced deck officers transitioning to azimuth propulsion who participated in the study provided valuable insights into simulator characteristics and their impact on the learning and unlearning process. Simulator realism and characteristics were considered important factors. While simulator scenarios were perceived as relatively realistic compared to the actual vessel, respondents expressed a clear desire for several improvements to enhance realism and thus improve training outcomes. The theoretical background emphasizes that high technical realism alone does not necessarily guarantee good transfer; instead, pedagogical choices, such as scenario design and instructor actions, have a greater impact. Functional similarity – the simulator's ability to replicate the behavior of real operations – is considered particularly important for transfer.

The study emphasized the critical importance of unlearning – the modification or discarding of previously learned knowledge and behaviors that are now interfering. The survey confirmed that the unlearning process involves challenges and that previously learned techniques can indeed interfere with new learning (negative transfer). The theoretical discussion recognizes the difficulty of unlearning and the consequences of an incomplete unlearning process, such as cognitive dissonance and mental confusion when new information conflicts with old, which can particularly hinder transfer. The emotional and psychological aspects of unlearning are also acknowledged, as it can be a challenging and uncomfortable process potentially involving questioning one's competence. However, one respondent stated that they personally do not wish to "unlearn" anything but prefer to retain their knowledge of handling conventional vessels and learn new things through repetition. Feedback is also key in the unlearning process, helping to identify and correct errors and reinforce the unlearning of incorrect practices.

The teaching and learning methods perceived as effective in the survey, such as practical exercises and simulations, received strong support. Simulator training was considered effective in improving the transfer effect relative to the time spent on it. Respondents felt that the training improved their ship handling skills, decision-making in real situations, and their ability to handle the vessel under pressure. The learning theories based on behaviorism, cognition, and constructivism mentioned in the theoretical part provide a basis for instructional design. For instance, experiential learning theories emphasize the significance of practical experience and reflection, while constructivist theories highlight the importance of collaboration, social interaction, and the role of feedback in the learning process and constructing new knowledge. The amount of practice and repetition emphasized by the respondents, was considered important for both unlearning old habits and learning new skills. Suggestions for improvement clearly mentioned "more practical simulator driving" and "more frequent exercises."

The role of the instructor was also identified as crucial for the transfer effect of learning. The instructor's expertise, skills, and personal qualities (such as communication and positive attitude) significantly influence the learning process and transfer. Respondents to the survey expressed a desire for an experienced captain (with azimuth experience) to be present on the simulator bridge during exercises, suggesting the potential of mentoring to enhance effectiveness.

It is important to remember that the study's small sample size (n=5) significantly limits the generalizability of the results to the broader maritime industry. The findings primarily reflect the subjective experiences of this limited group. Transfer requires learners to be able to apply knowledge and skills flexibly in different situations. Overcoming cognitive biases and rigidities that can prevent the acceptance and application of new knowledge in different contexts is a challenge. Instructional strategies that promote active participation and reflection are essential for enhancing transfer. Similarity between the original learning context and the target context significantly influences positive transfer. Metacognitive thinking – awareness of one's own learning processes and strategies – is essential for effective transfer.

In summary, this study supports the view that ship simulators play a vital role in enhancing the transfer effect of learning for experienced maritime professionals adapting to new technologies. This study highlights that unlearning – the process of modifying or discarding previously learned, now interfering, knowledge and behaviors – is a critical, albeit challenging, part of this transition. The results suggest that further development of simulator technology and refinement of pedagogical approaches, including leveraging experienced instructors and incorporating user-desired features, can further optimize the effectiveness of simulator-based maritime education, contributing to safer and more sustainable operations at sea. The study presents theoretical perspectives and practical recommendations aimed at developing simulator-based training models in the maritime sector. Careful training and scenario design that emphasizes functional similarity, as well as effective teaching methods such as practical exercises, feedback, and discussion, are key to enhancing transfer. It is also important to recognize the significance of the instructor's role and expertise, address the challenges of unlearning, and ensure sufficient repetition and practice.

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Appendix 1: Transfer effect of learning survey 20241016

Överföringseffekten av det inlärda, enkät 2024 oktober 16102024

12.03.2025, 18:46

Transfer effect of learning, survey 2024 October.

16102024

Report

First answer	16.10.2024, 16:45
Last answer	23.10.2024, 09:11

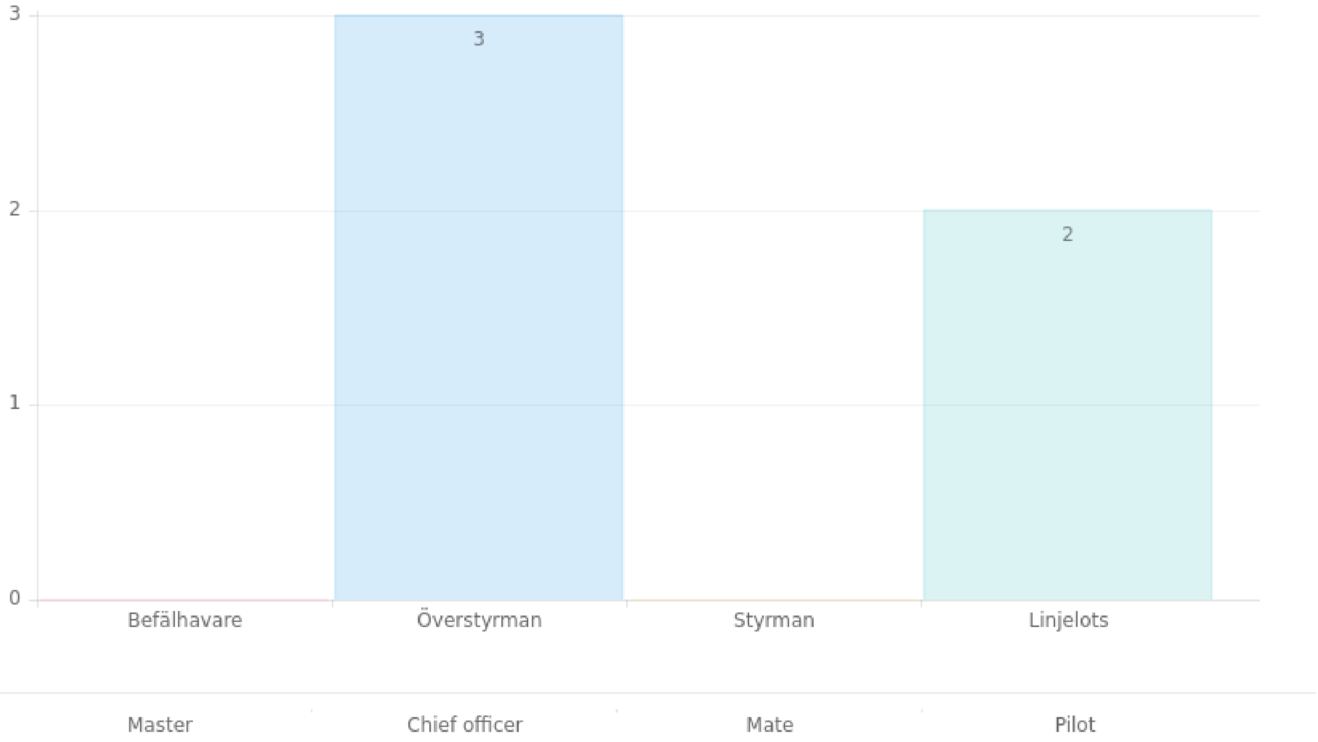
Info

Name	Överföringseffekten av det inlärda, enkät 2024 oktober 16102024 Transfer effect of learning, survey 2024 October 16102024
Subject	Överföringseffekten av det inlärda, enkät 2024 oktober 16102024 Transfer effect of learning, survey 2024 October 16102024
Release date	16.10.2024, 10:00
Expiry date	23.10.2024, 23:59
Total questions	29
Total responses	5

Answers

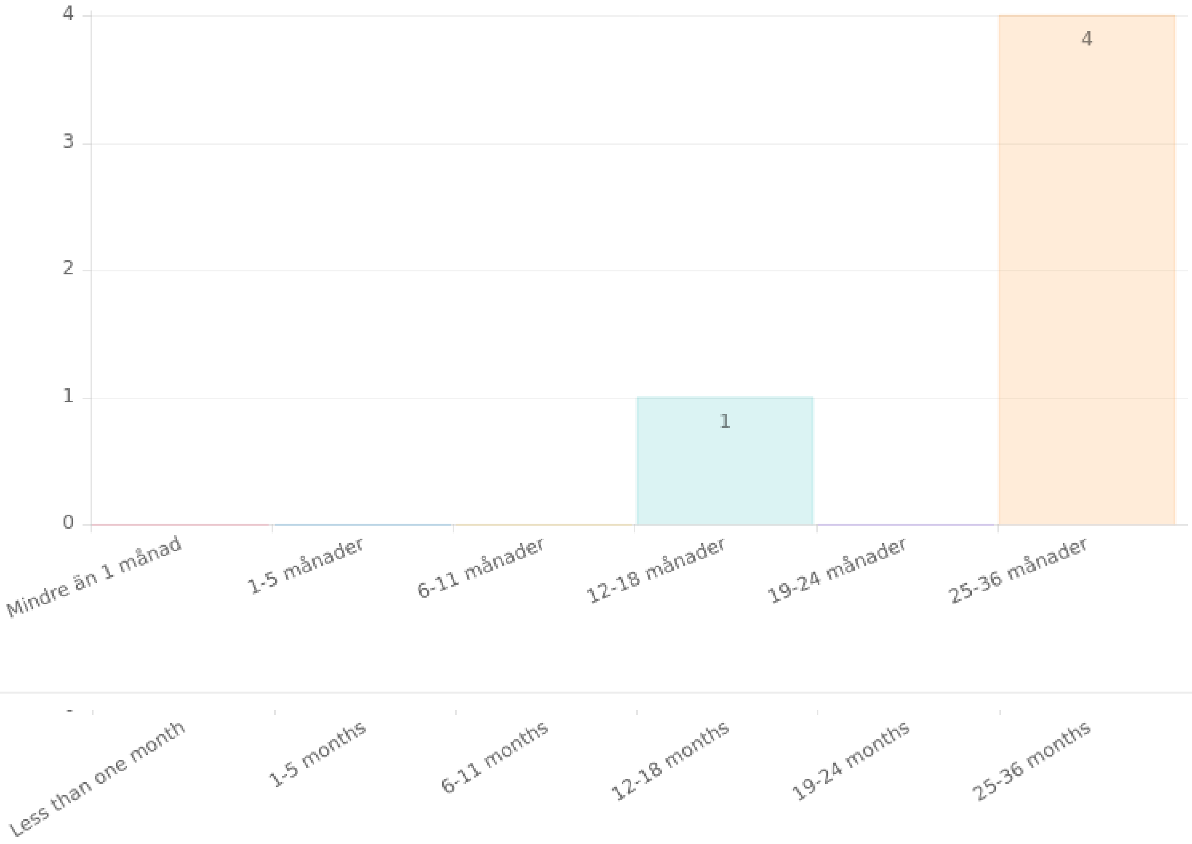
1. Vad är din primära arbetsuppgift på XXXXXXXX?
What is your primary duty onboard XXXXXXXX?

Question type	Drop down list
Total responses	5



2. Hur många månader har du arbetat som styrman på XXXXXXXX?
How many months have you worked as a deck officer onboard XXXXXXXX?

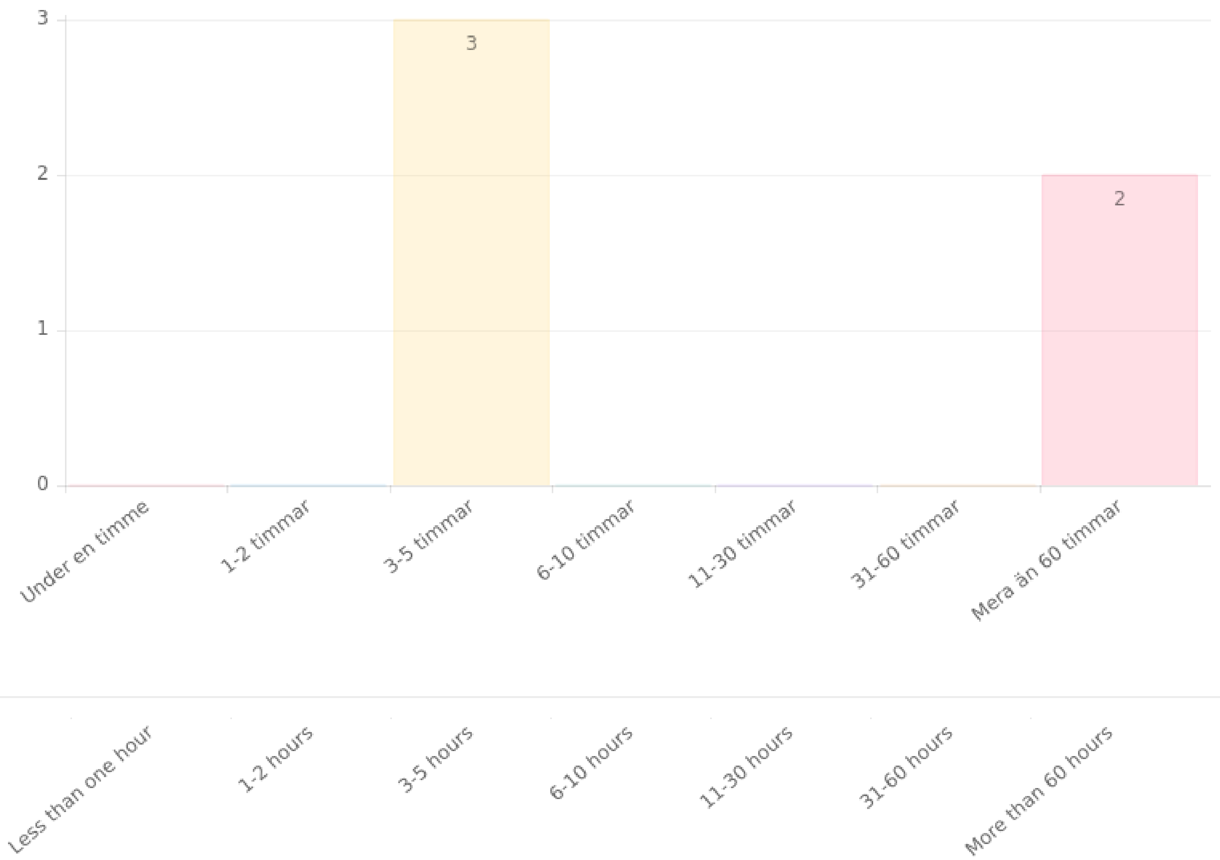
Question type	Drop down list
Total responses	5



3. Hur många timmar i genomsnitt navigerar du fartyget under en 7-dagarsperiod under din arbetsperiod ombord?

How many hours on average do you navigate the ship over a 7-day period during your working period on board?

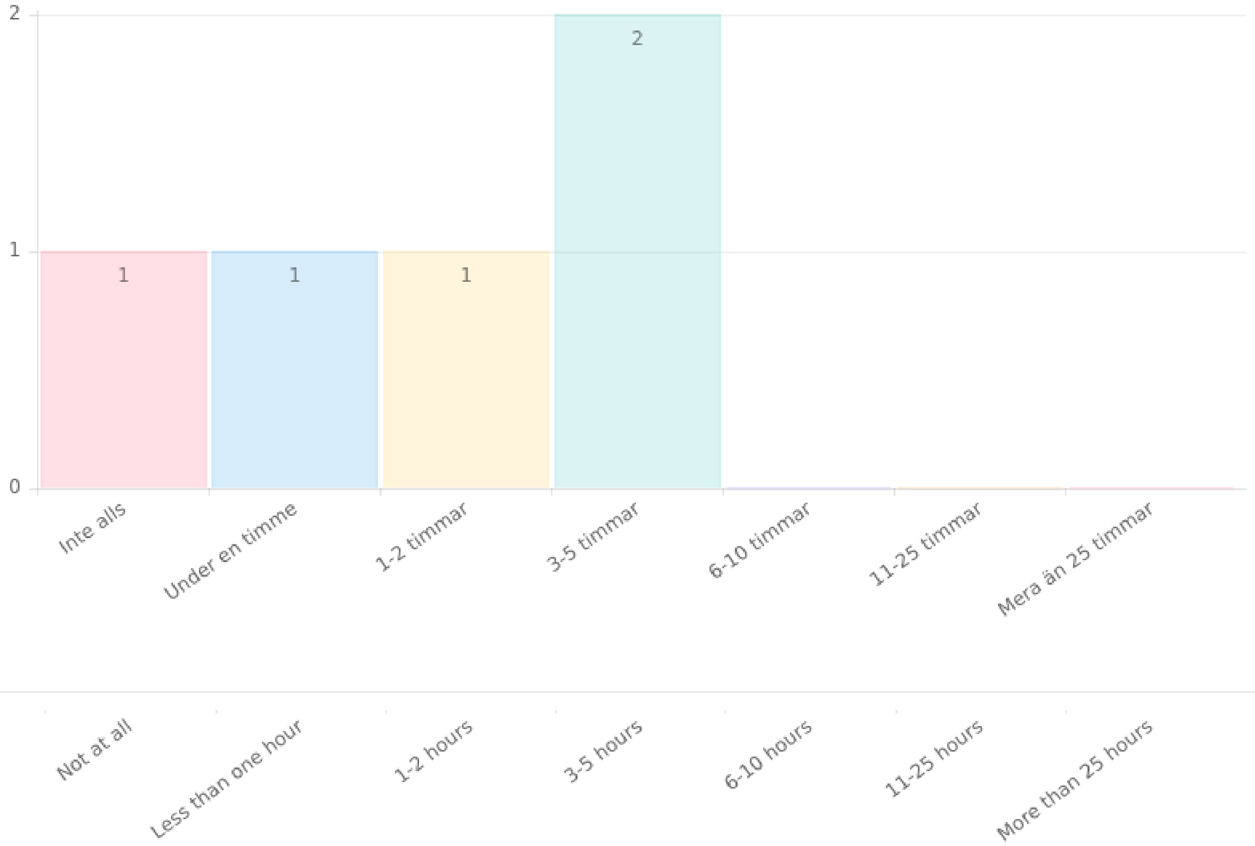
Question type	Drop down list
Total responses	5



4. Hur många timmar i genomsnitt manövrerar du ett fartyg i samband med ankomster till och avgångar från hamnen under en 7-dagars arbetsperiod ombord?

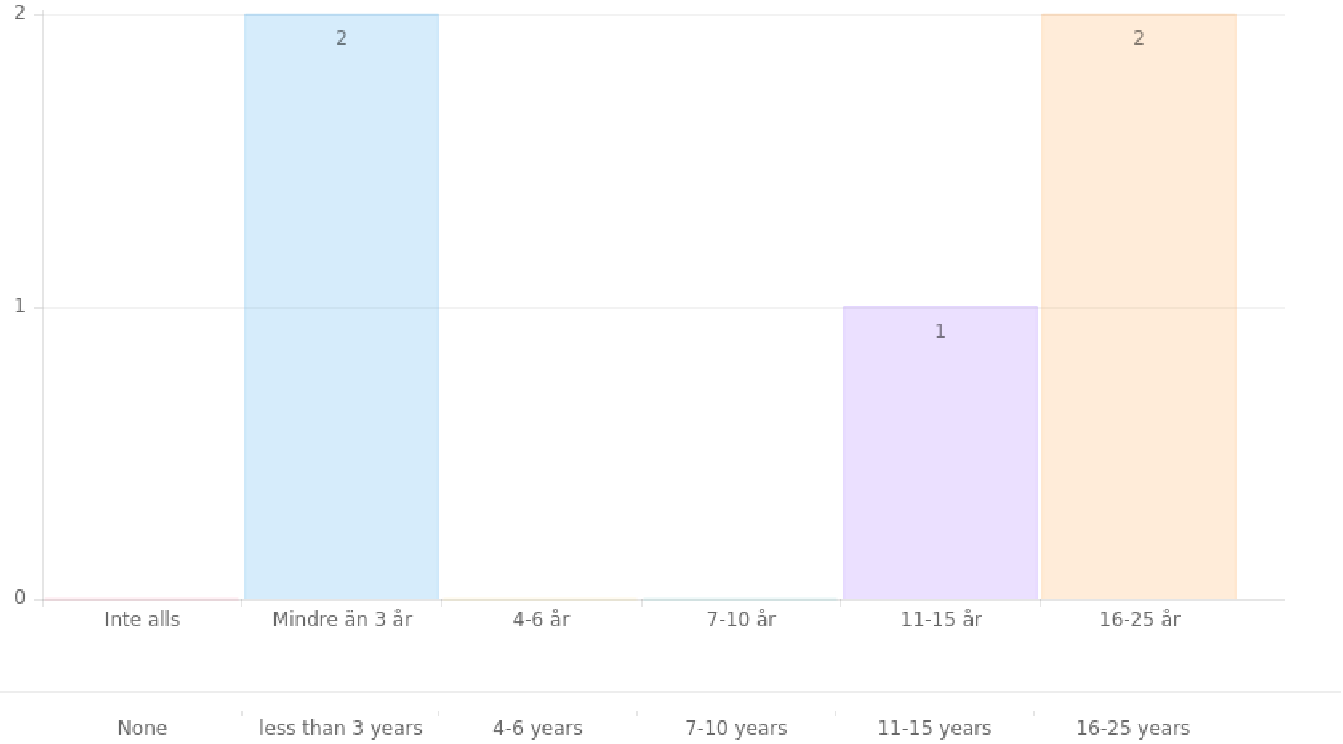
How many hours on average do you manoeuvre a ship in connection with arrivals to and departures from the port during a 7-day working period on board?

Question type	Drop down list
Total responses	5



5. Hur många år har du arbetat på andra passagerarfartyg innan du gick över till XXXXXXXX?
How many years have you worked on other passenger ships before you moved to XXXXXXXX?

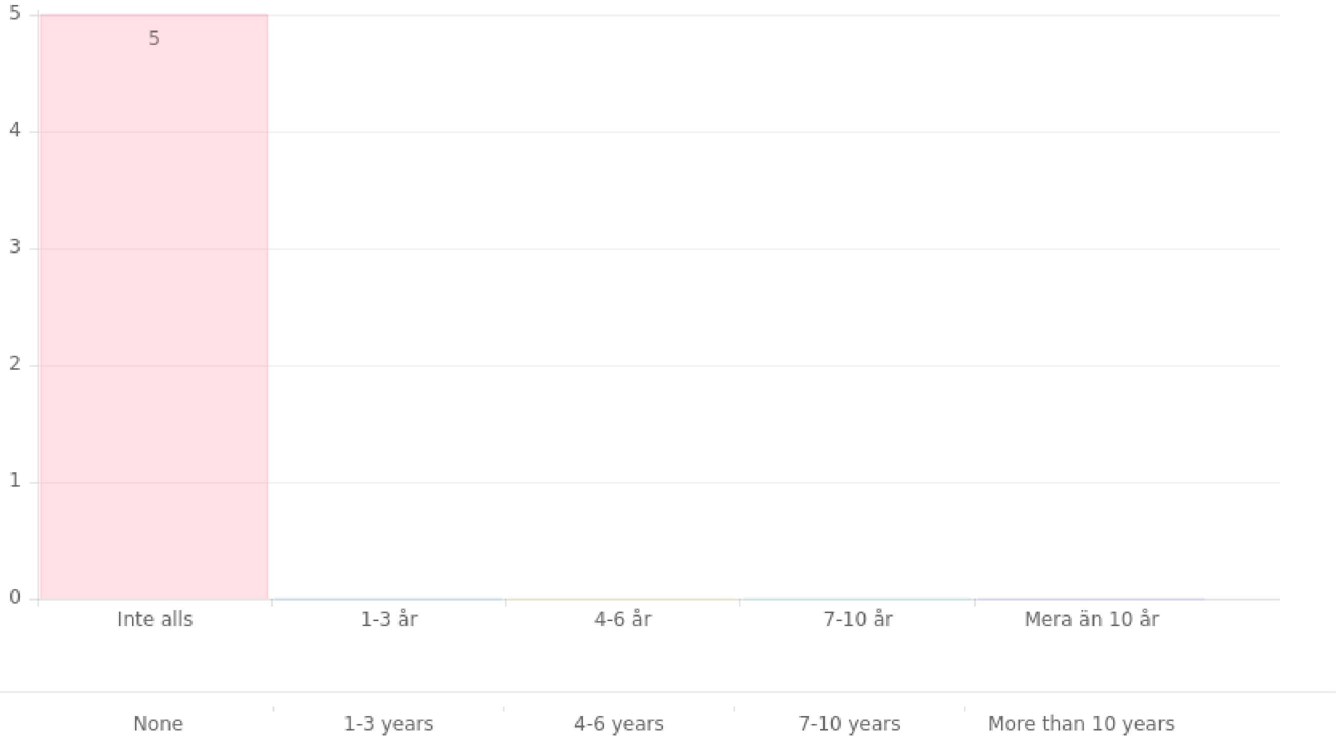
Question type	Drop down list
Total responses	5



6. Hur många år har du arbetat på ett fartyg med azimuth propulsion innan du gick över till XXXXXXXX?

How many years have you worked on a ship with azimuth propulsion before you moved to XXXXXXXX?

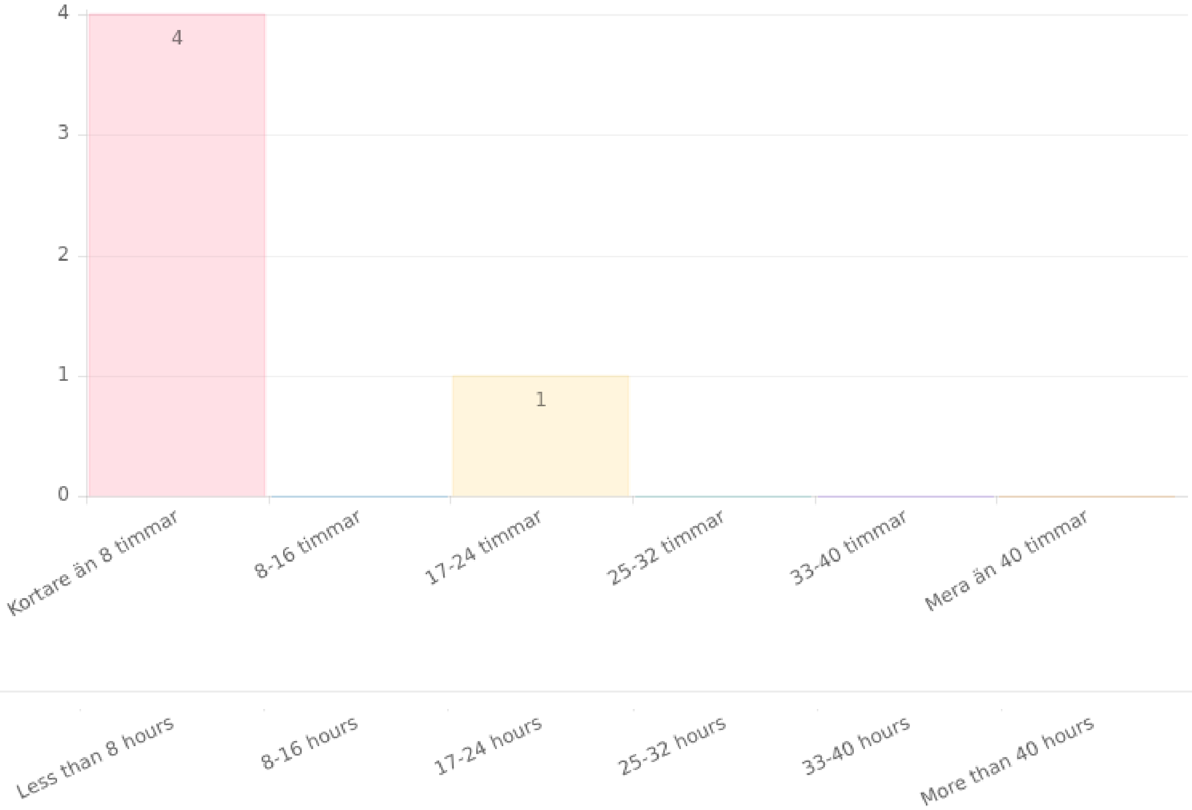
Question type	Drop down list
Total responses	5



7. Om du har deltagit i manövreringsutbildningen på ett fartyg som är utrustat med azimuth propulsion system i ett annat utbildningscenter än Aboa Mare, hur många timmar tog utbildningen?

If you have participated in the ship handling training of a vessel equipped with azimuth propulsion system in other training center than Aboa Mare, how many hours did the training take?

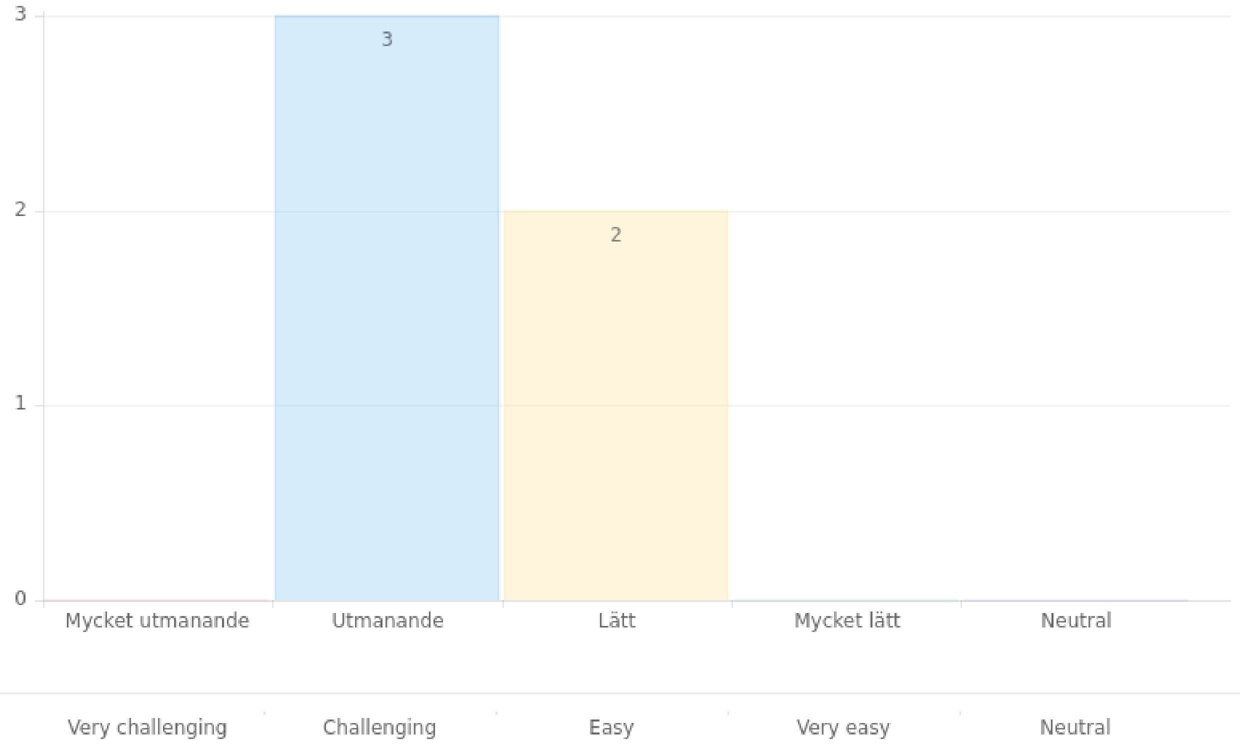
Question type	Drop down list
Total responses	5



8. Hur utmanande tyckte du att det var att avlära konventionella manövreringssätt och - tekniker (axelpropellrar, roder och tunnelpropellrar) medan du lärde dig att hantera ett fartyg utrustat med azimuth propulsion?

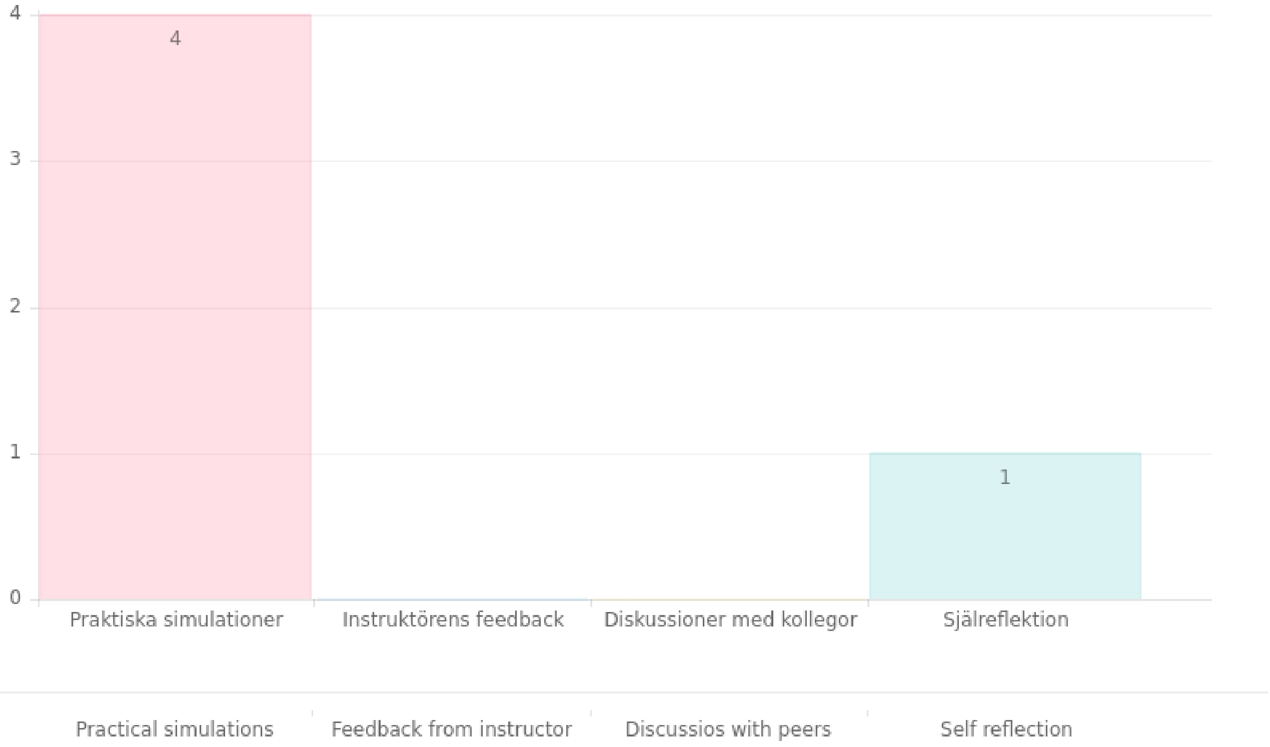
How challenging did you find it to unlearn conventional ship handling techniques (shaft propellers, rudders, and tunnel thrusters) while learning to handle a ship equipped with azimuth propulsion?

Question type	Drop down list
Total responses	5



9. Vilken specifik utbildningsrelaterade teknik hjälpte dig mest med att avlära?
What specific teaching-related methodology helped you the most in unlearning?

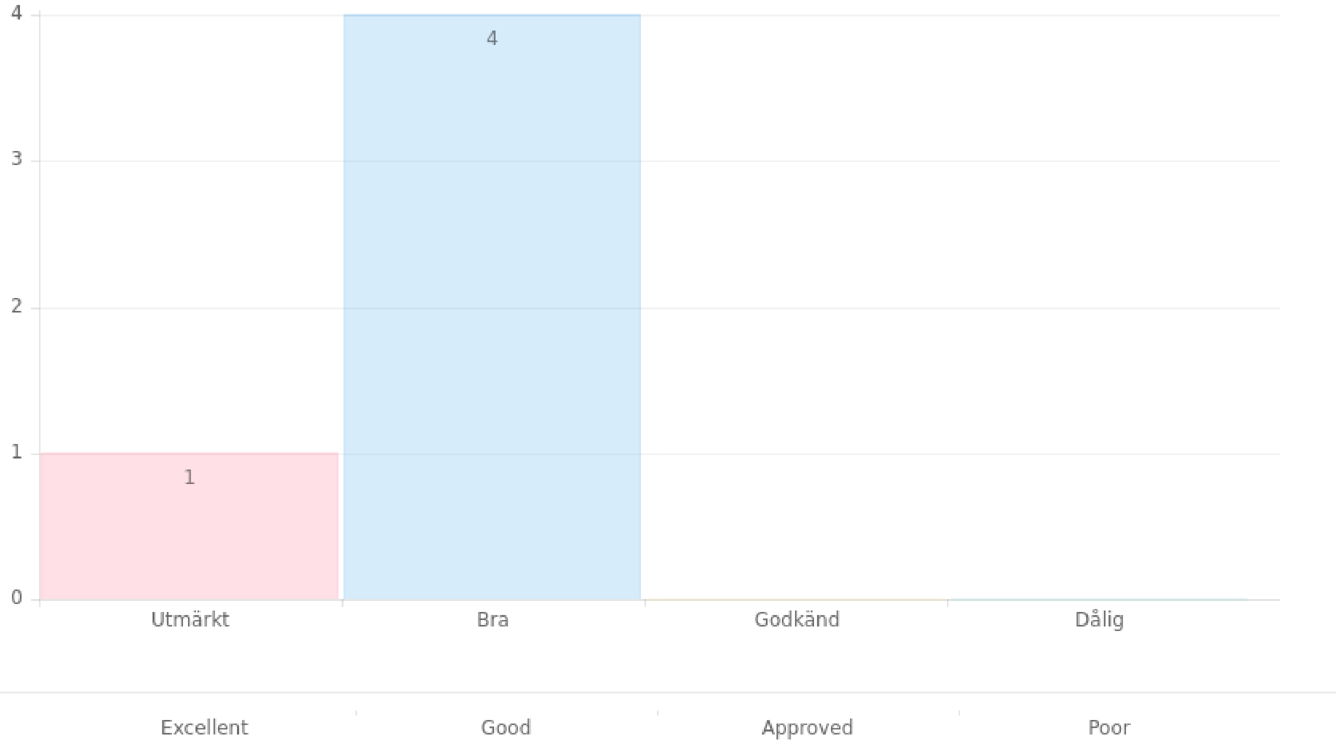
Question type	Drop down list
Total responses	5



10. Hur skulle du betygsätta kursens struktur för att underlätta övergången från konventionell till azimuth propulsion?

How would you rate the structure of the course to facilitate the transition from conventional to azimuth propulsion?

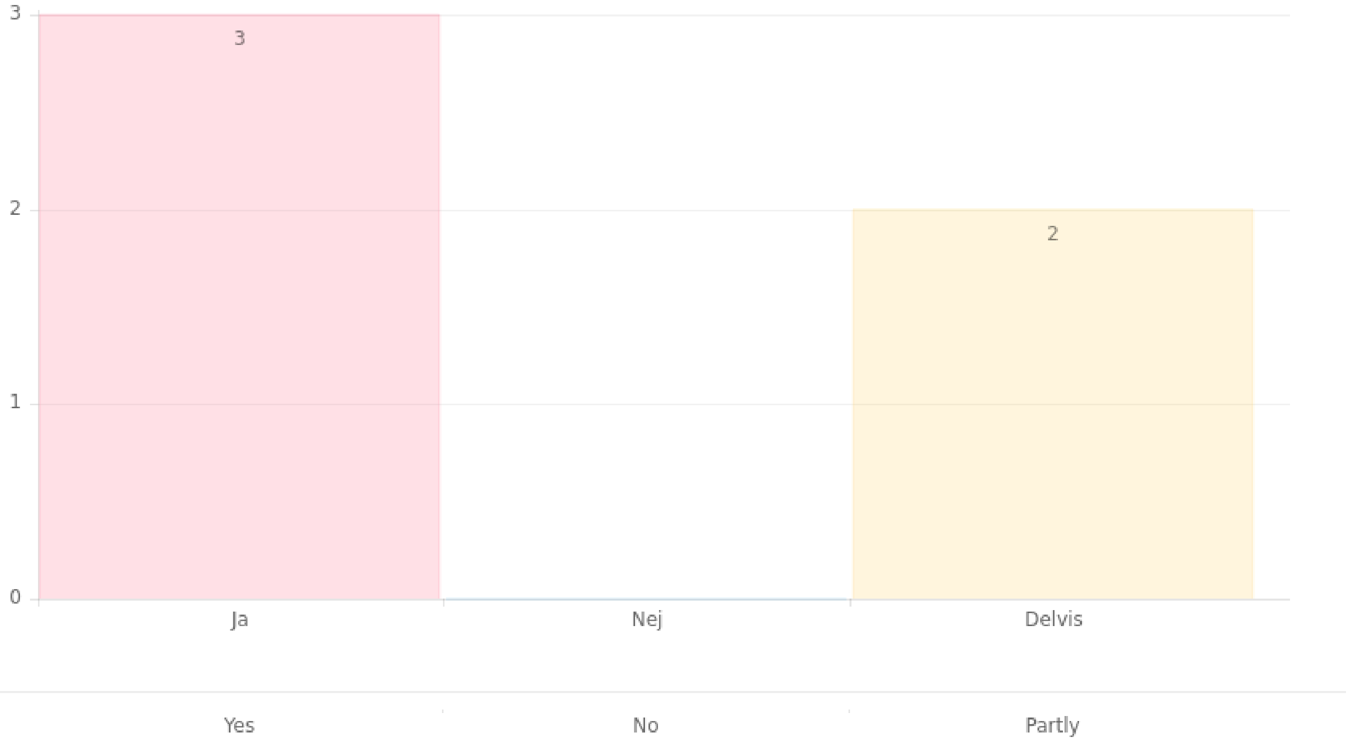
Question type	Drop down list
Total responses	5



11. Var balansen att avlära konventionella tekniker och att lära sig azimuth propulsion lämplig under simulatorkursen?

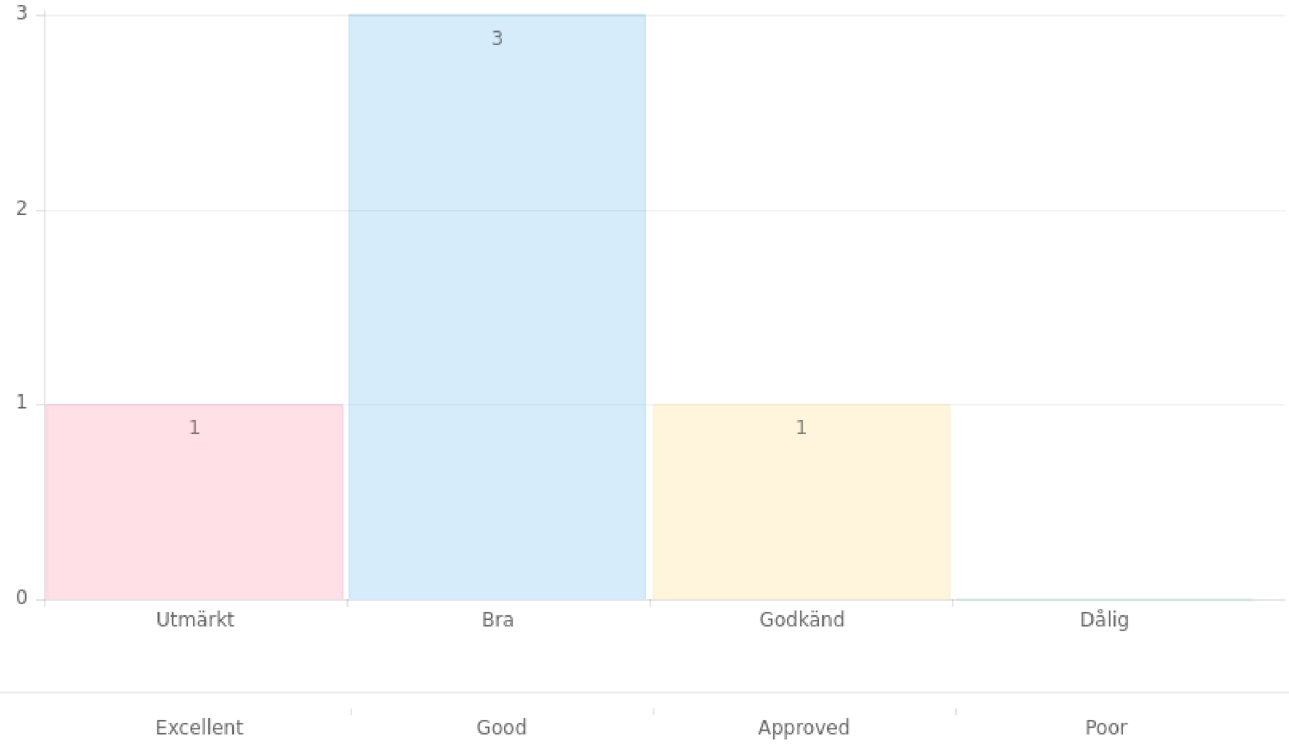
Was the balance of unlearning conventional techniques and learning azimuth-propulsion appropriate during the simulator course?

Question type	Drop down list
Total responses	5



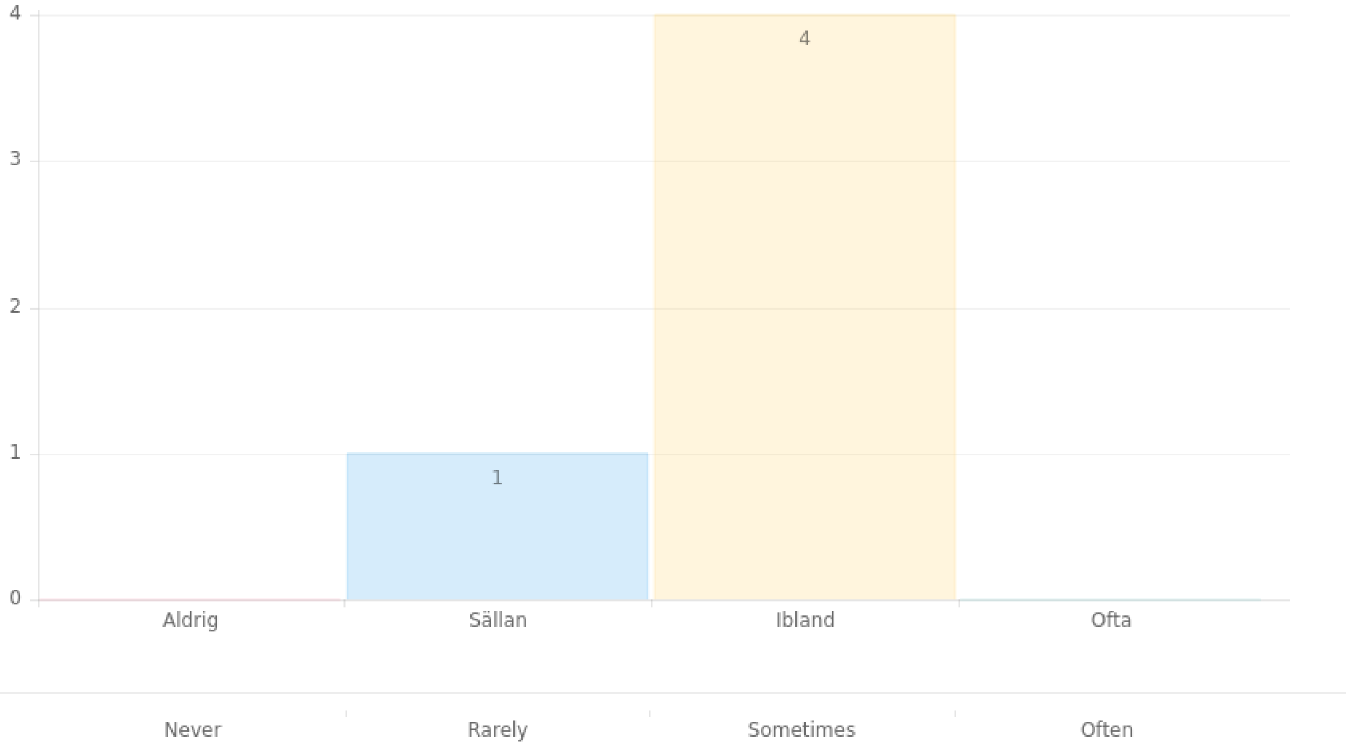
12. Hur skulle du betygsätta stödet från instruktörerna under avlärningsprocessen?
How would you rate the support provided by the instructors during the unlearning process?

Question type	Drop down list
Total responses	5



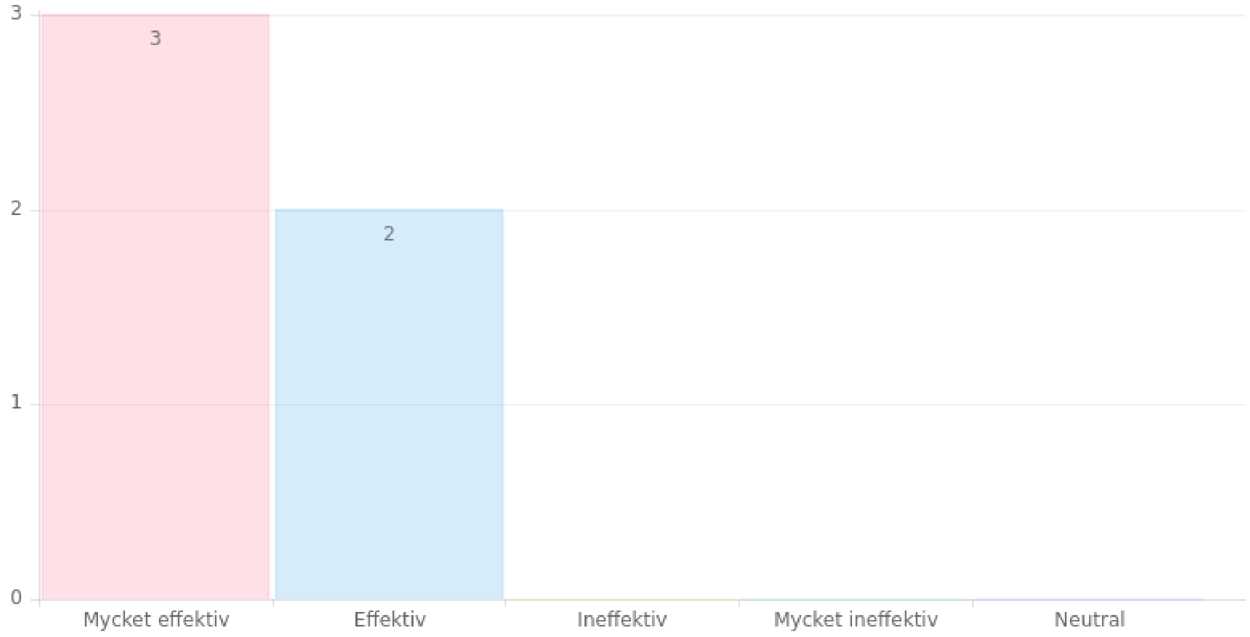
13. Hur ofta kom tidigare lärt manövreringssätt och -tekniker fram och störde avlärningen?
How often previously learned ship handling skills and techniques interfered with unlearning?

Question type	Drop down list
Total responses	5



14. Hur upplever du att simulatorträningen förbättrar din färdighet i fartygshantering?
How do you feel that simulator training improves your skill in ship handling?

Question type	Drop down list
Total responses	5

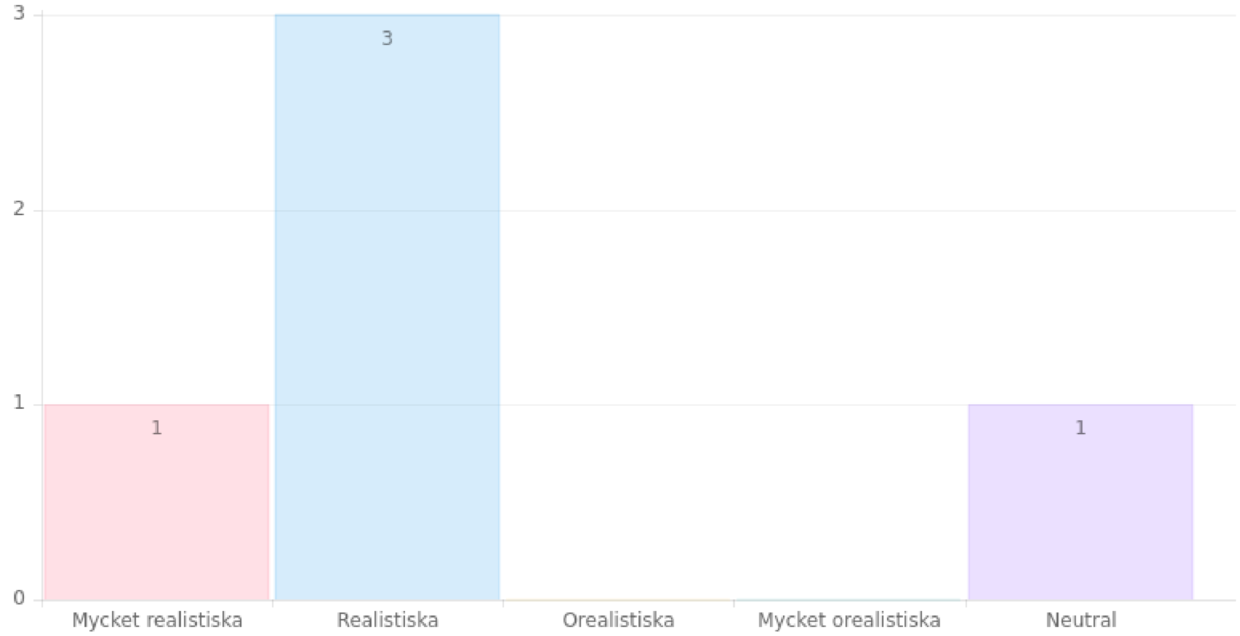


Very effective	Effective	Ineffective	Very ineffective	Neutral

15. Hur realistiska tyckte du att scenarierna som användes i simulatorträningen var jämfört med XXXXXXXX?

How realistic did you think the scenarios used in the simulator training were compared to XXXXXXXX?

Question type	Drop down list
Total responses	5



Very realistic | Realistic | Unrealistic | Very unrealistic | Neutral

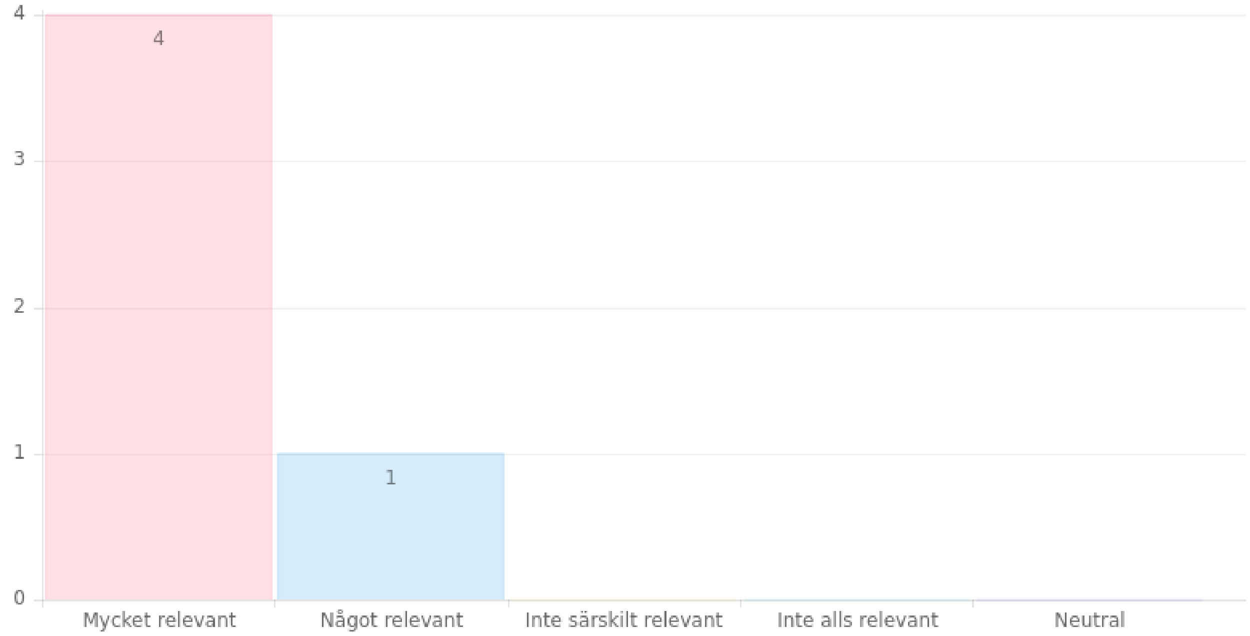
16. Vilket av följande alternativ tyckte du mest störde inlärningen av nya färdigheter under simulatorutbildningen?

Which of the following options did you think most interfered with the learning of new skills during simulator training?

Question type	Drop down list
Total responses	5

17. Hur väl kursens innehåll motsvarade dina uppgifter ombord?
How well did the course content correspond to your ship handling duties onboard?

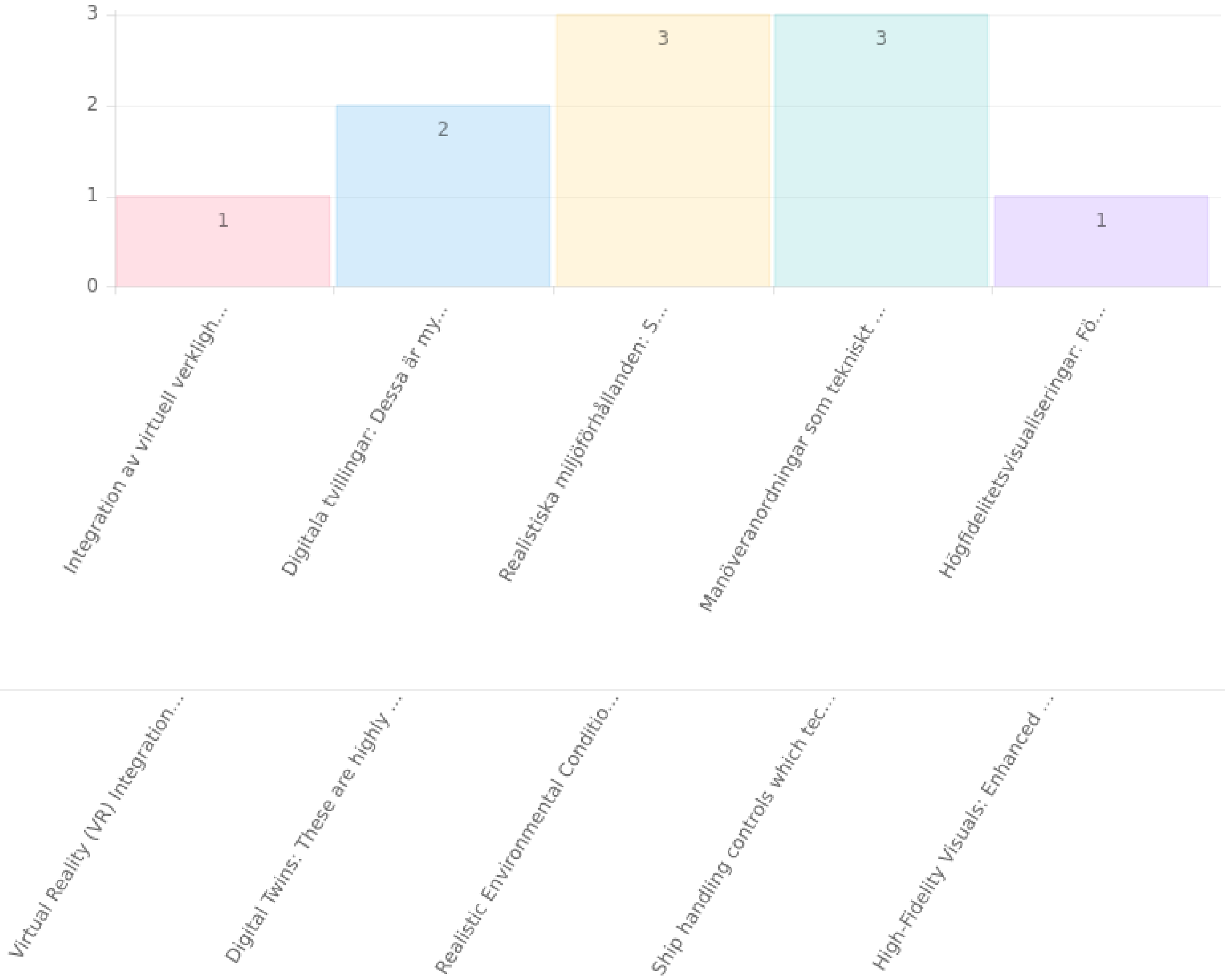
Question type	Drop down list
Total responses	5



18. Vilka funktioner eller egenskaper skulle du vilja se i fartygshanteringssimulatorer för att förbättra träningsresultaten?

What specific features or characteristics would you like to see in ship handling simulators to improve training results?

Question type	Multiple choice
Total responses	10



19. Beskriv med några ord hur du skulle ändra simulatorträningen för att uppleva ”avlärningsprocessen” tydligare.

In a few words, describe how you would change the simulator training in order to experience "unlearning process" more clearly.

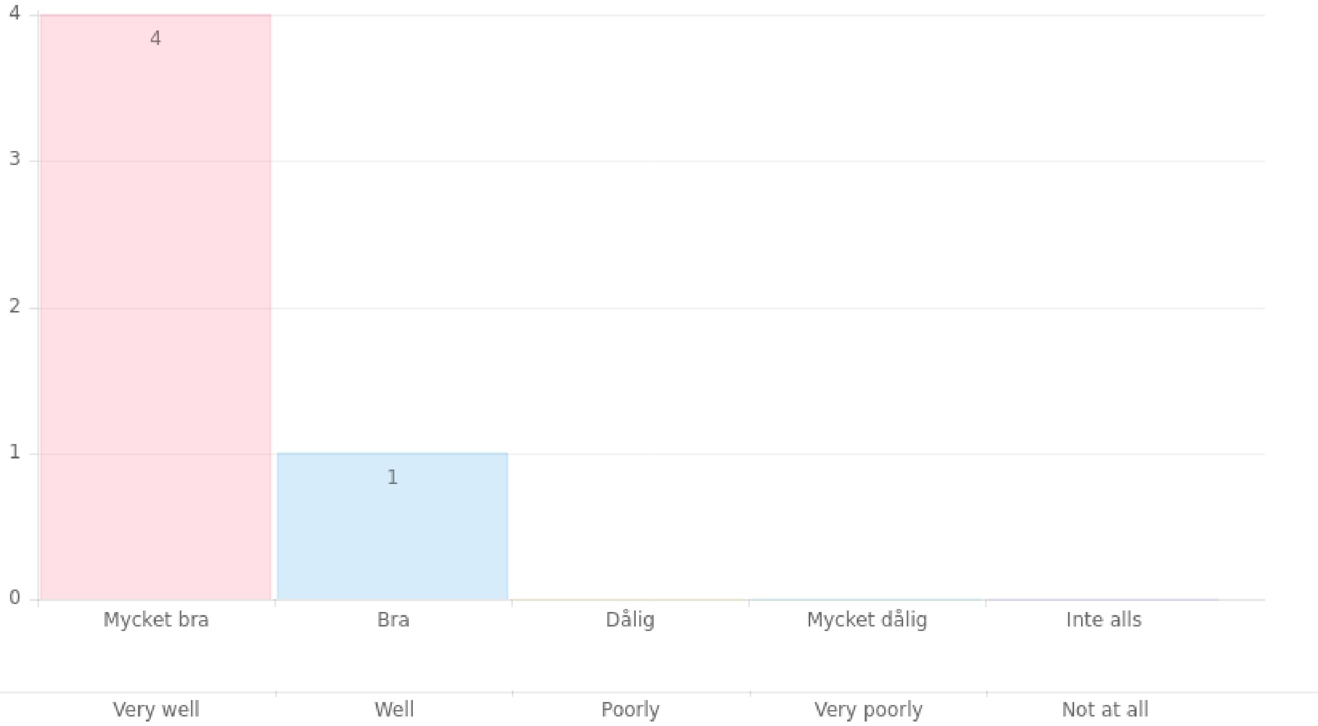
Question type	Open answer
Total responses	
Answers	

#ID	Answer
1836726	
1837098	
1837188	
1840590	Personligen vill jag inte avlära mig något, håller gärna kvar min lärdom om hur manövrear konventionellt fartyg. Dock lär jag mig alltid gärna nytt, och det gör man bäst med repetition. Så mera körning i simulatorn och sen in real life. Personally, I don't want to unlearn anything, I'd be happy to retain my knowledge and skills about manoeuvring conventional ships. However, I always like to learn new things, and this is best done with rehearsal. So, more driving in the simulator and then in real life.

20. Hur väl har du kunnat tillämpa de kunskaper och färdigheter som du lärt dig i simulatorträningen i ditt arbete ombord på fartyget?

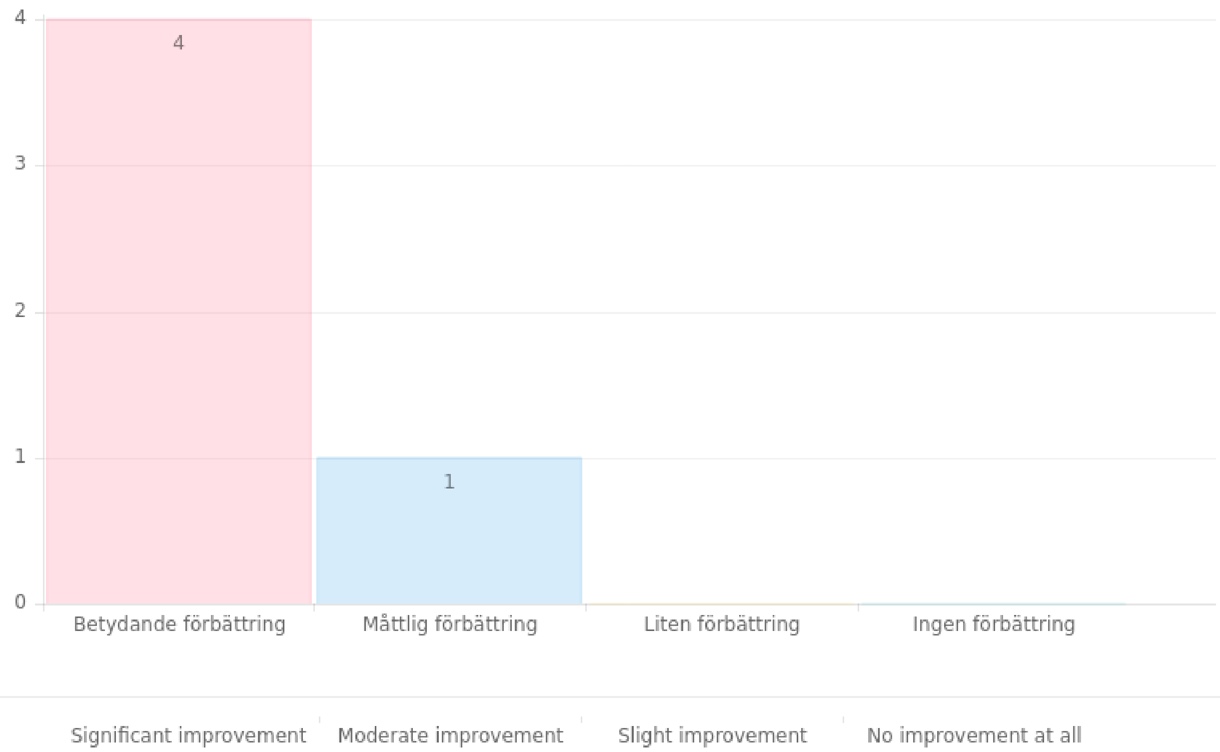
How well have you been able to apply the knowledge and skills learned in simulator training to your work on the ship?

Question type	Drop down list
Total responses	5



21. Har du märkt någon förbättring i din fartygshantering efter träningen?
Have you noticed any improvement in your ship handling performance after training?

Question type	Drop down list
Total responses	5



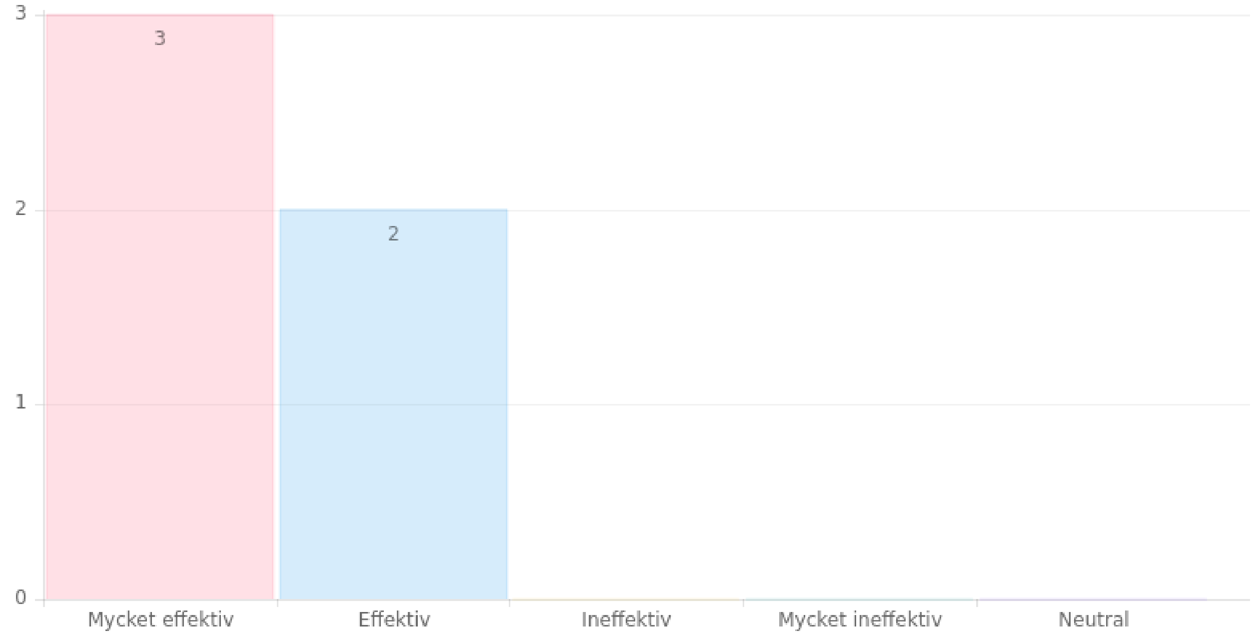
22. Vilka förbättringar tycker du kan göras på simulatorer för att öka överföringen av lärande?
What improvements do you think can be made on simulators to improve the transfer of learning?

Question type	Multiple choice
Total responses	11
Answers	**#ID** **Answer**

23. Hur effektiv anser du att simulatorträning är för att förbättra överföringseffekten till verkligheten i förhållande till den tid som spenderas på simulatorträning?

How effective do you consider simulator training to be in improving the transfer effect to reality relative to the time spent on simulator training?

Question type	Drop down list
Total responses	5

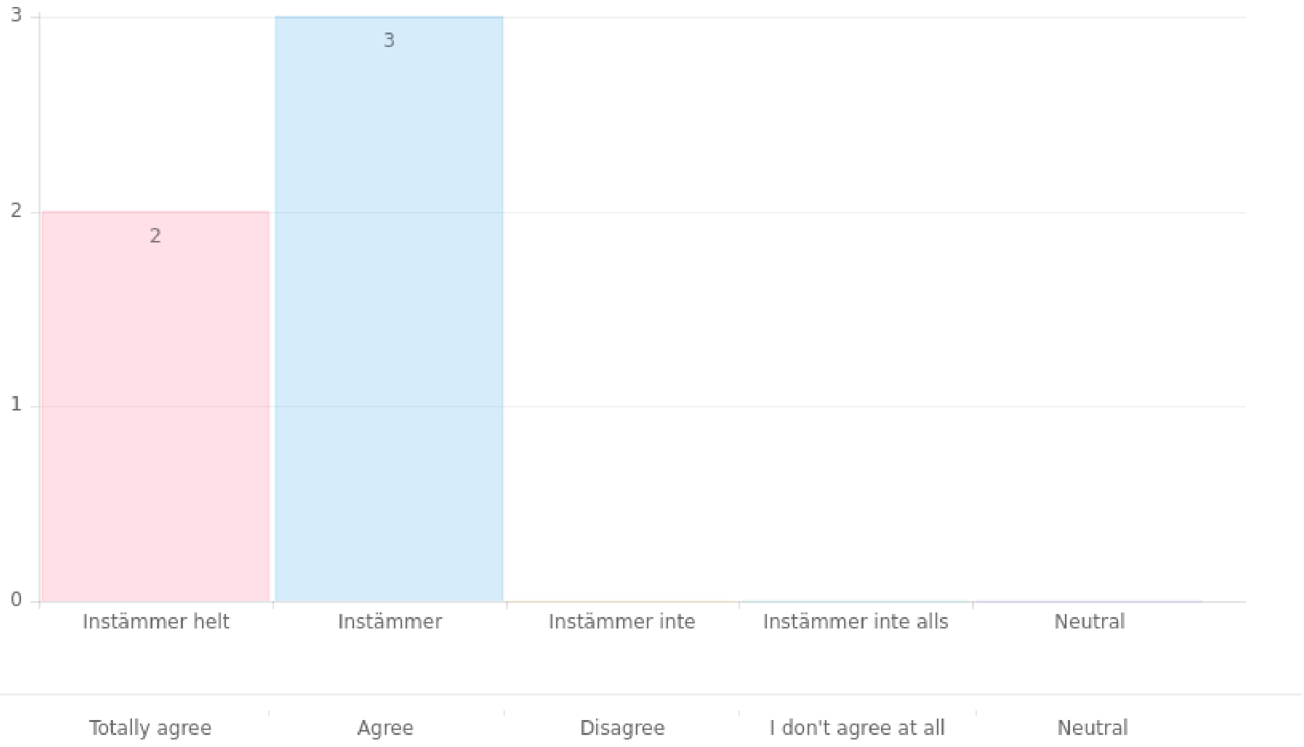


Very effective	Effective	Ineffective	Very ineffective	Neutral

24. Känner du att simulatorträning har förbättrat din beslutsfattande i verkliga fartygshantering?

Do you feel that simulator training has improved your decision making in real ship handling?

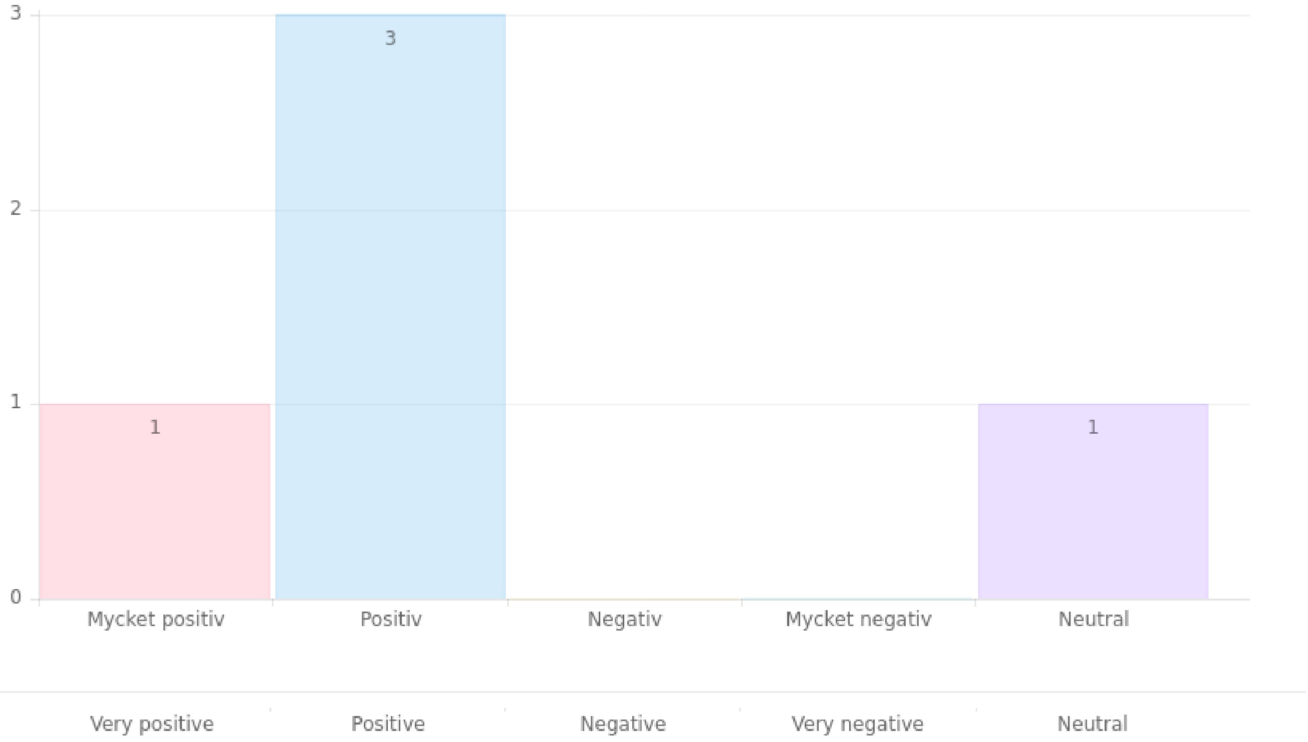
Question type	Drop down list
Total responses	5



25. Hur känner du att simulatorträning har påverkat din förmåga att hantera fartyget under potentiell arbetsrelaterad press?

How do you feel simulator training has affected your ability to handle the ship under potential work-related pressure?

Question type	Drop down list
Total responses	5

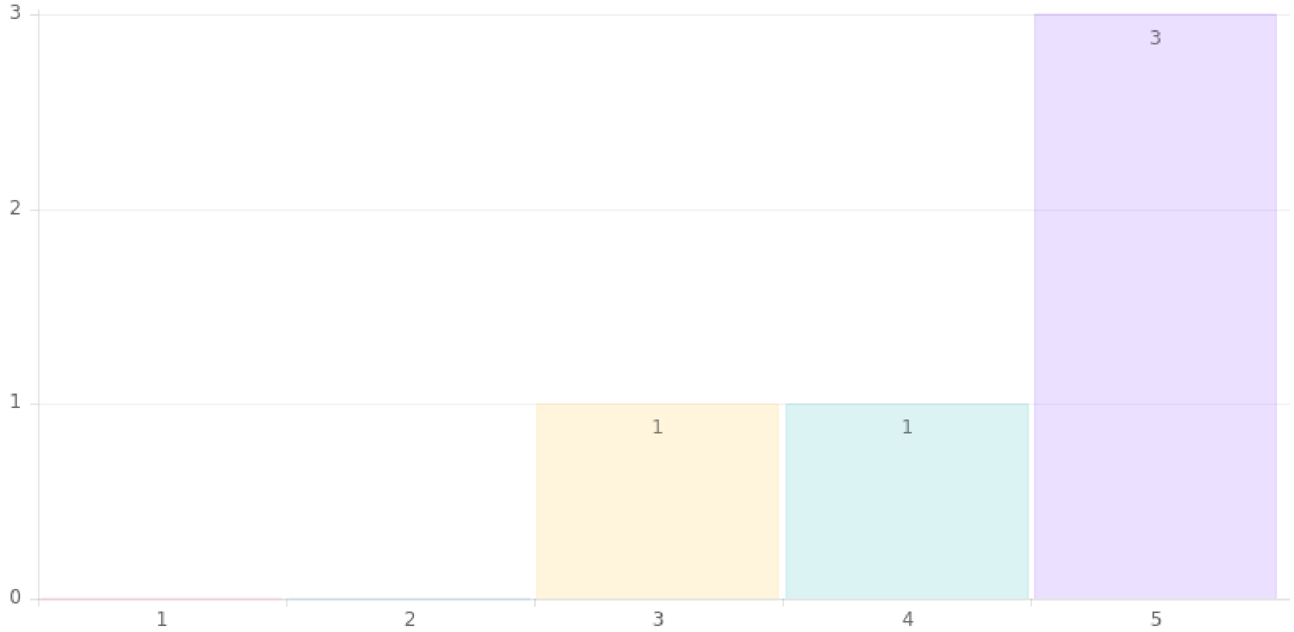


26. Hur skulle du bedöma att följande undervisningstekniker har haft betydelse för att uppnå en positiv inlärningsöverföring efter att du har gått simulator fartygshanteringsutbildning?

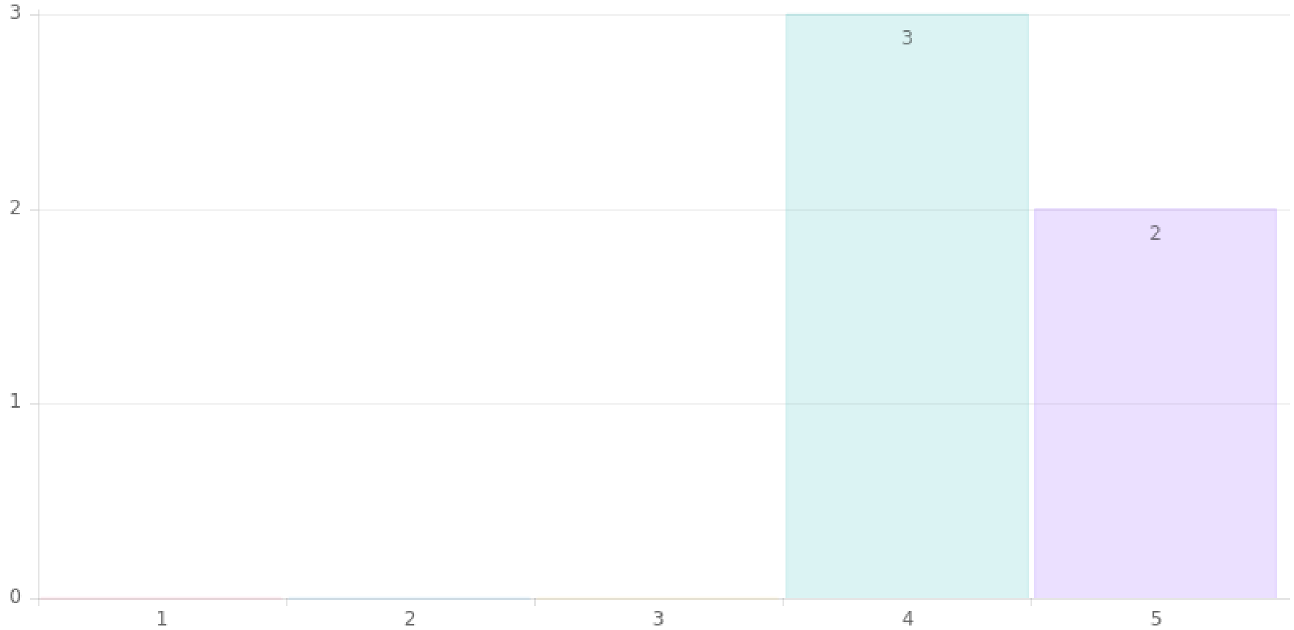
How would you assess that the following teaching techniques have had significance in achieving a positive learning transfer after you have completed simulator ship handling training?

Question type	Multi-line scoring
Total responses	25

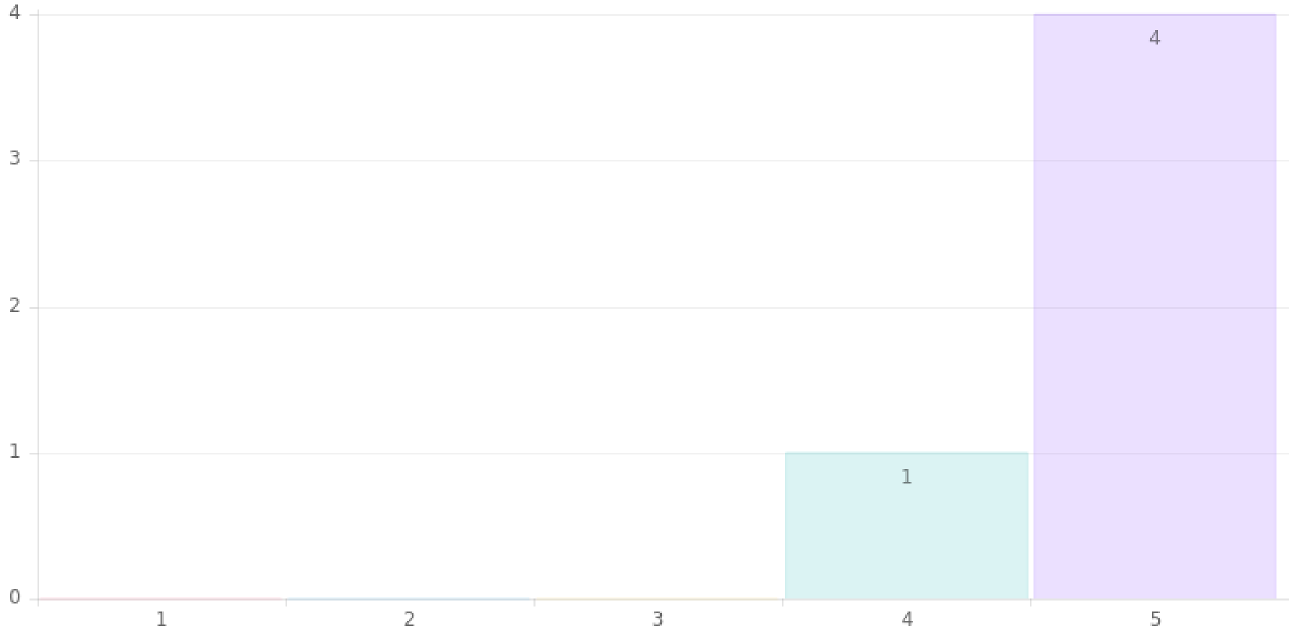
Individuell feedback och handledning. Individual feedback and supervision.



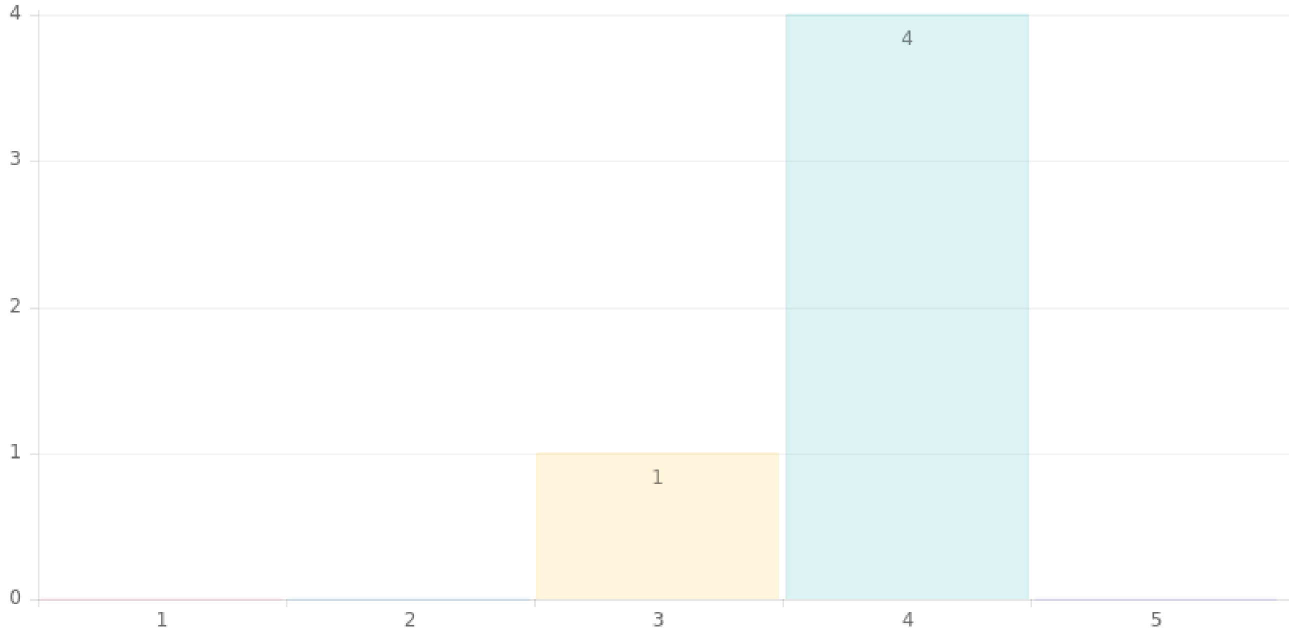
Gruppdiskussioner med kollegor. Group discussion and peer assessment.



Praktiska övningar och simuleringar. Practical exercises and simulations.



Teoretiska föreläsningar och skriftlig material. Theoretical lectures and written materials.



Blandad undervisning (t.ex. en kombination av simuleringar, föreläsningar och praktiska övningar)

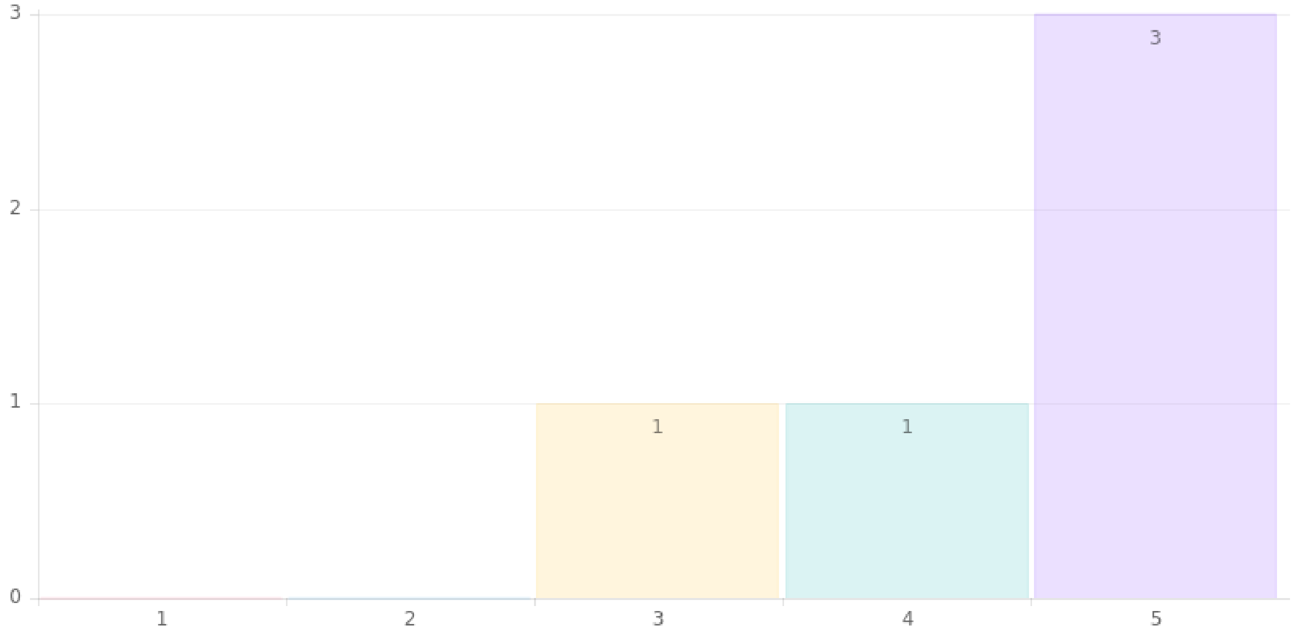
27. Värdera simulatorinstruktörens färdigheter för att påverka överföringseffekten av lärande?

Assess the importance of the simulator instructor in achieving the transfer effect of learning?

Question type	Multi-line scoring
Total responses	20

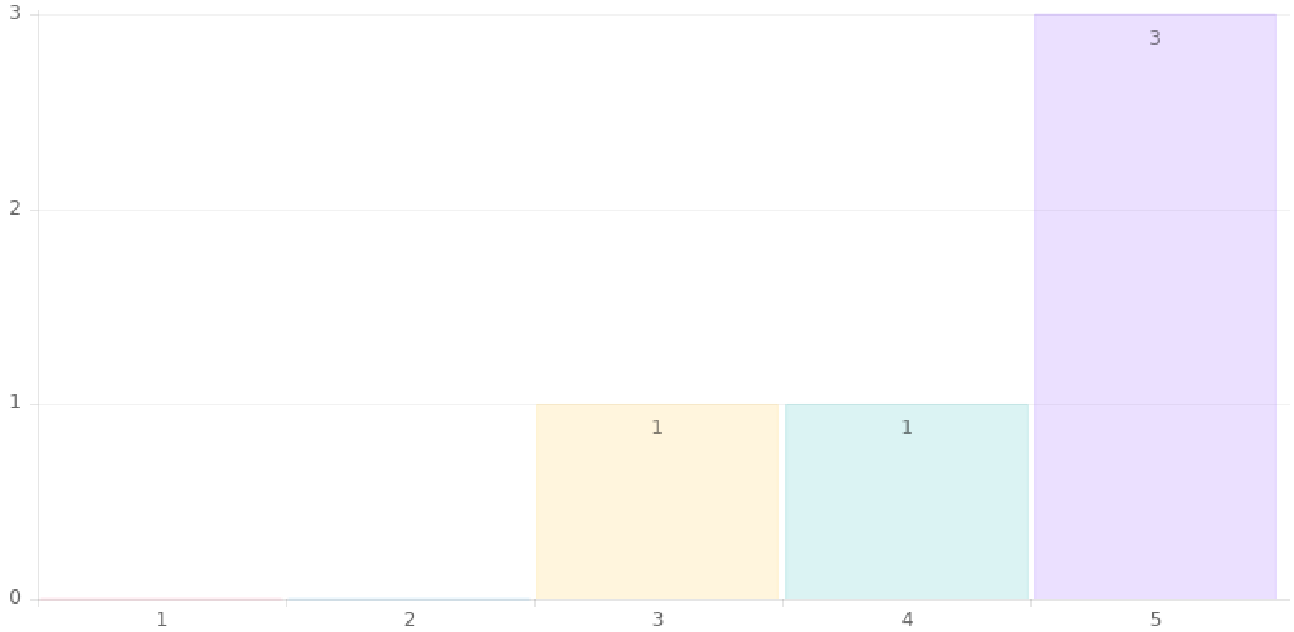
Simulatorinstruktörens kunskaper (t.ex. expertis, teoretisk kunskap).

Simulator instructor’s knowledge (e.g., expertise, theoretical knowledge).



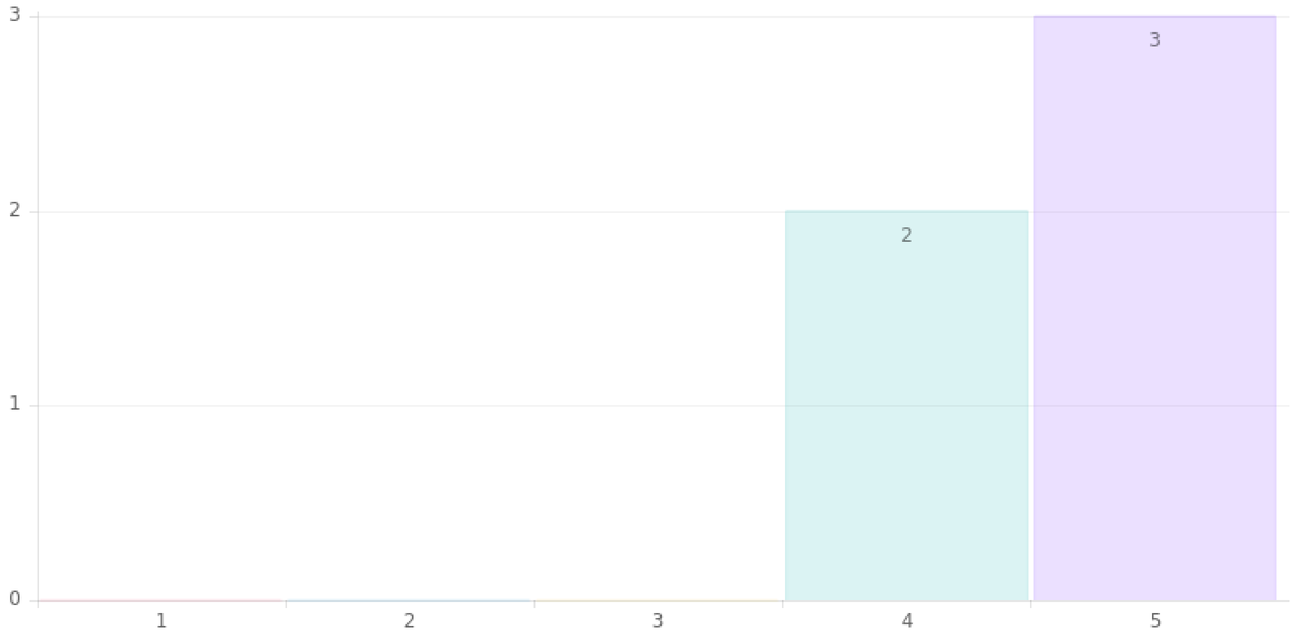
Simulatorinstruktörens färdigheter (t.ex. praktiska färdigheter, teknisk kompetens).

Simulator instructor's skills (e.g., practical skills, technical proficiency).



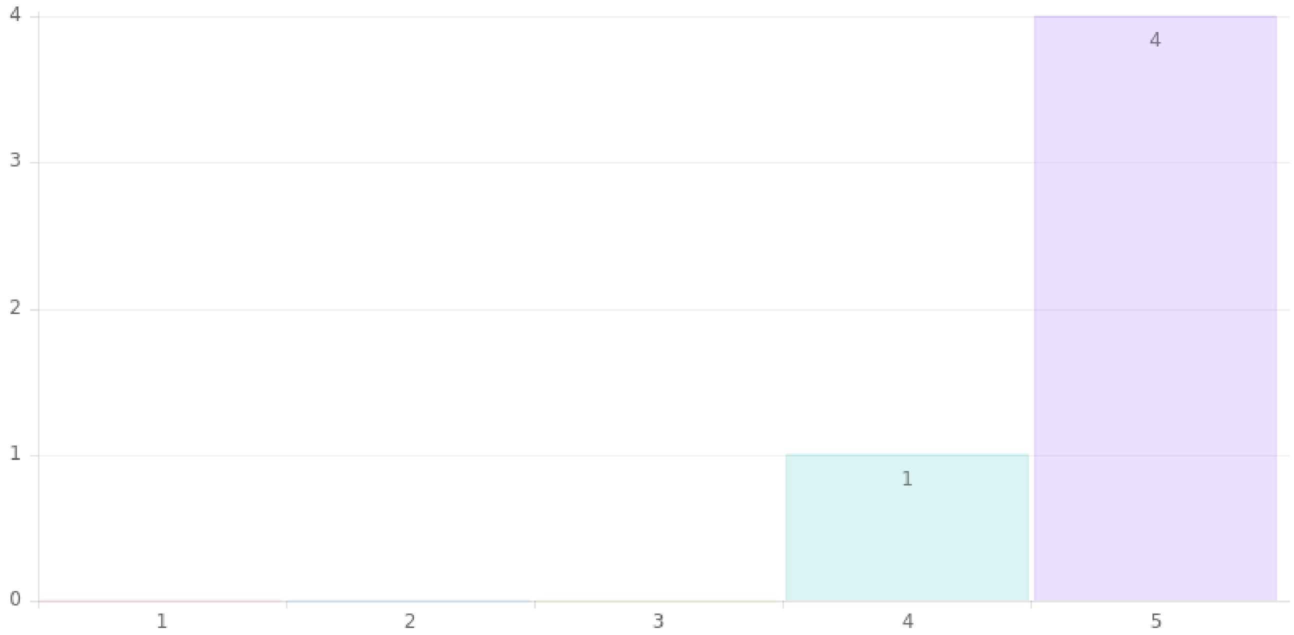
Simulatorinstruktörens personliga egenskaper (t.ex. kommunikationsförmåga, motivation).

Simulator instructor's personal qualities (e.g., communication skills, motivation).



Simulatorutbildarens personliga positiva attityd och beteende gentemot deltagarna.

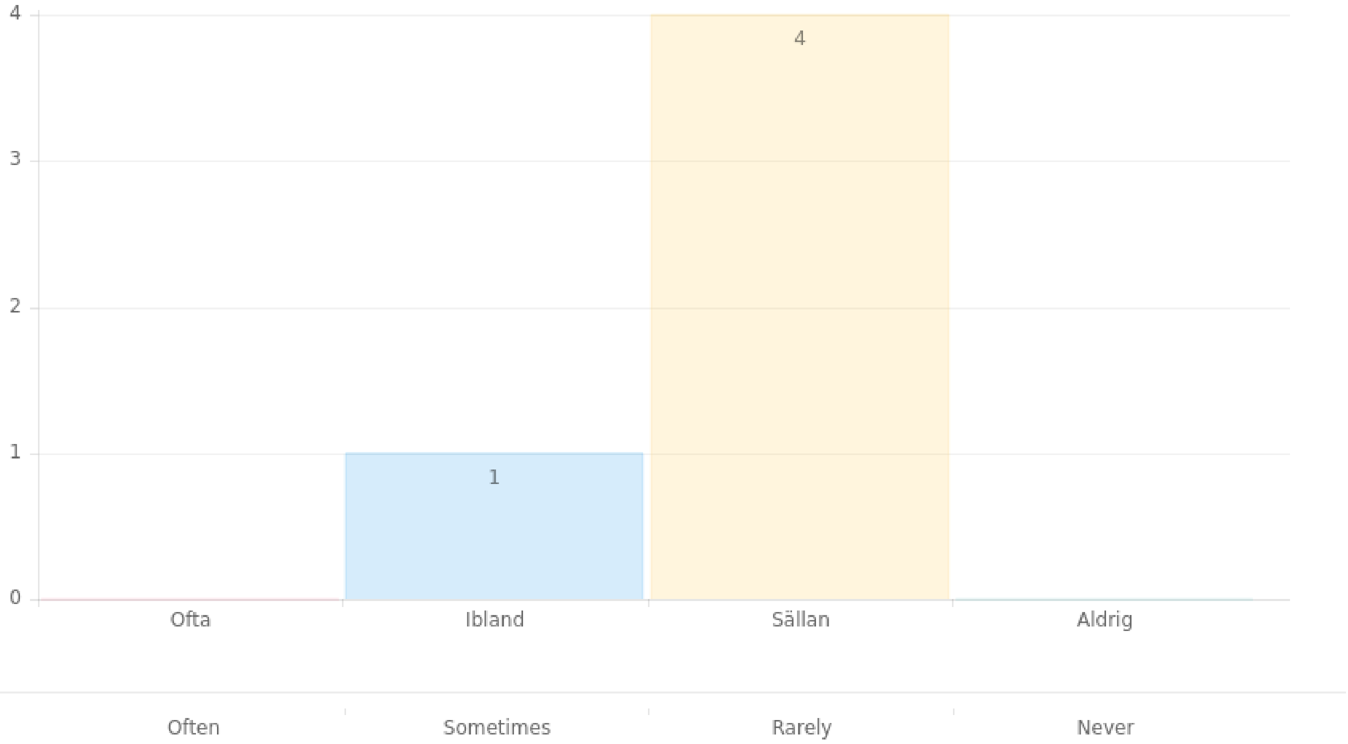
Simulator instructor's personal positive attitude and behaviour towards participants.



28. Upplever du ofta att konventionella fartygshanteringssätt och -tekniker stör nuvarande sätt och teknik av dig att hantera XXXXXXXX?

How often do you feel that conventional vessel handling techniques interfere with your current handling of XXXXXXXX?

Question type	Drop down list
Total responses	5



29. Beskriv med några ord hur du skulle ändra simulatorträning så att färdigheter som lärts i träningen skulle överföras till verkligheten på det mest effektiva sättet.

In a few words, describe how you would change simulator training so that skills learned in training would transfer into reality the most effective way.

Question type	Open answer
Total responses	
Answers	

#ID	Answer
1836726	
1837098	
1837188	gärna mer frekventa övningar. More frequent exercises.
1840590	mera praktisk simulatorkörning. More practical simulator driving.
1846308	De sku kanske vara bra om man hade en erfaren befälhavare med som har redan längre kört pod fartyg. It might be good to have an experienced captain who has already operated pod vessels for a longer time on simulator bridge during exercises.