Training to become a master mariner in a simulator-based environment

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Training to become a master mariner in a simulator-based environment

The instructors' contributions to professional learning

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Abstract

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In higher education programs that aim to prepare students for professional performance in safety-critical work activities, the introduction of simulators is seen as a fundamentally restructuring of the ways in which professional skills are developed and assessed. This, in turn, creates new challenges and possibilities for both teaching and learning a profession. This thesis examines maritime instructors' work in supporting students' collaborative training to become professional seafarers in simulator-based learning environments. The empirical material is based on ethnographic fieldwork and video data of simulator-based training sessions in a navigation course. The thesis consists of four studies. Study I is a literature review and synthesis of previous research on the use of simulators in master mariner training. Study II focuses on the overall organisation of simulator-based training (i.e. briefing–scenario–debriefing) and the instructor's work throughout the three training phases. Study III examines the organisation of instructions during the scenario phase, while exploring the practice of training to apply "the rules of the road at sea" in the simulator. Study IV connects to an on-going debate on the realism and knowledge transfer of simulator-based training with respect to the work practices on board seagoing vessels for which the students are training. While previous research on the use of simulators in maritime training argues that the current training system favours training towards simulator-based tests rather than to help students become competent professionals, the findings of this thesis point in a different direction. The results of the empirical studies reveal an instructional practice and training model founded on the need to account

for the general principles of good seamanship and the anti-collision regulations in maritime operations. The meaning of good seamanship and the rules of the sea are difficult to teach in abstraction, since their application involves an infinite number of contingencies that must be considered in every specific case. Based on this premise, the thesis stresses the importance of both in-scenario instruction and post-simulation debriefing in order for the instructor to demonstrate how general rules for action apply to practical situations in ways that develop students' professional competences. Moreover, based on the findings, I argue that the relevance of simulator-based training to work contexts is a dialogical phenomenon of relating between practices. Such interactional accomplishments draw on both the students' access to work contexts and the instructor's ability to systematically address the similarities, differences and irregularities between practices during training in the simulator.

Contents

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Gothenburg, October 2017

Charlott Sellberg

Preface

This thesis is part of a larger project called "Training skills and assessing performance in simulator-based learning environments", which is a collaboration between the Department of Mechanics and Maritime Sciences at Chalmers University of Technology and the Department of Education, Communication and Learning at the University of Gothenburg. A modern and, in several respects, unique maritime simulator centre has been built at Chalmers Lindholmen in cooperation with the Swedish Maritime Administration (Swe: *Sjöfartsverket*). The simulators are used for both educational purposes and research. One of the research areas of interest to the current project is the assessment of non-technical skills, which is made relevant by new legislative demands regarding simulator training and certification. When large parts of maritime skills and practices training are conducted in simulator-based learning environments, traditional written exams become increasingly irrelevant. As a result, there is a need for upgraded forms of assessment that, on one hand, acknowledge the multifaceted nature of performance in simulator-based training, and, on the other, meet the certification criteria set by international standards. The aim of the overall project to which this thesis belongs is to investigate the use of advanced technologies in the training and assessment of complex professional performance in simulator-based environments.

With a background in cognitive science and an established analytical interest in how cognition and learning are situated in the interaction between humans and technologies, I was recruited to write my thesis within the project. This PhD work is jointly funded by the University of Gothenburg Learning and Media Technology Studio (LETStudio); the Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society (LinCS); the Department of Mechanics and Maritime Sciences at Chalmers University of Technology; and the Department of Education, Communication and Learning at the University of Gothenburg.

Part One: Studying maritime instructors' work in simulator-based learning environments

I. Introduction: New challenges and opportunities for maritime training

This thesis explores instructors' work in simulator-based learning environments. My research focuses on the use of simulator technologies in higher education and how instructors support students' collaborative training to become master mariners in simulator-based environments. Simulator-based maritime training serves as an illustrative and paradigmatic example of a domain where the introduction of high-end technologies, together with new legislative demands, has created new possibilities and challenges for the organisation of higher education in general and for instructors specifically. This is partially due to changes in the work practices themselves: in recent decades, the maritime profession has been transformed as ship equipment and technologies have undergone rapid changes (Grech, Horberry, & Koester, 2008). Today, navigation is carried out by means of semi-automated navigation and communication systems requiring high levels of technical skills and professional knowledge of the bridge team. At the same time, there has been a generational shift in this professional domain, and the amount of on board experience has decreased, creating an experiential gap between juniors and officers (Hanzu-Pazara, Barsan, Arsenie, Chiotoroiu, & Raicu, 2008). Historically, becoming a seaman implied working one's way up the hierarchy of duties of the ship, learning the profession through years as an apprentice and a junior member of a team. Today, maritime competencies are cultivated through traditional academic activities, such as lectures and seminars, combined with practical exercises in simulator-based environments and periods of on-board practice. (Emad, 2010).

Simulators have been used for training in maritime education since the first radar simulators appeared in the 1950s. Hanzu-Pazara et al. (2008) describe how simulator-based training was introduced to maritime training with the primary intent to train such skills as passage planning and the master/pilot relationship. In more recent years, influences from training in the aviation industry have been strong, leading to a focus on training crew resource management (CRM) (Hayward & Lowe, 2010). CRM training focuses particularly on what are described as non-technical or cognitive skills, such as leadership, communication, situation awareness and decision-making (Flin, 2008). Today, simulators are used for training in many parts of the maritime industry, both for basic training and for competence development courses designed to update the skills of professional seafarers. Simulator-based training includes offshore operation training on vessels and oil rigs, in situations involving both bridge operations and cargo handling, engine control, crane operations, towing and anchor handling. Simulators are also used in ship-to-shore training, training for crane operations and training for vessel traffic services (VTS).

The practice of simulator-based training is well established in modern maritime education, and it is regulated by the International Maritime Organization's (IMO) Standard of Training, Certification and Watchkeeping for Seafarers (STCW), which provides a set of regulations for maritime education. To ensure that future mariners can act properly and safely, this convention stresses that simulators should be used for both training and assessment. The latest update of the STCW convention, the 2010 Manila amendments, places greater emphasis on proficiency and non-technical skills than previous updates. The division between technical and non-technical skills stems from perspectives inherent to classic cognitivist approaches to activities, technologies and people. Since this thesis draws on theories that situate cognition and learning in interactions among participants in socio-material environments, such a division between technical and non-technical skills is not valid when studying simulator-based training *in situ*. Instead, the various professional skills that are developed in the simulator are seen as increasingly intertwined with learning tasks and the technologies involved in solving these tasks. When considerable parts of the training of professional skills and work practices are conducted in simulator-based learning environments, there is a need for upgraded forms of training that acknowledge the complex nature of performance in simulator-based training, and, at the same time, meet the criteria for training and certification established by the STCW convention. However, though simulator-based training is well established within the maritime education system, few empirical studies focused on the use of simulators in the context of maritime training (Study I). At this point in time, I will argue, there are more questions than answers concerning the use of simulators in maritime training. There is a need for research that acknowledges the complex nature of performance in simulator-based training and examines how this relates to the STCW convention. In this context, this thesis contributes to a small corpus of work that takes the use of simulators in maritime training as an empirical case through which to study students' training of professional skills and work practices *in situ*.

In domains outside of maritime training, simulators provide risk-free opportunities for training safety-critical activities in such professions as aviation and health care (e.g. Dahlström, Dekker, Van Winsen & Nyce, 2009). During simulation, participants can operate at the edge of safety, and even beyond, to engage in training and assessment that would be inappropriate or even impossible in real work settings. It has been argued that the controlled environment of the simulator also has pedagogical advantages, since exercises can be designed to train and assess specific learning outcomes (e.g. Maran & Glavin, 2003). In the simulator, the layers of complexity of different situations can be increased or reduced to adjust to participants' prior experiences and knowledge. Simulator exercises also allow possibilities trainers to make changes during exercises to adjust to students' performance. It is even possible to pause a simulation for feedback and discussion. Furthermore, simulators provide an opportunity to train skills that are time-consuming or costly to practice in work settings, such as on board training. In the simulator, the argument goes, training can be achieved in a more time-efficient and cost-effective way (e.g. Barsan, 2009; Beaubien & Baker, 2004).

However, while simulators are believed to offer great potential for learning, their use in training also raises a number of practical and theoretical questions of interest to pedagogical research. It is far from evident how skills trained in the simulator relates to the professional practice or how to productively assess performance in simulator-based learning environments. In this context, this thesis connects to long-standing pedagogical debates on the character of knowledge in action, as well as recent research on how professional knowledge develops in and through observable interaction. In a study on simulations in healthcare, Rystedt and Sjöblom (2012) concluded that the development of professional knowledge is an interactional and situated matter, as well as an instructional concern, since the relevance or irrelevance of different simulated activities must be systematically addressed through professional guidance and feedback by an instructor. To quote the work of Hindmarsh, Hyland and Banjerjee (2014, p. 265) in their study on simulators in dental education:

> The simulator itself does not inform the student how to perform a manual skill, to develop a professional bodily technique. The simulator also does

> not provide the reason why the task should be accomplished one way and not another. Thus exploring the seams between simulation and clinical situations occasions debate and discussion of the clinical setting, clinical procedure, and clinical reasoning—issues to take into account and practices to adopt in developing clinical expertise (Hindmarsh et al., 2014, p. 265).

As outlined in this quotation, the simulator itself offers little in terms of learning, beyond providing a context in which experiences may be developed and analysed. In the case of maritime simulator-based training, Hontvedt and Arnseth (2013) highlight that, while the ship simulator exhibits great potential as an educational tool, what is simulated during training exceeds the simulator as a technological device. As their analysis shows, students' meaning making activities are highly dependent on the instructor's ability to design and facilitate simulations as relevant activity contexts: that is, contexts in which participants are solving relevant work-related tasks (Linell & Persson Thunqvist, 2003). Hence, in order for new technologies to improve academic performance, both appropriate implementation in terms of student engagement, instructional support and relevant connections to work contexts are critical to achieve positive results (cf. Säljö, 2010).

In the literature, two opposing views of the simulator dominate. Whereas some see simulators as rather neutral devices, others view their technical fidelity as highly relevant prerequisites for effective training. This thesis will challenge both of these views. Specifically, I propose that a more reasonable stance lies in-between these positions, in a perspective that considers both the resources and the constraints of the simulator environment with regard to developing professional competencies (cf. Leonardi, 2015). With respect to the challenges and opportunities the introduction of simulator technologies implies for maritime education, the perspective on the emergence and adoption of new technologies taken in this thesis is that simulators in rather fundamental ways restructure how professional skills are developed and how intelligent actions are being performed and assessed (cf. Säljö, 2010).

In sum, previous research has shown that the use of simulators in training shows clear potential for training skills and developing professional knowledge in educational settings. However, instructors' work of organising and facilitating training is also crucial for meeting learning objectives. Against the background of the challenges and opportunities in maritime education and the results of previous research, this thesis will focus on instructors' work during collaborative learning activities in simulator-based learning activities in maritime training. More specific aims and research questions are formulated below.

Aims and research questions

At the maritime simulator centre under study in this thesis, training sessions are organised across three phases that are regularly used in simulator-based training. Firstly, a short introduction, a so-called briefing, to the assignment of the day is conducted in a classroom next to the simulators. Secondly, a scenario plays out on a bridge operation simulator. Thirdly, the group engages in a post-scenario discussion, a so-called debriefing, about the exercise in which the students have taken part. It should be observed that the activities under study in this thesis are both part of a university course with learning objectives and part of certifying skills for navigation according to international standards. In this thesis, the overall aim is to gain knowledge, at the level of interaction in instructional settings, about the instructors' work of supporting the students' learning towards master mariners' expertise during simulator-based learning activities. More specifically, the research questions are as follows:

- What is the current status of research on simulator-based maritime training?
- How do instructors use the socio-material resources in the simulator environment in their instructional work?
- What is being taught and, thus, made accessible for students to learn in and through these instructions?

While the first research question aims to review and synthesise the research field, the second research question explores what is practically accomplished by instructions in the simulator environment. The third research question is of a different character. Though it aims to reveal the lesson being taught, it also examines trajectories of learning: that is, how the object of knowledge develops in and through observable interactions during lessons.

Study I, as has been pointed out, explores the first research question through a systematic literature review and qualitative synthesis of research on simulator-based maritime training (cf. Bearman & Dawson, 2013). The review provides a background to the use of simulators for learning to master bridge operations, as well as an overview of how simulator-based maritime training has been studied in previous research in the maritime domain. Studies II through IV follow a naturalistic and empirically driven research approach. Rather than starting the analytical work with a set of theoretical conceptions of what is being done, these analyses aim to unpack what constitutes training practice for the students and instructors in the setting of simulator-based maritime instruction. In line with this focus, Studies II through IV are designed as workplace studies (Heath, Hindmarsh, & Luff, 2010; Luff, Hindmarsh, & Heath, 2000). The argument for adopting a workplace studies approach, which combines ethnographic fieldwork with close and detailed analyses of video recorded interactions, is that such an approach is useful for identifying and explicating common patterns of interaction during activities in the simulator environment. Such explications are known to lead to a heightened awareness of interactions in learning settings amongst teachers, instructors and supervisors: that is, among practitioners themselves (Heath et al., 2010). Moreover, such analytical findings lay a foundation for reflecting on the impacts of new policies, procedures and technologies on educational activities (Heath et al., 2010). This is especially relevant considering the challenges and opportunities for maritime training posed by the introduction of simulator technologies and updates to the STCW convention. In line with these research interests, this thesis contributes to a corpus of educational research on how knowledge develops in and through instructional work, using maritime simulation as an illustrative case (e.g. Evans & Reynolds, 2016; Greiffenhagen, 2012; Lindwall & Ekström, 2012; Lindwall, Lymer, & Greiffenhagen, 2015; Zemel & Koschmann, 2014). Moreover, this thesis contributes to maritime education with empirically grounded results regarding the use of simulators in training.

The theoretical approaches differ across the studies comprising this thesis. The reason for this is that the phenomena that emerged as interesting during the early stages of the analysis of the empirical data lend themselves to different types of theoretical framings, depending on the observed interactions and the developing object of knowledge. However, all of the theoretical approaches can be described as interactional approaches that view instruction and learning as being situated in the socio-material world (Luff et al., 2000). As an end result, the combination of theories provides different perspectives on the learning practices that take place in the simulator environment and, thus, explain a variety of the different processes at work during learning activities. As argued by Leonardi (2015), combining theories can help to "generate new findings and surface new solutions to old problems" (p. 260).

Study II draws on a situated action approach (Suchman, 2007) to analyse how instructions from the briefing phase of simulator-based training are oriented towards during the subsequent scenario and debriefing phases of training. The study examines how general rules for action are connected with the specifics of particular situations during training sessions, tracing two different kinds of learning lessons connected to maritime work practices throughout the different phases of training in the simulator. Hence, the analysis concerns both the temporal organisation of instructions during training sessions and the different material conditions available to the instructor in the simulator environment.

Study III, which is co-authored with Mona Lundin, draws on Goodwin's (1994) notions of professional vision and professional intersubjectivity to analyse how instructors' work of highlighting and articulating semiotic structures in the simulator develops students' ability to coordinate with other vessels in the rule-governed traffic system. The analytical focus of this study is narrowed down to a single episode of the instructor's work on the simulated bridge during scenarios, exploring both how the instructional work is conducted and what is being taught, and thus made assessable for the students to learn, in and through instructions.

Study IV focuses on the instructors' work of representing and enacting missing aspects of the real work environment in the simulator to develop the students' professional knowledge about ship movements. Here, I use the concept of distributed cognition as a theoretical framework for the analysis (Hutchins, 1995). The analysis in this study draws on episodes of the instructors' work on the simulated bridge during scenarios to explore particularly how the body is used as an instructional resource in a simulator environment lacking aspects of motion dynamics.

Reading directions

Part One of the thesis consists of the extended abstract and seven chapters. Chapter I introduces the opportunities and challenges that the rise of simulator technologies and new legislate demands pose for maritime training, as well as the thesis aim and research questions. Chapter II provides a background to the use of simulators in students' training to become professionals, drawing on research from different but related fields, such as shipping, aviation and healthcare. Chapter III gives an account of the workplace studies approach that informs this thesis, focusing particularly on Suchman's (2007) plans and situated action, Goodwin's (1994) work on professional vision and Hutchin's (1995) distributed cognition approach, each of which are central to the studies comprising the thesis. Chapter IV discusses the empirical setting, the participants involved in the master mariner programme, the ethical considerations and the methods used for data collection and analysis. Chapter V summarises the four studies, and Chapter VI concludes and discusses the results in terms of their empirical, methodological and theoretical contributions, as well as their limitations. Chapter VII presents a Swedish summary of the thesis.

Part Two of the thesis contains the following four studies:

I. Sellberg, C. (2017). Simulators in bridge operation training and assessment: A systematic review and qualitative synthesis. *WMU Journal of Maritime Affairs*, *16*(2), 247–263.

II. Sellberg, C. (2017). From briefing, through scenario to debriefing: The maritime instructor's work during simulator-based training. Online First, *Cognition, Technology & Work*.

III. Sellberg, C. & Lundin, M. (2017). Demonstrating professional intersubjectivity: The instructor's work in simulator-based learning environments. *Learning, Culture and Social Interaction, 13*, 60–74.

IV. Sellberg, C. (2017). Representing and enacting movement: The body as an instructional resource in a simulator-based environment. *Education and Information Technologies, 22*(5), 2311–2332.

II. Background: Simulators as sites for learning work practices

A general concern for higher education in safety-critical work domains, such as maritime work, is to prepare students for complex tasks in future work settings. Simulators have been developed to meet this concern when training both students and professionals in such work domains as shipping, healthcare and aviation. Simulator-based maritime training encounters challenges similar to those of other domains, and its training is organised across a series of three phases that reflect those of other domains: specifically, briefing, scenario and debriefing (e.g. Fanning & Gaba, 2007). The first phase, briefing, introduces students to the assignment of the day. Briefing is commonly focused on sharing practical information, introducing materials and specifying the objectives of the exercise (Wickers, 2010). After the introduction, a scenario is played out in the simulator. Emad (2010) describes how, in navigation training, a simulator-based scenario is organised in a specific way. First, the instructor directs each student group to a simulator that mimics the bridge of a vessel. After that, the instructor assigns the group the roles and duties of a bridge team, and gives the group members specific work-related tasks. After the practical exercise, a debriefing is conducted. In the literature, debriefing is described as a post-experience analysis of and reflection on the exercise. It is widely considered to be especially important for learning from scenario-based experiences (e.g. Deickmann et al., 2008, Fanning & Gaba, 2007, Neill & Wotton, 2011, Wickers, 2010).

Although simulator-based training in maritime education shares some general learning features with other domains, there are also aspects specific to navigational work practices. Whereas Study I provides a systematic review of previous research on simulator-based training in the maritime domain, this chapter explores the use of simulators for learning navigational work practices by also drawing on research from such domains as aviation and healthcare. This approach seeks to make explicit the specifics of maritime navigation training in relation to the more general aspects of learning to become a professional in a domain involving safety-critical operations. In line with this focus, the first section of the chapter provides a backdrop to the history of maritime work. This is followed by a section about learning the practices involved in navigational work. This, in turn, is followed by three sections addressing the different features of simulator-based training. First, the simulator is explored as a realistic representation of a physical work setting, with a particular focus on such notions as the technical and environmental fidelity of simulator design. Second, the properties of simulations—that is, the organisation of learning activities as engaging, realistic and relevant work tasks in the simulator—are discussed[1]. Finally, the practices of post-simulation debriefing are presented, since the literature considers these to be especially important for learning in simulator-based training (e.g. Fanning & Gaba, 2007; Neill & Wotton, 2011; Wickers, 2010).

A historical background to navigation and bridge teamwork

For the entire time that a ship is sailing the sea, the team working on the ship's bridge performs navigational computations using a wide range of technologies. Navigation is part of a long tradition of social and technological work practices that date back well over two thousand years:

> Between the early attempts at measurement and map making and the present day, there lies a rich history of technical innovations. In a typical hour of navigation activities, a modern navigator may utilize technologies that range in age from a few years to many hundreds of years. The time scale of the development of navigation practice may be measured in centuries. (Hutchins, 1993, p. 36)

In examining the technological changes over the last century, Lützhöft (2004) shows how both navigational technologies and work practices have evolved over time. At the end of the 1920s, bridge teams relied on traditional and sometimes outdated technologies and navigation methods, such as dead reckoning, piloting and celestial navigation. Dead reckoning is a basic method for calculating a ship's current position by using a previously determined position and keeping track of speed and direction sailed. This method relies

[1] Without going into theoretical and philosophical debates on what a simulator or simulation is, the term simulator will be used for describing the technological artefact while simulations will be used to refer to the exercise that takes place in the simulator. When using the term simulator-based training, I refer to the whole training design: from briefing, through scenario, to debriefing.

on the use of paper charts, compasses, rulers, chart protractors and pens (Hutchins, 1995). Piloting is the practice of navigating using visual landmarks and navigation aids, e.g. lighthouses, buoys or depth soundings (Lützhöft, 2004). Celestial navigation is an ancient method of navigating by determining position using the sun, moon, stars and planets. It can be performed by using a sextant to measure the distance between two objects or, as described in Hutchins' (1983) study on Micronesian navigation, by visually following the linear constellations of star paths. By the end of the 1950s, radar systems had become commercially available. This advancement was followed by gyrocompasses and echo sounders in the 1960s and satellite navigation in the 1970s and 1980s (Lützhöft, 2004). Today, a technologically equipped bridge includes means for electronic navigation, e.g. electronic devices, such as radar, and electronic charts for positioning (Aizinov & Orekhov, 2010).

As new technology has entered modern navigational work practices, some have expected that navigators will have less work to perform (Lützhöft & Nyce, 2014). However, rather than having less work to do, navigators have simply shifted their work practices from manual work towards what is known as integration work. This type of work is not new in the maritime field. Lützhöft and Nyce (2014, p. 60) describe it as the kind of work practitioners have always performed in order to construct workplaces that "work for them" on board the bridge of a vessel. In their ethnographic study on board different types of ships, the work observed in bridge teams depended heavily on both electronic displays and the use of paper and pen to determine positions. Hence, navigation still relies on established methods, such as the practice of dead reckoning for plotting courses on paper charts. Combining these practices with electronic navigation tools, e.g. radar and electronic charts, makes it possible to construct an integrated view of the unfolding situation. One reason such triangulation is important is that navigational decisions require a great deal of assertiveness. The ships in traffic today are massive objects that are slow to respond to changes in speed and direction, making mistakes costly in terms of both time and resources (Bailey, Housley, & Belcher, 2006). Moreover, when sailing in narrow waters, restricted visibility or trafficked areas, the bridge team must be oriented towards "clear, concise and early action" (Hutchins, 1990, p. 193). In order to coordinate this time-critical work, the members of a bridge team must work together and make use of a number of technologies in order to constantly plan ahead and maintain a close eye on the environment so that they can make decisions (Bailey et al., 2006).

In recent years, a number of factors, such as increased automation, organisational changes and industry demands for greater efficiency and increased profitability in shipping, have significantly reduced the manning of vessels (Ljung & Lützhöft, 2014). For example, in the past 25 years, the crew of a normal-sized cargo vessel has been reduced from 40 or 50 people to 22 people. Furthermore, Ljung and Lützhöft (2014, p. 232) point out that the maritime work structure is "firmly rooted in a hierarchical order with defined roles for the performance of work" in one of the most conservative industries in the world. This hierarchy is also evident on the bridge, where the commanding order descends from the captain in charge of the ship, to the officer-of-the-watch navigating the vessel, to the helmsman in control of steering to, finally, the lookout keeping a close eye on the marine environment. With respect to the bridge team's work order, the bridge contains several key positions, such as radar displays and chart tables, where navigational decisions are made; helm and engine controls for manoeuvring the vessel; and the bridge wings adjacent to the bridge, where the lookouts keep watch (Bailey et al., 2006). This hierarchical and spatial organisation forms the basis for teamwork, which involves an intricate matrix of social and material interactions:

> Of crucial importance and relevance to the practical tasks the team performs is the unfolding temporal frame of navigational work and practice. It is a temporal frame within which interaction between team members is constituted and realised within a matrix of navigational equipment, control of the helm and engines, geographical/oceanographic features and other waterborne objects. (Bailey et al., 2006, p. 358)

While the bridge teamwork reported in Bailey et al. (2006) is, to a significant extent, centred around the bridge panel, both the layout of the bridge in terms of proximity among team members and the noise level on board a ship create challenges related to gaining and maintaining a shared perspective of the situation at hand. In order to ensure clear communication and avoid misunderstandings, bridge teams engage in what is known as confirmatory talk or closed-loop communication (Bailey et al., 2006). The main idea of such communication is that when someone delivers a message, the receiver of the message repeats it back. Then, if the message is repeated properly, the deliverer ratifies the message (Froholdt, 2015). This communicative structure is integral to the maritime communicative pattern and can also be seen between vessels and other actors, such as land-based services. Communication between such actors is radio-mediated through Very High Frequency (VHF) radio, a channel system that allows only one speaker to talk at the same time (Froholdt, 2015). In sum, learning to navigate implies becoming embedded in an environment with a long history of social and technological developments and changes in the division of labour.

From apprenticeship to formal maritime education

As pointed out, until recently, maritime competencies were trained primarily through years of apprenticeship on board ships. In other words, the skills of a mariner were fostered in the context of work, where the learner was a participant in the maritime culture (Hutchins, 1990, 1993, 1995). Hence, when mariners learned to navigate, their careers unfolded through a learning trajectory involving a multi-year transition from novice to master. For example, in the context of the US Navy, a career began with a socialisation period, during which newcomers acquired "the fundamental skills of a sailor" and moved from being mere recruits, to apprenticeships, to becoming "able-bodied seaman" (Hutchins, 1995, p. 15). Then, a seaman moved forward to learn the skills of a particular job, e.g. in the machine room or on the bridge. As a seaman's expertise developed, both ranking and responsibilities developed in the context of a strict hierarchal system (Hutchins, 1995).

In recent decades, learning to navigate through apprenticeship has been gradually replaced by formal learning in higher education (Emad, 2010; Emad & Roth, 2008). In the current maritime educational context, simulators are used to reduce the periods during which students practice on board vessels to learn the skills and practices of navigation (Barsan, 2009). In the current training system, the navigation of a vessel larger than 500 gross tonnage is regulated by the STCW convention, which requires an international standard of competence amongst seafarers (Hontvedt, 2005a). A class V maritime officer requires both an academic bachelor degree and a number of certificates obtained through on board practice and simulator-based competence tests. Hence, learning to navigate today involves a combination of learning through formal education and on board experience and participation.

Emad (2010) offers a brief ethnographic description of simulator-based navigation training and discusses the central role of the instructor in shaping the context for learning:

> He [the instructor] assigns a section of the lab as the simulated bridge of a ship with its entire equipment and other resources available to the mariner. He assigns each group of students the duties of members of a ship's navigation team. He gives them specific tasks and runs the simulation in real-time. His aim is to create an authentic marine environment—as he is in real life—and supervises the activities of the team. (p. 878)

As the students exhibit increased involvement and competence in handling tasks collaboratively, the instructor gradually decreases support. This gradual transition allows the students to take on the responsibilities of higher ranks, while allowing the instructor to take on the role of a background moderator or facilitator. Hence, the development of skills in educational settings differs in fundamental ways from the hierarchal and temporal nature of moving from novice to master in an apprenticeship (Emad & Roth, 2006). In educational settings, learning can be described as a dynamic exchange of competence or expertise among members, where responsibility can be attributed to anyone in the community that the group considers a resource for solving different tasks. In other words, in educational settings, novices such as students can take on the responsibilities of officers. The role of the instructor then becomes one of "shaping the context of the community to initiate, develop and evolve" (Emad & Roth, 2006, p. 597). This example illustrates how the introduction of new technology, such as simulators, into learning a profession helps to transform our notions of learning, what students should master and how skills should be cultivated (cf. Säljö, 2010). These changes, in turn, require changes in pedagogy and instructional practice. For maritime training, Emad (2010) suggests adapting towards cognitive apprenticeship by replicating the critical elements of traditional apprenticeship in an educational environment. This includes aspects such as modelling tasks, mentoring, coaching, and gradually decreasing support as the student learns, i.e. reducing the nature of the scaffolding provided to the learner (cf. Wood, Bruner & Ross, 1976).

What is particularly interesting in Emad's (2010) findings is how instructors strive to create what the author refers to as an authentic learning environment and realistic work tasks. The following sections of this chapter explore exactly what this means, focusing first on how the simulator itself might resemble a realistic work setting.

Simulators as contexts for training

Vidal-Gomel and Fauquet-Alekhine (2016) define a simulator as an "artefact that simulates (partially or completely) the operation or the behaviour of a technical system, facility, or a natural phenomenon" (p. 2). The literature typically distinguishes between low-fidelity simulators that simulate aspects of the physical work setting in an abstract way and high-fidelity simulators designed to match the appearance and behaviour of the setting to a high degree (e.g. Dahlström et al., 2009; Drews & Backdash, 2013; Maran & Glavin, 2003). For example, desktop-based simulators with simplified representations of visual aspects of the ship and the environment are considered to be low-fidelity, while simulators that simulate the ship's visual, auditory and motion cues in a realistic way are considered high-fidelity (Figure 1).

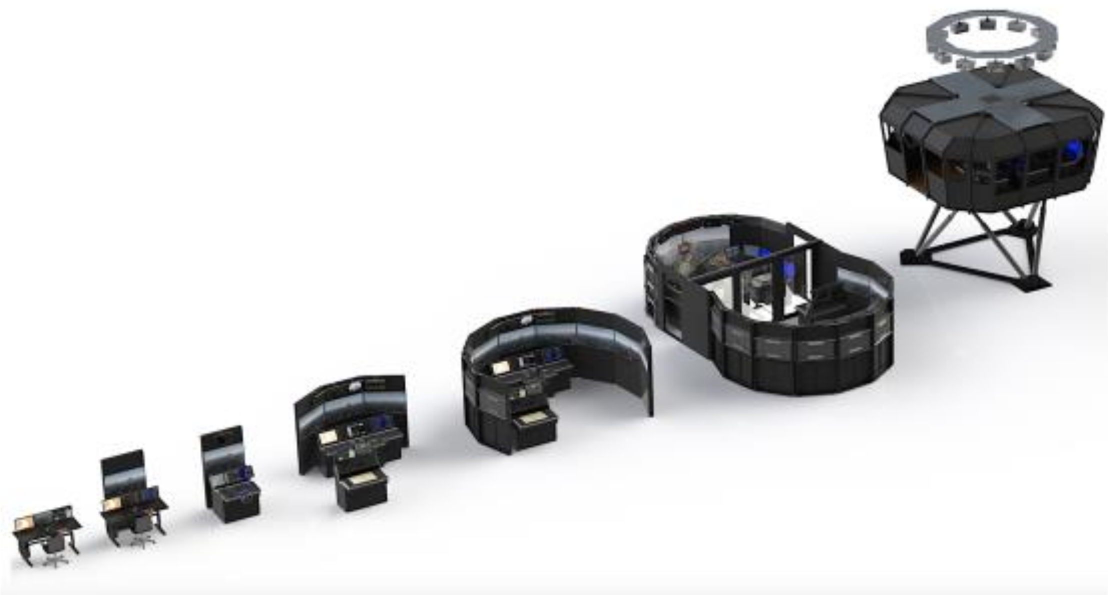

Figure 1. A range of different ship bridge simulators from desktop simulators (left) to high-fidelity simulators (right). Copyright KONGSBERG Group; used with permission from KONGSBERG Group.

Since situations encountered in high-risk domains, such as the maritime industry, are complex and dynamic, it is considered important for simulators to resemble the work context and for the simulation to resemble the conditions of real-world work tasks (e.g. Dahlström et al., 2009; Drews & Backdash, 2013; Hontvedt, 2015b). The prevailing idea is that if the simulator resembles the work setting and the simulation resembles regular work tasks, skills are more likely to transfer from one context to the other. In the STCW convention, the consequence of this view is that on board practice has been replaced by simulator-based training based on calculations of "sea service equivalency" for full mission simulators (Barsan, 2009). However, the relationship between the degree of fidelity and learning outcomes is not linear. In some cases, low-fidelity simulations are a cost-effective alternative to high-fidelity simulators and might actually improve aspects of learning:

> […] environmental presence experienced in simulated environments is determined more by the extent to which it acknowledges and reacts to the participant than by the simulation's physical fidelity. In other words, high levels of technologically driven fidelity can simply be wasteful in terms of costs and time relative to the pedagogical undertaking at hand. (Dahlström et al., 2009, p. 308)

For example, one study on developing maritime English compared an online conference software to training in a full mission bridge simulator (John, Noble & Björkroth, 2016). The task was designed to simulate a crossing of the Dover Strait, an intense traffic situation in which the students were to collaborate as a bridge team in order to make navigational decisions. A quantitative analysis of the students' language patterns showed that the students practising maritime English in the low-fidelity simulation used a "higher lexical richness" than those training on the full mission simulator (John et al., 2016, p. 345). Moreover, a qualitative analysis of the exercises revealed that the low-fidelity simulation increased the students' communicative competence, especially in terms of collaborative decision-making. The authors concluded that low-fidelity simulations provide students with the means to develop their maritime English in cost-efficient and user-friendly ways (John et al., 2016).

Given the intricate relationship between fidelity and learning, the distinction between low-fidelity and high-fidelity simulators has been criticised for being one-dimensional and overly simplistic and for putting too much emphasis on technology rather than learning objectives, content and design (Beaubien & Baker, 2004). Beaubeien and Baker (2004) propose an alternative typology of simulation fidelity based on three interrelated aspects: equipment/technical fidelity, environmental fidelity and psychological fidelity. First, the simulator's equipment/technical fidelity concerns the degree of realism of the technical system's appearance and feel (e.g. the degree to which the simulator accurately mimics the layout of the ship's bridge).

Equipment/technical fidelity is considered important for developing technical and motor skills related to professional knowledge (e.g. Dahlström et al., 2009; Hontvedt, 2015a). For example, when maritime pilots train to handle so-called Azipod controllers[2], a high level of fidelity is required to fulfil the learning objective of proficient handling of the technology (Hontvedt, 2015a). In other words, both the knobs and levers of the simulator must behave in ways similar to those of the Azipod controllers on board real ships, and the controllers must be properly aligned in relation to not only other bridge equipment, such as electronic charts, but also visualisations of the outside marine environment.

Figure 2. A bridge operation simulator equipped with systems for e-navigation. Copyright KONGSBERG Group, used with permission from KONGSBERG Group.

This first aspect of fidelity, equipment/technical fidelity, connects to the notion of environmental fidelity, a concept that concerns the extent to which the simulator represents visual and motion cues (Beaubien & Baker, 2004). In bridge operation simulators, environmental fidelity involves both the

[2] Azipods are 360-degree propellers used on vessels that require flexible steering capabilities (e.g. tugboats and passenger ships).

photorealism of the marine environment and the accuracy of the movement on board the ship, simulated via the visual outlook through the window and/or the use of motion platforms (Figure 2). In a study on training maritime students to leave Oslo Harbour with professional maritime pilots, Hontvedt (2015b) found environmental fidelity to be a crucial aspect of training correct work practices. The practice of piloting requires integrating information from multiple sources: the visual outlook out of a ship's window, the world as it is represented on the radar display and nautical charts, systems for ship identification and so on. Of all these information sources, it is the visual lookout that should be favoured whenever possible (i.e. in good visibility). In their study, Hontvedt (2015b) found that inconsistencies between the marine environment seen through the window of the simulator and the professionals' previous knowledge of the geographical area of Oslo Harbour caused them to choose different strategies for performing the piloting task:

> The pilots repeatedly criticised the fact that some navigation tasks were solved most successfully by using the electronic equipment, instead of via visual lookout. When they encountered such issues, the training participants were forced to decide whether to remain faithful to the professionally appropriate procedure of relying on their visual outlook or to adapt to the underlying dynamics of the simulation and navigate via the electronic map. (Hontvedt, 2015b, p. 83)

Hence, instead of using the visual lookout as their primary source of information, the pilots began to rely on their electronic charts, working around the inconsistencies of the simulator by adopting incorrect work practices for piloting. In line with this finding, Hontvedt (2015b) argues that simulators that lack fidelity risk training students to manipulate simulated models rather than to work on board a ship.

Beaubien and Baker's (2004) third aspect of fidelity is psychological fidelity, a notion that concerns the degree to which trainees perceive their training as relevant and realistic. Psychological fidelity is a complex matter that goes beyond the technical setting of the simulator and into what is simulated. In other words, it explores whether a simulation is perceived as capturing tasks as they would be performed in an actual work setting (Drews & Backdash, 2013). For example, Saus, Johnsen and Eid (2010) tested the effects of experience, perceived realism and situation awareness on students' perceived learning outcomes following simulator-based navigation training, using an experimental approach to isolate and measure the students' subjective situation awareness under various training conditions. The results showed that both the students' subjective situation awareness and the perceived realism of the training event had positive effects on the perceived learning outcomes of the training. For example, experienced professionals seemed to perceive the simulator-based training as "too basic", resulting in lower motivations to train. However, regardless of prior experience, the participants with "higher underlying situation awareness ability" performed better in complex tasks (Saus et al., 2010, p. 263). Saus et al.'s (2010) results highlight the need to consider students' experience levels when designing simulations and to avoid "exceed[ing] the cognitive capacity of novices" (p. 263–264) in order to support efficient training. However, the term psychological fidelity is somewhat problematic to use in this thesis. Psychological fidelity easily leads to a focus on the individual and on the internal, subjective perceptions of realism and learning, at the expense of the social and technical achievements of collaborative learning in simulator-based training that are the focus of this thesis. Thus, my claim is not that psychological fidelity is irrelevant, but, rather, that realism is often jointly constructed by participants as they engage in work. Simulations as social and technical work practices are explored further in the next section of this chapter.

Training work-related tasks through simulation

Hontvedt and Arnseth (2013) argue that "the simulation far exceeds the simulator" (p. 109). While the simulator refers to the technical artefact, the simulation relates to the design of the training sessions in order to meet different learning objectives (Vidal-Gomel & Fauquet-Alekhine, 2016). Hontvedt and Arnseth (2013) explore how a group of maritime students train in a full mission bridge simulator, with a focus on how their work roles and tasks are enacted through role-play in the simulator environment. More precisely, the analysis focuses on how both the institutionally defined roles and the simulator environment become resources for learning *in situ*. Their results highlight not only the importance of creating work relevant contexts in the simulator, but also that the simulator environment differs from the work practice simulated:

> It is evident not only that the simulated context provided opportunities for learning matters deeply situated in the professional doings of the profession, such as the emergency anchoring, but also that the simulation must not be confused with "reality" as such. (Hontvedt & Arnseth, 2013, p. 109)

While Hontvedt and Arnseth (2013) describe the simulator as offering clear potential for learning, they also suggest that maritime work practices rely heavily on aspects of space and temporality that can hardly be simulated in an educational setting. Following this, Hontvedt and Arnseth (2013) are taking a clear stance that the meaning making activities that take place in simulated learning are far more important than the simulator itself. Although the meaning making activities that take place during simulations are clearly important for learning, I find the notion of them being more important than the simulator itself to be problematic. Instead, this thesis proposes that the simulator and what is simulated are inherently interwoven, since meaning making practices are contingent on materiality: that is, the technical and semiotic features of the simulator environment. To borrow the words of Markauskaite and Goodyear (2017):

> Matter, and material and social space—what is often simply called "context"—is not some kind of container that can be easily detached from the "essence" of knowledge and problem-solving. It is an integral and fundamental aspect of this knowledge and knowing. (p. 465)

In the context of this thesis, the radar technologies that the students are training to master are the means through which navigation is accomplished. Hence, the studies that constitute this thesis focus not on determining what resources are the most important, but, rather, on analysing how and why these social and material resources are made relevant in training by instructors.

A small but growing corpus of empirical studies, including that by Hontvedt and Arnseth (2013), shows how simulation has emerged as a realistic and relevant learning activity and is maintained in and through interactions between participants and the material context (e.g. Hindmarsh et al., 2014; Hutchins & Nomura, 2011; Rystedt & Sjöblom, 2012). For example, in their study of interactions in flight simulators, Hutchins and Palen (1997) show how interactions in technical systems are interwoven performances accomplished through the communication among the crew in the context of the simulator environment. More precisely, they show how an explanation is carried out through the spatial organisation of artefacts in relation to the gestures and speech of the flight crew. In their analysis, the physical layout of a fuel panel in the simulator and its relation to previously encountered representations of the fuel system permit the flight crew to "see the panel as an object in itself and as the fuel system it represents" (Hutchins & Palen, 1997, p. 17). Hence, to quote Säljö (2010), "what we know and master is, to an increasing extent, a function of the mediating tools we are familiar with" (p. 53). For this reason, another important precondition for simulation is students' prior experience of the work setting for which they are training. Rystedt and Lindwall (2004) find that it is nursing students' prior experiences of anaesthesic care that enable them to perceive desktop simulations as "representing typical problems in anaesthesia, i.e. to see the cases as a simulation of something specific" (p. 181). Moreover, the students' prior experience and knowledge of the educational content are preconditions for them to be able to formulate and make sense of the work-related problems that occur during simulations. During simulations, problems arise in real time, just as they do in the work settings for which students are training:

> Since the events unfolded in real time, the participants were required to react immediately, leaving no time for checking in their literature. Most importantly, the students were compelled to consider *when* to give analgesics, *when* to decrease the delivery of anaesthetic gases, when to extubate and *when* to ventilate manually, etc. (Rystedt & Lindwall, 2004, p. 183)

As the simulation unfolds, the students relate the events both to different phases of anaesthesic work and to specific patterns that could indicate, for example, pain in a patient. In this way, students training in simulations handle several questions relevant not only to the curriculum, but also to their future work practice, in real time.

It is interesting to discuss not only the similarities, but also the so-called inconsistencies between simulators and previously encountered technical systems. Regardless of how much effort is devoted to the technical design of a simulator, glitches are always present (Hindmarsh et al., 2014; Maran & Glavin, 2003; Rystedt & Sjöblom, 2012). The previous section provided an example of how inconsistencies between a simulator model and the marine environment in Oslo Harbour led pilots in training to use an inappropriate navigation method. While Hontvedt (2015b) highlights the risks of adapting to wrong work practices in such situations, research on simulations in the healthcare domain points out that both similarities and differences between work settings and practices are important for understanding simulations in terms of work. For example, in a study of simulator-based training in healthcare, Rystedt and Sjöblom (2012) show how participants seem to continuously display to one another how the situations should be understood in terms of realism and relevance to the work practice, "as being objects of that sort" (p. 795). Similarly, in a study of dentists in training, Hindmarsh et al. (2014) argue that glitches and inconsistencies should be seen as instructional resources, rather than as deficiencies of the simulator. For example, the instructor may be able to use such inconsistencies to highlight aspects of the curriculum during simulations and, thereby, to provide students insights into work practices in clinical settings. Following this view, the realism of simulation-based training is seen as a continuously enacted social achievement that depends on the participants' "mutual orientation to the moral order of a good clinical practice and a proper situation" (Rystedt & Sjöblom, 2012, p. 785). Hence, in order for a simulation to be a realistic and relevant learning activity, it cannot be entirely predesigned. Rather, both the realism and relevance of the learning activity depend on the interactions between the participants and the context, and these interactions must be addressed from moment to moment through expert guidance and feedback. These results imply that realism is an instructional concern rather than an inherent technical feature of the simulator. Therefore, creating simulations that are perceived as authentic instances of work practice is highly dependent on participants' continuous orientation towards which aspects should be treated as relevant and irrelevant at any given moment. This, in turn, requires the participants to see and understand the simulation as a simulation: that is, to learn how to simulate (Rystedt & Sjöblom, 2012). For example, in Hontvedt and Arnseth (2013) the simulation is organised as a role-play. While this organisational approach is connected to maritime hierarchy and work roles, the practice of role-play sometimes makes instructions during simulations unclear, since the role-playing character of the delivery of an instruction can disguise the instruction as simply part of the role-play. Hence, students learning how to simulate is, in its own right, an important feature of simulator-based training (cf. Rystedt & Sjöblom, 2012).

Post-simulation debriefings as sites for learning

The literature on simulator-based training has focused extensively on post-simulation debriefings, which have been described as "the heart and soul of simulator training" (Deickmann et al., 2008). Debriefings have also been said to "transform experience into learning" (Hontvedt & Arnseth, 2013, p. 92) and to integrate theoretical knowledge with practical experience (Fanning & Gaba, 2007). For these reasons, the debriefing phase is often described as especially important for learning, as it helps participants understand and synthesise their experiences, thoughts, and feelings during the scenario. As a consequence, several pedagogical models for facilitating reflection in debriefing have been developed, mainly in healthcare (e.g. Fanning & Gaba, 2007; Neill & Wotton, 2011; Rudolph et al. 2008). A debriefing model provides a structure for the debriefing process. In general, the first part of debriefing is oriented towards describing what happened during the scenario (Fanning & Gaba, 2007). The second part is oriented towards feelings: that is, the emotional and empathic content of the scenario. The aim of this portion of the debriefing is to explore the participants' feelings in order to personalise the experience (Fanning & Gaba, 2007). The last part of the debriefing can be described as an evaluation stage. It involves identifying each participant's view of the experience and how these views apply to the events in the work setting for which the participants are training. This portion of the debriefing develops a holistic view of work practices through the explanation, analysis, and evaluation of behaviours (Fanning & Gaba, 2007).

The literature addresses the challenge of achieving what is referred to as deeper reflection during debriefing. However, the research offers different perspectives on the ways in which a supportive climate for instructor–student dialogue can be accomplished. Wickers (2010) and Fanning and Gaba (2007) suggest that reflection and discussion require a trusting and supportive climate, in which students feel free to share their experiences without judgment. This involves several challenges. First, the members of a group need to form a cohesive and productive team. In order to establish trust within the group, Wickers (2010) stresses the importance of the facilitator emphasising the need mutual respect and consideration and suggests that team members can build trust by signing a confidentiality agreement that ensures everything that happens within the group stays within the group. Wickers (2010) also recommends that instructors use the principles of therapeutic communication: attentive listening, asking open-ended questions, restarting and clarifying. The main idea of this approach is to facilitate discussion rather than to provide answers. Fanning and Gaba (2007) even claim that facilitators must position themselves as co-learners rather than as authorities or experts, as this will allow them to provide guidance and direction rather than lecturing. By contrast, Rudolph et al. (2008) emphasise the need for instructors to provide critical judgment, stating that:

> Effective debriefers are neither harshly judgmental nor falsely "non-judgemental": they neither berate students nor sugar-coat or camouflage criticisms. Rather, they provide clear, honest critique in a way that is respectful and curious about the student's perspective. (pp. 1010–1011)

Debriefing with good judgement is considered important for supporting formative assessment and achieving expected learning outcomes and improved performance. This model also highlights that debriefings should combine critical comments with short didactic lectures (Rudolph et al., 2007).

During debriefing, it is a common practice to use different technologies to provide feedback. For example, the research on healthcare has explored the use of video-assisted debriefs (e.g. Savoldelli et al., 2006). In the context of maritime debriefing, Hontvedt and Arnseth (2013) mention a visualisation described as "an electronic map", which replays the simulated scenario, as a means for organising debriefings. A pedagogical benefit of playback technologies is that they provide a record of the actions taken during the scenario, thereby allowing participants to view their prior actions from an observer's perspective (Fanning & Gaba, 2007). The main idea of this approach is that having an observer's perspective on one's own conduct allows participants to see how they actually performed, instead of relying on their own thoughts or perceptions of how they performed. This is argued to be helpful for "self-assessment" and reducing "hindsight bias" in debriefing (Fanning & Gaba, 2007, p. 122). Johansson, Lindwall and Rystedt (2017) build on this line of thinking by exploring what formulations like these might mean in practice. More precisely, in their close analysis of video debriefs for interprofessional team training in healthcare, they scrutinise how different perspectives are made relevant in debriefings. Their results show how participants regularly distinguish between appearances and experiences in relation to the videos of the scenarios. For example, the participants noted that they looked calm and professional in certain situations, assessments made possible by their third-person perspective of their own conduct. However, the participants' calm appearance on the videos might not always resemble their recollections or experiences of the scenarios. This discrepancy can be handled in various ways:

> That they actually looked calm, despite feeling nervous, could be presented as a *discovery*, which they discovered by watching the video. It could also be presented as *merely appearance*, and as part of an argument that the video provides a *limited*, *partial*, or even *misrepresentative* view of the matter. (Johansson et al., 2017, p. 19)

As seen in the above quotation, observations of one's own conduct still leave room for diverse evaluations. Hence, in my view, using video to reduce "hindsight bias", as proposed by Fanning and Gaba (2007, p. 122) is problematic. What is central to the use of video in debriefings, however, is that the technology re-actualises prior events, both enabling assessments of the participants' conduct and opening up discussions on what constitutes good work practices (Johansson et al., 2017). While the use of video is central to such reflections, the reflections acquire their meaning in and through professional guidance. During video-assisted debriefs, the instructor guides the students to see the recorded events in ways that are relevant to the professions for which they are training. Moreover, the contributions of fellow students serve as important resources during these guided reflections, allowing students to join the instructor in building positive assessments of fellow students' performances. Hence, while video has been argued to enable self-assessment in debriefings (e.g. Fanning & Gaba, 2007), Johansson et al. (2017) clearly show that such reflections are collaborative achievements rather than individual ones, dependent on the collaborative and instructional organisation of the debriefing.

In sum, this chapter has outlined changes in maritime work practices and the maritime training system. It has also described different views on simulators and their use in training. The next chapter explores the theoretical underpinnings of this thesis.

III. Theoretical framework: Situating learning in social, material and cultural practices

To accomplish the research objectives of this thesis, a workplace study approach is appropriate. Workplace studies are motivated by the desire to develop in-depth understandings of how people use technologies in their day-to-day work and learning practices (Luff et al., 2000). Workplace studies take the situated organisation of collaborative work and learning and the use of different technologies to accomplish these activities as their analytical interest. While workplace studies have traditionally been applied to learning in the workplace, there are studies that have applied this approach to learning in educational settings, as well as learning contexts outside formal education. Such studies include, for example, research on the use of blackboards in mathematics classrooms (Greiffenhagen, 2014) and on sports coaching in the gym and on the basketball court (Evans & Reynolds, 2016). Regardless of empirical setting, the objective is to explore the complexity of human–technology interactions "in the wild" as they unfold naturally in the setting under study (Heath et al., 2010). This implies a research approach that is empirically driven: that is, an approach in which the analysis begins by observing the empirical data to see what the participants are doing, rather than with a set of strong theoretical assumptions to be tested (see e.g. Rawls, 2008). The use of such an approach in this thesis implies that the theories used in the empirical studies vary depending on the research questions that emerged during the analysis of the empirical data. The employed theories stem from anthropology and sociology, including Suchman's (2007) situated action, Hutchins' (1995) distributed cognition and Goodwin's (1994, 1995, 1997) work on professional vision. Although the theoretical underpinnings of the various studies in this thesis differ, all share some commonalities that will discussed in this chapter. Specifically, they are all committed to 1) studying instructional practices from the participants' perspective, with a focus on not interfering with participants' practice; 2) using talk and bodily actions in the material world as the unit of analysis (e.g. Goodwin, 2003; Hutchins, 2006; Luff et al., 2011); and 3) the situated material and cultural natures of learning.

Before exploring these commonalites, however, the chapter begins with a historical backdrop of the paradigm shifts in studies of technology and learning that led to the emergence of workplace studies.

Paradigm shifts in research on technology and learning

There are several research fields that take an interest in technology and learning. The first to appear in the late 1950s was computer-aided instruction (CAI), a research field that drew on behaviourist principles of learning to explore how computers could transform learning (Säljö, 2010). As Koschmann (1996) describes, CAI reflected the beliefs and attitudes of the general education community at the time, viewing learning as "the passive acquisition or absorption of an established (and often rigidly defined) body of information" (p. 6). The main approach of CAI was to identify a specific set of learning goals, to deconstruct these goals into sub-goals, and to develop a sequence of activities to support the achievement of learning objectives (Koschmann, 1996). The behaviourist paradigm was followed by the intelligent tutoring systems (ITS) view (Koschmann, 1996). ITS emerged from artificial intelligence (AI) research in the beginning of the 1970s. It was a cognitive approach that viewed learning as a computational process in which the learner acquires a proper representation of a problem space. Whereas CAI's main research agenda was to evaluate the effectiveness of technologies in education, the primary concern of ITS was to understand expert tutoring in complex technological domains in terms of representations and representational states. What CAI and ITS had in common, according to Koschmann (1996), is that they both drew on a conventional view of learning as transmission, in which learning is seen as being transferred from an instructor to a student via a restricted set of operations.

Today, there are two main traditions within the learning sciences with an interest in technologies: cognitive psychology and the situated/socio-cultural perspective (Arnseth & Ludvigsen, 2006; Ludvigsen & Arnseth, 2017; Ludvigsen & Mørch, 2010). Arnseth and Ludvigsen (2006) frame these two traditions as ether systemic or dialogical. While the systemic orientation is grounded in classic cognitivist traditions of testing hypotheses based on variables, the dialogical tradition analyses collaboration and learning as situated phenomena that develop over time through interactions. Workplace studies, the research tradition that informs this thesis, belongs to the dialogical tradition, which emerged in recent decades to develop an open research agenda for exploring the complex interplay among instructors, students and technologies (Säljö, 2010). The shift towards the social and material aspects of work and learning in relation to technologies has been driven by growing criticisms of the cognitive approach and an increasing concern for its practical usefulness for studying the introduction of new technologies in work settings (see e.g. Bannon, 2000; Luff et al., 2000). One of the main issues was, and still is, the recognition of the role of failures in capturing and understanding how users adopt new technologies in their everyday practices. For example, Suchman's (2007)[3] early work at Xerox PARC in the 1980s involved resolving usability problems relating to users' experiences with photocopiers. Her analyses of users who interacted with photocopiers caused Suchman (2007) to "rethink the intricate, and increasingly intimate, configurations of the human and the machine" (p. 1). As a result, Suchman (2007) proposed a new approach to research on human–computer interaction: using methods for analysing face-to-face human conversations as the basis for human–machine communication. Suchman's (2007) main idea was not to ascribe intent to the machine, but, rather, to assume that the machine, like humans, behaves in accordance with the resources available in a given situation. The so-called Lancaster studies furthered this field by exploring social and organisational factors related to the software crisis in the 1990s and the failure of software development projects to live up to the expectations (e.g. Button & Sharrock, 1998; Plowman, Rogers & Ramage, 1995; Randall, Marr & Rouncefield, 2001). Another practical concern has been the ever-changing nature of technology, which creates not only new opportunities for communication and collaboration, but also new challenges for the successful implementation of digital resources in work and learning settings (Luff et al., 2000). However, workplace studies research has also been criticised for its lack of practical usefulness to system design (e.g. Dourish, 2006; Dourish & Button, 1998; Halverson, 2002; Plowman et al., 1995). The main problem is the tension between providing an adequate explication of a work or learning practice, on one hand, and translating this account into usable design recommendations, on the other: in other words, the tension between descriptive power versus application power.

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[3] The first edition of *Plans and Situated Actions* was published in 1987. I have read the second edition, to which I refer throughout the text.

On a more theoretical note, context has also been considered a problem in previous research paradigms. For example, Norman (1980), an advocate of the cognitive approach at the time, formulated early critiques of existing theories:

> The problem seemed to be in the lack of consideration of other aspects of human behaviour, of interaction with other people and with the environment, of the influence of the history of the person, or even the culture, and the lack of consideration of the special problems and issues confronting an animate organism that must survive as both an individual and as a species. (p. 2)

The quotation highlights what was considered a lack of contemporary theories in cognitive science that considered the social, material, cultural and ecological aspects of cognition (Dreyfus, 1992). The critique prompted a new kind of approach to human–computer interaction studies: one that shifted towards the social, material and cultural aspects of interactions with technology. This has been described as yet another paradigm shift built on disciplines devoted to understanding how language, culture and other aspects of the social setting play a role in working and learning with technologies (Koschmann, 1996). These disciplines include anthropology, sociology, linguistics and communication science. For example, Suchman (2007) criticised the dominant cognitive planning model, arguing that the plan was an underlying mechanism for action. To highlight the model's failures, the author used navigation as an illustrative case:

> Once the European navigator has developed his operating plan and has available the appropriate technical recourses, the implementation and monitoring of his navigation can be accomplished with a minimum of thought. He has simply to perform almost mechanically the steps dictated by his training and by his initial planning synthesis. (Gladwin, 1964, as cited in Suchman, 2007, p. 51)

In the classical cognitive view, a plan is a sequence of actions designed to meet a desired goal state. From this perspective, planning is tightly related to mariners' prior knowledge of the environment and the situations likely to arise, as well as unforeseen events that require re-planning or alternative plans on which to fall back. In contrast to this view, Suchman's (2007) work situates actions in their material and social circumstances to determine how intelligent behaviours are local productions rather than products of rational planning. This approach applies even in cases requiring a plan for future actions. While the cognitive view sees plans as determining actions, Suchman (2007) views plans as merely loose templates for action, since what people do is contingent on the ever-changing circumstances of the here-and-now in which action takes place. The notion of situated action, however, was coined well before Lucy Suchman introduced it into the field of human–computer interaction. As pointed out in a footnote in Suchman's (2007) *Plans and Situated Actions*, the notion of situated action was present in the 1940s writings of sociologist C. Wright Mill. However, Suchman's (2007) use of the term draws mainly on the ethnomethodological distinction between situated actions and accounts. As so elegantly formulated by Rooksby (2013), the introduction of the notion of situated actions serves as a "ticket into the ethnomethodological theatre, and can be torn up upon entry" (p. 4). Since Suchman (2007) draws on theories from sociology, including ethnomethodology (Garfinkel, 1967) and conversation analysis (Sacks, 1992), all social action is considered situated: that is, the relevant next thing to do in any activity is contingent on the social and material context, but what counts as a relevant context is determinable solely in the course of action. Hence, there is no longer a need to identify anything as situated because, following this approach, everything is. By introducing this concept, Suchman's (2007) early work moved research on human–computer interaction towards a view of human practices as situated and afforded by the ever-changing materials and social circumstances of practices.

Several important advances within the field of human–computer interaction came from research outside it. For example, Bannon (2000) mentions being particularly influenced by work in the field of anthropology, such as Hutchins' (1995) *Cognition in the Wild*. In an ethnographic study on board a naval vessel, Hutchins (1990, 1993, 1995) explored the work practices involved in navigating a large ship, analysing the computational basis of plotting a ship's past and projected movements, the historical roots of this practice and the social organisation of the bridge team. Hutchins (1990, 1993, 1995) also analysed in detail how practices are accomplished on the bridge of a vessel, showing how cognition is distributed across members of an activity and exploring the tools they use to accomplish their navigation tasks. The analysis produced an approach to cognition that views cognitive processes as being located in the external world and distributed in time and space, thus situating cognition in material practices and culturally constituted activities. Bannon (2000) describes distributed cognition as "a bold attempt to keep many of the concepts used in cognitive science" (p. 234), while staying mindful of the interplay among mind, body, activity and context.

As evidenced in this section, workplace studies draw on a diversity of disciplines and can be found in different research fields. There are also several different theories, perspectives and approaches that are considered suitable for studying the social and cultural aspects of learning with technology. These include, for example, ethnomethodology, conversation analysis, social psychology, situated learning, activity theory, situated action and distributed cognition (see e.g. Luff et al., 2000; Rogers, 2004; Stahl, 2005). While Stahl (2005) stresses that one does not have to commit to one of these theories, the process of choosing suitable theories for different research aims in a field as diverse as workplace studies should be considered in terms of both ontological and epistemological challenges and affordances:

> A problem with allowing a field to expand in this eclectic way is that it can easily get out of control. No one really knows what its purpose is anymore or indeed what criteria to use to assess its contribution and value to knowledge and practice. For example, of all the many new approaches, ideas, methods and goals that are now being proposed how do we know which are acceptable, reliable, useful and generalisable? Moreover, how do researchers and designers, alike, know which of the many tools and techniques to use when doing design and research? What do they use to help make such judgments? (Rogers, 2004, p. 88)

However, although these theories are not identical, Greeno, Collins and Resnick (1996) argue that the situated, pragmatist and sociocultural perspectives are still compatible in terms of their units of analysis, taking as their unit of analysis the embedding of actions and learning in the social, material and cultural practices of learning something specific.

In sum, there are a variety of views and opinions concerning how workplace studies emerged and what its purposes and practical values are. What is clear is that workplace studies draw on several different research disciplines in an attempt to develop in-depth understandings of how people use technologies in their work and learning activities and that the paradigmatic shift that launched the discipline was towards both "the wild" and "the social". These aspects are further explored in the following sections of this chapter.

Naturalistic studies of learning practices

The field of workplace studies is dedicated to exploring the complexity of human–technology interactions as they occur in the context of naturalistic work settings:

> These studies explore the ways in which artefacts are "made at home" in the workplace, and demonstrate how the use of the most seemingly "personal computer" rest upon a complex social organization, an indigenous and tacit body of practice and procedures through which tools and technologies gain their occasioned sense and relevance within workplace activities. (Heath, Luff & Knoblauch, 2004, p. 337)

Naturalistic studies are, at times (and as mentioned above), described as being "in the wild": a notion that has been popularly used to describe user phenomena in context, versus in lab-based research (Crabtree et al., 2013). According to Crabtree et al. (2013), the term originated in the works of Lave (1988), Hutchins (1995) and Suchman (2007) and their references to cognition being "in the wild". However, it is worth acknowledging that Suchman's (2007) influential work began in the laboratory of Xerox PARC. Thus, while Suchman (2007) analysed video recordings of human-machine interactions with a photocopier inside a laboratory setting, Rooksby (2013) argues that *Plans and Situated Action* should not be seen as an argument for ethnography or "in the wild" studies. Instead, Rooksby (2013) claims, the argument Suchman makes is that everything is situated, even in the laboratory. Rather than viewing action as being driven by its context, naturalistic research suggests that context is at the same time a driver and an achievement of action wherever interaction take place. However, in a 1995 article, Suchman clearly argues for ethnography and video recorded data, making a strong case for using these methods to "making work visible" in ways that allow participants to "speak with their own voices" (Suchman, 1995, p. 60). In the same year, Hutchins (1995) criticises approaches that rely on introspection, arguing that such approaches do not produce adequate or reliable accounts of what happens in a practice. He also criticises research that relies on laboratory studies, since such works seldom address the decisive role of context. Instead, Hutchins (1995, p. 287) argues for studies "in the wild", emphasising the need for close examinations of the context for thinking in order to understand the role of cognitive activities in human practices. This approach makes it possible to answer questions about what people do as they engage in activities, the social and material distribution of tasks and the sorts of strategies used to deal with work. Hence, the turn towards "the wild" was triggered by a corpus of studies concerned with the situated nature and organisation of everyday work, wherever such interactions take place. This shift is central to the empirical work in this thesis. Specifically, to order to explore how instructors' work supports students' learning during simulator-based activities, I undertook empirical work at a maritime simulator centre: an environment in which such learning activities take place on a daily basis.

Another central tenet of the empirical work in this thesis is an orientation towards the practitioner as the expert (cf. Rawls, 2008). The reason for this orientation is that practitioners already understand their practices, and their routines, practices and lived problems are of primary interest to workplace studies (Rawls, 2008). Schegloff (1987) argues that it is in the interactional details between participants that a practice can be found and that even macro-social issues can be answered through the detailed microanalysis of interaction. The argument is that this is the "bedrock of social life" and that the order and organisation of actions lie in their details (Schegloff, 1987, p. 102). Hence, the inner function of a practice lies within the order, organisation and details of talk at work. This perspective paves the way for a research approach that is empirically driven: that is, an analysis that begins with an observation of the empirical data rather than with a set of strong theoretical assumptions (see e.g. Rawls, 2008; Stahl, 2012). This approach has been said to represent an "ethnomethodological indifference" towards theory and can be traced back to the writings of Garfinkel (1967) and Sacks (1992):

> When Garfinkel and Sacks introduced the idea of ethnomethodological indifference, some of their language suggested a strong version of value-free sociology that would endeavor "to describe members" accounts of formal structures wherever and by whomever they are done, while abstaining from all judgments of their adequacy, value, importance, necessity, practicality, success, or consequentiality. (Lynch, 1987, p. 371)

Rather than specifying a research question or hypothesis in advance, empirically driven research begins with a single presumption: that the participants of a setting are creating the social order of that particular setting. Even if researchers have initial ideas about theories, they should attempt to look beyond them, at least initially, to discover "what more" there is to learn about the setting (Rawls, 2002, p. 30). It is at a later stage of analysis, when the lived problems of the participants in a setting emerge, that theories or analytical concepts become useful for understanding the practice in more theoretical terms (Stahl, 2012). Thus, the analytical work of this thesis began with scrutinising singular bits of data to explore what the participants appeared to be doing and what talk and other socio-material conduct conveyed about their actions (cf. Schegloff, 2007). The lack of theoretical stipulations concerning what to look for creates space, instead, for a sense of where to look. Following this, the focus of this thesis is on the sequential order of social interaction in the material world, including aspects of talk, gestures, gaze and body positions, the theories the thesis comprises also differ in terms of their units of analysis. These similarities and differences are discussed in more detail in the following section.

Talk and bodily conduct in the material world as the unit of analysis

As stated in the previous sections, workplace studies take the situated nature of learning with technologies as a baseline for analysis. This section explores how such analyses are achieved within the theoretical frameworks used in the empirical studies of this thesis. Beginning with the notion of situatedness, the section explicates how action, cognition and learning are local productions that are contingent on the material and social circumstances of specific situations (Suchman, 2007). Building on the theoretical underpinnings of the situated action approach, the analytical aim is to find the inner function of the practice in the unfolding of the events under analysis:

> A central tenet of social studies of practical action is that those resources are not only cognitive, but also interactional. While acknowledging the role of conventional meanings and individual predispositions in mutual intelligibility, therefore, this chapter focuses on the neglected other side of shared understanding; namely the local interactional work that produces intelligibility *in situ*. The starting premise is that interpreting the significance of action is an essentially collaborative achievement. Rather than depend on reliable recognition of intent, mutual intelligibility turns on the availability of communicative resources to detect, remedy, and at times even exploit the inevitable uncertainties of action's significance. (Suchman, 2007, p. 86)

As seen in the above quotation, the focus is on participants, how they analyse one another and how their understandings of one another are routinely displayed from one turn to the next. Hence, the participants are the first analysts on the scene, engaging in the practical sociological reasoning in which we all engage to understand one another in everyday social encounters. When the researcher then begins his or her analysis, the focus shifts to investigating how the participants handle turns in talk in the course of situated action. The analytical focus on the turns and organisation of sequences of talk connects to conversation analysis and the assumption that social interactions are structured or organised in action pairs called adjacency pairs (Schegloff, 2007). An adjacency pair comprises two turns by different speakers, and the turns are adjacent (i.e. positioned one after another). Adjacency pairs can be categorised in first- and second-pair parts, such as summons and answers, greetings followed by other greetings, invitations or offers followed by acceptances or declinations and so on. In traditional classroom discourse, adjacency pairs are frequently initiations and responses or responses and evaluations that occur during IRE sequences between teacher and student (Mehan, 1979). When analyses include both the spoken and the non-spoken dimensions of interaction, such as gestures, body positions and gaze, as well as the material environment, they are said to concern the production of action (cf. Heath & Luff, 2013; Streech, Goodwin & LeBaron, 2011). When they include the material environment, talk and the body in the unit of analysis, Goodwin (1994) views learning as being situated in communities of practice: that is, the historical and discursive practices that constitute and shape how a professional is seen. In order to build relevant action, the participants in Goodwin's (1994) analyses simultaneously use a range of different semiotic structures, all with different properties: some verbal, others embodied, and still others material (e.g. properties of the environment or tools). The analysis is not complete until these structures have all been accounted for:

> The recognizable and consequential actions they are building for each other cannot be found in any single semiotic medium. As noted earlier, by itself the talk is incomplete both grammatically and, more crucially, with respect to the specification of what the addressee of the action is to attend to in order to accomplish a relevant next action. Similarly the embodied pointing movements require the co-occurring talk to explicate the nature and relevance of what is being indicated. (Streech et al., 2011, p. 2)

For example, in a study on colour categorisation amongst chemists and learning to differentiate between black and jet black, Goodwin (1997) studies the use of gestures to highlight the subject of scrutiny. The perceptual salience of the fibre under study became clearer when it was extracted from the background, making it possible to establish a figure–ground relationship. It is also important to analyse the tools and intellectual practices for learning to make such distinctions. Goodwin (1995) scrutinises the process of learning to see a phenomenon like the depth of the sea. The analysis reveals a "historically constituted architecture for perception" stored in the tools used for seeing in great depths, such as sonars and instruments for measuring conductivity, temperature and pressure, each of which shape depth perception in a different way (Goodwin, 1995, p. 254). Practices are also embedded in the intellectual frameworks of the different work practices that make phenomena like depth visible. Hence, perception or the ability to see a phenomenon is organised not internally (i.e. inside the individual brain), but, rather, within a system of social and material practices that are distributed over both space and time as knowledge is passed forward in history.

While the ethnomethodologically informed theories study turns of talk and bodily conduct, distributed cognition focuses on the input and output of functional systems (Hutchins, 1995). To achieve this, such studies take the flow of information in the system as their unit of analysis, paying particular attention to how information propagates across system nodes or actors. In this sense, Hutchins' (1995) tradition of distributed cognition connects to the classic cognitivist theories that see cognition as a process of internal computation (see e.g. Neisser, 2014). Hutchins (1995) expands what were seen as cognitive processes to include the social and material circumstances outside the brain of the individual. In this tradition of distributed cognition, the boundary between what are considered internal mental processes and what are considered external socio-material structures is blurred and plastic (Hutchins, 1995). What happens inside an individual is a propagation of certain kinds of system structures to other systems through mediation. Hutchins (1997) draws on Vygotsky's work, referring to mediation as the organisation of behaviour towards a task "by achieving coordination with a mediating structure that is not itself inherent in the domain of the task" (p. 338). Mediating structures can be immaterial systems, such as ideas, norms and rules; culturally constituted objects, artefacts and tools; or the behaviours of others in a social group. For example, in analysing a written procedure for the quartermaster[4] on watch, Hutchins (1995) explains:

> When a person first performs a task using written instructions, there is an apparent alternation between coordination with the written procedure and

[4] A quartermaster is a naval petty officer with responsibility for steering and signals.

> coordination with the world. One deals first with the written procedure and then with the world it describes. However, no alternation of attention is necessary once one has developed an internal representation of even the lexical level of the procedure description. (p. 304)

The relationship between internal and external is described here is very interesting. Unlike studies following the traditional cognitivist paradigm, Hutchins' (1995) work does not see the relationship between individuals' internal cognitive processes and external socio-material processes as moving coded information across boundaries. Rather, Hutchins (1995) looks not only for processes of coordination and resonance inside functional systems, but also for processes of synchronisation towards systems outside the functional system. The boundaries between internal and external structures can be re-integrated into the analysis if they are shown to be important to the system; however, they should not serve as a point of departure for analysis (Hutchins, 1995). Study IV of this thesis, in which the analysis is informed by distributed cognition, examines representations and representational states and how information propagates in the flow of information in order to study how a bodily action acquires its meaning. In particular, this study focuses on how a bodily action becomes a representation or enactment of certain aspects of the world (cf. Hutchins, 2010). Although the units of analysis used in their chosen theories differ, and regardless of whether they are informed by ethnomethodology or distributed cognition, the studies that comprise this thesis share a common commitment to analysing the sequential unfolding of events. The relationship among the theories and concepts of learning employed in this thesis will be the topic of the next section of this chapter.

Trajectories of learning in observable interactions

Existent research has proposed several different notions of what learning is and what characterises the learning process. Rather than commit to a theoretical definition of learning in this thesis, I aim to gain interaction-level knowledge of instructors' work of supporting students' learning towards master mariner competence during simulator-based learning activities. Following the tradition of workplace studies, I explore what learning specific work practices means for the participants under study. The theoretical perspectives used in the thesis are not learning theories *per se*; rather, they focus on what is made visible in locally produced social interactions. Stahl (2012) argues that one can observe learning processes at work through detailed analyses of the interactions and discursive practices that occur between participants without making inferences about hidden changes in mental models or invisible social structures. Instead, according to Stahl (2012), analysts should explore how resources are used by looking for the resources that participants employ in concrete activities. Other researchers, such as Sahlström (2009), argue that conversation analytical studies have added to our understanding of how interactions in learning situations are organised. Furthermore, there is an interest in the relationship between what is constructed, e.g., learning, identity or gender, and how such constructions are accomplished in interaction (Sahlström, 2009). According to Sahlström (2009), this concerns both moment-to-moment interactions and processes over time:

> […] participation always changes, from syllable to syllable, from turn to turn, from action sequence to action sequence. Quite clearly, not all of these changes are to be understood as learning, whether arguing from within CA or within participationist learning research, but exactly how to deal with change is not, at the time of writing, fully developed. (p. 108)

Sahlström (2009) suggests that participation is in constant fluctuation and that the analytical research concern is the organisation of this flexible phenomenon, even in microanalyses. However, Sahlström (2009) also notes that this tradition has not yet determined exactly how to deal with change. It appears that an analytical focus on both how participants learn and the content[5] of learning is critical for being able to deal with changes in participation (Melander & Sahlström, 2009a). In their study of the progressive development of situation awareness for pilot training in a flight simulator, Melander and Sahlström (2009a) show how content is constantly being negotiated and renegotiated in interactions and, thus, how learners achieve "changes in the orientations toward the co-constructed content [that] can be understood as learning" (p. 151). This argument is extended by Melander and Sahlström (2009b), who attempt to break down what is identified into the two aspects of what and how in order to understand participants' orientations towards content as a "constituent aspect of participation" (p. 1523). Their results demonstrate, in interactional detail, not only how participants

[5] In my research questions, I use the formulations of learning lessons to address both content and topics. Similarly, but in a more analytical vein, I use the term object of knowledge to address questions of content.

collaboratively construct a perception of the learning content, but also how the topic evolves throughout the activity. Hence, in order to understand learning, we must treat learning as relational (Melander & Sahlström, 2009b). Others, like Koschmann (2013), argue that learning cannot be found in such local instances; rather, learning is a matter of how activities are transformed over time. What is put on display in microanalysis is the exhibited understanding of the participants (cf. Hindmarsh, Reynolds & Dunne, 2011). Hence, what these analyses offer is an understanding of understanding as an interactional achievement. In this way, the focus is on studying embodied social actions in what has been described as a primordial site of learning: local instances of situations in which participants carry out courses of action together (e.g. Goodwin, 2000; Macbeth, 2011).

Study II draws on the work of Suchman (2007), who proposes an ethnomethodologically informed approach, and the analysis addresses locally produced exhibits of students' understanding rather than their learning (cf. Hindmarsh et al., 2011). In Studies III and IV, the analysis focuses on instructive demonstrations of the object of knowledge, with a clearer focus on how different topics evolve throughout the activity (cf. Melander & Sahström, 2009a, 2009b). One reason for this focus is that Goodwin's (1994) work on professional vision, as well as the distributed cognition approach, offers an analysis of what Hutchins (2014) calls multiple time-scales to contextualise microanalyses of work in the larger context of a community of practice. For example, Hutchins (1993) suggested that learning to navigate can be simultaneously seen in local instances of interaction and situated in a long tradition of work practices:

> While every navigator and navigation team depend upon the long tradition that precedes them to structure their task environment, they also are part of the tradition for those who follow. The innovations that change the shape of the navigation activity come into being in the practice of navigation and their development can be studied in the microstructure of the interactions among people, tools, and tasks. We can see patterns of technological change over the long run, but we can also see the details of the process of innovation in the minutia of actual practice. (pp. 36–37)

In this way, a distributed cognition analysis implies not only a microanalysis of the local production of cognition available in the socio-material available here and now, but also an exploration of the large-level time scales that situate learning in cultural practices extending over time. In distributed cognition, learning is seen as an adaptive reorganisation within a complex system that includes “a web of coordination among media and processes inside and outside the individual task performer” (Hutchins, 1995, p. 289). Hence, the focus on learning processes becomes one of the participants’ adaption towards the socio-technical system, of internalizing knowledge through interactions with mediating structures, such as the instructions given by a teacher to a student or provided by the artefacts used to support learning. In Hutchins’ (2014, p. 46) view, learning takes place in the “local features of a cultural ecosystem” of different cultural practices; however, the reverse is also true: that is, the cultural practices are dependent on the stability of such ecosystems. The individual’s learning in cultural systems changes the ecology of the system itself. Such changes can be seen, for example, in the transformations of communicative practices between members in the setting or through their coordination with artefacts. Hence, the practices within a cultural system is both a premise for learning to occur as well as a premise for the cultural system to persist. It is these practices that make knowledge and expertise continuing through space and time.

Whereas this chapter has described the shift towards the social and the wild in theoretical terms, the next chapter outlines the empirical case and the methodological work done in this thesis.

IV. Research setting and methods

Drawing on the theoretical assumption that learning is constituted in locally situated social and material practices, this thesis follows a methodological approach based on ethnography and video-recorded data. These are methods that, when combined, are argued to make learning practices visible (e.g. Heath et al., 2010; Jordan & Henderson, 1995; Suchman, 1995). The research approach used in this thesis called for an inductive and empirically driven inquiry, which became iterative in nature through a back and forth between fieldwork, video recordings and analysis (cf. Derry et al., 2010; Eriksson, 2006). Coming from a background in cognitive science with previous experiences conducting ethnographic fieldwork and video-based research on technological work, I found this research design a promising option for answering the research questions posed in this thesis. This chapter describes the empirical case explored in the research, as well as the methods, the research process, the analytical work and the ethical considerations.

The empirical case

As pointed out in the preface, this thesis is part of a larger project, which is a collaboration between the Department of Mechanics and Maritime Sciences at Chalmers University of Technology and the Department of Education, Communication and Learning at the University of Gothenburg. While the project has a broader interest in training and assessment in simulator-based environments, my thesis work contributes to the larger project through analyses of instructions during training in a bridge operation simulator. The simulators are located at a maritime simulator centre at Lindholmen in Gothenburg, part of the Department of Mechanics and Maritime Sciences at Chalmers University of Technology. The department offers education in several areas of the maritime domain, including navigation, machinery systems, cargo handling, resource management and the marine environment. It comprises approximately 630 students and 100 employees[6] across three bachelor programs: master mariner, marine engineering and shipping and

[6] From the Department's Annual Report 2015.

logistics. The first of these serves as the context for my work. The department also offers several master programmes and a research school. The simulators at the centre are used both for educational purposes and for research and include cargo operation simulators (COS), engine room simulators (EOS), simulators used for radio communication (GMDSS)[7] and several types of navigation simulators ranging from desk-top simulators, to bridge operation simulators (BOS), to high-fidelity full mission bridge simulators (FMBS).

Participants and the master mariner programme

The simulator-based learning activities of interest in this thesis are part of a four-year master mariner programme with approximately 60 students in each year. The student group is largely homogenous with respect to gender and age: approximately 85 percent are young men and approximately 10 percent are young women, with most entering higher education directly from upper secondary school education. A smaller group of students are older, with prior working experience on board vessels. The study also involves three different simulator instructors and three additional lecturers. All of the instructors are well-experienced mariners; however, their experience as instructors at the maritime centre varies. One of the instructors has a background as a marine officer and has been teaching at the maritime school since the 1990s, when the simulator centre comprised a handful of computers in the basement. This instructor has been a driving force in developing the simulator centre towards state-of-the-art technology, working in close collaboration with the company that provides the simulator equipment to design the learning environment. This instructor has also been the director of the course under study for several years and is responsible for much of the educational design. Another instructor works primarily as a captain for a Swedish cruise line and has been a part-time instructor in simulator-based training in this specific course, as well as in other navigation courses, for the last ten years. The third instructor was newely employed, and still working alongside and observing the more experienced instructors during the time that the data were gathered (2014-2015).

[7] The Global Maritime Distress and Safety System (GMDSS) is an international system for radio communication between vessels, search rescues and maritime safety information.

Table 1. Overview of training activities in the master mariner programme. Navigation courses and bridge team management courses involving the use of simulators are highlighted in blue.

First year			
Terrester navigation (BOS)	Navigation A	On board practice	Mathematics
Ship stability	Cargo handling (COS)		Meteorology and oceanography
Safety	Cargo handling		Navigation B (BOS)

Second year			
On board practice	Economics	Maritime law	Navigation (BOS)
	Navigation systems	Navigation systems (FMBS)	Communication (GMDSS)
	Navigation C (BOS)	Communication	Communication

Third year			
Manoeuvring (BOS and training vessel)	On board practice	Cargo handling (COS)	Sustainable maritime environments
Machinery and electrics (EOS)		Elective course	Emergency health care
Cargo handling (COS)			Safety

Fourth year			
Final year project		Bridge team management (FMBS)	On board practice
Leadership	Elective course	Communication (GMDSS)	
		Safety	

During their education, the students spend approximately 16 percent of their time in different navigation courses and approximately 32 percent of their time as apprentices on board vessels[8]. In addition, some courses address maritime safety and emergency health care, cargo handling, economics and management, mathematics and physics. Students also complete a final year project report on an area of specialisation of their choice (see Table 1).

Navigation training in the bridge operation simulator

The navigation course was chosen as the focal point for this thesis in collaboration with project members from the Department of Mechanics and Maritime Sciences. The reasons for this choice were twofold: first, in the navigation course, simulator-based training is mandatory in accordance with the STCW convention, and second, the course trains and certifies students on both technical and non-technical skills. The course runs during the second year of the programme (Navigation C), meaning that the students have prior experience with both on board practice and simulator-based training through previous navigation and cargo handling courses (see Table 1). Furthermore, several students practice in the bridge operation simulator during extracurricular activities, led by fourth year students working as mentors at the simulator centre.

The contents of the lectures focus mainly on the technologies used in navigation (e.g. radar and ARPA equipment), the anti-collision regulations (COLREG) that serve as “rules of the road” at sea, communication among vessels and bridge team communication and operations. The simulator-based exercises are intended to train the students to apply these aspects of navigation in practice, and they consist of five mandatory simulator-based training sessions, each comprising two to three different scenarios. The scenarios are designed to train the appropriate use of ARPA functions in different traffic and weather conditions and to promote understanding of the strengths and limitations of the semi-automated system. Another learning objective outlined in the syllabus[9] is the ability to interpret and apply COLREG. A scenario for training these kinds of skills may require students,

[8] From the programme’s webpage (retrieved 15 October 2017): https://www.chalmers.se/sv/utbildning/program-pa-grundniva/Sidor/Sjokapten.aspx

[9] The learning objectives in the syllabus relate to questions about educational content; however, when studying training empirically, the terms learning lessons and object of knowledge are used to highlight the unpacking of the educational content in analytical terms.

for example, to navigate in the shallow waters near the coast of Skagen; to navigate the narrow and trafficked waters of the Great Belt Strait; or to connect, cross or follow the traffic separation scheme in the heavily trafficked English Channel.

At the end of the course, the students are examined by means of individual driving tests in the simulator using a scenario that is familiar to them, typically in confined and heavily trafficked waters. During the test, the students are expected to exhibit an understanding of how to use ARPA functions and to follow COLREG in the tested situation. Performance is assessed based on both the actions taken during the scenario and interviews with students on the bridge. The test certifies proficiency in handling radar and ARPA equipment in accordance with STCW conventions. The students are also examined by means of a written examination on COLREG at the end of the course.

Simulator-based training in the studied course is, like in other courses in the program, organised in the three phases mentioned earlier. During the briefing phase, the instructor leads an introduction to the day's assignment in the classroom, or the so-called briefing room (Figure 5). The seats in the briefing room are arranged in a horseshoe shape, and the students are seated in teams of two in prearranged positions according to which of the simulators they will use in the upcoming scenario. At the front of the room, there is a desk and a whiteboard, which are used mainly by the instructor. During briefings, instructions draw primarily on such technologies as Power Point, overhead sheets, paper-based course documentation and a white board. At times, nautical charts are used for instructions on course planning.

During the second phase, a scenario takes place in the bridge operation simulator, which comprises five different bridges that combine the physical space of a ship's bridge with digital projections of the marine environment (Figure 3). The bridge systems used here resemble the workspace of a technologically equipped bridge on board a larger-sized merchant vessel. They contain radar equipment with tools for automated plotting (ARPA)[10], electronic charts (ECDIS) [11], systems for automated ship identification (AIS), technologies for automatic steering and so on. In the corner of the room is a

[10] ARPA is an abbreviation for Automatic Radar Plotting Aid. ARPA is used to calculate course, speed and distance from other objects (e.g. other vessels or landmasses) in order to avoid collisions and groundings.
[11] ECDIS is an abbreviation for Electronic Chart Display and Information System. It is a computer-based navigation information system used for navigating with higher efficiency and precision.

chart table that allows the students to use nautical paper charts for course planning and plotting.

Figure 3: Students training in the bridge operations simulator. Picture from the empirical data.

During scenarios, the students work in pairs of two on each of the five bridges, training in the work roles of officer-of-the-watch and lookout. This work order places the students in pre-defined maritime work roles connected to bridge teamwork described in Chapter II. The officer-of-the-watch in front of the starboard (right hand) radar, in control of navigating and manoeuvring the simulated vessel, and the lookout in front of portside (left hand) radar, maintaining a close look on the marine environment as seen through the window of the bridge and on the radar display. During scenarios on the bridge, the students practise bridge team communication in a closed loop format. Specifically, the officer-of-the watch and the lookout engage in closed loop communication to discuss the situation at hand and make decisions. Moreover, the instructor regularly makes VHF radio calls from the instructor's room using this communicative format. The work hierarchy between the officer-of-the-watch and the lookout also affects speaking rights and responsibilities: that is, who has the right to speak to whom. For example, when the instructor makes a call over the VHF, perhaps role-playing as the captain of another vessel, it is the commanding officer who has the responsibility, and the right, to answer the call.

Figure 4. The monitoring technologies in the instructor’s room. Picture from the empirical data.

Figure 5. Instructions on the playback used in debriefings. Picture from the empirical data.

During scenarios, the instructor monitors the students from the instructor’s room (Figure 4). In the instructor’s room, several computer screens show different aspects of the activities in the simulator: the settings of the instruments, audio-visual recordings of the students’ teamwork and data for monitoring the students’ view of the marine environment as they see it during exercises. The instructor also has an overall view of the scenario through a screen showing the actions of each vessel from a birds-eye perspective.

During the third and last phase of simulation, a debriefing (i.e. a post-simulation discussion) is organised in the briefing room. The discussion is led by the instructor, who uses different technologies (e.g. PowerPoint presentations and scenario playbacks) as bases for instruction and collaborative discussion (Figure 5).

Method: Ethnographic fieldwork and video recorded data

For this thesis, persistent and prolonged examinations of the context for learning were vital in order to understand what people do as they engage in activities, the social and material distribution of their interactions and the sorts of strategies they use to deal with their tasks (cf. Heath et al., 2010; Hutchins, 1995; Jordan & Henderson, 1995). This implies that ethnographic fieldwork is an extensive part of my methodological approach:

> Ethnographic fieldwork within organizational settings immerses the participant observer (the researcher) in the work practices and processes of the organization. Participant observers may sit in on meetings, talk formally or informally with various organizational members, obtain copies of documents, gather stories, watch events unfold, overhear comments […] Questions arise *in situ*, just as the analytic framework arises out of the data itself, and field data may include interview transcriptions, field notes, meeting memoranda, sketches, even cartoons collected from cubicle walls. In some settings, the participant observer may be able to become a part of the organization by taking on some of the work, or by playing a legitimate role within the work setting. (Ruhleder & Jordan, 1997, p. 249)

The quotation emphasises several key aspects of fieldwork that are reflected in my own efforts: engaging in different activities, using different techniques for inquiry and moving from being an outsider towards being a participant in the setting through an inductive and empirically driven research method.

Moreover, in order to collect and engage in a detailed analysis of stable records of interactions during training in the simulator environment, video is an important part of the research design. Video documentation grounds theories of interaction and learning in records of empirical evidence (cf. Derry et al., 2010; Goldman et al., 2014; Jordan & Henderson, 1995). Video recorded data offer unique ways of representing and presenting ethnographic data. They capture a version of an event as it happens, including aspects of real-time social activities, such as talk, visible conduct and the use of different technologies (Heath et al., 2010). Moreover, video provides powerful opportunities for analysis, as it allows repeated and detailed analyses with possibilities for time-outs and playbacks. As pointed out by Jordan and Henderson (1995), it is through repeated viewings that "previously invisible phenomena become apparent and increasingly deeper orders of regularity in actors' behaviours reveal themselves" (p. 52). Hence, video creates stable records that can be reviewed, revisited and analysed collaboratively and, thus, has the potential to offer several different viewpoints of data in a way that textual representations, such as field notes, seldom do (Goldman et al., 2014). Finally, video supports the sharing of data among colleagues and peers, thus supporting collaborative analysis (Derry et al., 2010; Heath et al., 2010; Jordan & Henderson, 1995).

However, it is important to emphasise that the analyses conducted in this thesis would have been impossible without the contextual understanding of the empirical setting gained through ethnographic fieldwork and, in my case, the instructions captured in the videos. In this thesis, the ethnographic fieldwork is a premise and serves as an invaluable resource for both collecting and analysing video data. Spending time in the field (i.e. in the context of maritime training) is useful for identifying the routine patterns of learning activities that take place, learning which events would be considered unusual or adverse and, thus, determining which activities to record (Heath et al., 2010). The fieldwork conducted in this thesis provided knowledge about the setting that allowed me to find and frame the action when actually filming. Since the activities in the simulator are distributed across rooms, participants and a range of different artefacts, knowing the setting was critical for placing cameras in the right positions. Furthermore, spending time in the field was essential for being able to analyse the interactions captured on film, guiding the selection process and understanding the interactions taking place in the simulator environment (cf. Heath et al., 2010; Leonardi, 2015; Ruhleder & Jordan, 1997). The argument is that work and learning practices are not immediately available in the actions observed in the video data; such practices are, as Leonardi (2015) explains: "goal oriented, historically influenced, temporally emergent, materially bound, and recursively enacted" (p. 255). Following this, the argument is that, in order to answer questions on how various social and material phenomena are intertwined, how those practices develop in a given context and what functions they have in the current organisation of activities, the researcher must enter the space in which these practices take place. In my own work, I needed to get close to the learning context under scrutiny and to participate in the cultural setting of the instructional practices I sought to understand. In the thesis, the interest in how social, material and cultural practices evolve over time can be seen in the accounts in the previous chapters of the historical background of navigation methods and navigation training. This interest is also found in Studies III and IV, which outline the objects of knowledge under study as part of professional discourse.

While observational methods, such as fieldwork, certainly have several strengths when it comes to analysing work and learning practices, they also have some limitations. Work and learning activities, although captured on video, are also constituted in the participants' lived experiences of the practice (Suchman, 1995). Thus, video offers only an outsider's perspective of the activities. During the research process, I found it important to understand the participants' perspectives of their experiences of instructional practices in the simulator environment. To achieve this understanding, informal and contextual interviews with the instructors were included among the techniques used for gathering information during the fieldwork. Asking questions and gaining the perspectives of key informants were important sources of information for framing the context, and this contextual information should not be underestimated or overlooked (Heath et al., 2010; Jordan & Henderson, 1995; Leonardi, 2015).

Research ethics

The ethical considerations for the project were scrutinised and approved by a local ethical committee[12] in 2013. In accordance with the general ethical requirements of the Swedish Research Council (2017), the following considerations have been made and followed.

Informed consent has been obtained from all instructors and students in the studies of this thesis in line with the requirements for consent (Swe: *samtyckeskravet*). Information about the study was communicated both verbally and in writing at the beginning of the project, but also verbally to the participants before filming. This information was formulated in accordance with the information requirements (Swe: *informationskravet*). It outlined the project funding and the partners involved, as well as the main purpose of the

[12] In Swedish: Regionala etikprövningsnämnden i Göteborg

study. It also included information on how the data were to be collected, processed, presented and stored in order to ensure the participants' anonymity. Furthermore, the voluntary nature of the participants' engagement, including the possibility of discontinuing participation, was highlighted. Participants had the opportunity to reflect on their involvement and contact the principal researcher with any questions before submitting their written informed consent (Attachments I and II). If the students did not wish to be video recorded, they were offered the opportunity to participate in training sessions that would not be video recorded. Participants were also informed about the possibility to withdraw from the study during filming, if they wished. All instructors and students in the course participated in the study, and none chose to withdraw.

To ensure the participants' anonymity in accordance with the confidentiality requirements (Swe: *konfidelitetskravet*) of the Swedish Research Council, all photo and video contents have been anonymised during the reporting of the research results. No names have been used when referring to the instructors or the students, and faces have been blurred in any displays of photographs or video materials. For publications, photographs of participants have been transformed into sketched images. The data collected within the project will not be used for commercial purposes; rather, it will be used primarily for scientific communication, publishing and educational purposes. The results will also be used as the basis for applications for external research funding, in line with the ethical requirements for usage (Swe: *nyttjandekravet*).

In addition to being handled according to the Swedish Research Council's general requirements, the video material has been processed and stored in accordance with the Personal Data Act and its guidelines for unstructured material, since the videos contain identifiable images of individuals. The video material is stored in a locked safe in accordance with the regulations of the Department for Education, Communication and Learning at Gothenburg University. Computer files of the video recorded material and the ethnographic data are stored on password-protected computers and servers. All data will be kept for a minimum of ten years.

Conducting ethnographic fieldwork

In this PhD work, ethnographic fieldwork has been conducted in different phases of the research process (see Figure 6).

Figure 6. Phases of ethnographic fieldwork

In Phase 1, carried out in the autumn of 2013, I conducted observations to familiarise myself with the field of maritime training and gain an overview of the simulator centre as a whole. These observations included several different types of simulators and activities within the setting: cargo operations, engine control operations, and radio communication in the GMDSS simulator. However, the main focus was on different navigational tasks, and observations were conducted both in the ECDIS lab and in different navigation simulators. These observations included watching the master mariner students' first simulation-based exercise on the bridge operation simulator and participating in the usability testing of new software on the full mission bridge simulator. Furthermore, three different training sessions that were video recorded during the pilot study were followed up the next day with camera-free observations. The main goal of returning the next day was to follow up on the recorded observations with questions for the instructors concerning the setting and activities captured during the filming. Furthermore, the observations during this phase of the fieldwork included observations of basic lectures on navigation and bridge teamwork undertaken by the students in the master mariner program during their first year. These data were crucial in helping me gain basic knowledge of how to navigate and the specialist terms used in navigation.

In Phase 2 of the ethnographic fieldwork, my intent was to gain first-hand experiences of using the simulators. During training sessions or scenarios carried out on the bridge operation simulator, I familiarised myself with manoeuvring different types of vessels in different kinds of scenarios, such as navigating a large tanker in the Gothenburg archipelago or taking a small and fast rescue boat in and out of Sidney Harbour.

In Phase 3, the fieldwork became less structured as I slowly became more familiar with the setting. Time was spent in the field as part of the prolonged engagement at the simulator centre. Informal interviews with instructors, and, at times, students were important sources of information about the setting and the learning activities throughout the thesis project. However, the questions I asked tended to change as the project developed. At the beginning of the project, my questions were open-ended; they sought to capture the viewpoints of the respondents without any preconceptions. Informal interviews were carried out with all six of the instructors involved in the navigational courses under study, but also with instructors from other simulator facilities. All provided valuable insights into and perspectives on training and assessment in the simulator environment. As Heath et al. (2010) recommend, these interviews were carried out when they were the most convenient, and they often took the form of informal talks during coffee breaks, lunches, after-work activities, and even instructional activities. For example, when filming in the instructor's room, questions tended to arise in relation to using monitoring techniques to overview, instruct and assess the students' actions on the bridge. Although I attempted not to intervene in the on-going instructional work, the informal interviews were valuable for explicating the instructors' work practices and uses of technology in this setting (Heath et al., 2010). Towards the end of the data collection, my questions became more specific and specialised. These later questions were closely tied to the educational practices captured on film and were typically answered by the instructors in the course over telephone or through instant messaging.

Participating in industry events was also a part of the ethnography. For example, I presented the project at Swedish Maritime Day 2014, an annual industry event in Gothenburg. Furthermore, in 2013, 2014 and 2015, I attended the Kongsberg User Conference, which is an annual European simulator conference gathering approximately 150 to 180 industry actors with an interest in simulators. These events involve visits to different simulator centres, which offer opportunities to gain insight into simulator-based training in other settings. Additionally, as part of the overall project and the networking with actors in other domains, I took field trips to simulator centres outside the maritime domain, i.e. healthcare simulator centres as well as a simulator centre at a nuclear plant.

During the course of the structured observations, I took descriptive field notes by hand in order to create information-rich data with the potential to support analysis of the video recorded material. Other types of textual data (i.e. documents like course plans, course guides, different forms of assessment matrixes, PowerPoint lecture presentations and so on) also served as a basis for collecting information of the training practices at the simulator centre (cf. Ruhleder & Jordan, 1997). While the fieldwork primarily generated textual descriptions of the maritime domain—descriptions that, from an outsider's view, might seem fragmented and incoherent—it was the video recorded data that facilitated close and collaborative analyses.

Recording video data

Derry et al. (2010) describe video research as a non-linear process that moves back and forth between different phases: planning a study, collecting video data and selecting and analysing the video data. This is also the case in the present project, during which video recordings took place on different occasions. The main reason for this design was to ensure that the setting and the activities were captured in ways that would allow the research questions to be answered in sufficient depth. The highly technical simulator environment under scrutiny in this thesis is a complex setting to capture on video. It is both technically mediated and socially and spatially distributed, and it comprises several different rooms and numerous participants. These aspects make finding the action and framing it in a suitable way when video recording a non-trivial task. The description of the video data recording activities that follows discusses how the video data were gathered in the overall project to which this thesis belongs. Hence, it is important to point out that not all collected video data were used in the thesis project, which focuses specifically on instructors' work during training as part of the more general focus of the larger project on training skills and performance assessment in the simulator environment.

The collection of the video data in the simulator setting was designed together with other project members and members of the LinCS video lab. The design aimed to capture interactions simultaneously on all five simulators and in the instructor's room. It also sought to document the briefings and debriefings that took place before and after scenarios. Several set-ups were tested before one that framed the action in a productive way was found. This process is described in more detail in the following text (Figure 7).

Figure 7. Phases of filming in the simulator

First, at the beginning of the project in April 2013, test filming was carried out, coordinated and conducted by a senior researcher in the project. The recorded training session is part of a navigation course taken during the first year of training in the master mariner program, and it takes place in the bridge operation simulators. The learning objectives of the course are to develop skills in navigation and ship handling, but also to develop the ability to execute actions in accordance with COLREG. The video data captured all three parts of the training session (i.e. briefing–scenario–debriefing) across approximately three hours of video recorded data from a single fixed camera. This material served as a basis for early analysis and familiarisation with simulation training in the maritime domain, and one episode from these data is analysed in Study IV.

Second, a pilot study was conducted during November and December 2013. The recorded training sessions are part of the navigation course in the master mariner programme, which is the same course as that scrutinised in this thesis. While the project members assisted in designing the data collection, I was responsible for coordinating and conducting it, with assistance from a member of the LinCS video lab. When video recording, we used fixed cameras in both the briefing room and the instructor's room, as well as a roving camera that followed Instructor 1 during the exercise. The data from the pilot study comprise video recorded material from the briefings, scenarios and debriefings of three different exercises. In the educational setting, these are referred to as labs 2, 5 and 6, and they capture a total of 15 hours of simulation-based training of one student group with two different instructors. However, due to participants' feedback that the set-up interfered with their activities, as well as difficulties obtaining high-quality video records using a roving camera, the set-up was not considered successful. Some data from the instructor's room and the debriefing phase, including, specifically, the materials captured by the fixed cameras, are used in Study II.

Table 2. Overview of video recorded activities in the main study. The videos highlighted in blue are the videos that are closely analysed in this thesis.

Date	Time	Activity
Nov 3	08.00–10.00	Lecture on COLREG
Nov 5	13.00–17.00	Lecture on ARPA theory
Nov 10	08.00–10.00	Lecture on bridge teamwork
Nov 18	08.00–13.00	Lab 2
Nov 19	08.00–13.00	Lab 2
Nov 19	13.00–18.00	Lab 2
Nov 25	08.00–13.00	Lab 3
Nov 26	08.00–13.00	Lab 3
Nov 26	13.00–18.00	Lab 3
Nov 26	08.00–12.00	Lab 4
Nov 26	08.00–12.00	Lab 4
Dec 4	13.00–17.00	Lab 4
Dec 8	08.00–10.00	Lecture on COLREG
Dec 9	08.00–12.00	Lab 5
Dec 10	13.00–17.00	Lab 5
Dec 12	13.00–18.00	Lab 5
Dec 16	08.00–12.00	Lab 6
Dec 17	13.00–17.00	Lab 6
Dec 18	13.00–17.00	Lab 6

During November and December 2014, the main study, which involved recording video data from training sessions in the simulator, was carried out. An overview of the video recorded activities is presented in Table 2. At this time, three different training sessions per lab were recorded, yielding approximately 60 hours of simulation-based training. The aim was to collect data capturing all three course instructors and different student groups. During the two-month period, we filmed four of the six student groups, representing a total of 40 students from the master mariner programme. The set-up of the cameras was altered based on feedback and evaluations of the data from the pilot study. Specifically, we kept the fixed camera set-up used in the briefing room to capture instructions during the briefing and debriefing phases, and we placed a fixed camera in the instructor's room to capture the instructors' use of monitoring technologies during scenarios. Furthermore, instead of using a roving camera to follow the instructor (as in the previous set-up), we placed wall-mounted GoPro cameras on each of the five simulators in order to record the action on the bridges. In addition to the GoPro cameras, we used camcorders on the bridges to secure good-quality audio recordings. Although the use of multiple cameras is known to complicate data collection and analysis (Heath et al., 2010), we considered it necessary to simultaneously record the activities occurring in different physical locations in order to make sense of events occurring during the scenarios. The fixed camera set-up on each bridge was also considered to interfere with the participants less than the roving camera used in the pilot study.

In addition to the video recorded training sessions described in Table 2 above, four lectures were also filmed during the autumn of 2014. Although these lectures fall beyond the analytical focus of this thesis, I wanted to gather material to enhance my contextual understanding of the theoretical content of the course in order to improve the quality of the analyses. The video recorded lectures yielded approximately 10 hours of video data covering general information about course content and design, ARPA theory, bridge team operations and COLREG.

Analysing the data

The following sections provide insight into the analytic work in the thesis, including matters of data transcription and selection and the detailed and collaborative analysis of the empirical data.

Since the data-collecting phase generated a large amount of video material, the overall project established an analytical approach for handling the quantity in a structured way. In a sense, the analysis began as early as the data-collecting phase, as the data corpus was catalogued in relation to some basic aspects of the activities (e.g. dates, lab, camera and instructor). A map structure and an Excel document were used to keep the data organised (cf. Luff et al., 2011). The analytical process that followed can be described as a whole-to-part inductive approach that sought to identify patterns in the data without predetermined hypotheses, predictions or theories (Erikson, 2006). Following this approach, continuous viewings, re-viewings and collaborative viewings of the video material were conducted to identify patterns in the data (Derry et al., 2010; Erikson, 2006; Heath et al., 2010; Jordan & Henderson, 1995). Hence, an important part of the analytical process was viewing data together with other project members, my co-author in Study III and other researchers interested in the use of video analysis. Organised data sessions included collaborative viewings of data from a test filming in a workshop at King's College in London and recurring viewings with a network for analysing interactions in the learning sciences (NAIL) at the University of Gothenburg.

While the collaborative analyses of the video data with project members were more informal and took place regularly whenever I wished to validate my interpretations, the NAIL data sessions were more formal and structured events.

Because the instructions made during the scenario phases of the training sessions emerged as especially interesting during the fieldwork and early viewings, a decision was made in agreement with the other project members to begin the analysis by looking for instances of instructional talk in the bridge simulator during scenarios. Labs 3 and 5 were considered especially interesting and appropriate for this analysis for two main reasons: first, because the goal of the exercises in labs 3 and 5 is to train the students to navigate in confined waters, a situation that trains the students in all of the course's learning objectives, and second, because in lab 4 (unlike in labs 3 and 5), the students train alone. Training without a fellow student to keep lookout is primarily a preparation for the certifying assessment in lab 6, during which the students are alone on the bridge. Similarly, labs 3 and 5 are both representative of the more common training practice of teams of two students per bridge. In all, the video analyses in the thesis project are based on approximately 30 hours of training captured with multiple cameras.

From this data corpus, 70 instances of instructional talk from the scenario phase were identified. Each of these episodes begins when an instructor enters the simulator and ends when the instructor leaves. As a first step, these episodes were listed in a content log (cf. Jordan & Henderson, 1995). The content log was created in an Excel sheet that contained identifying information (e.g. date, time, lab, camera and instructor) and a summary listing for each event. The analysis first sought to label episodes as instances of certain kinds of topics for instruction, and through repeated viewings of the data, categories began to emerge from the material. As the analysis continued, 33 instructional episodes were selected for closer examination, leaving out the check-up rounds conducted by the instructor before each scenario to ensure that the students are ready to begin the exercise. The selected episodes range from one to eight minutes and centre mostly on the bridge panel and/or the chart table in the simulator. These episodes were transcribed using Inqscribe. The Inqscribe software maintains a close link between data materials and transcripts and allows users to insert time codes at any point in a transcript. These time codes can then be used to jump back and forth to exact points in the video. Moreover, the software offers opportunities for pausing, slowing down or speeding up the play rate of a video, facilitating a detailed analysis of the practices under study (cf. Eriksson, 2006). Initial transcripts were intended to capture talk at a more general level, examining what was said and some of the basic features of the talk (e.g. overlaps, pauses and volume; cf. Heath et al., 2010).

During the transcription work, as different kinds of phenomena started to emerge from the analysis, the categories of the different types of instructions continuously changed: from a focus on members' categorisations towards analytical conceptions of the topics of their interactions. Ultimately, five categories remained, all addressing different topics related to applying rules *in situ* and technical proficiency in using radar technologies:

1. Professional intersubjectivity (n=9)
2. Showing intentions (n=4)
3. Temporal aspects of coordinating in traffic (n=6)
4. Anticipating future states in traffic (n=8)
5. Technical proficiency (n=6)

It is important to point out that these categories occasionally overlap. For example, an instructional episode categorised as demonstrating professional intersubjectivity is complex, involving not only instructions related to showing one's own intention in a timely manner, but also corrections to the radar setting (Study III). By contrast, an instruction categorised as technical proficiency targets only the proper settings of the radar equipment, with no further discussion of the situation at hand.

During the next stage of analysis, particularly interesting categories of the transcribed instructional episodes were chosen for further examination. As the selection of what was analytically interesting was increasingly narrowed down, the chosen transcripts became more detailed. In particular, the selected transcripts focused on how talk is organised not only in terms of such features as intonation and pause lengths, but also in terms of bodily conduct and gaze, as recommended by Heath et al. (2010). It was during this stage of the process that the different studies started to take form, focussing particularly on matters of COLREG applications and technical proficiency (Studies II & III). Moreover, a research question emerged concerning a specific class of instruction noticed in the viewing of the video material: gestures that demonstrate movement in different ways (Study IV). This interest launched a revisiting of the data corpus to look for instances of such gestures. In all, five different episodes were identified in the video material from the test filming and labs 3 and 5 of the main study. In order to represent interactions that go beyond the verbal, frames from the video material were edited into sketches and used to portray the embodied conduct in the simulator environment while maintaining the participants' anonymity (cf. Derry et al., 2010; Heath et al., 2010).

While the early analysis aimed to explore the empirical data from different analytical viewpoints, it was not until this late stage of analysis that definite commitments were made with respect to the analytical concepts and theoretical frameworks to be used for each case. As pointed out in the previous chapter, it is not until a late stage of any analysis that the lived problems of the setting emerge and theories or analytical concepts become useful (cf. Stahl, 2012). Hence, the theoretical frameworks and concepts came to vary across the different studies. This is made evident in the summaries and discussions of the different studies comprising this thesis, which are presented in the next chapter.

V. Summary of the studies

As specified in the introduction, the overall aim of this thesis is to gain knowledge about instructors' work of supporting students' learning towards master mariner expertise during simulator-based learning activities. The research questions are as follows:

- What is the current status of research on simulator-based maritime training?
- How do instructors use the socio-material resources in the simulator environment in their instructional work?
- What is being taught and, thus, made accessible for students to learn in and through these instructions?

The four studies of this thesis address these questions in different ways. Study I answers the first research question by means of a systematic literature review examining the current state of the research in the field of simulator-based navigation training. The three empirical studies are set in the context of Swedish master mariner education, and they scrutinise activities in which students train to navigate in a simulator environment with the support of instructors in order to address research questions two and three. An overview of each of the four studies is provided in this chapter.

Study I: Simulators in bridge operation training and assessment: A systematic review and qualitative synthesis

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Study I is a systematic review of the literature on the use of simulators in bridge operation training, including training for work practices in the contexts of navigation, manoeuvring and teamwork. The benefits of conducting a review in a systematic way are several. First, a systematic literature review makes studies accessible and guides the reader towards relevant sections of the literature. It the research process more trustworthy and accountable and allows readers to make their own judgements concerning the quality and relevance of the studies included in their work. Moreover, the studies reviewed are synthesised using a narrative summary approach as a means to pool different sets of data and, thus, to gather research from a range of disciplines and methodologies (Bearman & Dawson, 2013).

The systematic review was conducted based on the *Cochrane Handbook's* specifications concerning how to achieve an explicit, reproducible and methodological review process (Moher et al., 2015). These guidelines suggest using a clearly defined set of objectives with pre-defined inclusion criteria, a systematic search designed to identify all studies meeting the inclusion criteria, an assessment of the validity of the study findings and a systematic presentation and synthesis of the studies included. The inclusion criteria in Study I were: articles with a focus on the use of simulators for training and assessing bridge operation in maritime training, published in recognised peer-reviewed journals, searchable in major academic databases, available in English and published between 2000 and 2016.

The systematic literature review identified 34 articles on simulator-based maritime training. These 34 articles represented a rather small and quite diverse field of research, comprising what I found to be three main areas of research: maritime professionals (n = 15), human factors (n = 13) and education (n = 6). Several of the articles lacked empirical data as a basis for the reported analyses and instead relied primarily on the experiences and best practices of maritime professionals within the maritime education system (n = 13). Maritime professionals have mostly positive perceptions of simulator-based training and view simulators as having obvious potential for training both technical and non-technical skills, although some are concerned about achieving learning objectives and fulfilling the requirements of the STCW convention (e.g. Hanzu-Pazara et al., 2008; Malik & Zafar, 2015; Pekcan, Gatfield, & Barnett, 2005). The potential of simulators for training skills like situation awareness and decision making is supported by human factors research, which uses an experimental research design is used to study the effectiveness of simulator-based training (Chauvin, Clostermann & Hoc, 2009; Saus et al., 2010; Saus, Johnsen, Eid, & Thayer, 2012). What is interesting, however, is that, in empirical studies examining the actual use of simulators in maritime training, the conclusions drawn are at times formulated as warnings that simulator-based training and assessment are being poorly implemented in maritime education (Emad & Roth, 2008; Gekara, Bloor, & Sampson, 2011; Sampson, Gekara, & Bloor, 2011). The problems reported concern both simulator misuse and a lack of knowledge about how to provide efficient training and valid assessment in simulators. Several studies emphasise the importance of skilled instruction during simulator-based training in order to accomplish learning objectives (Ali, 2008; Hanzu-Pazara, Arsenie & Hanzu-Pazara, 2010; Hontvedt, 2015b; Hontvedt & Arnseth, 2013). Hence, the results of the review suggest that, in order to address what has been identified as a possible safety hazard for the shipping industry, research is needed to provide guidelines for a) maritime simulator instructors during training and b) how to conduct simulator-based assessments of competence to ensure the validity and reliability of simulator-based tests. In relation to these directions for further research, Studies II, III and IV contribute with further knowledge about instruction in simulator-based training.

In May 2017, a new literature search was conducted, using the same inclusion criteria used in the published literature review (Sellberg, 2017) in order to update the review with results from studies published between 2016 and 2017. After excluding my own published studies (n = 3), an additional systematic search found four studies that met the inclusion criteria, all of which were categorised as human factors research studies (n = 4). These studies and their results are briefly summarised in the following.

John et al. (2016) compare the use of a low-fidelity simulation with that of a high-fidelity simulation in training maritime English for communication and decision-making in bridge teamwork. Their results are in line with those of previous research, showing that low-fidelity simulations provide students with the means to develop their communicative skills in ways that are both cost-efficient and user friendly (cf. Dahlström et al., 2009). Castells et al. (2016) report on the design of a simulator-based model course to train, demonstrate and revalidate professional seafarers' competences and certificates in accordance with the STCW convention. An IMO model course provides both the learning objectives and a premise for the assessment and certification of the 37 different courses for deck officers regulated by the STCW convention. The study contributes by enhancing, updating and supplementing existing training materials involving simulator-based training. Benedict et al. (2017)

conducted a design-based research of a different kind, reporting advances in simulator technologies by presenting the development of a new tool for briefing and debriefing manoeuvring skills. In particular, the tool is designed to enable demonstrations of a ship's motion characteristics, allowing immediate responses through rudder, engine or thruster commands. The tool shows promise for enabling discussions on not only the effects of different environmental conditions in manoeuvring, but also different strategies and alternative manoeuvres, which are useful in both the briefing and the debriefing phases of training. Finally, Baldauf et al. (2016) explore aspects of crisis management and team training for emergencies at sea in simulator environments by systematically comparing simulator-based exercises to the principles for this type of training outlined in the STCW convention. Their findings show that the dynamic unfolding is partially dependent on trainees' actions and interactions within the simulator environment and, thus, is not entirely predetermined by the scenario. Moreover, Baldauf et al. (2016) show that the simulation environment helps to improve the training of skills like communication and leadership by providing the means for accurate and enhanced feedback of the situation at hand. Based on these findings, Baldauf et al. (2016) stress the importance of continuous, real-time feedback in the simulator-based training process in order to achieve learning objectives.

Study II: From briefing, through scenario to debriefing: The maritime instructor's work during simulator-based training

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In simulator-based training, learning activities are generally organised in three different phases: briefing, scenario and debriefing. The first phase, briefing, serves as an introduction to the assignment. This phase commonly focuses on practical information relating to the upcoming scenario and the learning objectives. After the briefing, a scenario is played out in the simulator. In the navigation course that serves as the empirical context of Study II, the students work in teams of two in bridge operation simulators, under the supervision of a simulator instructor. Lastly, a debriefing (i.e. a reflection on the scenario) is carried out.

In the literature on simulator-based training, the debriefing phase is generally pointed out as especially important for learning (see Chapter II). However, during the ethnographic fieldwork, I observed that instructions frequently occurred during the scenario phase throughout the navigation course. Therefore, the analysis in Study II, which is guided by a situated action approach (Suchman, 2007), seeks to investigate the frequent occurrence of instructions during the scenario and the role of these instructions in the briefing–scenario–debriefing organisation of simulator-based training. For Suchman (2007), prospective instructions, such as those that occur during the briefing phase) are seen as reasoning about actions rather than providing a generative mechanism for action. Rather, it is during the course of actions, when problems are encountered, that instructions for action become useful (Suchman, 2007). During debriefing, after the scenario has been played out, the plan is reconstructed in retrospect, filtering out those aspects that can be seen to follow the initial plan (Suchman, 2007). Thus, the research questions of Study II are: a) How do participants orient towards instructions from the prospective briefing phase during the subsequent scenario and debriefing? and b) How do the social and material resources in the simulator environment structure the learning activities?

Study II draws on ethnographic observations and video data from the pilot study (see Chapter IV). Initial results from the study were presented as a poster at the 11th International Conference on Computer Supported Collaborative Learning (CSCL 2015; Sellberg & Rystedt, 2015). As the study was further developed towards a journal article, video recorded episodes from the main study were added to the analysis (see Chapter IV). In the final research design, episodes from one of the scenarios are used to trace two types of instructions throughout the different phases of the training. During the scenario, the students are training to pass the Great Belt[13] strait in clear weather. The instructions chosen from this exercise involve following the "rules of the road at sea" and using a specific radar function in a proficient way.

The findings of Study II provide explanatory accounts of the temporal and material conditions for the maritime instructor during different phases of

[13] The Great Belt is a strait between the islands Zealand (Sjælland) and Funen (Fyn) in Denmark.

training. During the briefing, before the scenario is played out, all the specific contingencies of the scenario are unknown. The instructor, therefore, must provide open instructions in order to encompass an infinite number of possible courses of events that may occur during the upcoming scenario. The students, by contrast, face the classical problem of the instruction follower: turning open and partial descriptions into concrete and practical actions towards a desired outcome (cf. Suchman, 2007). During scenarios, the instructor monitors the students' bridge work from the instructor's room. The monitoring technologies in the instructor's room allow a shared but partial view of the instructor and the students on the different bridges and, thus, enable an assessment of the students' on-going actions during the scenarios. This also allows the instructor to make corrections when students fail to follow the instructions given during the briefing, as it is during the scenario that the open instructions from the briefing can be delivered in a way that considers the contingencies of specific situations. Providing these immediate and detailed instructions during scenarios is crucial for developing professional competences, such as rule application. Finally, during the debriefing, the instructions from the briefing are revisited, the scenario is reconnected to the learning objectives and assessments are afforded in general terms. The use of simulator technologies (in this case, a playback of the scenario) makes it possible for the instructor to reconstruct the students' prior actions and to produce further instructions and, thus, assessments of specific details of students' conduct during the scenarios.

The findings of Study II highlight the importance of systematic professional guidance and feedback throughout the briefing–scenario–debriefing phases of training (cf. Hindmarsh et al., 2014; Hontvedt & Arnseth, 2013; Rystedt & Sjöblom, 2012). Moreover, the findings point to the monitoring technologies in the instructor's room and the playback of the scenario used in the debriefing as important pedagogical tools for the instructor. Specifically, the monitoring technologies provide opportunities to observe the students' activities and, in this way, support the instructor's work of continuously assessing and instructing the students' conduct towards the desired learning outcome. Moreover, the playback used during the debriefing provides sufficiently stable and accountable records of actions taken to support detailed assessments and allow discussion and reflection (cf. Hontvedt & Anseth, 2013; Savoldelli et al., 2006). Consequently, in addition to providing relevant contexts for professional training, the simulator environment also provides the means for the instructor's work.

Study III: Demonstrating professional intersubjectivity: The instructor's work in simulator-based learning environments

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Whereas Study II examines the relationships among the different phases of training, with findings pointing towards the role and importance of providing instructional guidance throughout the briefing–scenario–debriefing process, Study III specifically scrutinises the organisation of instructional work during on-going scenarios. In Study III, the students are training to cross the Dover Strait in restricted visibility, a traffic situation that requires them to coordinate with other (in this case, simulated) vessels in the rule-governed traffic system. For analytical purposes, Goodwin's (1994) notions of professional vision and professional intersubjectivity emerged as appropriate theoretical concepts for the instructional work examined in this study. In Goodwin's (1994) case considering archaeologists' work, professional vision and professional intersubjectivity involve being able to interact socially with other professionals, as well as using and producing artefacts that offer relevant representations of the world that other professional archaeologists are able to interpret. Hence, learning to see as a professional implies seeing and categorising the world in accordance with the expectations and accountabilities of other professionals. Goodwin (1994) notes that learning this discursive seeing and situating it within communities of practices are subject to instructions organised as demonstrations. Such demonstrations, in turn, are oriented towards professional coding schemes (in the case of Study III, radar displays and nautical charts) and the practices of highlighting and articulating these graphical resources. In keeping with this perspective, Study III explores how aspects of rule application, analytically understood as professional vision and professional intersubjectivity, are trained in the simulator environment by investigating the following research questions: a)

How does the instructor scaffold the students towards professional vision and professional intersubjectivity through instructions of rule application in on-going simulator-based scenarios? and b) How does the instructor use the different socio-material resources in the simulator-based learning environment in these instructions? The analysis is based on a single episode of instructional work during the scenario phase of training. The chosen episode resembles other episodes in the data corpus in two critical ways. First, it involves the material practices of using both radar technologies and the nautical paper chart to highlight semiotic fields and articulates the same core messages about rule application. Second, it shares a similar overall organisational structure for the instructions on rule application in the simulator.

The findings of Study III, like the findings in Study II, stress the importance of the instructor's professional guidance through all three phases of training. Study III also adds some findings concerning the structural organisation of instructions during the scenario. Specifically, it produces findings concerning how assessments precede instructions and, second, how assessment and instructions are closely intertwined and embedded in instructional practice in the course of action (cf. Greiffenhagen, 2012; Lindwall et al., 2015). Study III illustrates how the instructor's monitoring of students' on-going activities from the instructor's room enables the instructor to make assessments. In the empirical example, the criteria on which the students are assessed while carrying out the crossing of a traffic separation scheme lane in restricted visibility measure the quality of the students' integration of several sets of simultaneously active rules: a) the general rules that always apply at sea, b) specific rules that apply to particular situations and c) local criteria formulated by the specific maritime school. The instructor uses the students' displayed understandings of the rules to continue the instructions in order to, for instance, clarify or correct the students' actions. In the analysed episode, the instructor articulates how the students' navigational actions can be seen from the perspectives of other vessels in the scenario and encourages the students to view themselves through the eyes of the other vessels. In rule-governed sea traffic systems, considering others' perspectives is crucial for coordinating with other vessels and maintaining traffic flow. What is also analytically interesting about this instructional episode is that, to demonstrate professional intersubjectivity, the instructor draws on several different semiotic resources, such as the radar display and the nautical chart, as well as mediating structures, such as a laser pointer and gestures, to highlight relevant features. These instructions represent a continuous achievement that reflects the instructor's ability to recognise the fit or, as is the case in the single episode analysed in Study III, the gap between learning objectives and on-going activities in the simulator as they unfold. Study III shows how these embedded assessments and instructions in the simulator rely heavily on socio-material resources, including the monitoring technologies in the instructor's room, the radar technologies in the simulator and the students' displayed understandings of the situation as observed through these means.

Moreover, Study III provides an empirical analysis of activities of training to follow the "rules of the road at sea" in simulator-based training that, to our knowledge, has not yet been conducted in such a detailed manner. The findings show that the lessons towards which the instructor is oriented illustrate to the students the underlying functions and general patterns of the rule-governed traffic system (cf. Sharrock & Button, 1999). The instructor accomplishes this by highlighting and articulating different aspects of the on-going traffic situation to show students what they, as future professionals, will be accountable for in terms of recognising certain actions as in line with the rules of the traffic system. The findings illustrate how these instructions are carried out by means of diverse socio-material resources, including language, gestures (or alternative mediating objects, such as a laser pointer) and the semiotic structures in the simulator environment (e.g. the radar image or the nautical chart). Furthermore, Study III shows how developing the students' seeing as professionals goes beyond teaching the students to see and interpret other vessels according to the rule-governed traffic system; it is also a matter of teaching them how to produce actions in line with a maritime professional discourse. The students' manoeuvring actions, as represented on the radar, produce a semiotic structure that must use unambiguous representations in order to be accurately seen and interpreted by other professionals (cf. Goodwin, 1994). Using this structure, in turn, requires a level of professional conduct that goes beyond merely following the "rules of the road at sea": the students need to develop their seeing through the eyes of others with regard to the intentions they project through their own manoeuvring actions. This ultimately implies that the students need to develop professional intersubjectivity, which is accomplished through professional guidance in concrete training situations (cf. Goodwin, 1994).

Study IV: Representing and enacting movement: The body as an instructional resource in a simulator-based environment

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The background of Study IV relates to a general discussion across professional domains about the fidelity of simulators: that is, simulators as realistic and relevant contexts for training skills connected to work practices (see Chapter II). As pointed out by Rystedt and Sjöblom (2012) in a study on simulations in healthcare, no matter how advanced the design of the simulator is, inconsistencies, or "glitches", between the simulator environment and the work context will always appear and must be handled during instruction. In a study of simulations in dental training, Hindmarsh et al. (2014) found that such glitches often occasion debates and discussions and, thus, contribute to developing students' professional expertise. However, in contrast to Hindmarsh et al.'s (2014) view, research in the field of maritime training highlights the importance of simulators representing the work setting of a ship's bridge and the marine environment in a realistic way (Hontvedt, 2015a). One argument is that a lack of simulator fidelity may cause learners to simply manipulate the simulated model instead of training towards a maritime work environment (Hontvedt, 2015b). Hence, in order for simulator-based maritime training to be successful, Hontvedt (2015a) stresses, it is important to choose the right level of simulator fidelity for different learning objectives. Therefore, the aim of Study IV is to explore how the embodied activity of shiphandling is trained in simulators that lack kinaesthetic and proprioceptive feedback of movements in the world. The analysis is guided by two research questions: a) How are body and talk coordinated with the environment to create and coordinate representations of the missing aspect of the simulator during instructions? and b) What is the role of these representations in developing the students' understanding of the ship's movements in manoeuvring?

In order to investigate these questions, I analysed two episodes in the empirical data, each involving glitches between the simulator and the ever-moving work setting on board a seagoing vessel that were addressed during the instruction. As described in Chapter IV, the bridge operation simulator used in training is a high-fidelity navigation simulator that mimics several of the features of the bridge of a real ship, such as the technologies used for navigating and manoeuvring the vessel and projections of the marine environment as seen through the front window of the bridge. However, since the bridge operation simulator is not a full mission simulator with a motion platform that mimics the ship's movements, the sense of moving in the world is simulated through visual input rather than through kinaesthetic or proprioceptive simulator inputs. In Study IV, this lack of movement in the simulator is viewed as a glitch that is made relevant in different situations. The first episode is a scenario in which the students are entering a close encounter with another vessel and are about to perform an evasive action to avoid collision. They are supported by the instructor in carrying out a sharp turn. What is interesting here is that if this turn were carried out on a real ship, the ship would sway (i.e. lean) considerably inwards during the turn: an aspect of manoeuvring that is not represented in the layout of the bridge operation simulator. The second episode is a scenario in which the students have been reducing speed while navigating in heavy traffic and restricted visibility. During this scenario, in which both visual and kinaesthetic feedback of speed are missing, the students' main source of information about speed is the feedback available from the navigational instruments. Hence, rather than seeing or sensing speed, the students must grasp the notion of speed on an abstract level.

The analysis of these instructional episodes is guided by a distributed cognition approach, taking the transformation and propagation of representations in the functional system as the unit of analysis (Hutchins, 1995). In particular, the analysis concerns how bodily action becomes a representation and how a representation acquires its meaning through an examination of the coordination of talk and bodily conduct in instructions that take place on the bridge operation simulator.

Like Studies II and III, Study IV shows the rich variety of resources available to instructors and students in face-to-face instructions during scenarios in the bridge operation simulator. In the context of simulator-based training, the instructor coordinates his bodily conduct (i.e. gaze, bodily posture and gestures) with talk oriented towards the simulator environment. The coordination of different representations enables the students to grasp and communicate the dynamic relations between elements in the world: a feature of using bodily conduct in conversation that can be seen in all types of settings. Study IV also demonstrates that the coordination of different representations is oriented towards an imagined vessel and its movements in an imagined marine environment. This includes representations of the objects involved in ship handling missing in the simulator, i.e. the rudders or the vessel, and the instructor's bodily conduct and talk to show and enact their movements during these learning activities. Moreover, the events and activities that constitute ship handling are addressed in instruction, using the body as an instructional resource for enacting dynamic aspects such as sway and inertia. Following this, the results suggest that the coordination of representational states is used to fill in glitches in the simulator environment, adding imagined layers of functionality where functionality is missing. Hence, the findings show how realism is an instructional concern and interactional achievement during training rather than a property of the simulator as such, and that this applies also in simulator-based maritime training.

The second research question concerns the role of the various representations in developing students' understanding of the ship's movements when manoeuvring. Instructions that fill in the glitches seem to have potential to prevent the types of training pitfalls that are caused by a lack of simulator fidelity, as warned by Hontvedt (2015b). Exploring inconsistencies between the simulation and the work setting provides opportunities for instruction and discussions that can further students' understanding of the work practices for which they are training. This, in turn, requires fastidious instructors who closely monitor students' work and are ready to support them through exercises in the simulator. Thus, one conclusion is that the instructors' concern in simulator-based environments is one that teachers everywhere regularly ponder: questions about whether the students understand their instructions or not. Hence, instructors routinely look for students' displays of understanding during the instructional work that takes place in the simulator environment. Even if it is difficult to make strong statements concerning whether and how students learn from the verbal instruction and the enactments of the ship's movements, Study IV clearly illustrates the role and importance of professional guidance during simulation. The instructional work of a qualified instructor with professional experience as a seafarer connects the simulated event with the students' experiences of the work practice encountered during on board training and illustrates the relevance of theoretical and abstract knowledge in practical situations.

VI. Discussion and conclusions

In the Introduction to this thesis, the overall aim is stated as to gain knowledge, at the level of interaction in instructional settings, on the instructors' work of supporting the students' learning towards master mariner expertise during simulator-based learning activities. The research questions were formulated as follows:

- What is the current status of research on simulator-based maritime training?
- How do instructors use the socio-material resources in the simulator environment in their instructional work?
- What is being taught and, thus, made accessible for the students to learn in and through these instructions?

With regard to the first research question, Study I shows that simulator-based maritime training is a rather small and diverse field of research. Moreover, several of the studies concerned with simulator-based maritime training draw on professional experience rather than empirical data as a basis for analysis and, hence, conclusions. Instead of providing empirically grounded results, these studies provide normative accounts of what can be referred to as best practices based on the opinions and experiences of professionals within the maritime educational system (e.g. Hanzu-Pazara et al., 2008, 2010; Suppiah, 2007). Although such contributions might provide insights into the problems and practices of simulator-based maritime training, there is also a need for empirical analyses that move beyond preconceptions about learning in simulator-based environments. In this thesis work, I carried out three empirical studies (Studies II, III and IV) in order to address this gap and, thus, provide empirically grounded findings concerning instructors' work in supporting students' learning during simulator-based learning activities. The empirical results are discussed further in the following sections. Subsequently, the theoretical and methodological contributions of the thesis are discussed, and directions for future research on simulator-based maritime training are pointed out. After this, the main conclusions of the thesis are summarised and highlighted. The chapter concludes with final remarks regarding the limitations of the thesis.

The instructors' role in simulator-based learning environments

One result that is at the forefront of all of the empirical studies in this thesis concerns the role and importance of professional guidance during simulator-based training. Study II shows how instructors work to bridge theory and practice throughout all phases of training, from briefing and throughout the scenario to debriefing, via a structured process of abstraction and application of general rules for action. While learning is commonly ascribed to the debriefing phase in other studies (e.g. Fanning & Gaba, 2007; Wickers, 2010), my results point to the significance of instructors' work to support students during scenarios through moment-to-moment instructions. Such contingent instructions draw on the specific circumstances of each scenario as it unfolds. They target professional matters of rule application and skill acquisition that are difficult to address during later stages of the learning process, such as during the debriefing, since they are sensitive to the specific details of the context in the midst of action. For the instructors, monitoring the students' on-going activities in the simulator makes it possible to attend to specific details of the students' conduct to make assessments. My results show how such assessments represent a continuous and on-going process that is grounded in the instructors' abilities to recognise the fit or gap between the learning objectives and the students' activities in the simulator as they unfold. The students' actions as well as their understandings of the situation shown in their answers to questions are then drawn on to continue the instructions in ways that support each student bridge team. Moreover, when instructors enter the simulators and interact with the students face-to-face, they make use of the variety of navigational technologies in the simulator as a basis for their instruction. Hence, instructions in the simulator can be used to target critical aspects of navigational work, such as how to direct attention and integrate information under specific circumstances. Moreover, the results show how the instructors' interventions during scenarios are doing critical corrective work to prevent that the students focus on mastering sailing within the confines of a simulated model. Instead, throughout simulations they guide training by invoking the work practices of a seagoing vessel. Hence, the role of the instructor in simulator-based environments goes beyond training specific skills, the instructors also have an important function in preventing that students adopt incorrect work practices.

During debriefing, the event is revisited and, thus, has to be reconstructed in order to reactualise prior actions. Certain details of the event may be difficult to reconstruct in retrospect, even when using a playback of the scenario as a basis for the debriefing. Through scenario playbacks, the students can receive feedback and, thus, opportunities to reflect on both their own conduct and their peers' performance. This involves learning not only through one's own experiences, but also from discussing the experiences of others. Hence, the instructions that occur during debriefings are accomplished in a different way than during scenarios, allowing for abstraction and generalization of the specific events, which in turn, are critical for learning from the practical exercises. An almost unison conclusion in research across domains highlights the importance of post-simulation debriefing for learning for these reasons (e.g. Dieckmann et al 2008; Fanning & Gaba 2007; Johansson et al., 2017; Wickers, 2010). Hontvedt and Arnseth (2013) even note that debriefings "transform experience into learning" (p. 92). With regard to previous studies, my results provide empirical analyses of how debriefing relates to the briefing and scenario phases of simulator-based training. In particular, the results of Study II highlight how bridging between general rules for action and specific situations and relating simulated events to the work practices for which students are training occurs not only during debriefings, but also throughout all of the phases of simulator-based training.

In sum, the results of this thesis highlight the importance of systematic professional guidance and feedback in simulator-based training, supporting results from research on simulations in healthcare (Rystedt & Sjöblom, 2012), dentistry (Hindmarsh et al., 2014) and the maritime domain (Hontvedt & Arnseth, 2013). Moreover, the empirical results of the different studies in this thesis highlight not only the importance of instructors' work, but also the specifics of how and why this work is important for students' training to become master mariners. Whereas this section of the discussion has focused on instructors' crucial work during simulations, the next section focuses on the use of simulator technologies in order to further reflect on how and why the material resources in the simulator environment are made relevant during training.

The use of simulator-based technologies in training

As stated in the Introduction, this thesis challenges the view that the simulator is a mere training context: that is, a rather neutral device. Instead, this thesis focuses on how the use of simulator technologies is restructuring the ways in which maritime work practices are taught and learned. Chapter II outlines how the development of skills in educational settings differs from the hierarchical and temporal development from novice to master through apprenticeship in the maritime domain. In the navigation course under study, the students are training in the simulator to handle demanding navigational operations, including, for example, crossing the confinded and trafficked waters of the Dover Strait in restricted visibility. This is an operation that only experienced master mariners would handle on board a seagoing vessel, and, as shown in Study III, the professional vision the second year students are expected to develop in the exercises requires a level of professional intersubjectivity that typically takes years of experience to acquire. However, it is possible for the students to carry out the exercises with the support of an instructor who does the work of highlighting the relevant aspects of the semiotic environment and demonstrating how to interpret what the students should see in line with the discourse of maritime practice (cf. Goodwin, 1994). As the students' professional vision develops, the instructor gradually decreases this instructional support, while still being attuned to when instructional support is needed. As Chapter II describes, a simulator is a place in which novices like students can function as masters, taking on the responsibilities of officers in educational settings. The role of the instructor during training, then, becomes one of "shaping the context of the community to initiate, develop and evolve" (Emad & Roth, 2006, p. 597). The empirical results of Study III illustrate how the instructional work accomplished in the simulator environment fosters the students' understanding of the prevailing norms of what is considered good seamanship in the maritime discourse. It is such instructional work, seen in the continuous assessments and instructions of an experienced instructor, that shape and create a community of practitioners.

What the simulator offers is something quite different than learning work practice on board a seagoing vessel, since both the conditions and the primary goal of the activities differ. On board a vessel, the primary goal is to navigate the vessel in a safe way. In the simulator, the primary goal is to learn to navigate any vessel in safe manner in a setting that allows exploration, experimentation and mistakes. As argued for in Chapter II and demonstrated in Study II, simulator-based training is a hybrid activity: that is, an activity in which students can practice handling several questions relevant to their future work practice in relation to the curriculum (cf. Rystedt & Lindwall, 2004). The view of on board practice and simulator-based training as two different training practices has practical implications for the maritime training system, since on board practice cannot easily be replaced by simulator-based training (cf. Barsan, 2009). Study IV shows how matters of realism in the simulator environment rely on both instructors' work of connecting simulated events with work practices on board a vessel at sea and students' prior experiences with on board practice. I argue that the combination of on board practice and simulator-based training, as well as the constant pondering of questions concerning the realism and relevance of these contexts, are prerequisites for relating skills trained in the simulator setting to work on board a vessel (cf. Hindmarsh et al. 2014; Rystedt & Sjöblom, 2012). In line with this view, instead of taking the notion of knowledge transfer as a point of departure, I suggest discussing these results in terms of a boundary crossing (Säljö, 2003). The notion of a boundary crossing highlights the dialogical phenomenon of relating two practices, as can be seen in the instructive works of both Rystedt and Sjöblom (2012) and Hindmarsh et al. (2014). Furthermore, while the notion of transfer emphasises the need for similarities between practices, a boundary crossing implies finding productive ways of relating partially similar and dissimilar practices across contexts (cf. Akkerman & Bakker, 2012). In Study IV, such dissimilarities are referred to as "glitches", or aspects that are missing in the simulator. When using the body as a resource to represent and enact missing aspects of movement, the dissimilarities between the simulator environment and an ever-moving seagoing vessel can be thematised in instruction. What makes the simulator such a useful boundary-crossing artefact between training and work is that it is designed to be a realistic training context that fits into existing work practices in the maritime domain. At the same time, it is rather open and, thus, allows for flexible use. Therefore, the simulator provides a training environment that can be used by both students learning to become professional seafarers and experienced professionals developing their competences and skills throughout their professional careers. Hence, learning how to simulate is, in its own right, a professional skill required in the maritime industry that deserves more research attention (cf. Hontvedt, 2015a; Rystedt & Sjöblom, 2010).

While much effort goes into developing and evaluating the realism and fidelity of maritime simulators, the results of this thesis point towards the role and importance of other pedagogical tools in the simulator environment. These tools include the monitoring technologies in the instructor's room, which enable the instructor to make on-going assessments and, in turn, to provide students with the instructional support necessary to achieve learning objectives (Studies II and III). They also include technologies for debriefing, such as scenario playbacks that make prior actions accountable and, thus, enable post-scenario discussions, reflections and assessments of the events that are played out (Study II).

Directions for future research

In the Introduction, I highlighted the need for upgraded forms of training and assessment that, on one hand, acknowledge the multifaceted nature of performance in simulator-based training and, on the other, meet the criteria for certification established by international standards. In the literature on simulator-based maritime training, several points concerning the current training and assessment system stand out as alarming (Study I). For example, Emad and Roth (2008) conclude that not only does the current training system fail to achieve its learning objectives, but the assessment system has actually changed the learning objectives. Rather than training for work practices on board ships, Emad and Roth (2008) argue that the main goal of the current training system is to help students pass competence tests in accordance with the STCW convention. Furthermore, competence tests in simulator environments have been claimed to be lacking in validity, reliability and security (Gekara et al., 2011; Sampson et al., 2011). The argument is that the current system fails to train students in what are often referred to as higher cognitive skills, such as comprehension, application, analysis, synthesis and evaluation: skills that are supposed to be a central focus of training and assessment, according to the convention:

> […] the multiple choice tests and simulator scenarios we examined seemed to fall short of any desirable standards even accepting the limitations of the form of assessment applied, thus putting to question the capacity of these new assessment methods to deliver valid assessment results. (Gekara et al., 2011, p. 98)

What Gekara et al. (2011) finds when observing simulator-based competence tests is a focus on such aspects as maintaining vessel course and speed, maintaining a safe distance from other vessels in the scenario and maintaining the required draft. Furthermore, the scenario in the competence test is argued to be very similar to the scenarios that students carry out during training. Rather than pointing to the dynamic nature of scenarios or viewing so-called higher cognitive skills as intertwined with these particular work tasks, Gekara et al. (2011) conclude that the current training system favours "examination coaching" and "rote learning" rather than high-quality training or the effective evaluation of "essential knowledge and skills" (p. 98).

One reason why previous studies have found that the maritime training system is failing to deliver high-quality training to students might lie in the conflict between different theoretical standpoints. Research that draws on classical cognitivist theories and separates technical and non-technical skills works well under experimental conditions for measuring the effects of training in simulators (e.g. Chauvin et al., 2009; Saus et al., 2012). By contrast, qualitative studies, which draw on theoretically constructed distinctions for analysis to identify good or less good practices in accordance to the fulfilment of international standards, might lead in the wrong direction. The reason is that technical and non-technical skills are intertwined in naturally occurring learning practices and are difficult to separate from one another by merely observing activities during fieldwork. When instead drawing on situated theories, which implies analysing interactional details by means of video data, there are opportunities to study how learning practices unfold during simulations. Thus, when taking this approach, it is possible to produce adequate explications of existing training practices in the simulator (cf. Hontvedt, 2015a). The theoretical and methodological contributions of this thesis point to the value of taking an empirically driven, explorative research approach. Specifically, by scrutinising the instructional practices in the simulator environment in their own right and avoiding the abstract and normative notions of learning practices in the analytical process, this thesis produces an adequate explication of existing training practices in the simulator environment (cf. Lindwall et al., 2015). The results of the thesis show how current simulator-based training, at least in the setting under study, even goes beyond training technical proficiency and cognitive skills in line with the requirements of the STCW-convention. The learning activities that take place in simulator environments are systematically related to becoming a competent master mariner. The results emphasise the need to account for principles of good seamanship and international regulations, which are at the core of formal maritime training. Moreover, they demonstrate how and why the nature and meaning of good seamanship and the rules of the sea are hard to teach in the abstraction; their application relies on an infinite number of circumstances that have to be accounted for in every specific case (cf. Belcher, 2002; Taylor, 1998). In particular, Studies II and III show how instructors' practice of highlighting details of students' performance together with explanations of general principles and formal rules at the core of good seamanship is key to developing master mariner students' professional competence.

These results call for a shift in perspectives when studying simulator-based maritime training: from a focus on isolating and measuring different sets of abstracted skills towards a focus on how students learn the routines and discourses of the profession in and through instructional guidance on specific work-related tasks involving a variety of intertwined skills. The theoretical and methodological implications of such a shift point away from classic cognitive theories, towards the testing of hypotheses based on variables and situated and socio-cultural theories in which learning is seen as a situated phenomenon that emerges in interactions over time (cf. Ludvigsen & Arnseth, 2017). With respect to analysing simulator-based training in a manner that considers the social and material practices of culturally constituted activities, the workplace study approach has much to offer. In three different studies, this thesis demonstrates how the combination of ethnographic fieldwork and a detailed interaction analysis of video data is a fruitful approach to render the learning practices in technological settings analysable and, in turn, visible in interactional detail.

Conclusions

The empirical findings reveal an instructional practice centred on the need to account for general principles of good seamanship and the anti-collision regulations of maritime operations. With respect to this training model, my results illustrate the close connection between the technical proficiencies and non-technical at play in training for maritime work. Based on this premise, the empirical contribution of this thesis emphasises the role and importance of providing students with specific instructions during both scenarios and debriefing. I conclude that simulator-based training fulfils the STCW convention's requirements to train both technical proficiency and non-technical skills. Moreover, I argue that the learning activities that take place in simulator environments are related to becoming a competent master mariner. Systematic professional guidance and feedback on the similarities, differences and irregularities between practices are critical for helping students relate the simulation to the work settings on board vessels. It is also important to emphasise that simulator-based training should not replace time at sea. Rather, to ensure that students can relate between practices, simulator-based training should be combined with periods of apprenticeship on board a vessel.

Final remarks

It is important to keep in mind that the thesis draws on brief episodes of the instructors' work in a simulator environment where sufficient resources are invested in order to ensure high quality training. Although the STCW convention strives to maintain international standards for training and assessment, one reason previous studies have found problems in the training system is likely that simulators are implemented in various ways in different settings (see e.g. Emad & Roth, 2008). The simulator environment under study in this thesis was developed in close collaboration between simulator developers and the instructors at the simulator centre, such that the simulator environment has been tailored to the instructors' requirements in order to fit into their work practices. In fact, the monitoring systems seen in the instructor's room have been awarded a design prize for their user-centred design and functionality[14]. Including users in the design process and considering their work practices is key to successfully implementing technical solutions in work and learning settings (see e.g. Button & Sharrock, 1998; Luff et al., 2000; Randall et al., 2001). In light of previous research on simulator-based maritime training, the results of this thesis should serve as an example of experienced and competent instructors working in a state-of-the-art simulator environment.

Another limitation of this thesis is that its empirical study is restricted to simulator-based activities designed as trainings for maritime operations. While initial results from Hontvedt (2015b) have shown that training models that separate and individually target technical and cognitive skills may conflict with

[14] Award for Design Excellence from the Norwegian Design Council.

participants' professional knowledge of work practices, there is still a need for research that analyses such training models further in order to explore their usefulness for maritime training.

There is also reason to pay serious attention to the results of Gekara et al. (2011) and their warnings concerning how computer-based assessments are introduced and applied in maritime training settings. Especially alarming are the reports of a commercialised system where corruption, cheating and manipulation of test result are frequently occurring, and these, in turn, pose a threat to safety in the maritime industry (Gekara et al., 2011; Sampson, et al., 2011). The limited scope of the thesis on the instructors' contributions to professional learning during simulator-based training leaves several critical questions that concern the assessment system unexplored and unanswered.

VII. Swedish summary

Som avhandlingens titel indikerar, är det övergripande intresset i denna studie att analysera hur sjökaptensstudenter tränar navigering i simulator-baserade lärandemiljöer. Avhandlingsarbetet är en del av forskningsprojektet ”Träning och bedömning av professionellt agerande i simulatormiljö” som genomförs i samarbete mellan Institutionen för mekanik och maritima vetenskaper vid Chalmers tekniska högskola och Institutionen för pedagogik, kommunikation och lärande vid Göteborgs universitet. Projektet initierades av instruktörer vid sjöfartsutbildningen som en reaktion på uppgraderingar av nationella och internationella regelverk som ställer uttalade krav på valida och reliabla kriterier för träning och bedömning. De senaste två decennierna har sjöfartsutbildning i viss utsträckning övergått från pappersbaserade test och skriftliga tentamina, till tester och kunskapsprövning grundade på praktiska övningar i simulatorer. Detta leder till ett antal nya utmaningar. Å ena sidan måste de simuleringsbaserade kunskapsprövningarna uppfylla de kriterier för bedömning och certifiering som formulerats i regelverken. Å andra sidan bör proven vara känsliga och relevanta i relation till komplexiteten i simulatorträningen. Hur kunskap i handling utvecklas och kan bedömas är en klassisk fråga inom pedagogisk forskning och praktik. När traditionella examinationsformer ersätts med bedömning i simulerade situationer ställs frågan på sin spets. Projektet berör frågor kring hur professionell kunskap utvecklas inom och genom observerbara samspel i högre utbildning samt hur bedömning av studenternas agerande genomförs. I relation till dessa forskningsfrågor svarar avhandlingen på den första frågan genom fyra olika delstudier, medan det övergripande projektet utforskar frågor kring bedömning i simulatorn med särskilt fokus på formativ bedömning och dess roll för utvecklandet av professionell kunskap. Den svenska sammanfattningen ger en övergripande bild av avhandlingens problemområde, syfte och frågeställningar, den studerade praktiken samt teoretiskt angreppssätt och metod. Slutligen sammanfattas och diskuteras resultaten från de olika delstudierna och avhandlingsarbetets kunskapsbidrag.

Introduktion

Sjöfartsutbildning är ett illustrativt exempel på en utbildning som under de senaste decennierna genomgått ett flertal genomgripande förändringar. Dessa kan hänföras till en rad olika omständigheter. Dels har själva arbetet ombord på fartyg förändrats; besättningen har minskat i storlek samtidigt som en rad nya teknologier för navigering har förändrat hur arbetet på bryggan organiseras (Lützhöft & Nyce, 2014; Ljung & Lützhöft, 2014). Samtidigt har lärandepraktiken förändrats; från ett system med lärlingskap, där en sjöman arbetade sig upp i hierarkin ombord, till en akademisk utbildning där delar av den fartygsförlagda praktiken är ersatt med träning i simulator-baserade lärmiljöer (Emad, 2010). Sedan 1978 regleras sjöfartsutbildning av internationella regelverk, framförallt av STCW-konventionen[15], som formulerar standarder för hur träning och bedömning ska ske för fartygsbehörighet och olika typer av certifikat. Konventionens senaste tillägg, Manilaändringarna från 2010, betonar allt mer vikten av att träna och certifiera så kallade icke-tekniska färdigheter och professionellt agerande i simulatormiljö. De förändrade arbets- och utbildningsvillkoren ställer således höga krav på lärosäten att utbilda tekniskt kunniga och professionellt kompetenta sjöbefäl, och att på ett systematiskt sätt använda simulatorer för träning och bedömning av professionell kompetens.

Simulator-baserad träning beskrivs som ett riskfritt, ekonomiskt och tidseffektivt sätt att träna för säkerhetskritiska yrken inom domäner som luftfart, sjukvård och sjöfart (se t.ex. Dahlström et al., 2009). Simulatorns kontrollerade miljö erbjuder en arbetsrelevant kontext för lärande där övningar kan utformas för att träna och bedöma specifika lärandemål. Simulator-baserad träning erbjuder även möjligheter att anpassa svårighetsgraden i varje övning till studenternas tidigare erfarenhet och kunskap. Exempelvis går det att göra förändringar av scenariot under pågående övning för att justera svårighetsgraden, eller till och med pausa övningen för instruktion och diskussion (se t.ex. Maran & Glavin, 2003). Samtidigt som simulator-baserad träning visar på en rad möjligheter för att träna och bedöma professionellt agerande, utgör träningssituationerna utmaningar också för instruktörerna. Tidigare forskning visar att simulatorn inte är självinstruerande. Som Hindmarsh et al. (2014) understryker så informerar inte simulatorn studenterna om hur en aktivitet ska utföras eller

[15] STCW är en förkortning av *Standard of Training, Certification and Watchkeeping for Seafarers*

varför aktiviteten ska utföras på det ena eller andra sättet. Istället betonas vikten av att utforma övningarna i simulatorn som arbetsrelevanta aktiviteter där viktiga erfarenheter kan göras (Hontvedt & Arnseth, 2013). Även vikten av en instruktör som systematiskt pekar ut vad som är relevant och irrelevant i förhållande till professionen under simuleringen har lyfts fram som kritiskt för att professionell kompetens ska utvecklas (Hindmarsh et al., 2014; Rystedt & Sjöblom, 2012). En konklusion är således att det är långt ifrån självklart hur professionella kompetenser utvecklas inom och genom aktiviteter i simulatormiljön och hur bedömning av kompetent agerande ska ske.

Avhandlingen bidrar till ökad kunskap om den simulator-baserade träningens praktiska genomförande genom detaljerade analyser av instruktörens arbete under navigeringsövningar i simulatormiljö. Det empiriska material som ligger till grund för dessa analyser är baserat på etnografiskt fältarbete och videoinspelat material av simulator-baserad träning i en kurs i radarnavigering. Teoretiskt positionerar sig avhandlingen i ansatser som ser lärande som situerat, och som lägger stor vikt vid de sociala, materiella och kulturella aspekter som ingår i aktiviteter och som deltagarna samspelar med (Goodwin, 1994; Hutchins, 1995; Suchman, 2007). Det finns tre frågeställningar i avhandlingen som utforskas på olika sätt i de olika delstudierna:

- Vilket är det aktuella kunskapsläget i forskning om simulator-baserad maritim träning?
- Hur använder instruktörer de olika sociala och materiella resurser som finns i den simulator-baserade lärandemiljön för att ge instruktioner?
- Vilken sorts kunskap förmedlas inom och genom dessa instruktioner i den simulator-baserade lärandemiljön?

Den första forskningsfrågan analyserar det nuvarande kunskapsläget kring maritim simulering genom ett systematiskt sökande efter publicerade forskningsstudier. Medan den andra forskningsfrågan är riktad mot hur instruktioner ges i simulatormiljön, är den tredje forskningsfrågan av en annan karaktär. Den handlar om hur lärande av någonting specifikt sker i olika situationer, det vill säga, hur kunskapsobjektet utvecklas inom och genom observerbara interaktioner i den simulator-baserade lärandemiljön. Det övergripande målet med avhandlingen är att bidra med empiriskt grundad kunskap om användningen av simulatorer för träning inom sjöfartsutbildning.

Resultaten från delstudierna kan ligga till grund för vidareutveckling av instruktionsmetoder i simulator-baserade lärandemiljöer både inom och utanför sjöfartsområdet. Resultaten kan även vägleda designen av pedagogiska verktyg i simulator-baserade lärandemiljöer.

Analytiskt förhållningssätt och metod

Avhandlingens övergripande forskningsfrågor rör instruktörernas arbete för att stödja elevernas lärande under simulator-baserade aktiviteter, vilka syftar till att förbereda studenterna för att arbeta som befälhavare ombord på fartyg. Teoretiskt tar avhandlingen sin utgångspunkt i ett antagande om att lärande är situerat, det vill säga, konkret förankrat i samspel mellan människor, teknologier och den kulturella kontexten för interaktionen (Goodwin, 1994; Hutchins, 1995; Suchman, 2007). Det analytiska förhållningssättet är empiriskt drivet, det vill säga, analysen börjar med att observera empiriska data för att se vad deltagarna ägnar sig åt i sitt arbete snarare än att utgå från teoretiska modeller om vad som sker eller borde ske under aktiviteterna (t.ex. Rawls, 2008). Utifrån dessa antaganden och förhållningssätt är den ansats som i litteraturen benämns workplace studies väl lämpad för studien (t.ex. Luff et al., 2000). Studier i denna tradition syftar till att skapa en djupare förståelse för hur människor använder teknologier i sitt dagliga arbete, och de har den lokala organisationen av datorstött samarbete som sitt analytiska intresse. Konsekvensen av att använda detta perspektiv är att studierna är naturalistiska, det vill säga, analyserna bygger på data av naturligt förekommande lärandepraktiker där deltagarnas observerbara handlingar står i fokus. I avhandlingen har episoder där instruktioner sker i simulatormiljön valts ut för närmare analys av instruktionernas sekventiella organisering och interaktiva koordinering. I dessa episoder utgörs analysenheten av deltagarnas tal, kroppsliga handlingar och av användandet av materiella resurser i simulatormiljön.

Det analytiska förhållningssättet har metodologiska konsekvenser. För att kunna analysera naturligt förekommande instruktioner i simulatormiljön har ett etnografiskt fältarbete genomförts och videoinspelat material från navigeringskursen samlats in. Fältarbetet har varit nödvändigt för att närma sig praktiken på ett sätt som möjliggör analyser av kunskapsinnehållet i navigeringskursen, medan det videoinspelade materialet ger förutsättningar för detaljerade analyser av de aktiviteter som pågår under de simulator-baserade aktiviteterna. Fältarbetet har pågått under perioden 2013-2017, i olika faser och med olika intensitet. Den första fasen, under 2013, kännetecknades av ett strukturerat fältarbete. I denna fas observerades en mängd olika föreläsningar och simulator-baserade övningar i olika kurser på simulatorcentret. Den andra fasen, under 2014, kännetecknas av deltagande observationer. Under denna fas provade jag själv på att använda simulatorerna, till exempel genom att navigera ett tankfartyg i Göteborgs skärgård och att köra en snabb räddningsbåt i hamnen i Sydney. Den tredje fasen, 2016 till 2017, kännetecknades främst av ett fortsatt arbete i miljön på simulatorcentrum. Under denna period har kontakterna med verksamheten behållits och jag har deltagit i olika aktiviteter, även om fältarbetet under denna fas varit mindre strukturerat och mer sporadiskt.

Videoinspelat material har samlats in för projektet i sin helhet. Under våren 2013 genomfördes en testfilmining av en hel övning, med briefing-scenario-debriefing, under en navigeringskurs under studenternas första år på programmet. Det inspelade materialet användes som underlag för att närma sig undervisningens innehåll och för tidiga analyser av praktiken. Under hösten 2014 valdes dock en fortsättningskurs i navigering som studenterna går under sitt andra år i programmet ut som studieobjekt, och en pilotstudie genomfördes där tre olika övningar filmades genom att följa instruktören med en kamera under övningarna. Erfarenheter från pilotstudien användes sedan som underlag för att designa studien, som under hösten 2015 genomfördes med stöd och resurser från LinCS videolabb. Fyra av de fem träningstillfällena i kursen samt den certifierande uppkörningen har filmats med kameror utplacerade i klassrummet, instruktörsrummet och på var och en av de fem navigationssimulatorer som är i bruk under övningarna. Datainsamlingen har genererat en stor mängd videoinspelat material, men för avhandlingens analysarbete har endast material från övning 3 respektive 5 använts, vilka tillsammans omfattar cirka 30 timmar av träning. Orsaken till urvalet är att dessa två övningar tränat färdigheter av större intresse för avhandlingens syfte och frågeställningar än övriga övningstillfällen. Det videoinspelade materialet har transkriberats och använts för upprepade och detaljerade analyser av instruktioner i simulatormiljön, men även utgjort en gemensam bas för analytiska observationer inom och utom projektet.

Studiens design etikprövades 2013 av den Regionala etikprövningsnämnden i Göteborg och följer de etiska riktlinjer som Vetenskapsrådet (2002) formulerat för forskning inom humaniora och samhällsvetenskap. Det innebär att deltagarna har informerats om studiens syfte, deras roll i studien, hur data kommer att användas och om deras absoluta rätt att avbryta sitt deltagande i studien. Informerat samtycke har inhämtats från samtliga studenter som ingår i studien och av instruktörerna i kursen.

Den studerade praktiken

I sjöfartsutbildningen används en modern simulatormiljö som byggts upp på Chalmers campus på Lindholmen i samarbete med Sjöfartsverket. Simulatorcentret invigdes 2012 och är i flera avseenden en unik miljö, ett av få center i världen där forskning, utbildning och myndigheter är samordnade. I Chalmers hus finns tio olika simulatorer, bland annat simulatorer för radiokommunikation, maskinrumssimulatorer, lasthanteringssimulatorer, bryggsimulatorer och navigationssimulatorer. I utbildningssyfte används dessa för att utbilda och vidareutbilda lotsar, sjökaptener, sjöingenjörer och sjöräddningspersonal. Simulatorerna är ihopkopplade, vilket gör att man kan genomföra simuleringar av hela farleder med flera aktörer inblandade.

Navigeringskursen som utgör fokus för avhandlingsarbetet ingår i ett fyraårigt sjökaptensprogram som utbildar cirka 60 studenter per år. Det finns två viktiga anledningar till att navigeringskursen valdes som empiriskt exempel för studien: a) det är en kurs där simulator-baserad träning är obligatorisk enligt STCW-konventionen, och b) kursen tränar och certifierar eleverna på både så kallade ”tekniska” och ”icke-tekniska” kompetenser som rör radarnavigering och att följa trafikregler i simulatorn. Kursen ges för programstudenter under programmets andra år, vilket innebär att studenterna har erfarenhet av både fartygsförlagd praktik och simulator-baserad träning i tidigare kurser. Kursinnehållet består av föreläsningar samt fem olika simulator-baserade lärandetillfällen, och involverar tre olika simulatorinstruktörer och ytterligare tre föreläsare. Studenterna examineras genom obligatoriskt deltagande i den simulator-baserade träningen, en skriftlig tentamen och en uppkörning i simulatorn. Uppkörningen ger förutom avklarade kurspoäng ett av de certifikat som är behörighetsgivande för fartygsbefäl.

I den simulator-baserade träningen som utgör fokus i avhandlingsarbetet tränas två till tre olika scenarier för en studentgrupp om 10 studenter vid varje tillfälle. Träningen sker vanligtvis parvis och studenterna turas om att fördela ansvar för scenariot som styrman respektive matros under övningarna i simulatorn. Träningen är organiserad i tre faser som är vanligt förekommande i simulator-baserad träning: briefing-scenario-debriefing. Briefingen fungerar som en introduktion till dagens övning och äger rum i ett klassrum i nära anslutning till simulatorerna. Själva övningen, scenariot, utspelar sig i navigeringskursen i en navigationssimulator. Efter varje övning sker en debriefing, det vill säga en efterföljande genomgång av övningen.

Delstudierna och deras resultat

Studie I är en ensamförfattad systematisk litteraturöversikt, publicerad i den vetenskapliga tidskriften WMU Journal of Maritime Affairs 2016. Artikeln har titeln "Simulators in bridge operation training and assessment: A systematic review and qualitative synthesis". Syftet med studien är att identifiera relevant forskning om simulator-baserad träning i sjöfartsutbildning och skapa en överblick över forskningsfältet och det aktuella kunskapsläget. Den systematiska litteraturöversikten kännetecknas av ett metodiskt sökande efter litteratur, där identifikation, urval och sammanställning av vad som anses vara relevant forskning sker på ett metodiskt och transparent sätt (t.ex. Moher et al., 2015). Genom att systematiskt kombinera ett antal sökord, relaterade till användandet av simulatorer för träning och bedömning inom sjöfartsutbildning i olika databaser, identifierades 34 artiklar publicerade i vetenskapliga tidskrifter. En sammanställning av artiklarna visar att simulator-baserad träning i sjöfartsutbildning är ett internationellt men tämligen litet och något spretigt forskningsfält med fokus på tre olika discipliner: praktiker som är verksamma inom fältet (n=15), human factors forskning (n=13) och pedagogik (n=6). Slutsatsen av den systematiska litteraturstudien är att simulator-baserad träning har en betydande potential som del i träning och bedömning i sjöfartsutbildning, både för studenter som lär sig yrket och för vidareutbildning av yrkesverksamma praktiker inom fältet (t.ex. Muirhead, 2004; Stan & Buzbuchi, 2012; Suppiah, 2007). I nuläget saknas dock empiriskt belagd kunskap om hur träning och bedömning av olika färdigheter i simulatorn ska utformas för att säkerställa att lärandemål uppnås och för att bedömning av studenternas agerande ska kunna genomföras på ett tillförlitligt sätt. Empiriska studier visar snarare på brister i utbildningssystemet gällande träning och bedömning av kompetens i simulator-baserade lärandemiljöer, vilket framställs som en potentiell säkerhetsrisk för sjöfarten (Emad & Roth, 2008; Gekara et al., 2011; Sampson et al., 2011). Det finns även empiriska studier, som i likhet med studier av simulator-baserad träning inom hälso- och sjukvård, pekar på vikten av handledning av en instruktör under simuleringen för att undvika fallgropar och uppnå lärandemål i träningen (Hontvedt & Arnseth, 2013; Hontvedt, 2015b).

Studie II är avhandlingens första empiriska artikel, även den ensamförfattad och publicerad i tidskriften Cognition, Technology and Work hösten 2017. Studiens titel är "From briefing, through scenario, to debriefing: the maritime instructor's work during simulator‑based training". Som rubriken anger handlar artikeln om hur teori och praktik knyts samman i de olika faserna av simulator-baserad träning. Teoretiskt tar studien sin utgångspunkt i begreppet "situated action" (Suchman, 2007). Begreppet refererar till en syn på handlingar som situationsbundna och beroende av de sociala och materiella resurser som står till buds för aktören i varje givet ögonblick. Genom att följa två olika sorters instruktioner genom de olika faserna i träningen analyseras vilka sociala och materiella resurser som används för att ge instruktioner, före, under och efter själva övningen. De instruktioner som valts ut berör navigeringskursens lärandemål, och handlar om hur trafikregler till sjöss ska följas samt instruktioner som gäller hur och när information från olika informationskällor (radar, sjökort, visuell utkik o.s.v.) på bryggan ska användas och integreras.

Under briefing-fasen, innan övningen startar, samlas gruppen i klassrummet bredvid simulatorerna. Under briefingen används mest traditionella presentationstekniker för att introducera övningens lärandemål och förutsättningar. I den här fasen behöver instruktionerna täcka in alla tänkbara händelseutvecklingar för fem olika studentgrupper som startar på olika positioner i scenariot, men samtidigt måste de vara specifika nog för att förbereda studenterna för övningen. Därför är instruktionerna i den här fasen öppna och allmänt hållna, vilket i sig utgör en utmaning för studenterna som behöver ta med sig de generella instruktionerna och försöka tillämpa dem i specifika situationer under scenariot (jmf. Suchman, 2007).

I scenario-fasen tränar studenterna i fem olika navigationssimulatorer som ska likna bryggan ombord ett modernt fartyg. I simulatorn projiceras bilden av en nautisk miljö genom bryggans fönster, och här finns teknisk utrustning som radar, elektroniska sjökort och instrument för manövrering tillgänglig. På den simulerade bryggan finns även kartbord där positionsbestämning sker med hjälp av bestick som passare och transportör på sjökort. Under scenariot övervakar instruktören händelseförloppet från instruktörsrummet. Via en rad olika monitorer skapas en överblick över vad som händer på de olika bryggorna, hur studenterna använder sin radarutrustning, hur situationen ser ut genom fönstret på var och en av bryggorna, men också hur scenariot som helhet fortlöper. Uppsikten över studenternas agerande gör det möjligt för instruktören att gripa in och stötta med instruktioner när studenterna behöver hjälp med tillämpningen av de generella instruktioner från briefing-fasen i de specifika situationer som uppstår under scenariot. Instruktionerna som sker under scenariots gång tar hänsyn till de temporala aspekterna av övningen, det vill säga, timingen av olika handlingar och hur man utför dem. Instruktionerna i den här fasen involverar även de materiella och sociala resurser som står till buds i simulatorn, till exempel kan instruktören peka ut relevanta aspekter av scenariot som studenterna har förbisett (jmf. Suchman, 2007).

Efter varje scenario samlas gruppen i klassrummet igen för en efterföljande diskussion om övningen, en så kallad debriefing. Debriefingen leds av instruktören och med stöd i olika teknologier för presentation, vilka främst används för att återkoppla och göra en övergripande bedömning av huruvida studenterna följt de generella instruktioner de fick innan övningen (jmf. Suchman, 2007). Under debriefingen används även en visualisering av händelseförloppet under scenariot. Genom sin design utgör visualiseringen en förenklad representation av händelser och ageranden under scenariot, vilken möjliggör bedömning och diskussion av specifika händelseförlopp.

I forskningen om simulator-baserad träning pekas ofta debriefingen ut som särskilt betydelsefull för lärande (t.ex. Fanning & Gaba, 2010; Wickers, 2010). Resultaten från den här studien visar tydligt instruktörens viktiga roll att stötta studenterna i att koppla samman teori och praktik genom träningens samtliga faser. Studien bidrar till en liten men växande samling av studier som framhåller vikten av en instruktör som systematiskt pekar ut vad som är relevant och irrelevant under simuleringen för att professionell kunskap ska utvecklas (Hindmarsh et al., 2014; Hontvedt & Arnseth, 2013; Rystedt & Sjöblom, 2012). Medan dessa studier ibland framhåller att instruktören är viktigare för lärande än simulatorn, bidrar Studie II med resultat som även visar på vikten av de sociala och materiella resurser som står till buds för instruktören i simulatormiljön.

Studie III är en artikel som författats tillsammans med Mona Lundin: ”Demonstrating professional intersubjectivity: The instructor's work in simulator-based learning environments” och som har publicerats i Learning, Culture and Social Interaction under 2017. Studien bygger på en videoinspelad instruktion under en övning i att korsa den tätt trafikerade Engelska kanalen i simulatorn. Forskningsfrågorna knyter an både till organiseringen av instruktioner under pågående scenarier i simulatorn och till den kunskap som förmedlas inom och genom dessa instruktioner. Analysen grundas i Goodwins (1994) begrepp ”professional vision”, det vill säga fokus är att lära sig att se världen med den kompetenta blick som en yrkesutövare använder. Att utveckla den professionella blicken är likaså själva grunden för att utveckla vad Goodwin (1994) beskriver som ”professionell intersubjektivitet” med andra kompetenta yrkesutövare inom professionen. Även om de aldrig har träffat varandra, som så ofta när fartyg möter varandra till havs, förväntar de sig att andra sjöfarare de möter kan se och kategorisera världen i enlighet med de diskurser som råder inom sjöfart. Ur vårt perspektiv är professionell intersubjektivitet själva grunden för att kunna samordna med andra i trafiken, och med denna premiss som utgångspunkt syftar studien till att undersöka hur instruktioner utförs under simulator-baserade scenarier där trafikreglerna som gäller till sjöss tränas.

Analysen av en hel instruktion visar på en tät sammanflätning och kontinuerlig växelverkan mellan bedömning och instruktion under pågående scenario i simulatorn, så kallade ”embedded assessments” (jmf. Greiffenhagen, 2012; Lindwall et al., 2015). I likhet med Studie II visar resultaten från Studie III vikten av instruktioner i simulatormiljön, där teknologierna i instruktörsrummet och radarutrustningen i simulatorn, gör det möjligt för instruktören att följa studenternas agerande under övningen och bedöma när de uppvisar bristande förståelse och har behov av vidare instruktioner för att närma sig de kunskaper som är centrala enligt lärandemålen (jmf. Greiffenhagen, 2012). Resultaten visar även hur instruktören demonstrerar den bakomliggande funktionen för varje trafikregel, det vill säga, vad regeln säger åt oss att göra i specifika situationer. Dessutom visar instruktörens demonstrationer på ett generellt mönster i regelsystemet, som framträder som en dialogisk praxis där studenterna tränas i att tolka andras handlingar i linje med diskurser kring vad som anses vara ”gott sjömanskap” (jmf. Sharrock & Button, 1999). Vidare visar resultaten att studenterna även tränas i att själva utföra tydliga manövrar som andra sjöfarare kan se och tolka via de semiotiska strukturer dessa skapar i radarutrustningen. Följaktligen tränas studenterna inte bara i att följa regler eller att se världen genom en professionell sjöfarares ögon. De tränas även i att producera otvetydiga handlingar i linje med de diskurser som råder inom sjöfarten. Detta kräver i sin tur en utvecklad nivå av professionell intersubjektivitet som innebär att aktören kan se sitt eget agerande genom andras ögon.

Studie IV är en ensamförfattad artikel, publicerad i den vetenskapliga tidskriften Education and Information Technologies, tillgänglig on-line 2016: "Representing and enacting movement: The body as an instructional resource in a simulator-based environment." Bakgrunden till studien knyter an till en ständigt aktuell och pågående diskussion om simulator-baserad träning, närmare bestämt diskussionen om simulatorer som realistiska och relevanta kontexter för lärande av professionella kompetenser. Som Rystedt och Sjöblom (2012) påpekar i en studie om simuleringar inom sjukvård: oavsett hur tekniskt avancerad simulatorn är, så kommer det alltid att finnas ofullkomligheter och inkonsekvenser i överenstämmelsen mellan simulatormiljön och arbetskontexten som måste hanteras i undervisningen. I en studie om simuleringar i tandläkarutbildning fann Hindmarsh et al. (2014) att sådana inkonsekvenser leder till både instruktioner och diskussioner, som i sin tur bidrar till att utveckla studenternas professionella kompetens. I motsats till Hindmarsh et al. (2014) visar resultat från en studie inom sjöfartsutbildning istället betydelsen av att simulatorn representerar ett fartygs brygga och den maritima miljön på ett realistiskt sätt (Hontvedt, 2015a). Ett argument som förs fram är att bristande realism i simulatormiljön gör att studenterna riskerar att träna på att manipulera en simulerad modell snarare än att träna mot de förhållanden som gäller ombord på ett verkligt fartyg.

Syftet med Studie IV är att undersöka spänningen mellan dessa argument genom att utforska hur träningen av fartygsmanövrering påverkas av sådana inkonsekvenser. Analysen i studien är grundad i ansatsen distribuerad kognition (Hutchins, 1995) och bygger på två korta episoder av instruktioner under övningar i en navigationssimulator som inte ger någon kinetisk eller proprioceptiv[16] återkoppling på rörelse. Två forskningsfrågor är utgångspunkter för analysen: Hur är kroppsliga handlingar och verbala instruktioner koordinerade i den simulator-baserade lärandemiljön för att representera de frånvarande aspekterna av rörelse i simulatorn? Vilken roll har dessa representationer i att utveckla studenternas förståelse för ett fartygs rörelser i manövrering?

[16] Proprioception innebär människans förmåga att avgöra de egna kroppsdelarnas position, vilket är en del av kroppsuppfattningen.

I linje med resultaten från Studie II och Studie III visar Studie IV på det rika utbud av resurser som finns tillgängliga för instruktion under scenariot i simulatorn. I de här episoderna är det samordningen av kroppsliga handlingar och tal som är riktade mot den simulatormiljö deltagarna befinner sig i som möjliggör instruktioner av dynamiska aspekter såsom fartygets rörelser i olika situationer. Genom att med hjälp av kroppsliga handlingar representera och imitera rörelser, till exempel lutningen av fartyget i en gir eller skakningarna på däck som uppkommer när fartyget stöter på motstånd, adresserar instruktören de inkonsekvenser mellan simulator-miljön och arbetet ombord som uppkommer under simuleringen. Att instruktören adresserar den bristande överenstämmelsen mellan simulatormiljön och miljön ombord på ett fartyg till sjöss, minskar risken att studenterna endast lär sig att manipulera den simulerade modellen som Hontvedt (2015b) varnar för. Resultaten visar, i linje med resultat från simuleringar i hälso- och sjukvård, att realism inte endast är en egenskap hos simulatorn utan skapas i interaktionen med simulatormiljön under övningarna, och att detta gäller även i sjöfartsutbildning (jmf. Hindmarsh et al., 2014; Rystedt & Sjöblom, 2012). Även om det är vanskligt att dra några bestämda slutsatser av hur och vad studenterna lär sig av dessa instruktioner utifrån de videoinspelade episoderna, framstår professionell vägledning under simulering som kritisk även i Studie IV. Instruktören stödjer studenterna i att koppla samman den simulerade händelsen med studenternas egna erfarenheter från perioder av fartygsförlagd praktik och visar på betydelsen av abstrakt teoretisk kunskap i konkreta situationer.

Diskussion

Avhandlingen utforskar användandet av simulatorer i sjöfartsutbildning med fokus på tre forskningsfrågor: 1) Vilket är det aktuella kunskapsläget i forskning kring simulator-baserad maritim träning? 2) Hur använder instruktörer de olika sociala och materiella resurser som finns i den simulator-baserade lärandemiljön för att ge instruktioner? 3) Vilken sorts kunskap förmedlas inom och genom dessa instruktioner i den simulator-baserade lärandemiljön? Den första forskningsfrågan har besvarats genom en litteraturöversikt av det aktuella fältet, besvaras de två senare frågorna genom en kombination av etnografiska fältstudier och interaktionsanalyser av instruktioner under simulator-baserade lärandeaktiviteter. I de sammanlagda resultaten framträder instruktörens kritiska roll för att utveckla studenternas professionella kompetens (jmf. Hindmarsh et al., 2014; Hontvedt, 2015a; Hontvedt & Arnseth, 2013; Rystedt & Sjöblom, 2012). Vidare belyser avhandlingens resultat även den kritiska roll teknologin i simulatormiljön har för att möjliggöra instruktioner i specifika praktiska situationer. Här betonas speciellt användandet av bedömningssystem, så som teknologierna i instruktörsrummet och den visualisering av scenariot som används som underlag för feedback i debriefing-fasen, som särskilt betydelsefulla för undervisningspraktiken i simulatormiljön.

Tidigare forskning varnar för att simulatorer och annan teknik implementeras på ett negativt sätt i det nuvarande utbildningssystemet och knappast stödjer utvecklandet av de professionella kompetenser som betonas i internationella konventioner (t.ex. Emad & Roth, 2008; Gekara et al., 2011, Sampson et al., 2011). Bilden som framträder i avhandlingen är annorlunda och betydligt mer positiv. Ett av skälen till detta är självfallet att simulator-baserad träning implementerats på olika sätt i olika kontexter. Fallet som utgör analysenhet i den aktuella avhandlingen kan ses som ett positivt exempel. På simulatorcentret har varje simulatormiljö utvecklats genom ett användarcenterat designfokus på att utveckla simulatormiljön utifrån instruktörernas behov. Även de simulator-baserade läraktiviteterna i fokus i avhandlingen har implementerats med eftertanke av instruktörer med långvarig erfarenhet både av sjökaptensyrket och undervisning i sjökaptensprogrammet. Orsaker till skillnader i resultat med andra studier finns även att finna i skillnader i teoretiska och metodologiska utgångspunkter. Medan till exempel Gekara et al. (2011) utgår från en frågeställning kring huruvida den teknikstödda undervisningen stödjer den typ av träning och bedömning som betonas i STCW-konventionen, med en distinktion mellan tekniska färdigheter och högre kognitiva förmågor, söker jag en annan förståelse av undervisningspraktiken. Istället för att utgå från kognitiva begrepp och normativa uppfattningar av vad träningen borde vara, strävar jag efter att analysera instruktioner i simulatormiljön på deras egna villkor (jmf. Lindwall et al., 2015). Den teoretiska utgångspunkten är då istället att lärande är konkret förankrat i samspelet mellan människor, teknologier och den kulturella kontexten i simulatormiljön. Det är genom systematiska och detaljerade analyser av dessa samspel som kärnan av undervisningspraktikerna kan synliggöras.

Avhandlingens teoretiska, metodologiska och empiriska bidrag till sjöfartsutbildning visar hur och varför uppdelningen mellan tekniska färdigheter och kognitiva förmågor är problematisk för studier av simulatorbaserad träning och bedömning (jmf. Hontvedt, 2015a). Den yrkespraktik studenterna tränas för i simulatormiljön utgår från diskurser kring vad som anses vara gott sjömanskap, liksom vad det innebär att följa de internationella regelverk som gäller till sjöss, vilket också blir huvudbudskapen i undervisningspraktiken. Dessa färdigheter, i sin tur, är svåra att undervisa om genom abstrakta förklaringar. Vad som utgör gott sjömanskap eller en korrekt tillämpning av regler är högst situationsbundet och definieras i samspelet mellan fartyg (jmf. Belcher, 2002; Taylor, 1998). Avhandlingen visar hur studenterna skolas in i dessa diskurser genom instruktörens demonstrationer av gott sjömanskap och regelföljande under övningar i simulatorn. Dessa demonstrationer består i utpekandet av resurser i simulatormiljön, till exempel genom att visa på specifika situationer på radarskärmen, tillsammans med verbala instruktioner kring den konkreta situationen (jmf. Goodwin, 1994). Implikationen av dessa resultat visar på ett behov av att skifta fokus i forskning kring sjöfartsutbildning: från ett fokus på abstrakta och generella färdigheter gentemot utvecklandet av professionella kompetenser i konkreta situationer. Vidare pekar avhandlingens resultat även på vikten av att kombinera simulator-träning med perioder av fartygsförlagd praktik, som sker i nuvarande utbildningssystem. Argumentet är att det som ibland kallas kunskapstransfer mellan kontexter är avhängigt studenternas tillgång till bägge kontexter, liksom instruktörens arbete med att stötta studenterna att relatera de olika praktikerna till varandra. Genom att systematiskt peka ut både skillnader och likheter mellan kontexter under övningarna i simulatorn, erbjuds möjligheter till professionellt lärande även i utbildningskontexter (jmf. Akkerman & Bakker, 2012; Säljö, 2003).

References

Aizinov, S. D, & Orekhov, A. V. (2010). Simulator training for the high technology ship crews. *Gyroscopy and Navigation, 1*(4), 258–262.

Akkerman, S. F., & Bakker, A. (2012). Crossing boundaries between school and work during apprenticeships. *Vocations and Learning*, *5*(2), 153–173.

Ali, A. (2008). Role and importance of simulator instructor. *International Journal on Marine Navigation and Safety of Sea Transportation*, *2*(4), 423–427.

Arnseth, H. C., & Ludvigsen, S. (2006). Approaching institutional contexts: Systemic versus dialogic research in CSCL. *International Journal of Computer-Supported Collaborative Learning*, *1*(2), 167–185.

Bailey, N., Housley, W., & Belcher, P. (2006). Navigation, interaction and bridge team work. *The Sociological Review*, *54*(2), 342–362.

Baldauf, M., Schröder-Hinrichs, J. U., Kataria, A., Benedict, K., & Tuschling, G. (2016). Multidimensional simulation in team training for safety and security in maritime transportation. *Journal of Transportation Safety & Security*, *8*(3), 197–213.

Bannon, L. (2000). Situating workplace studies within the human computer interaction field. In P. Luff, J. Hindmarsh, & C. Heath (Eds.). *Workplace studies—Recovering work practice and informing systems design* (pp. 230–241). Cambridge, MA: Cambridge University Press.

Barsan, E. (2009). Sea service equivalency for full mission simulators training. *Maritime Transport & Navigation Journal*, *1*, 14–23.

Bearman, M., & Dawson, P. (2013). Qualitative synthesis and systematic review in health professions education. *Medical Education*, *47*(3), 252–260.

Beaubien, J. M., & Baker, D. P. (2004). The use of simulation for training teamwork skills in health care: How low can you go? *Quality and Safety in Health Care*, *13*(suppl. 1), i51–i56.

Belcher, P. (2002). A sociological interpretation of the COLREGS. *Journal of Navigation*, *55*(02), 213–224.

Benedict, K., Fischer, S., Gluch, M., Kirchhoff, M., Schaub, M., Baldauf, M., & Müller, B. (2017). Innovative fast time simulation tools for briefing/debriefing in advanced ship handling simulator training and ship operation. *Transactions on Maritime Science*, *6*(01), 24–38.

Button, G., & Sharrock, W. (1998). The organizational accountability of technological work. *Social Studies of Science*, *28*(1), 73–102.

Castells, M. L., Ordás, S., Barahona, C., Moncunill, J., Muyskens, C., Hofman, W., & Skorokhodov, S. (2016). Model course to revalidate deck officers' competences using simulators. *WMU Journal of Maritime Affairs*, *15*(1), 163–185.

Chauvin, C., Clostermann, J. P., & Hoc, J. M. (2009). Impact of training programs on decision-making and situation awareness of trainee watch officers. *Safety Science*, *47*(9), 1222–1231.

Crabtree, A., Chamberlain, A., Grinter, R. E., Jones, M., Rodden, T., & Rogers, Y. (2013). Introduction to the special issue of "The Turn to the Wild". *ACM Transactions on*

Computer-Human Interaction (TOCHI), *20*(3), 1–4.

Dahlstrom, N., Dekker, S., Van Winsen, R., & Nyce, J. (2009). Fidelity and validity of simulator training. *Theoretical Issues in Ergonomics Science*, *10*(4), 305–314.

Derry, S., Pea, R., Barron, B., Engle, R., Erickson, R., Goldman, R., … Sherini, B. (2010). Conducting video research in the learning sciences: guidance on selection, analysis, technology, and ethics. *Journal of the Learning Sciences*, *19*(1), 3–53.

Dieckmann, P., Reddersen, S., Zieger, J., & Rall, M. (2008). A structure for video-assisted debriefs in simulator-based training of crisis recourse management. In R. Kyle & B. W. Murray (Eds.), *Clinical simulation: Operations, engineering, and management* (pp. 667–676). Burlington, VT: Academic Press.

Dourish, P. (2006). Implications for design. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 541–550). New York, NY: ACM Press.

Dourish, P., & Button, G. (1998). On "technomethodology": Foundational relationships between ethnomethodology and system design. *Human-Computer Interaction*, *13*(4), 395–432.

Drews, F. A., & Bakdash, J. Z. (2013). Simulation training in health care. *Reviews of Human Factors and Ergonomics*, *8*(1), 191–234.

Dreyfus, H. L. (1992). *What computers still can't do: A critique of artificial reason*. Cambridge, MA: MIT Press.

Emad, G. R. (2010). Introduction of technology into workplace and the need for change in pedagogy. *Procedia—Social and Behavioral Sciences*, *2*(2), 875–879.

Emad, G. R. & Roth, W. M. (2008). Contradictions in the practices of training for and assessment of competency: A case study from the maritime domain. *Education + Training*, *50*(3), 260–272.

Erickson, F. (2006). Definition and analysis of data from videotape: Some research procedures and their rationales. *Handbook of Complementary Methods in Education Research*, *3*, 177–192.

Evans, B., & Reynolds, E. (2016). The organization of corrective demonstrations using embodied action in sports coaching feedback. *Symbolic Interaction*, *39*, 525–556.

Fanning, R. M., & Gaba, D. M. (2007). The role of debriefing in simulation-based learning. *Simulation in Healthcare*, *2*(2), 115-125.

Flin, R. (2008). *Safety at the sharp end: A guide to non-technical skills.* Abingdon, UK: Taylor & Francis.

Froholdt, L. L. (2015). "I see you on my radar": Displays of the confirmatory form in maritime technologically mediated interaction. *The Sociological Review*, *64*(3), 468–494.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice Hall.

Gekara, V. O., Bloor, M., & Sampson, H. (2011). Computer-based assessment in safety-critical industries: The case of shipping. *Journal of Vocational Education & Training*, *63*(1), 87–100.

Goldman, R., Pea, R., Barron, B., & Derry, S. J. (2014). *Video research in the learning sciences*. New York, NY: Routledge.

Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*(3), 606–633.

Goodwin, C. (1995). Seeing in depth. *Social Studies of Science*, *25*(2), 237–274.

Goodwin, C. (1997). The blackness of black: Color categories as situated practice. In L. Resnick, R. Säljö, C. Pontecorvo, & B. Burge (Eds.), *Discourse, tools and reasoning* (pp. 111–140). New York, NY: Springer.

Goodwin, C. (2000). Action and embodiment within situated human interaction. *Journal of Pragmatics*, *32*(10), 1489–1522.

Goodwin, C. (2003). The semiotic body in its environment. In J. Coupland & R. Gwyn (Eds.), *Discourses of the body* (pp. 19–42). Basingstoke, UK: Palgrave Macmillan.

Grech, M., Horberry, T., & Koester, T. (2008). *Human factors in the maritime domain*. Boca Raton, FL: CRC Press.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 15–46). New York, NY: Macmillan Library Reference.

Greiffenhagen, C. (2008). Unpacking tasks: The fusion of new technology with instructional work. *Computer Supported Cooperative Work*, *17*(1), 35–62.

Greiffenhagen, C. (2012). Making rounds: The routine work of the teacher during collaborative learning with computers. *International Journal of Computer-Supported Collaborative Learning*, *7*(1), 11–42.

Greiffenhagen, C. (2014). The materiality of mathematics: Presenting mathematics at the blackboard. *The British Journal of Sociology*, *65*(3), 502–528.

Halverson, C. A. (2002). Activity theory and distributed cognition: Or what does CSCW need to DO with theories? *Computer Supported Cooperative Work*, *11*(1–2), 243–267.

Hanzu-Pazara, R., Barsan, E., Arsenie, P., Chiotoroiu, L., & Raicu, G. (2008). Reducing of maritime accidents caused by human factors using simulators in training process. *Journal of Maritime Research*, *5*(1), 3–18.

Hanzu-Pazara, R., Arsenie P. & Hanzu-Pazara, L. (2010). Higher performance in maritime education through better trained lecturers. *TransNav: International Journal on Marine Navigation and Safety of Sea Transport*, *4*(1), 87–93.

Hayward, B. J., & Lowe, A. R. (2010). The migration of crew resource management training. In B. Kanki, R. Helmreich, & J. Anca (Eds.), *Crew resource management* (pp. 317–344). London, UK: Academic Press.

Heath, C. & Luff, P. (2000). *Technology in action.* Cambridge, MA: Cambridge University Press.

Heath, C., & Luff, P. (2013). Embodied action and organizational activity. In J. Sidnell & T. Stivers (Eds.), *The handbook of conversation analysis* (pp. 281–307). Chichester, UK: Blackwell.

Heath, C., Hindmarsh, J., & Luff, P. (2010). *Video in qualitative research: Analyzing social interaction in everyday life.* London, UK: SAGE.

Heath, C., Luff, P., & Knoblauch, H. (2004). Tools, technologies and organizational interaction: The emergence of the workplace studies. In D. Grant, C. Hardy, C. Oswick, & L. Putnamn (Eds.), *The Sage handbook of organizational discourse* (pp. 337–358). London, UK: Sage.

Hindmarsh, J., Hyland, L., & Banerjee, A. (2014). Work to make simulation work: "Realism", instructional correction and the body in training. *Discourse Studies*, *16*(2), 247–269.

Hindmarsh, J., Reynolds, P., & Dunne, S. (2011). Exhibiting understanding: The body in apprenticeship. *Journal of Pragmatics*, *43*(2), 489–503.

Hontvedt, M. (2015a). *Simulations in maritime training: A video study of the socio-technical organisation of ship simulator training* (Doctoral thesis, Faculty of Educational Sciences, University of Oslo). Oslo: Akademika Publishing.

Hontvedt, M. (2015b). Professional vision in simulated environments—Examining professional maritime pilots' performance of work tasks in a full-mission ship simulator.

Learning, Culture and Social Interaction, *7*, 71–84.

Hontvedt, M., & Arnseth, H. C. (2013). On the bridge to learn: Analyzing the social organization of nautical instruction in a ship simulator. *International Journal of Computer-Supported Collaborative Learning*, *8*(1), 89–112.

Hutchins, E. (1983). Understanding Micronesian navigation. In D. Gentner & A. Stevens (Eds.), *Mental models* (pp. 191–225). Hillsdale, NJ: Lawrence Erlbaum.

Hutchins, E. (1990). The technology of team navigation. In J. Galegher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp. 191–220). New York, NY: Lawrence Erlbaum.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

Hutchins, E. (2006, April). *Imagining the cognitive life of things*. Paper presented at The Cognitive Life of Things: Recasting the Boundaries of Mind, the McDonald Institute for Archeological Research, Cambridge University.

Hutchins, E. (2010). Enaction, imagination, and insight. In J. Stewart, O. Gapenne, & E. A. Di Paolo (Eds.), *Enaction: Toward a new paradigm for cognitive science* (pp. 425–450). Cambridge, MA: MIT Press.

Hutchins, E. (2014). The cultural ecosystem of human cognition. *Philosophical Psychology*, *27*(1), 34–49.

Hutchins, E. & Nomura, S. (2011). Collaborative construction of multimodal utterances. In J. Streech, C. Goodwin, & C. LeBaron (Eds.), *Learning in doing: Social, cognitive and computational perspectives. Embodied interaction. Language and body in the material world* (pp. 29–43). Cambridge, MA: Cambridge University Press.

Hutchins, E. & Palen, L. (1997). Constructing meaning from space, gesture, and speech. In L. B. Resnick, R. Säljö, C. Pontecorvo, & B. Burge (Eds.), *Discourse, tools and reasoning* (pp. 23-40). Berlin, Germany: Springer.

Hutchins. E. (1993). Learning to navigate. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 35–63). Cambridge, MA: Cambridge University Press.

Hutchins. E. (1997). Mediation and automatization. In M. Cole, Y. Engestrom, & O. Vasquez (Eds.), *Mind, culture, and activity: Seminal papers from the Laboratory of Comparative Human Cognition* (pp. 338–370). Cambridge, MA: Cambridge University Press.

Johansson, E., Lindwall, O., & Rystedt, H. (2017). Experiences, appearances, and interprofessional training: The instructional use of video in post-simulation debriefings. *Computer supported collaborative learning*, Online ahead of print, pp. 1–24.

John, P., Noble, A., & Björkroth, P. (2016). Low-fi simulation of bridge team communication: A study of the authenticity of language patterns observed in 'chat' messaging to facilitate Maritime English training. *WMU Journal of Maritime Affairs*, *15*(2), 337–351.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences*, *4*(1), 39–103.

Koschmann, T. (1994). Toward a theory of computer support for collaborative learning. *The Journal of the Learning Sciences*, *3*(3), 219–225.

Koschmann, T. (1996). Paradigm shifts and instructional technology. In *CSCL: Theory and practice of an emerging paradigm* (pp. 1–23). Mahwah, NJ: Lawrence Erlbaum Associates.

Koschmann, T. (2013). Conversation analysis and learning in interaction. In C. A. Chapelle (Ed.), *The encyclopedia of applied linguistics.* (pp. 1038–1043). Oxford, UK: Blackwell Publishing Ltd.

Lave, J. (1988). *Cognition in practice*. Cambridge, MA: Cambridge University Press.

Leonardi, P. M. (2015). Studying work practices in organizations: Theoretical considerations and empirical guidelines. *Annals of the International Communication Association*, *39*(1), 235–273.

Lindwall, O. & Ekström, A. (2012). Instruction-in-interaction: The teaching and learning of a manual skill. *Human Studies*, *35*(1), 27–49.

Lindwall, O., Lymer, G., & Greiffenhagen, C. (2015). The sequential analysis of instruction. In N. Markee (Ed.), *The handbook of classroom discourse and interaction* (pp. 142–157), Malden, MA: Wiley.

Linell, P., & Thunqvist, D. P. (2003). Moving in and out of framings: Activity contexts in talks with young unemployed people within a training project. *Journal of Pragmatics*, *35*(3), 409–434.

Ljung, M., & Lützhöft, M. (2014). Functions, performances and perceptions of work on ships. *WMU Journal of Maritime Affairs*, *13*(2), 231–250.

Ludvigsen, S., & Arnseth, H. C. (2017). Computer-supported collaborative learning. In E. Duval, M. Sharples, & R. Sutherland (Eds.), *Technology enhanced learning* (pp. 47–58). New York, NY: Springer International Publishing.

Ludvigsen, S., & Mørch, A. (2010). Computer-supported collaborative learning: Basic concepts, multiple perspectives, and emerging trends. In P. Peterson, E. Baker, & B. McGaw (Eds.), *The international encyclopedia of education* (Vol. 5, pp. 290–296). Amsterdam, NL: Elsevier Science.

Luff, P., Hindmarsh, J., & Heath, C. (2000). Introduction. In P. Luff, J. Hindmarsh, & C. Heath (Eds.), *Workplace studies—Recovering work practice and informing systems design* (pp. 1–28). Cambridge, MA: Cambridge University Press.

Lützhöft, M. (2004). *"The technology is great when it works": Maritime technology and integration on the ship's bridge* (Unpublished dissertation). Department of Mechanical Engineering, University of Linköping, Sweden.

Lützhöft, M., & Nyce, J. M. (2014). Integration work on the ship's bridge. *Journal of Maritime Research*, *5*(2), 59–74.

Lynch, M. (1997). Ethnomethodology without indifference. *Human Studies*, *20*(3), 371–376.

Macbeth, D. (2011). Understanding understanding as an instructional matter. *Journal of Pragmatics*, *43*(2), 438–451.

Malik, A., & Zafar, N. (2015). Applications of simulation technology-pitfalls and challenges. *TransNav: International Journal on Marine Navigation and Safety of Sea Transportation*, *9*, 391–396.

Maran, N. J., Glavin, R. (2003). Low- to high-fidelity simulation—A continuum of medical education? *Medical Education*, *37*(1), 22–28.

Markauskaite, L., & Goodyear, P. (2017). Rethinking the material, the embodied and the social for professional education epistemic fluency and professional education. In *Innovation, knowledgeable action and actionable knowledge* (pp. 461–493). Dordrecht, the Netherlands: Springer.

Mehan, H. (1979). "What time is it Denise?": Asking known information questions in classroom discourse. *Theory in Practice*, *18*(4), 286–294.

Melander, H., & Sahlström, F. (2009a). Learning to fly—The progressive development of situation awareness. *Scandinavian Journal of Educational Research*, *53*(2), 151–166.

Melander, H., & Sahlström, F. (2009b). In tow of the blue whale: Learning as interactional changes in topical orientation. *Journal of Pragmatics*, *41*(8), 1519–1537.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., & Stewart, L.

A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1), 1–9.

Muirhead, P. M. (2004). New technology and maritime training in the 21st century: Implications and solutions for MET institutions. *WMU Journal of Maritime Affairs*, *3*(2), 139–158.

Neill, M.A., & Wotton, K. (2011). High-fidelity simulation debriefing in nursing education: A literature review. *Clinical Simulation in Nursing*, *7*(5), e161–e168.

Neisser, U. (2014). *Cognitive psychology: Classic edition*. New York, NY: Psychology.

Norman, D. (1980). Twelve issues for cognitive science. *Cognitive Science*, *4*, 1–32.

Pekcan, C., Gatfield, D., & Barnett, M. (2005). Content and context: Understanding the complexities of human behaviour in ship operation. *Seaways, The Journal of the Nautical Institute*.

Plowman, L., Rogers, Y., & Ramage, M. (1995, September). What are workplace studies for?. In: ECSCW, Vol. 95, pp. 309–324.

Randall, D., Marr, L., & Rouncefield, M. (2001). Ethnography, ethnometodology and workplace studies. *Ethnographic Studies*, *6*, 31–44.

Rawls, A. W. (2002). Editor's introduction. In A. Rawls (Ed.), *Ethnomethodology's program: Working out Durkheim's aphorism*. Maryland, US: Rowman & Littlefield.

Rawls, A. W. (2008). Harold Garfinkel, ethnomethodology and workplace studies. *Organization Studies, 29*, 701–732.

Rogers, Y. (2004). New theoretical approaches for HCI. *Annual Review of Information Science and Technology*, *38*(1), 87–143.

Rooksby, J. (2013). Wild in the laboratory: A discussion of plans and situated actions. *ACM Transactions on Computer-Human Interaction*, *20*(3), 1–17.

Rudolph, J. W, Simon, R., Raemer, D. B., & Eppich, W. J. (2008). Debriefing as formative assessment: Closing performance gaps in medical education. *Society for Academic Emergency Medicine*, *15*(11), 1010–1016.

Rudolph, J. W., Simon, R., Rivald, P., Dufrense, R. L. & Raemer, D. B. (2007). Debriefing with good judgment: Combining rigorous feedback with genuine inquiry. *Anesthesiology Clinics*, *25*, 361–376.

Ruhleder, K., & Jordan, B. (1997). Capturing complex, distributed activities: video-based interaction analysis as a component of workplace ethnography. In A. S. Lee, J. Liebenau, & J. I. DeGross (Eds.), *Information systems and qualitative research: Proceedings of the IFIP TC8 WG 8.2 International Conference on Information Systems and Qualitative Research* (pp. 246–275). Boston, MA: Springer.

Rystedt, H., & Sjöblom, B. (2012). Realism, authenticity, and learning in healthcare simulations: Rules of relevance and irrelevance as interactive achievements. *Instructional Science*, *40*, 785–798.

Rystedt, H., & Lindwall, O. (2004). The interactive construction of learning foci in simulation-based learning environments: A case study of an anaesthesia course. *PsychNology Journal*, *2*(2), 168–188.

Sacks, H. (1992). *Lectures on Conversation* (Vols. I–II). Oxford, UK: Blackwell.

Sahlström, F. (2009). Conversation analysis as a way of studying learning—An introduction to a special issue of SJER. *Scandinavian Journal of Educational Research*, *53*(2), 103–111.

Säljö, R. (2003). Epilogue: From transfer to boundary-crossing. In T. Tuomi-Gröhn & Y. Engeström (Eds.), *Between school and work: New perspectives on transfer and boundary-crossing* (pp. 311–321). Amsterdam, the Netherlands: Pergamon.

Säljö, R. (2009). Learning, theories of learning, and units of analysis in research. *Educational*

Psychologist, *44*(3), 202–208.
Säljö, R. (2010). Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. *Journal of Computer Assisted Learning*, *26*(1), 53–64.
Sampson, H., Gekara, V., & Bloor, M. (2011). Water-tight or sinking? A consideration of the standards of the contemporary assessment practices underpinning seafarer licence examinations and their implications for employers. *Maritime Policy Management*, *38*(1), 81–92.
Saus, E. R., Johnsen, B. H., & Eid, J. (2010). Perceived learning outcome: The relationship between experience, realism, and situation awareness during simulator training. *International Maritime Health*, *61*(4), 258–264.
Saus, E. R, Johnsen, B. H., Eid, J., & Thayer, J. F. (2012). Who benefits from simulator training: Personality and heart rate variability in relation to situation awareness during navigation training. *Computers in Human Behaviour*, *28*(4), 1262–1268.
Saus, E. R., Johnsen, B. H., & Eid, J. (2010). Perceived learning outcome: The relationship between experience, realism, and situation awareness during simulator training. *International Maritime Health*, *61*(4), 258–264.
Savoldelli, G. L., Naik, V. N., Park, J., Joo, H. S., Chow, R., & Hamstra, S. J. (2006). Value of debriefing during simulated crisis management: Oral versus video-assisted oral feedback. *Anesthesiology*, *105*(2), 279–285.
Schegloff, E. A. (1987). Analyzing single episodes of interaction: An exercise in conversation analysis. *Social Psychology Quarterly*, *50*(2), 101–114.
Schegloff, E. A. (2007). *Sequence organization in interaction.* Cambridge, MA: Cambridge University Press.
Sellberg, C. & Rystedt, H. (2015, June). Temporal and material conditions for instruction in simulation-based maritime training. Presented at CSCL2015: *Computer Supported Collaborative Learning*. Gothenburg, Sweden.
Sharrock, W. & Button, G. (1999). Do the right thing! Rule finitism, rule scepticism and rule following. *Human Studies*, *22*(2–4), 193–210.
Stahl, G. (2005). Group cognition in computer‐assisted collaborative learning. *Journal of Computer Assisted Learning*, *21*(2), 79–90.
Stahl, G. (2012). Ethnomethodologically informed. *International Journal of Computer-Supported Collaborative Learning*, *7*(1), 1–10.
Stan, L. C. & Buzbuchi, N. (2012). Considerations on maritime watch keeping officers' vocational training. *TransNav: International Journal of Marine Navigation and Safety at Sea Transportation*, *6*(4), 533–536.
Streeck, J., Goodwin, C., & LeBaron, C. (2011). Embodied interaction in the material world: An introduction. In J. Streech, C. Goodwin, & C. LeBaron (Eds.), *Embodied interaction: Language and body in the material world* (pp. 1–26). Cambridge, MA: Cambridge University Press.
Suchman, L. (1995). Making work visible. *Communications of the ACM*, 38(9), 56-64.
Suchman, L. (2007) *Human-machine reconfigurations: Plans and situated actions* (2nd ed.). Cambridge, MA: Cambridge University Press.
Suppiah, R. (2007). Bridging the gap between theory and practice in the maritime environment: Implications for educators. *Maritime Studies*, *153*, 17–20.
Swedish Research Council (2017). *Good research practice*. Stockholm, SE: Vetenskapsrådet.
Taylor, D. H. (1998). Rules and regulations in maritime collision avoidance: New directions for bridge team training. *Journal of Navigation*, *51*(1), 67–72.

Vidal-Gomel, C., & Fauquet-Alekhine, P. (2016). Reflections and theoretical contributions regarding trainers' practice and simulation. In P. Fauquet-Alekhine & N. Pehuet (Eds.), *Simulation training: Fundamentals and applications—Improving professional practice through simulation training*. Heidelberg, Germany: Springer.

Wickers, M. P. (2010). Establishing the climate for a successful debriefing. *Clinical Simulation in Nursing, 6*(3), e83–e86.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, *17*(2), 89–100.

Zemel, A., & Koschmann, T. (2014) "Put your fingers right in here": Learnability and instructed experience. *Discourse Studies*, *16*(2), 163–183.

Part Two: The studies

Study I: Simulators in bridge operation training and assessment: A systematic review and qualitative synthesis[17]

Study II: From briefing through scenario to debriefing: The maritime instructor's work during simulator-based training[18]

Study III: Demonstrating professional intersubjectivity: The maritime instructor's work on the simulated bridge[19]

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Study IV: Representing and enacting movement: The body as an instructional resource in a simulator-based environment[20]