Simulations in Maritime Training

A video study of the socio-technical organisation of ship simulator training

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SUMMARY

This thesis is situated within the field of educational research, and examines the use of ship simulators to create work-like contexts in maritime training. Within the maritime domain the use of ship simulators is customary to connect theoretical and practical aspects of seamanship. In a broader educational context, this use of simulators can be considered a strategy to overcome the gap between school and work.

For investigating ship simulator training on an empirical level, training sessions were videotaped and scrutinised using interaction analysis. The thesis is founded on three studies conducted in a Norwegian educational facility between 2009 and 2014.

The thesis employs sociocultural and situated approaches to learning, which posit that opportunities for learning and instruction are founded in social interaction. The main findings show that simulators may be useful for situating learning in work-like contexts. Study I shows that role-playing can be an important resource for creating work-like contexts with distinct opportunities for learning and instruction. It is suggested that future practice should address this interactional level of training more effectively. Study II examines how maritime pilots enacted a simulated training environment and shows that full-mission simulations need to be closely linked to participants' professional ways of solving work tasks—their *professional vision*. Study III outlines a framework for aligning learning objectives, simulator technology and learning outcomes in simulator training. This framework was developed to support trainers in their efforts to configure the socio-technical organisation of training.

Together, the three studies that form this thesis provide findings on the ways in which simulations can provide technological and social scaffolding for enacting work tasks in a safe and controlled setting. These findings contribute to earlier studies on simulation-based training as well as to studies of learning as a situated activity.

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Hontvedt, M. (under revision). Professional vision in simulated environments: Examining maritime pilots' performance of work tasks in a full-mission ship simulator. *Learning, Culture and Social Interaction*

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PART ONE—EXTENDED ABSTRACT

1. INTRODUCTION

The sea and the life of seafarers have always fascinated me. In the small, coastal town where I grew up, seafarers comprised a sizeable part of the community, and their occupation was often apparent in very concrete, physical manners. 'Shoot here', with an arrow pointing to a target, was tattooed on my neighbour's chest. At the local grocery store where my family shopped, the owner displayed the characteristic seaman's tattoo—three dots in a triangle on the skin between the thumb and forefinger—when he put his hand on the counter. Others wore tattoos of anchors, hearts or sail ships. Their tattoos often depicted ocean-crossings, loved ones or fellowship with other sailors. To me, working on ships seemed to go beyond a mere occupation and be more like a way of life.

To rise to the ranks of officers, sailors had to pass an examination, but to Norwegian generations before my own, livelihood as a ship crew member was still very accessible without any formal education. This caused generations of young people to go to sea, where learning and work became integrated into nautical practice. During the past century, the maritime industry has gone through significant changes, especially the automation of navigational systems, development of more specialised ships and standardisation of crew communication. Consequently, seamen face more demands for formal courses and certificates. In addition, the massive reflagging of Norwegian ships and the internationalisation that occurred during the past three decades have changed young Norwegians' opportunities to pursue careers at sea. Nonetheless, even if the training of Norwegian seamen has been relocated to classrooms from practice on ship, some of the profession's traditional models for learning through participation and apprenticeship are still evident in practical training periods and the extensive use of simulators. As well as my interest in seamanship, I began this project because of a curiosity about the use of simulations as learning resources in formal schooling. Accordingly, the use of ship simulators struck me as interesting for several reasons.

Simulations in professional training

Within vocational schooling and professional training in shipping, the use of simulators is an important strategy for learning the maritime profession. In Norway, students tend to highly regard the use of ship simulators in maritime education (Brandt, 2008). Ship simulators provide contexts for learning by instruction, learning from peers and learning by actively

testing tools for ship handling and receiving feedback from the system. Unlike a regular teaching situation such as a lecture or literature studies, support is linked to situated actions within a work-like environment. Simulators also allow opportunities to participate in ship-handling activities whilst maintaining high levels of safety and control in training. In this way, ship simulators provide immersive simulations for participants to enact collaborative work in a mediating sphere between schooling and work activities.

Training within the maritime domain is often oriented to meeting international performance standards and objectives within the research field of *human factors*. Primarily derived from cognitive psychology and engineering, human factors refer to human performance in technology-saturated environments and the design of these environments (Vicente, 2003). There is not much research on the use of ship simulators, but some studies have demonstrated how ship simulators can be put to use as work-like resources suited for the re-creation of professional actions (Gould et al., 2009; Øvergård, Bjørkli, Hoff, & Dahlman, 2005).

The use of simulations for professional training and schooling is especially common in the shipping, aviation, healthcare and military fields, and it can be productive to review research from other domains. Prior research within this cross-disciplinary field has focused on crew resource management (Salas, Wilson, Burke, & Wightman, 2006) and opportunities for skill acquisition (Ross, 2012; Silvennoinen, Helfenstein, Ruoranen, & Saariluoma, 2012). Many of the expectations for accumulating professional expertise in simulators concern whether simulated experiences resemble real work settings—often conceptualised as simulator *fidelity*. Consequently, the relationship between fidelity and learning has been much discussed (Alessi, 1988; Dahai, Nikolas, & Dennis, 2008a; Dahlstrom, Dekker, van Winsen, & Nyce, 2009; Rehmann, Mitman, & Reynolds, 1995; Stoffregen, Bardy, Smart, & Pagulayan, 2003). There exists prior research that investigates the social practices of simulating (Rystedt & Lindwall, 2004; Rystedt & Sjöblom, 2012). Also, the importance of providing proper debriefing sessions is commonly acknowledged in simulator training and is frequently connected to learning opportunities (Baker, Jensen, & Kolb, 1997; Fanning & Gaba, 2007; Shinnick, Woo, Horwich, & Steadman, 2011; Tannenbaum & Cerasoli, 2012).

The empirical study

This thesis reports analyses of video observations of students and professionals who attended training at a Norwegian educational facility and comprises three independent studies on the use of ship simulators as a means of creating life-like, hands-on learning experiences for

nautical students and professional maritime pilots. In these studies, the *simulator* is regarded as a device 'that duplicates the essential features of a task situation and provides for direct human operation' (Vincenzi, Wise, Mouloua, & Hancock, 2008, p. 426). Accordingly, *ship bridge simulators* should replicate the functions of a ship's control room. I consider simulators to be devices or systems that emulate certain aspects of a real environment, whilst the term *simulation* refers to the whole of the socio-technically constituted training simulation. *Socio-technical* is a descriptive term that encompasses work systems that rely on the joint efforts of human and technological interlocutors.

The research site consisted of 5 full-mission simulators. The most immersive simulator had a replica of a ship's bridge placed in a cinema-like room with a 240-degree visual display, and 4 other simulators offering varying degrees of immersion. However, for reasons that are further discussed in the methods section, 2 full-mission ship simulators were chosen for detailed analysis: Bergen and Frøya.

Figure 1. The full-mission simulators Bergen and Frøya.

Bachelor students in nautical science

To investigate ship simulators as tools of learning, I decided to observe bachelor students in nautical science. This is the major group of students who use ship simulators as part of their education, and the ways in which large groups of novices can be trained in situated ship handling by the use of simulators stood out as especially interesting. A bachelor degree in nautical science is a three-year course that provides instruction, skill training and necessary work experience for carrying out jobs at sea. Also known as cadet time, it qualifies students for the first in a series of certificates (Class 1—Sea Captain). Students participate in mandatory simulator training and various simulator tests. After graduation, students are qualified for a range of job opportunities on ships, as well as in ports and shipping offices nationally and internationally. However, the maritime domain is highly professionalised, and

its institutional methods of solving work tasks might be difficult for outsiders to assess. By adding a complementary group for observation, I was able to probe further into the profession-specific ways of enacting tasks in the simulators.

Maritime pilots

After investigating students' training for three semesters, I was allowed to observe two one-day courses for professional maritime pilots who received training in close manoeuvring using Azipods, which are a type of rotatable propellers. Within the field of shipping, maritime pilots play a crucial role as local guides with extensive knowledge of the waters in which they are certified. The Norwegian state pilotage service has 290 maritime pilots in service stationed at 18 locations along the coast of Norway (The Norwegian Coastal Administration, n.d.). Using specific boarding marks, the pilots typically enter a ship by boat or helicopter. It is mandatory that ships have a qualified pilot on board while entering and leaving ports or other areas that require specialised local knowledge for navigation (International Maritime Organisation [IMO], 1968). Maritime pilots usually build on the same basic certificates that bachelor students attain, and most achieve the rank of captain before acquiring further training and certification to serve as local guides for a specific area (IMO, 2003). They also attend various courses and training sessions beyond their initial qualification, such as the training sessions observed. This particular professional group served as a complementary set of participants which enabled investigations of the ways in which experienced professionals might put simulators to use in a manner that differs from that of students.

Theoretical approach

In this thesis, I primarily draw on ideas and concepts from a *sociocultural perspective on learning* (Vygotsky, 1978; Säljö, 2001), but also *situated learning theory* (Lave, 1988; Lave & Wenger, 1991). These perspectives have provided me resources for investigating how learning is supported in sociocultural settings—in processes of teaching and training in simulators. Because of its outset in sociocultural and situated learning theory, the current thesis differs from prior studies done on simulators within human factors research. By taking a sociocultural perspective, I am directing my attention to the participants' meaning making and tool-mediated interaction. This theoretical framework affords an attention to the socio-technical constitution of simulations in situ, which will be elaborated in the following chapters.

Aims

This thesis aims to contribute to *research and development* and to the *practical pedagogical organisation* of simulator training.

Regarding *research and development*, this thesis aims to contribute increased understanding of the learning opportunities offered by simulations for professional training in general and for maritime training in particular. By drawing on video-recordings of ship simulator training, this thesis aims to gain new insights into the interactional aspects of simulator practices. Accordingly, Study I focuses on the ways in which participants co-construct simulated contexts and investigates how structuring role play and fostering social interactions can prove valuable for designing simulator training. This is especially relevant to ship simulators as, following a strict division of labour according to the maritime profession's hierarchical system of officers, the maritime domain demands efficient teamwork for safe navigation. Examining how these institutionally defined positions become important resources for meaning making in role play is of interest to the scholarly community and to instructors and designers of training. Further, I aim to contribute to the existing body of knowledge on how work tasks are re-created and enacted in simulated environments. Study II especially contributes in this regard by providing detailed investigations of how full-mission ship simulators support professional actions and by scrutinising the importance of high fidelity simulators *in situ*.

Regarding *the practical pedagogical organisation of ship simulator training*, the thesis aims to provide concrete advice on what types of simulators are suited to what types of training and how to create instructional designs and support different types of learning activities. My aim to contribute to the practical pedagogical organisation of simulator training is motivated by the lack of models for configuring the social and technical requirements for such training. Accordingly, Study I examines the importance of enacting professional roles in training to meet training objectives that involve teamwork. Study II scrutinises participants' professional strategies for solving work tasks and the complexity of isolating specific features of an intricate work setting. Also, simulator training has been the subject of investigation from several research perspectives which tend to conceptualise learning differently and emphasise different types of learning objectives. These various research perspectives and the concrete findings they have generated provide guidance to practitioners' endeavours to design simulator training activities. Therefore, I claim that the field of practice will profit from studies that compare and review the practical implications of different streams of research.

Accordingly, Study III discusses and compares prior research from different traditions. This third study addresses the requirements for simulator fidelity in relation to the different types of learning activities and provides advice on how to select appropriate technological and social supports for creating useful instructional designs using simulators. Outlining such a framework could aid practitioners and researchers in their efforts to align simulator technology with learning objectives.

Outline of the thesis

The thesis is organised into two parts. The first part is the *Extended Abstract*, whilst the second part, *Studies*, consists of three scientific articles.

The extended abstract is intended to provide an account of the project as a whole, particularly its aims, theoretical approach, analytical strategies and the joint contributions of the three articles. The extended abstract has the following structure. After this introduction, I outline the background and research review in Chapter 2, which clarifies professional expectations within the maritime domain and prior research on simulation-based training. In Chapter 3, I outline a theoretical approach that enables analyses of ship simulator training on an interactional level. In Chapter 4, I describe the methodological approach employed to study interaction. In Chapter 5, I present the empirical setting and methods. In Chapter 6, I share reflections on the process of orienting the studies to different journals and provide summaries of the studies, including the main findings. In Chapter 7, I discuss the empirical, methodological and theoretical contributions of the thesis. Lastly, in Chapter 8, I make some concluding remarks to Part I.

In Part II, the three studies that shape this thesis are presented in the order in which they were submitted for publication. The articles are as follows.

Study I:

Hontvedt, M. & Arnseth, H. C. (2013). On the bridge to learn: Analysing the social organization of nautical instruction in a ship simulator. *International Journal of Computer-Supported Collaborative Learning, 8*(1), 89–112. doi: 10.1007/s11412-013-9166-3

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2. BACKGROUND AND RESEARCH REVIEW

The maritime domain represents a distinct professional system with specific demands for expertise; therefore, the first section provides a background on maritime training and prior research on simulator training within this particular professional domain. Thereafter, I review research on the socio-technical organisation of simulator training in general as ship simulator training involves collaborative work in technology-rich environments. Then, I explore research on the importance of work-like, immersive simulators and discuss conceptual frameworks for assessing simulator fidelity and research on the relationship between fidelity and learning. Finally, I briefly review the role of debriefing in simulator training. At the end of this chapter, I provide some reflections on the main findings in the literature.

Maritime training

Within the field of shipping, professional practice follows strict procedures and a hierarchical division of labour. Current standards for competence among seafarers who navigate ships exceeding 500 gross tonnes are defined by the Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). These standards are internationally agreed upon and are issued by the International Maritime Organisation (IMO), the United Nations' specialised agency responsible for the safety and security of shipping and the prevention of marine pollution by ships (IMO, 2011).

The Norwegian educational facilities are also oriented towards the Norwegian ordinances concerning qualifications and certificates for seafarers (Ministry of Trade, Industry and Fisheries, 2012), which specify how the international regulations are to be implemented in Norwegian educational facilities. This document specifies the minimum requirements for competence among deck officers performing such duties as serving as watch officers and being responsible for the ship's navigation. These standards stipulate the necessary proficiency in planning, positioning and undertaking a journey; keeping a safe lookout; using electronic navigation equipment and IMO's standard maritime vocabulary; and knowledge of maritime search and rescue. The regulations dictate that several of these competence measures require testing on a ship or in a simulator.

To meet the requirements for competence in the maritime domain, ship simulators are customarily used in educational and follow-up training for professionals. Various simulators and other ways of simulating practice on ships are used for learning key aspects in the

maritime domain, so the use of simulators is crucial in maritime training. Under Norwegian ordinances and in keeping with STCW requirements, simulators are allowed as a means of demonstrating competence. Therefore, seafarers frequently demonstrate, maintain and increase their level of proficiency using simulators. However, even if the STCW regulations explicitly mention simulators, what type of simulator is required is not specified. This reflects a lack of standardisation in equipment on ships as different ship bridges might have quite dissimilar layouts and equipment.

The nautical profession is characterised by a high degree of teamwork because one individual alone cannot operate a large ship. Consequently, professional behaviour involves participation in a larger work system (Hutchins, 1995). Therefore, full-mission simulators, which allow for coordination among crew members and for physical and communicational structures, are especially important in maritime training. Usually, a bridge team is led by a captain and supported by other personnel operating as helmsmen, navigators and lookout. In close waters, a ship is often obligated to have a maritime pilot who supplements the bridge team. The crew communicates with other ships and the harbour administration by radio and navigates using buoys, landmarks, electronic maps and Global Positioning System (GPS). For meeting such training objectives, full-mission simulators are potentially interesting as they allow for the re-creation of complex teamwork.

Ship simulators range from plain desktop simulators to full-mission bridge simulators. In maritime training, desktop simulators are often used to isolate specific navigational skills, whilst full-mission simulators are considered especially beneficial for working on team-based activities and for training in realistic settings (Vincenzi et al., 2008). In this thesis, the use of full-mission ship simulators is examined. The various forms of training studied are usually devoted to quite specific learning objectives. However, the training of both the maritime pilots and the bachelor students relate to the overarching STCW competence requirements. Frequently addressed aspects of the observed training involve abilities related to *positioning*, *bridge resource management (BRM), watchkeeping* and *situation awareness*.

Skill in *positioning* is mandatory for deck officers. Often, the processes of determining a ship's position are monitored continuously by satellite systems, but all deck officers are required to check the position manually. In case of instrument failure, the crew is dependent on active positioning through the use of visual lookouts. If no such visually identifiable landmarks are available, the crew must navigate by dead reckoning, which means calculating the progress of the ship from the last known position by measuring speed and compass course. The increase in the use of electronic equipment on ships provides opportunities for more

accurate and safer navigation but also raises new challenges for crew coordination and workload (Porathe, 2006). Different strategies for positioning are frequently taught using simulators, both part-task trainers and full-mission simulators. This choice of simulator type often depends on the degree to which the learning objective involves individual handling of tools or the collaborative management of tasks within the bridge team.

BRM is the implementation of a way of working that enables all members of the team to know the role that they are required to carry out and the roles of other members of the team. Poor communication is considered hazardous to safe shipping (Hetherington, Flin, & Mearns, 2006), and all certified seafarers are obligated to follow the STCW regulations on communication. Safe navigation entails careful planning and course setting as the crew has limited opportunities to change the direction and speed of a ship at short notice. Even large ships are exposed to external factors, such as wind and waves, and respond slowly to steering compared to other forms of transport. A breakdown in effective communication might result from the lack of a common language, differing procedural methods or simple misunderstandings. Therefore, team management is crucial to ensure that task management is effective and that no tasks are ignored or overlooked, this demand a system of checking and crosschecking situations and decisions (Swift & Bailey, 2004).

Watchkeeping is considered the ability to notice obstacles at an early stage and to keep a ship on course and away from danger. This ability includes knowing the routines for watch changes and the principles for proper lookout. Watchkeeping practices must be attuned to the actual waters in which a ship is and should be followed by the team, as well as individual. Closely related to watchkeeping is the notion of situation awareness.

Situation awareness is knowing what is going on around the ship and is broadly recognised as a key factor in safe shipping. As in other professional domains such as aviation and military training, situation awareness is often related to the much cited framework of Endsley (1995). This framework reviews earlier research and constructs a three-level theoretical model of situation awareness: 1. *Perception*, or monitoring, recognising and perceiving the relevant situational elements in an environment; 2. *comprehension*, or actively treating information used to recognise patterns and integrating the meaning of information into goals and objectives; and 3. *projection*, or predicting the future actions of the elements in the environment. Achieving this highest level of situation awareness requires knowledge of the status and dynamics of the elements and assessing their future impact on the operational environment. Endsley (1995) also outlines the notion of *joint* situation awareness, which is the ability of the participants on a team to distribute elements of the environments that need

attention. Obtaining joint situation awareness—that is, the bridge team possesses a shared perception of what is happening and what will happen in the near and distant future—is critical for a safe journey. Endsley's (1995) definition of situation awareness relies heavily on a cognitive perspective of human thinking and action.

In contrast to Endsley (1995), Melander and Sahlström (2009) re-conceptualise situation awareness from an interactional perspective. Their study is based on detailed studies of interaction between a student learning to fly an airplane and her teachers. Through this study, Melander and Sahlström (2009) provide situated accounts of achieving, maintaining and learning situation awareness on a plane. The authors use conversation analysis (CA) to show how situation awareness is constituted in interaction and demonstrate how it can be empirically examined as a learnable practice (Melander & Sahlström, 2009).

Current research on ship simulator training

Within shipping, there is put an extensive weight on simulators for training. However, to my knowledge, few empirical studies on ship-bridge team training have been conducted. During the literature review, I was interested in finding peer-reviewed research publications that had studied the use of ship simulations for learning, in particular studies that had focused on training on an interactional level. Together with a librarian in January 2014, I conducted searches for such studies in databases—ERIC, Springer LINK, Science Direct and IEEE Xplore—using search terms such as 'ship simulator', 'ship simulator training' and 'maritime simulation-based training'. I also did more unstructured searches on Google Scholar and screened the literature references in other studies. However, I have not found studies that scrutinised the use of ship bridge simulators for *learning purposes* on an interactional level.

Human factors research, originating mainly from engineering and cognitive psychology, has dominated research on safety in shipping (Hetherington et al., 2006) and on team training in simulators (Salas et al., 2006). Accordingly, I did find some studies of ship simulators as test beds for researching the role of human factors in shipping. Researchers have investigated the cognitive demands of collision avoidance (Robert et al., 2003), comparing electronic chart display and information systems (ECDIS) against paper chart navigation (Donderi, Mercer, Blair Hong, & Skinner, 2004), assessing the effect of stress on safe navigation (Murai et al. 2009), and determining the effects of display design and navigation system complexity on performance in a simulated ship navigation environment (Nilsson, Gärling, & Lützhöft, 2009; Sauer et al., 2002). However, none of these researchers primarily addressed the training situation or learning activities as such.

Some human factors studies empirically examine simulations on an interactional level. For example, Gould et al. (2009) investigated mental workload and performance in simulated high-speed ship navigation. Two navigation methods based on an ECDIS and a conventional system using paper charts were compared. In high-fidelity simulators, naval cadets navigated a course with varying levels of difficulty, and Gould et al. (2009) used a triangulated measurement strategy simultaneously assessing performance, subjective workload and psychophysiological activation, such as heart rate variability and skin conductance. The results showed that ECDIS navigation significantly improved course-keeping performance but reduced the total amount of communication on the bridge. Although Gould et al. (2009) did not address the simulator activity as a learning situation, they examined the participants' mental workload and how changing the socio-technical system might affect strategies for more effective navigation.

Øvergård, Bjørkli, Hoff, and Dahlman (2005) evaluated the differences between real- and simulator-based military high-speed craft navigation. Swedish recruits formed two-person teams and navigated a route around the archipelago outside Gothenburg. Two days later, they navigated the same route in a CB90 full-mission simulator. Three different route segments of differing complexity were analysed. The results indicated that the complexity of the navigational task affected the choice of speed and trajectory variation (Øvergård et al., 2005). In complex segments, speed and trajectory variability were lower for real navigation than for simulator-based navigation. For simple segments, the opposite was true: Higher speeds and larger trajectory variability were observed in the real navigation compared to the simulator-based navigation (Øvergård et al., 2005). The data from the questionnaires indicated that a lack of experienced danger in simulator-based navigation could have led to the observed speed trajectory pattern.

Some studies have addressed the use of simulators for training by discussing how to delineate objective criteria for assessment (Kobayashi, 2005). These studies have considered foci for future ship simulator training, such as the degree of transfer of learning between the simulator and the real work setting, the assessment of non-technical skills, behavioural markers of expertise and the ways in which organisational culture might impact accident causation (Barnett, 2004; Barnett, Gatfield, & Pekcan, 2006). However, these studies have relied more heavily on literature reviews and descriptions of educational programmes than on empirical observations.

While not studying learning per se, these studies on how professionals' solve tasks offer potential for studying human performance in technology-saturated work settings and

might also inform us on what types of expertise that are needed among seafarers. However, unlike analyses of simulators as test beds or replicas of real situations, I treat simulator trainings as a situated activity in which work relevance is not a static feature but is socially constructed by the participants.

Though navigation has a very specific nature, some lessons can be learnt from assessing detailed studies of simulator training in other professional domains. In the following, I present studies that can shed light on the conditions for learning in simulators on an interactional level.

Research on the socio-technical organisation of simulator training

Within several specialised domains, simulators provide environments in which professionals collaboratively enact work tasks that afford specific types of interaction, coordination and problem solving. The situated nature of professional actions on board a ship bridge was described in detail by Hutchins (1995), who demonstrated that a ship's bridge team, along with the artefacts of their profession, forms a system of activity with collective effort that exceeds the sum of individual capacities. Hutchins (1995) conceptualised this joint effort as *distributed cognition*, which he developed from anthropological studies of how humans solve tasks, cooperate and distribute labour within institutional practices. However, after studying teamwork on board a ship bridge in his seminal work *Cognition in the Wild* (1995), Hutchins shifted his attention to airplane cockpits, where he and fellow researchers explicated and refined his theory of distributed cognition (Hutchins & Klausen, 1996; Hutchins & Palen, 1997). Interestingly, and unlike *Cognition in the Wild*, these detailed investigations of the interactions of a flight crew were conducted in simulators for practical reasons. Without focusing on the simulation as a training activity per se, these researchers revealed the pilots' collaborative work efforts and opportunities for re-creating situated patterns of work actions in a credible manner in a simulator. The studies demonstrated that the efficiency of the cockpit system as a whole is created by the pilots' cognitive and collaborative efforts, along with the physical properties of representational media (Hutchins & Klausen, 1996; Hutchins & Palen, 1997).

Especially within healthcare, there have been detailed studies on how simulators scaffold learning and instruction which could inspire similar studies within shipping. Rystedt (2002) applied interaction analyses to examine the use of simulations as a learning resource in nursing education. His thesis showed that students' framing of activities was the key to understanding their learning processes and that simulating authentic practice depended not

only on the realism of the simulations but also on the authenticity of the collaborative activities among participants (Rystedt, 2002). In a later study, Rystedt and Sjöblom (2012) further discussed matters of authenticity by investigating how two groups working with high- and low-fidelity simulators in medical training experienced realism. Rystedt and Sjöblom (2012) showed that the learning potential of a simulation cannot be predesigned or considered an affordance of the simulator but emerges from the interaction among participants, the simulator and the context. In contrast to studies that seek stable relations between levels of fidelity and learning opportunities, such interactional studies tend to relate demands for fidelity to specific practices and tasks.

Rystedt and Lindwall (2004) demonstrated how learning foci were collaboratively managed when working with simulations at a course in anaesthesia care. The researchers described how the dynamics of the simulation interact with participants' actions and orientations, depending on the available resources and how the scenarios were interpreted.

Krange, Moen and Ludvigsen (2012) examined the use of a computer-based three-dimensional (3D) model to simulate a trauma team setting. Krange et al. (2012) used interaction analysis to investigate the collaborative effort to determine a diagnosis for a simulated injured patient. The participants' *professional vision* (Goodwin, 1994) was displayed and clearly became an important resource for participants to collaboratively solve the assignment. The main finding was that highly specialised virtual worlds, such as this computer-based 3D model, have the potential to facilitate relevant communication training (Krange et al., 2012). However, Krange et al. (2012) also suggested a continued focus on the actual practices of simulating, rather than solely relying on post-scenario debriefings, which is a typical perspective in investigations of simulator training.

These prior studies showed that the coordination of work tasks is the key to solving simulations. Husebø, Rystedt, & Friberg (2011) detailed such coordination among resuscitation teams in simulated cardiac arrest situations. In healthcare, as in the maritime domain, communication failure and poor coordination among team members is a dominant factor in error making. This analysis demonstrated that verbal communication by itself is not sufficient for achieving coordinated actions and that sufficient coordination in resuscitation teams involves a combination of bodily conduct, gestures and verbal communication. It was shown how the simulation enables participants to take part in a complex interplay of taking position, pointing and receiving verbal statements and directives (Husebø et al., 2011). This analysis demonstrates that simulations offer promising solutions for training as they provide

possibilities for training in the entirety of coordinated actions in teams, which would otherwise not be possible.

Collectively, these studies show that seeing simulator training as social practice offers possibilities for considering what specific characteristics of the simulator practice are central to (re-) create different sorts of relevant professional features. This, however, occurs an interactional level that has seldom been made an object of investigation in the use of ship simulators.

Conceptualisations of simulator fidelity

Fidelity is a much-used concept for describing simulators' accuracy and resemblance to real work settings (Dahai et al., 2008a; Dahlstrom et al., 2009) and is especially applicable to discussing the design of simulator experiments and simulator training. Accordingly, a great deal of research has provided conceptual descriptions of simulator fidelity and the effect of fidelity on learning. In this section, I give some examples of conceptual frameworks before reviewing earlier positions on the relationship between fidelity and learning in the next section.

In a dictionary definition, the concept of fidelity encompasses faithfulness and precision: 'the degree of exactness with which something is copied or reproduced' (Fidelity, 2014). Within the context of simulator training, fidelity can be defined as 'the degree of similarity between the training situation and the operational situation which is simulated' (Hays & Singer, 1989, p. 50). Conceptual models of simulator fidelity provide a vocabulary for describing simulator affordances. Conceptions of high- and low-fidelity provide a useful distinction in how immersive simulators are on a general level but soon become insufficient as a simulator often has high fidelity in some aspects and low fidelity in others. In such cases, it is a common strategy to specify different types of fidelity. Several conceptual frameworks relate fidelity to certain parts of the simulation. For example, Hays and Singer (1989) distinguish between the physical and functional characteristics of fidelity: '(1) the physical characteristics, for example visual, spatial, kinaesthetic, etc.; and (2) the functional characteristics, for example the informational, stimulus, and response options of the training situation' (p. 50). Rehmann et al. (1995) reviewed types of flight simulator fidelity and reported more than 20 conceptualisations, such as *equipment* fidelity*, environmental* fidelity*, psychological* fidelity*, task* fidelity*, physical* fidelity *and functional* fidelity. Such descriptions might be useful for describing simulator technology, but in the literature, it is often unclear whether the concept of fidelity is applied to describe exactness and similarity between the

physical and technical environments or the exactness and work relevance of the simulated activity.

Relations between fidelity and learning

In the early years of simulator training, a strong link was made between the level of fidelity and the amount of learning (Dahai et al., 2008a). Although such one-dimensional relationships between simulator fidelity and learning have been heavily criticised, they still appear frequently (Beaubien & Baker, 2004; Dahlstrom et al., 2009). Various experimental studies have attempted to delineate stable relations between simulator fidelity, conceived as the technical and physical design of simulators, and learning affordances on more or less general levels (e.g. Alessi, 1988; Grober et al., 2004; Hochmitz & Yuviler-Gavish, 2011; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Oskarsson, Nählinder, & Svensson, 2010).

The much-cited Alessi (1988) hypothesis suggests that the effect of fidelity on learning depends on the learner's existing level of proficiency. Alessi (1988) suggested that low-fidelity simulators are more efficient for novices as high-fidelity simulators may be overwhelming and too complex to handle. For more experienced learners, high-fidelity simulators may be useful, but there is a point at which increasing simulator fidelity results diminish (Alessi, 1988). Dahai, Nikolas, Elizabeth, and Dennis (2008b) conducted a recent review of research on relations between simulator fidelity and learning and found support for Alessi's (1988) claims, particularly for the usefulness of progressing from low to high fidelity based on participants' level of competence and for a diminishing effect from simulator fidelity at a certain level as training progresses.

Types of simulators have different affordances for organising training, and suggestions for how different types of simulators might facilitate learning activities are of interest to the scholarly community and to practice. For example, Beaubien and Baker (2004) distinguish among three types of simulation-based training and their affordances: case studies/role plays, part-task trainers and full-mission simulators. The strengths of case studies and role plays were considered their high flexibility to address different tasks and dilemmas and re-enact demanding situations. Case studies and role plays are low cost and generate positive trainee reactions. Part-task trainers also provide focused training in a distraction-free environment at a low cost. Full-mission simulators were considered to provide possibilities for safe training for more complex, demanding tasks with higher level of environmental complexities.

Researchers have undertaken experimental studies attempting to delineate stable relations between simulator fidelity, conceived as the technical and physical design of the simulator, and stable learning affordances on more or less general levels for specific users and types of training. For example, Hochmitz and Yuviler-Gavish (2011) studied the effect of simulator training types on the successful completion of a Lego® assembly task. The researchers compared training based on virtual–physical and cognitive fidelity to real-world training and no training. To measure the degree of transfer of learning, a post-training test was administered to assess the development of procedural skills. Hochmitz and Yuviler-Gavish (2011) showed that both virtual–physical and cognitive training methods produced good results and suggested that combining physical fidelity and cognitive training methods can enhance procedural skills acquisition when real-world training is not convenient. However, as the authors point out, even if the experiment design is appropriate, the degree to which this experiment is applicable to other types of procedural skills is uncertain (Hochmitz & Yuviler-Gavish, 2011).

However, an answer to why extensive research on the effect of fidelity has not provided definite findings seems connected to the fact that fidelity is often one of many factors that affect training and, therefore, is difficult to isolate. For example, Silvennoinen et al. (2012) studied surgical residents during computer-based simulator training in basic laparoscopic surgical skills. Laparoscopic skills require mastering various instruments and visuomotor skills before performing on patients, and simulator training is considered a suitable learning tool. The study examined the use of a laparoscopic training simulator with real surgical instrument handles and pedals for conducting procedures in 3D virtual interfaces provided in specially designed exercises. The study suggested that the simulator training provided increased performance but that autonomous training with the simulator was not ideal; instead, the residents needed certain levels of content-based feedback and supervisor support during their training activity (Silvennoinen et al., 2012).

Thus, technical skills are perhaps easiest to measure in experimental designs. There are also examples of research on the effect of psychological fidelity on the development joint conceptions of collaborative task demands, often conceptualised as shared mental models. Van den Bossche, Gijselaers, Segers, Woltjer and Kirschner (2011) investigated the development of shared mental models among first-year bachelor students using the business simulation game *Steer the Economy*. A computer model simulated decisions by consumers, employees, banks and governments and it facilitated teams' management of different companies. The findings of this study supported the premise that team-learning behaviours

are related to the development of a shared mental model, although these teams have to pay explicit attention to their socio-cognitive processes, such as productive disagreements and actively confrontation of other's understandings, in order to promote team learning as an avenue for the development of shared mental models (Van den Bossche et al., 2011).

As these studies show, notions of psychological and cognitive fidelity are common in simulator training. However, they are defined rather differently and are often difficult to observe empirically. According to Kozlowski and DeShon (2004, p. 75), psychological fidelity concerns the extent to which the training environment prompts the relevant underlying psychological processes for performance. Kozlowski and DeShon (2004) argue that basic cognitive theory, along with knowledge of instructional design and relevant types of professional expertise, provides an effective background for developing simulator training designs. Systematically working to develop the underlying mental model, simulations—also of low-fidelity—might provide resources for acquiring problem-solving and adaptive expertise. Throughout the study, Kozlowski and DeShon (2004) emphasise the individual perspective, including in team processes.

Based on these studies, the level of fidelity is relevant to the creation of learning opportunities, but its definition and relation to learning are ambiguous and unclear. All three studies that form this thesis provide input into how fidelity can be conceptualised and shed light on its relationship to learning. In particular, Study III provides a discussion of different perspectives on simulator fidelity and a suggested framework for aligning demands for fidelity with learning objectives.

The role of debriefing

Within simulator training, debriefing sessions are commonly acknowledged and frequently connected to learning opportunities (Baker et al., 1997; Fanning & Gaba, 2007). Debriefings are post-scenario situations that facilitate learners' efforts to analyse, make sense of and assimilate learning experiences with existing knowledge. Though devoted to different functions and employing many strategies, debriefings within simulator training are often aimed at bridging the gap between *experiencing* and *making sense* of these situated experiences (Fanning & Gaba, 2007). In simulator training, the importance of debriefings is highlighted as the required mental models can be cultivated through debriefing techniques (Baker et al., 1997; Tannenbaum & Cerasoli, 2012). Accordingly, research related to simulator debriefings has assessed simulations' ability to facilitate discussions and debriefings

and have found that, in many cases, low-fidelity simulators offer such affordances, as well as more immersive simulators (Baker et al., 1997; Beaubien & Baker, 2004).

The analytical unit in these studies is participants' mental models, which are the knowledge components recognised as important, for example, for team performance. However, it is not clear how these common models are effectively developed by *in situ* simulator operation. This sometimes tacit relationship to underlying principles and routines in participants' situated doings explains the common strategy in debriefings to address specific parts of participants' understandings. Prior accounts of debriefing seem to be closely related to the founding assumptions of cognitive psychology—that is, the schematic organisation of cognition in mental models that might be reinforced or modified. Cognitive psychology is here referred to in a broad sense to describe the number of influential theories that focus on individuals' thinking and their construction of representations of the world (Anderson, 2010; Papert, 1980; Reisberg, 1997). However, debriefing might also be an instructional strategy that has various functions and is viewed differently between domains.

Reflections on current research

Within the domain of maritime training, simulations are believed to enable risk-free training in critical situations and to provide means for the formal assessment of competence in line with STCW demands. Full-mission ship simulators provide resources for re-creating the coordinating activities of teams, but few studies have shed light on these activities at an interactional level. In the preceding presentation of maritime training and overview of relevant research, some distinct findings and gaps in the existing body of research surface.

I have not found studies that examine how ship simulators are put to use as educational resources in naturalistic settings. Examples of scholars who have studied the socio-technical practices of simulating for learning purposes in other domains have been highlighted, but to my knowledge, there are none within the maritime domain. Given this limited amount of research on specifically ship simulators, it is pertinent to add to the scarce body of research by examining research on simulator training within other professional domains. However, such research should be scrutinised for its validity in the maritime domain as the type of skills and knowledge that participants acquire might be somewhat different. For identifying key aspects of navigation and communication within the maritime profession, earlier research on actual bridge teams can contribute. This research shed light on how work tasks in various training exercises have a cooperative character—and consequently, that the socio-technical environment re-created in the simulator needs to support such cooperation.

The notion of fidelity recurs in research on the technical facilitation of simulator training. Different conceptualisations of fidelity have been developed to grasp the accuracy of simulator training and the physical similarity between the simulator and the work environment per se. Studies show that, in terms of representing reality, simulators will always be second to practice within the actual work setting. However, in terms of creating conditions for learning, simulators have some advantages that learning in real environments does not (Hollnagel, 2011). This suggests that realism, or simple similarity with the real work setting, is perhaps not the most relevant measure for assessing simulators' potential as tools for learning. Rather, the training process allows participants to deal with work-relevant problems and participate in the situated activity systems of work. As studies show that simulations are constituted in interaction, I argue for the benefits of considering fidelity an affordance of the interactionally generated simulation, not simulator technology alone.

The findings presented in this review suggest that the use of ship simulators on an interactional level is an underexplored topic. Against this background, this study relates to the current body of research and advances the existing knowledge by exploring ship simulators as learning resources on an interactional level from what might be termed an interactional approach to the study of learning.

3. A THEORETICAL ACCOUNT FOR LEARNING IN INTERACTION

Learning is broadly acknowledged to be an everyday activity, but its meaning is still heavily disputed. What complicates discussions about learning is that different theoretical perspectives have radically different units of analysis, such as behaviours, mental processes or human action (Säljö, 2003, p. 314). This thesis is concerned with learning as an interactionally constituted phenomenon. For this endeavour, I draw on two theoretical approaches that share an interest in conceptualising and defining learning as an interactional achievement. In particular, the focus is upon the *sociocultural approach to learning* (Vygotsky, 1978; Säljö, 2001), and *situated learning theory* (Lave & Wenger, 1991) also provides an important source of inspiration.

Put simply, *sociocultural learning theory* is founded on the seminal work of Vygotsky and related scholars' efforts to account for the social formation of mind. In this perspective, learning is seen as a complex process that involves interplay among the mind, body and their sociocultural settings mediated by cultural artefacts (Säljö, 2001; Vygotsky, 1978). Vygotsky's theory grew from psychological studies of children's learning and development and the interplay between the individual and the social. Vygotsky described how social activity originates from the construction of consciousness in intricate ways, without clear boundaries between internal and external factors. Hence, employing a sociocultural perspective involves a focus on mediated activities as they progress within sociocultural, physical and institutional contexts. By focusing on peoples' actions, their situated construction of meaning and how these practices are mediated through physical and symbolic cultural tools, the sociocultural perspective moves the locus of investigation away from internal processes of the mind and enables seeing and conceptualising participants' joint meaning making and identifying learning opportunities in social activity.

A characteristic of *situated learning theory* is a focus on learning in the workplace and other types of institutional settings, as well as in schooling. Its focus on learning by participating in social practices has similarities with the ideas of Dewey and American pragmatism (Bredo, 1994; Rogoff, 2003), and according to Lave and Wenger (1991), it has been influenced by the social foundation of mind emphasised in Russian psychology but pays more attention to the function of context—and less to humans' ability to absorb knowledge through internalisation. As well, from the use of tools and mediation, situated learning theory expanded the analytical unit to regard learning as participation in larger communities of

practice. In this endeavour, inspiration from Marx' theories of the production and reproduction of social order is visible in the analytical attention given to persons' development and changes across everyday activities (Lave & Wenger, 1991, pp. 38, 45–50). Instead of psychological studies of pairs and small groups, ethnographical studies of learning and cognition in naturalistic settings provide sources for insight. Situated learning theory is concerned with the relational and negotiated character of human understanding and communication. The important point in this regard is not that all learning must be done *in situ* but, rather, that the acquisition of an abstract principle is itself a specific event under specific conditions (Lave & Wenger 1991, p. 33). Consequently, situated learning theory can be conceptualised as a theory of the nature of learning, rather than an instructional strategy. Situated learning theory views learning as an interactional phenomenon and addresses the ways social practices shape thinking, learning and action (Lave, 1988). In the current project, this entails paying attention to the ways participants orient to ways of conduct within their profession and how this practice is situated within and affected by a specific setting.

In the following, I expand on the key issues that have guided the analyses of this thesis. The objective of this chapter is not to draw up a comprehencive model for learning but to show some of the ways we can conceptualise and grasp learning on an interactional level. These issues are helpful in conceiving the practices of simulating for learning a profession, which is an instructional strategy that differs from both traditional schooling and apprenticeship learning at the workplace.

Situatedness

From a sociocultural and situated perspective on learning, it does not make sense to abstract learners from the contingencies of the situation in which they operate. The term *situated* is commonly used within learning theory, but the concept has a somewhat ambiguous meaning. On one hand, it can be conceived as a descriptive statement of learning as located in time and place and consequently closely tied to the sociocultural practices of a community. On the other hand, situated learning can be regarded as a normative concept which describes learning situations that are connected to 'real' or 'authentic' situations (Arnseth, 2004, p.36). In this latter usage, situated learning is often used to signal a normative model for learning and instruction that is different than traditional school practices (e.g. Brown, Collins & Duguid, 1989). In this thesis, the notion of *situatedness* is used in the first sense, as an analytical concept that places learning in interaction. Similar to Arnseth (2004), I argue that situatedness should be regarded as a generic concept for conceiving of learning and knowing as

interactional phenomena. Although the term has limitations for describing concrete action—as all action can be considered situated—it highlights an aspect of learning and a mode for doing inquiry.

The current thesis is concerned with providing empirical accounts of the situated practices of simulator training in their own right, not as a duplication of the actual work situation. Prior research has pointed out that opportunities for learning in technology-saturated environments should not be considered to be static or inscribed within the technological environment itself but, rather, situated and social achievements (Arnseth, 2004; Dillenbourg, Järvelä, & Fischer, 2009; Petraglia, 1998). The purpose of investigating learning as situated in this regard is to display the interactional configuration of the simulation. From a normative stance, simulations may be considered a desired strategy for schooling as they can provide a true-to-life setting for learning by participation. However, one might discard the value of simulations from the same standpoint—as real settings are so complex and reliant on contextual dependencies that they cannot be replicated without losing their relevance.

Studies of participants' situated practices can shed light on such overarching questions. However, to investigate the situated practices of simulating, the analyst needs additional concepts that enable grasping the collaborative efforts of bridge teams to make sense of and act upon their surroundings.

Meaning making

In the sociocultural learning perspective, participants' construction of meaning is seen as an interactional, tool-mediated achievement. Accordingly, *meaning making* can be defined as 'social interactions in which participants make sense of one another's actions, scientific concepts and the social settings where their actions are carried out, including the artefacts they make use of, to accomplish their tasks' (Furberg, 2009, p. 7). This definition stresses that meaning making involves participants' configuration of joint action through the use of conceptual, institutional and physical tools. Hence, focusing on participants' meaning making enables the identification of resources that participants employ for collaboratively solving tasks. The concept of *meaning potentials* describes how linguistic resources do not have set meanings but have potentials for interpretation that are negotiated in interaction (Linell, 2009, pp. 40, 332). This notion sheds light on how participants make meaning of a situation by highlighting the available interpretations and resources in their environment, and provides a way of conceiving the relation between human agency and the affordances of a setting. However, these potentials should not be regarded as unlimited but as structured by both

sociocultural and physical contingencies. In meaning making, participants draw on resources other than words, such as gestures, body placement, and physical tools, which can prompt specific situated meanings of spoken language (Furberg, 2009, p.161).

Accordingly, I do not view participants' meaning making in simulator activities processes of identifying meaning as the finding of answers, as if meaning were an abstract unit. Instead, meaning making is conceived as the interpretive processes of learners as they together enact a domain and undertake concrete tasks. In my conception, this perspective provides a focus of attention that can bridge the cultural, physical and interactional aspects of creating a simulation.

Suthers (2006) introduced the notion of *intersubjective meaning making* as an observable process of finding common ground in group processes, that is, the 'joint composition of interpretations of a dynamically evolving context' (p. 321). Suthers's (2006) aim is to set the research agenda of computer-supported collaborative learning (CSCL), which has a special focus on how technology can support such joint meaning making. However, Suthers's (2006) text also presents an interesting discussion of learning as an observable phenomenon in more general terms, which points to some key issues for analysis. Suthers (2006) proposes intersubjective meaning making as a productive way of empirically investigating learning opportunities. He claims that it is problematic to claim to identify acts of learning when observing interaction; however, we can provide detailed descriptions of contingencies for learning in joint meaning making (Suthers, 2006, p. 320).

From this perspective, the notion of meaning making can be considered supplemental to the notion of learning through increased ability for participation, developed as an analytical concept by Martin (2009) and Melander and Sahlström (2009). The first notion entails the active (re-)construction of knowledge on the group level, whilst the second involves the acquisition of norms, knowledge and skills for participation in a community of practice. However, a focus is not put on meaning making in order to suggest that the material entities fade into the background as the very process of meaning making is facilitated by the use of conceptual and physical tools in a larger system of activity.

Activity systems

Throughout this thesis, I frequently use the expression 'enactment of professional roles and work tasks'. This expression signals a view of professionalism as a way of participating and operating in a complex setting that involves situated contingencies and co-action by physical and social interlocutors. I argue that the simulations I have studied are best understood as

activity systems. In this thesis, I employ a broad understanding of this concept in order to grasp the interconnected relationship between different actors in the simulation. In line with Greeno (2006, p. 79), I define activity systems as situated social organisations which contain learners, teachers, tools, curriculum materials, software tools and the physical environment. In professional settings, institutional practices, artefacts and individual actions are closely interdependent and enacted by various participants who obtain different institutional roles and responsibilities for solving work tasks.

Shedding light on this matter from a different perspective, Goodwin (1997) defines *situated activity systems* as 'the range of phenomena implicated in the systematic accomplishment of a specific activity within a relevant setting' (p. 116). He used this term in his investigation of how a team of geochemists determines how to make a particular colour in a laboratory (Goodwin, 1997). Here, material objects and mental representations were integrated into a joint process, which draws on the resources of several actors. Another example of such a work system was analysed in detail by Heath and Luff (1996), who explicated the collaborative and socio-technical coordination of the line control rooms of the London Underground. Here, Heath and Luff (1996) pointed to actors' ability to participate in the coordinating and communicative patterns at work as crucial to success.

The notion of constituting activity systems through the use of physical and social tools is especially visible on a ship's bridge as this system demands a collaborative team effort. From a situated perspective, workplaces may facilitate efforts that exceed individuals' accumulated capacity as their performance is linked to participation in larger work systems (Lave & Wenger, 1991, p. 102).

This background enables the perspective of the sociotechnical configuration of simulator training. Accordingly, in such settings, participants cannot be considered to only execute professional techniques but also to take part in work systems in which the techniques become inseparable from the social doings.

Studying the co-configuration of a simulated context

Within the learning sciences, the notion of *context* is frequently used, but its meaning is somewhat ambiguous. According to Lave (1988, pp. 40, 150), notions of context range from the behaviouristic perceptions of human behaviour as caused by the environment to cognitive conceptions of context as an isolated container that surrounds activity and, finally, to various phenomenological and ethnomethodological analyses that see contexts as exclusively social situations—as if a context can be socially produced regardless of material and cultural

contingencies. Among sociocultural approaches, it seems to be agreed that context is created in the relations between acting persons and their settings. Contexts are composed simultaneously by concrete interaction and participants' partly shared background knowledge. However, the degree of continuity across situations is subject to conceptual and empirical investigation and debate (e.g. Duranti & Goodwin, 1992; Linell, 2009).

If context is interactionally constituted, then it dynamically changes with participants' communicative and cognitive activities, which makes assessing its exact composition challenging. However, there are several relevant concepts for analytically approaching this active shaping of context. For example, Goffman (1974, p. 662) introduced the notion of *frame* as an analytical concept for understanding the ways that social activity unfolds within frameworks for interpretation. Goffman (1974) explains that framing is interactionally accomplished through language, as well as physical signs, and that situations are defined through such framing processes. From this perspective, context cannot be regarded as a stable factor but as dependent on how participants attend to and organise their perception of events in relation to a basic 'storyline' (Goffman, 1974, p. 564).

Duranti and Goodwin (1992) emphasise participants' joint construction of *focal events*—meaning the phenomenon being contextualised by participants bringing particular elements into focus in interaction. Here, the context forms the stage on which these events take place Duranti & Goodwin, 1992, p. 2–9).

Linell (1998) conceptualises *realised contexts* as those aspects that are made communicatively relevant by the participants *in situ* through the use of *contextual resources*—that is, the accessible phenomena that can be made relevant and thereby form affordances for meaning making. In a study of simulated job encounters, Linell and Persson Thunqvist (2003) developed the concept of *activity contexts*. The researchers demonstrated the role-play simulation to be an ambiguous, hybrid talk activity. The simulated context of a job interview was surrounded by meta-talk and evaluations of the simulated interview as it progressed (Linell & Persson Thunqvist, 2003, p.428). Activity contexts provide different resources for meaning making, and several activity contexts can be handled simultaneously. Linell and Persson Thunqvist (2003, p. 432) point out that a stronger emphasis on sociocultural practices that transcend situations allows the notion of activity contexts to be regarded as a contrast to the focus of orthodox conversation analysts (see a discussion of these orientations in Chapter 4) on the situated meaning making by only co-present participants.

The various conceptual resources for analysing context are highly relevant to investigating simulators' potential as learning environments. That humans are influenced by

yet also constitutive of context makes the unfolding activity an open-ended process. In other words, humans generate contexts that again make certain experiences possible. This relation implies that our ability to shape relevant contexts affects our opportunities to learn. This is a relevant consideration to the use of simulators for learning as the simulator can provide a technical setting with relevant contextual resources, but its potential as a learning environment needs to be made relevant by the participants in training.

Studying professional vision as an enactment of expertise

Being a professional requires the capacity to respond to changing conditions and to exert specialist expertise within a specific field of practice. Thus, from a sociocultural perspective, expertise is viewed as actively constructed and enacted in practice, not as a stable skill set or ability. Edwards (2010) claims that cognitive perspectives on learning have been dominant within research on professional expertise, but emphasisess a 'relational turn' in expertise. This relational turn can be recognised by the increased attention to the value and meaning of collaboration, in addition to individual skills and knowledge (Edwards, 2010, p. 2). The emphasis on the coordinating and situated nature of learning a profession supplements prior studies which tended to make either the technical skills or the cognitive abilities of the individual the basic unit of analysis.

More than mere physical locations, sociotechnical workplaces have been delineated as actively constituted fields of perception and interaction that are continuously maintained by participants and involve a range of coordinating actions (Heath & Luff, 1996; Suchman, 1997). Accordingly, *professional vision* encompasses how differently positioned actors use spaces and representational technologies to create a common course of action. Goodwin (1994) defines professional vision as 'socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group' (p. 606). Goodwin's (1994) notion of professional vision, thus, is not restricted to the use of gaze but encompasses the discursive practices used by the members of a profession to conceive their professional environment.

One way Goodwin (1994, p. 614) demonstrated the meaning of the concept is through detailed reports of how a novice is introduced to an archaeological digging site and learns to partake in embodied and interactionally constituted activities. Through this analysis, Goodwin described how this professional practice was both socially situated and historically constituted—and that these characteristics shaped the knowledge produced within the profession.

As stated, the training of seamen involves teaching novices to participate in a specific communicative work system and operating the artefacts that mediate professional action. In Study II, professional vision is employed as a resource to explain how professional pilots in training were put off by discrepancies between the simulators' equipment and the real work setting and how they failed to disregard these inaccuracies, even if they were not relevant to the learning objective. Here, the concept of professional vision is used to conceptualise the professional pilots' orientation to salient information in the simulator environment, and the contingencies for such a vision in simulated environments.

An interactional account for learning in ship simulators

As pointed out, a joint concern in the sociocultural and situated approaches to learning is sensitivity to the contextual and collaborative aspects of learning. In professional training, one strategy for facilitating activities with a high degree of validity to the situations students encounter outside school is to create learning environments similar to the everyday activities of professionals who work in the discipline (e.g. Brown, Collins, & Duguid, 1989; Sawyer, 2008). Simulations are a possible approach to construct learning environments that relate what is taught in schools to the corresponding work settings. This is an interesting subject of analysis both as an instructional strategy and for studying the nature of learning. Simulations provide hybrid settings with the potential to support learning across contexts and, consequently, allow investigations of the concrete tools and strategies applied to learning, as well as empirical examinations of learning activities in simulated contexts.

The key concepts highlighted in this chapter enabled me to shed light on the situated practices of ship simulator training. Together, they allowed investigations of learning opportunities on different levels. For example, the concept of meaning making enabled an analysis of how members of ship bridge teams guided each other in the appropriation of professional concepts and artefacts. This collaborative work adds up to more than the sum of individual efforts and takes the form of a joint enterprise through the effort of an activity system. As a supplementary concept, professional vision demonstrates how the social practices of a profession are apprehended on an interactional level. This permits the analysis of the opportunities and constraints on enacting professional expertise in simulated environments.

In this thesis, I seek to contribute to *research and development* and to the *practical pedagogical* organisation of simulator training. Accordingly, in this thesis, Study III presents the main foci of attention within different streams of research on simulator training and

suggests a framework for aligning learning objectives and requirements for simulator fidelity and assessment. This study has a two-fold function in the current thesis as it provides a selected review of research on simulator training and positions the contribution of situated approaches within this body of research. This endeavour offers potentially deep theoretical underpinnings that suggest the need for further elaboration.

Comparing research across theoretical frames

The need to position the sociocultural and situated perspective within the existing body of research became clear when I started to review the research on ship simulators. As shown in chapter 2, maritime training refers to both formal educational standards and cultural practices for learning and initiation, and the use of simulators in maritime training is extensive. In the training practices observed for this thesis, the underlying learning principles and training guidelines were mostly tacit or explained using terminology from behaviouristic or cognitive psychology.

Two main objectives of Study III were to present a range of researches on simulator training and to discuss the three main sources of knowledge in relation to each other in a practical framework—highlighting their potential implications for instructional design. Study III discusses findings in light of three different domains that on other levels are less compatible—behaviouristic approaches, cognitive psychology and situated approaches—to aid practitioners seeking to formulate a research-based practice. However, comparing different theories is not without controversy and has deep implications for how one regards science. A study's theoretical approach guides the methodological foci, the vocabulary for reporting findings and the recommendations for future practice. But even if theoretical traditions can have incommensurable concerns, they might provide complementary suggestions to practitioners. Accordingly, there have been extensive discussions about the (in)commensurability of learning theories (e.g. Anderson, Reder & Simon, 1996; Greeno, 1997; Packer & Goicochea, 2000; Sfard, 1998). Rather than elaborating on these underlying differences, Study III identifies the different research foci and the terminologies for which empirical phenomena are described, providing a review of implications for practice with the aim of making the different research agendas transparent. In research studies, it is not always clear how specific research findings might be isolated from their theoretical framing and used to solve real-world issues. However, this does not mean that they are not fruitful from the practitioner's perspective. Both practitioners and researchers need some joint concepts and models that carry meaning across positions.

A main objective of science has been to develop scientific theories and methods to gain reliable insights into particular aspects of the empirical world, and these theories and models are intended to deal with both the observable and unobservable aspects of the world. Hacking (1999) proposed a pragmatic starting point for creating scientific theories: Instead of arguing for truth, the researcher should develop theories that are *useful* for doing scientific inquiry. This criterion of usefulness, in some sense, might be more reasonable than whether a given theory replicates reality as such. The degree of similarity between theoretical entities and aspects of the real world might be better suited for the natural sciences than the learning sciences. In the learning sciences, one can define the criteria of usefulness as the potential to create specific activities and practices.

Behaviouristic approaches tend to treat the learning of skills as a matter of developing desired patterns of behaviour and do not focus on the context or underlying inner processes (Flin, O'Connor, & Crichton, 2008). The main concern for studies exploring simulator training from this perspective is the various forms of procedural-skills learning which involve repetition in settings with a high level of similarity to the actual work setting (e.g. Taber, 2013)

A key feature of the perspective of cognitive psychology is the attention to learners' underlying mental models, which are shaped through learning and exploring the world (Reisberg, 1997). In research on simulator training, this perspective can be seen in the emphasis on how individual team members' mental models affect team performance (e.g. Mathieu et al., 2000) and on the efficacy of confronting mental models in debriefing for therapeutic or learning purposes (Fanning & Gaba, 2007). Studies oriented towards cognitive psychology tend to address mental processes, such as memory and attention, which underlie more complex, higher-order processes, such as goal orientation, controlled behaviour and planning. Typically, these studies have the individual as the core unit of analysis, rather than the group interaction.

This thesis is concerned with situated and sociocultural theory; therefore, in Study III, it became an important objective to position this perspective in and compare it with the existing body of research. The study seeks to relate findings on a practical level without judging other perspectives as less useful. The study positions the situated perspective as a practical theory that explains learning on an interactional level. In addition, by arguing for viewing ship bridge training as partaking in activity systems, this study underscores how successful ship handling relies on communicative and coordinating practices, as well as technical skills and problem-solving strategies.

From my perspective as a researcher positioned within a situated perspective, I believe that more extensive research within this perspective would be beneficial for the field. However, the current body of research has been developed within other perspectives. If one were to provide advice to practice based on research now conducted within a situated approach, this would form an inadequate foundation for practice. Therefore, I believe it is important to collaborate and compare findings across theoretical frames. Suitably, I also collaborated with Kjell Ivar Øvergaard, Professor in Human Factors, in conducting the review (see Chapter 6 for details). Thus, Study III suggests a practical framework for organising training and positions the situated approach as a research agenda with a high potential for addressing the interactional level of training and developing a practice-based theory for simulator training.

4. INTERACTION ANALYSIS AS A METHODOLOGICAL FRAME

> Seeing cognition as socially and ecologically distributed has methodological consequences: Interaction Analysis finds its basic data for theorizing about knowledge and practice not in traces of cranial activity (for example, protocol or survey interview data), but in the details of social interactions in time and space, and particularly in the naturally occurring, everyday interactions between members of communities of practice.
>
> (Jordan & Henderson, 1995, p. 41)

According to Mjøset (2009), methodologies can be considered constructs that mediate between the philosophical and empirical levels of analysis. From the outset of my PhD project, Jordan and Henderson's (1995) multidisciplinary research methodology *interaction analysis* was my main source of inspiration which provided the mode for analysis and guided the research design. Therefore, I believe it is appropriate to explain how Jordan and Henderson's (1995) framework has been conceived in this project on a broader level before I discuss in detail the research methods and concrete research process in the Chapter 5.

As this chapter's opening quotation illustrates, Jordan and Henderson's (1995) seminal paper considers interaction analysis to be a means to analyse social interaction and naturally occurring talk within joint activity. It is important to make clear that the term 'interaction analysis' can be conceived differently and that, in this thesis, it is Jordan and Henderson's (1995) meaning of the concept that is intended. Other uses of the concept can be seen, for instance, in Sawyer (2006b), who uses the term 'interaction analysis' to indicate a broader concept that encompasses more specific methods—turning, for example, CA into a type of interaction analysis.

From the outset, I wanted to study naturally occurring data, with a qualitative and video-based approach. Appropriately, Jordan and Henderson (1995) state that interaction analysis draws on elements from 'ethnography (especially participant observation), socio-linguistics, ethnomethodology, conversation analysis, kinesics, proxemics, and ethology' in order to investigate social practice (p. 39). However, not every interaction analytic study draws equally from all these traditions; rather, elements and resources from these traditions can be made use of depending of their relevance to the purpose at hand. For example, even if Jordan and Henderson's (1995) framework encourage detailed study of tool use and gestures,

one might very well zoom in on other aspects of the interaction depending on the research interests and affordances of the data. This flexible attitude offers distinct opportunities for doing analysis but also noticeable problems regarding the framework's consistency in analysing data and generating outcomes. Consequently, the boundaries between interaction analysis and some similar methodologies are sometimes unclear. When merging several traditions, as in interaction analysis, one is in danger of the blurring differences between them. Therefore, in the following, I outline how I conceive interaction analysis in relation to similar methodologies. Before expanding on the concrete analytical processes of this thesis, I discuss my understanding of interaction analysis in relation to three different approaches that provided inspiration for interaction analysis, which I refer to more loosely in the studies. These are *ethnography*, *ethnomethodology* and *CA*.

Interaction analysis and ethnography

Ethnography is a founding element of anthropological studies of group culture and was developed as an empirical, participatory, inductive approach to the study of social phenomena in naturally occurring settings (Brewer, 2000; Silverman, 2011). Traditionally, ethnography has involved living and partaking in a community for a long period of time, and researchers have often travelled to unknown parts of the world. Later, ethnography has also been used frequently to study professional communities and institutional settings in which understanding the group culture and social patterns requires continuous observation. Ethnographers tend to provide reflexive, detailed descriptions of observational fieldwork, and a range of disciplines, such as sociology, education and communication studies, has adopted ethnographic approaches.

The term *ethnography* is often used quite broadly, sometimes to refer to a concrete method and other times to a philosophical paradigm (Atkinson & Hammersley, 1994, p. 248). Ethnography is closely related to the notion of participant observation. Atkinson and Hammersley (1994) point out that, to some, participant observation has a more descriptive meaning, whilst ethnography involves a comprehensive fieldwork and more suggestive theoretical implications. However, Atkinson and Hammersley (1994) also contradict this stance and argue that participant observation is not easier to pin down. After all, what counts as a participate role? In its broadest sense, all social sciences research is a form of participant observation (Atkinson & Hammersley, 1994, pp. 248–249). In Atkinson and Hammersley's (1994) line of reasoning, it is not so that ethnography involves a theoretical stance, whilst

participant observation is merely a research technique—but that they both involve a mode of doing research.

I have chosen to use the term *ethnographic* to describe my initial mode for approaching the research subject and process of exploring the maritime educational facility that I studied. At the outset, I had no specific boundaries for the observation or specific hypothesis to test. I wanted to understand this educational practice from the inside and to study the use of simulations within its natural context. However, I do not conceive of my study as primarily an ethnographic study. Rather, I employed an analytical mode inspired by ethnography to approach and define the research subject. During this period, I was not particularly detailed or methodical but defined the overall means for the fieldwork in order to identify especially interesting phenomenon to videotape and analyse in detail. However, this identification of attention-grabbing occurrences had not ended when the filming began but had initiated an iterative process of observation, dialogues and filming. In my conception, this process is an essential part of interaction analysis. As Jordan and Henderson (1995) put it:

> We rely on participant observation, in situ interviewing, historical reconstruction, and the analysis of artifacts, documents, and networks for providing the framing context. In the course of this ethnographic work, we attempt to identify interactional 'hot spots'—sites of activity for which videotaping promises to be productive. Ethnographic information then furnishes the background against which video analysis is carried out, and the detailed understanding provided by the microanalysis of interaction, in turn, informs our general ethnographic understanding. (p. 43)

As this quotation shows, ethnographic exploration is conducted to reveal hot spots, which can be further examined through the use of video analysis. This process enables the researcher to explore a specific practice in a more inductive manner before zooming in on especially interesting aspects. This movement is fruitful for providing a framing context and grasping issues of representativeness and variations within a practice before zooming into a close analysis of recorded sequences. This strategy is in contrast to the traditional textual practice of ethnography, in which reports are condensed from extensive field-notes and inquiries (Atkinson & Hammersley, 1994).

This practice of always linking findings to observable, recorded instances might increase the level of detail and reliability in interaction analysis because of the transparency of the research process and the possibility for repeated viewings of interesting instances. However, this stance is not unproblematic. Firstly, one might claim that the holistic aspect of

ethnography is in hazard as interaction analysis postulates that findings should be identified in specific situations. Secondly, the criteria and strategies for identifying interactional hot spots might become unclear. Finally, the impact of findings and their epistemological underpinnings might be different than in traditional ethnography.

In this thesis, ethnographic studies inspired sensitivity towards the cultural ways of perceiving work and training amongst participants. The possible pitfalls described above are indisputable, but I attempt to meet them by explaining the observed practice and the criteria for picking hot spots and contextualising the findings in the articles and the coming sections.

Interaction analysis and ethnomethodology

Ethnomethodology originates from Garfinkel (1967) and others' interest in people's everyday practices of social order (Heritage, 2001). By investigating the methods that people employ to make sense of the world, ethnomethodologists obtain insights into how meaning and social order are created communicatively. A fundamental assumption of ethnomethodology is that people within a specific culture have particular procedures for carrying out everyday activities which often seem mundane but are crucial to understanding societies. In ethnomethodology, the ways such everyday actions are carried out is key to how the everyday common world is created.

Different than traditional ethnography which involves holistic and inductive inquiries into group culture, ethnomethodology can be considered a branch of sociology that provides a vocabulary and agenda for mapping social patterns within socio-cultural groups with a more flexible stance towards method. The core of ethnomethodology is the focus on group members' shared methods for doing social life. The research methods for investigating these doings are secondary to this overarching objective.

Ethnomethodology has emphasised a bottoms-up approach to sociological analysis which has inspired interaction analysis with its analytical focus—that is, the belief that social life is best studied by the enactment of peoples' doings in social sceneries. This approach also involves investigations of the micro level of participation within a community of practice. However, I conceive the agenda of ethnomethodology to be more oriented to social mechanics and the shared procedures for doing social life—understood as a mapping of members' usual ways—than interaction analysis. Interaction analysis, in my use, is applicable to describe regularities within group interaction but may also be applied for other purposes, such as to document a specific learning strategy without dealing with its regularities. My emphasis on education also gives more attention to theoretical models of learning, than is

preferred in ethnomethodology. As well, interaction analysis is wedded to the use of video for analysing such participation. Interaction analysis shares this stance with another relative of ethnomethodology—namely, CA. These methodologies are both built on some of the same assumptions as ethnomethodology, and the differences between them are not clear. Their relationship is discussed in further detail in the following section.

Interaction analysis and conversation analysis

CA can be considered a specialised branch of ethnomethodology formed by writers such as Sacks, Schegloff and Jefferson (1974), who developed strict procedures for analysing how conversations unfold sequentially. CA provides a distinct perspective on analyses of social life through its rigorous analysis of the unspoken rules of conversation in turn-taking systems. However, there have been intensive discussions within CA about the relevance and use of institutional context in the analytical work, as well as the degree of inductive analysis. This difference is often referred to as 'pure' versus 'applied' CA (ten Have 2007, p. 174). According to ten Have (2007), pure CA is recognised to take a radical stance on participant's perspectives and the doctrine of analysing extracts of talk without drawing on contexts that are not articulated explicitly by the speakers themselves. Whilst pure CA has a more explicit intention to map the mechanics of talk, such as conversation starters and the function of pauses in talk, the focus of applied CA is oriented to the usage of these insights to gain broader insights within the social sciences. Correspondingly, CA has been applied to study learning as an increased ability for participation in social practices as such processes unfold moment by moment in interaction (Martin, 2009). For example, in studying situation awareness, Melander and Sahlström's (2009) use CA to scrutinise how a student taking flight lessons gains proficiency at flying by participating in this specific professional practice.

Consequently, scholars have different conceptions of what counts as CA, but a joint enterprise stands to investigate patterns of turn taking to examine how the meaning of an action can be interpreted and validated through investigations of the preceding and following actions (Sacks et al., 1974). In the analysis of video, Jordan and Henderson (1995) position themselves as related to CA but not as CA. Interaction analysis and CA have some similarities. Firstly, they both rely on close analysis of audio and video recordings. Secondly, they are concerned with analysing social practices as the relatively stable patterns by which we organise our lives. Thirdly, the sequential unfolding of talk activities is a key centre of attention. However, in my conception, interaction analysis differs from CA in several ways. The collection of data is less inductive, often driven by theoretical or practical interests. This

approach entails a more pragmatic stance to the use of participant' perspectives by allowing, for example, using ethnography as framing or to discuss theoretical issues in an analysis. Overall, interaction analysis draw on contextual contingencies to a larger degree than CA. Lastly, methods for transcription and analytical procedures are more adapted to the researcher's interests and the overall fieldwork in interaction analysis than in CA.

Reflections on methodology

In my argumentation for using interaction analysis, I do not claim that there are clear-cut boundaries between interaction analysis and related methodological frameworks. Jordan and Henderson (1995, p. 39) themselves refer and acknowledge several other approaches as sources of inspiration for their framework, and I have already pointed out some differences and similarities among the different approaches. Even if using such an eclectic framework requires explicit descriptions of how it is put to use for doing concrete studies, interaction analysis has served as a pragmatic, useful guide for analysing the learning activities in ship simulators investigated in this study. Interaction analysis appealed to me for several reasons.

Firstly, it provided a way of doing detailed analyses of learning in social interaction, with a pragmatic stance towards linking video-material, observational data and use of artefacts. Accordingly, interaction analysis formed the way I closed in on the research subject by reading students' curriculum, participating in training and talking to trainers. In this initial phase, I identified certain aspects of the training that were interesting to pursue before identifying specific aspects to zoom in on by the use of video.

Secondly, interaction analysis provided distinctive guidelines for working together in a research community and ensuring a broad entrance to a research subject. Accordingly, I have participated in a research group that regularly watches data and provides input to analytical takes on the material.

Thirdly, Jordan and Henderson's (1995) framework appeared to be a rational tool for studying learning because of their explicit links to concepts and processes within the learning sciences, such as their focus on the group level and communities of practice. Interaction analysis enabled me to focus on how simulations can be constituted interactionally in different ways.

In sum, interaction analysis provided the methodological starting point for investigating the potential of ship simulators to provide work-relevant learning environments. Interaction analysis allowed a focus on the situated constitution of simulations, which stood in contrast to previous studies where pre- and post-tests suggested the effects of the use of

simulations but black-boxed the situated doings of participants. Also, interaction analysis provided an alternative to survey designs and task analysis, which are highly dependent on participants' self-assessment of their doings. This thesis set out to study the learning environment as co-constructed and socially activated *in situ* by the use of physical and cognitive tools. This methodological stance guided the research design and the concrete tools for analysis. However, as the concrete analysis progressed, a range of methodical studies provided input. The following chapters will share my reflections on how these methodological principles were turned into concrete analysis.

5. RESEARCH DESIGN

In this chapter, I firstly present the empirical setting before describing and reflecting on the fieldwork, recording of video material and transcription. Then, I share reflections on the analysis, particularly identifying interesting aspects and describing how the findings were developed methodically. This section also includes reflections on research credibility—reliability, validity and generalisability—and concluding remarks on research ethics.

Empirical setting

The training facility in which this study was conducted has hosted training on advanced ship simulators since the early 1990s and provides formal professional education and individually designed exercises for various companies and institutions. The facility consists of five full mission simulators with differing degrees of immersion. The simulators can be linked for participating in cooperative scenarios, such as a close-traffic situation for a cruise ship entering the Oslofjord, with students navigating the cruise ships, ferries, cargo ships and so forth.

Figure 2. The full-mission ship simulator Bergen: the main control panel with thruster controllers, the exterior of the bridge replica with projectors underneath it, the map table and the steering wheel.

Bergen is the most immersive of the simulators. Here, a full-sized replica of a steering house is placed in a large room with seven projectors forming a 240-degree visual display. The steering house is credibly equipped with a radio, controllers, a mid-centred steering wheel and navigational tools.

Figure 3. The ship simulator Frøya with a control panel, map table, radio and LCD displays.

Frøya is simpler but also fully equipped for team navigation. Frøya consists of a table with controllers, radars, ECDIS and more placed beneath three LCD screens that function as windows. The simulator also has a chart table and radio.

Figure 4. On the left, the instructors' control room is shown. Here, the instructors guide the exercises and communicate with the five simulators. On the right, the brief/debrief room is shown; it has a smart board that enables trainers to replay the exercises.

During exercises, four to five groups of three participants each usually worked in separate simulators and participated in the same scenario. They were often assigned specific roles in the training, and they communicated with each other and the instructors through a radio system, as is the case on a real ship. Simulator sessions typically consisted of a short briefing before simulator sailing and debriefing. Briefings and debriefings were facilitated in a room

dedicated to that purpose, which had a smart board that allowed replaying the movements of an exercise on an electronic map.

In the control room, the instructors oversaw the movements of all simulators and could change weather and traffic conditions and ship placements. They had an especially good view of the activities in Bergen through a surveillance camera (without sound) in the simulator (top left in the picture), along with Bergen's visual outlook on seven PC monitors. Sometimes, the instructors entered the simulators, but contact was often facilitated through the radio system. Through radio contact, the instructors in the control room usually served the role of harbour authorities in the scenarios.

Fieldwork

In the initial phase of this PhD project, I engaged in conversations with instructors and observed several teaching activities within the nautical educational programme. My contact with the nautical students was initiated by contacting the head of the department, who put me in touch with the team responsible for student training. This group of instructors was very welcoming and became key participants and facilitators in the data collection. The team was responsible for the training of bachelor students and also for part of the training courses for the professional market. This made it possible to broaden from the original emphasis on bachelor students to observing both students and professional maritime pilots in training.

During the initial stages of the data collection, I was introduced to the training of nautical students, the simulator environment and how the trainings were conducted. I was also introduced to three other simulator environments: PC-based desktop simulations for practising navigational skills, a machine room simulator and a full-mission simulator for specialised training in the oil industry. In addition to getting to know the simulators, I read parts of the course literature and curriculum, participated in a team meeting with the instructors and observed a traditional lesson.

Throughout this period of time, I strove to ensure that my observations were open-minded, and I was concerned with increasing my familiarity and knowledge of the simulator practices. I took notes and gathered information. I refer to these notes as field-notes, but they are not as extensive or treated analytically as is often done in ethnography. Instead, the notes and all the information I gathered became part of an overall exploration of the educational facility, with an aim of identifying what parts of the training were interesting and accessible for filming and detailed analysis. Typically, I wrote down important concepts, ideas and

routines. Given the distributed and changeable character of the simulator activities, the observations, notes and curriculum documents helped set a backdrop to the video recordings.

During this time, I decided to observe different groups as they entered the most immersive simulator, instead of tracking individuals across the simulators. I alone was doing the data collection, so I had only the resources to follow at most two simulators at the same time as the control room. My choice fell on the full-mission simulator Bergen and its neighbouring simulator Haugar. Bergen was a natural focus of attention as it was the most immersive simulator and had more sophisticated tools than the other simulators. Its similarity to an actual ship bridge also allowed for physical positioning and team work more similar to the affordances of the real work setting. An additional reason for following the different student teams working in Bergen was that these groups were often given a key position in the scenarios. For example, in the exercise described in Study I, the student group in Bergen was the only group to have a professional pilot joining them.

Field notes, conversations and course materials became useful for grasping the cultural norms of the participants beyond the situations available for video recordings. The maritime domain has a specific professional system to which I am an outsider, so it was sometimes important to ask questions and use other methods of gaining insight into the professional concerns and assessments that affected participants' actions. Even though I never interrupted training in the simulator, I often overheard and requested trainers' evaluations of the on-going activities in the control room during training.

Three semesters after I started to observe nautical students, I saw the opportunity to observe complementary group training in the same simulator facility. At the same time as doing the fieldwork I participated in a course that the university college offered to the Norwegian Coastal Administration, which manages Norwegian pilot services. I gave a presentation and took part in discussions on how the overall training and certification of maritime pilots should be organised. Subsequently, I was allowed to follow two course days with two groups of pilots who participated in manoeuvring training. However, only two of the pilots from the workshop attended, and neither had a key role in the highlighted material.

During the observations of both students and professionals, it became clear to me that participants in training tended to interpret the training situation very differently because of the different objectives of the exercises and the formation of groups. When the fieldwork began, I expected a more consistent, comparable use of the simulator across groups and simulators and saw coding as a potentially fruitful strategy to document the simulator practices. However, when I started filming a range of exercises, I found that different groups used the simulators

in quite different manners. I found that, given the scarce amount of research on an interactional level in simulators, it would be most interesting to analyse in detail the exercises that stood out as especially rewarding. The constant variation of teams and the dissimilar training objectives made structured coding of the entire material less rewarding.

Video materials

The video data corpus consists of video from the simulators Frøya and Bergen, the control room and the briefing/debriefing room. The letters A, B, C and D in Fig. 1 show the different camera positions used throughout the study. I usually had two cameras placed in Bergen and one in Frøya. The data corpus includes 45 hours of recordings of training of differing quality collected from 2010 to 2013.
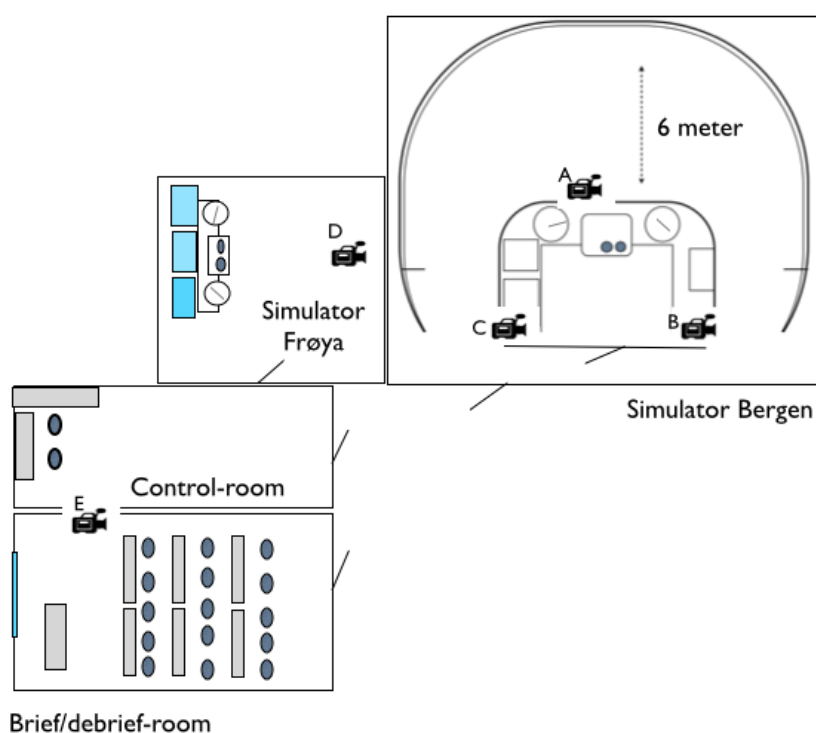
Figure 5. Sketch of the two simulators that were filmed, the control room and the connected classroom that was used for briefings and debriefings.

Physically, I decided to shift between the control room and the simulator; consequently, I did not know all times when the cameras were recording. The (usually) two instructors' on-going assessments of the exercises made the control room the best place to observe and have cameras at positions A, B, E and occasionally D (see camera positions in Fig. 5). However, I frequently walked into the simulators to keep abreast of the students' discussions of the activities. Due to the simulator layout, I could enter Bergen and stand outside the steering

house without disturbing the training. During training, I continued to take notes when potentially interesting events occurred, especially when reviewing them would require coordination between different tapes.

Table 1

Data material

Semester	Hours	Cameras	Description
1st semester	6 hours	Camera positions: A, B, E	Two sessions of simulator training comprising 6 hours of video.
2nd semester	20 hours	Camera positions: A, B, E	One class of bachelor students observed and filmed throughout 6 sessions of simulator training during the fall semester.
3rd semester	2 hours	Camera positions: B, E + surveillance camera	Filming of 1 new session where I was also allowed to use tapes from a surveillance camera that had been installed in the simulator. Due to poor technical quality, my camera still ended up taking the best shots.
4th semester	17 hours	Camera positions: C, D, E	Recordings of 2 full-day training courses for 2 groups of professional maritime pilots who worked simultaneously in 2 simulators and met during briefings and debriefings.

Throughout the data collection process, the simulators proved to be a difficult environment in which to obtain high-quality recordings. Due to the noise from different machines and alarms, low-quality sound was the main problem, which necessitated tests and searches for different equipment. I achieved an acceptable-quality sound using wireless microphones and a directional microphone which minimised the surrounding sound. I also faced problems capturing the cooperative activity in the simulators on video as the crews constantly moved and oriented differently to various resources in their environment. Finding the best camera angles and the best equipment was a challenge throughout the project. When filming the pilots, I used Sony cameras with wireless microphones connected by Bluetooth, on loan from the University of Oslo. When filming the students, I started out with a Kodak Zi8 flip-camera with a wide-angle lens and a conventional JVC-camera (HF M31) and then switched to GoPro4 action-cameras and a directional Røde microphone. One GoPro camera with a Røde mic was placed in front of the crew, and another GoPro camera behind them. This last setup proved to be quite effective and, in retrospect, should have been used from the outset.

44 Extended abstract

Transcripts

In the tradition of interaction analysis, the analyses of this thesis are based on transcribed extracts of interaction. Within the broad field of video analysis, transcriptions and the act of transcribing have central roles. However, the rationale and practice of transcribing have somewhat differing views in regards to the level of detail, from whether all material should be transcribed to the function of extracts in the published work.

In all video studies, it is important that transcription of speech provides a faithful presentation of what was actually said. Transcriptions can be concerned mainly with talk or can include nonverbal behaviours, such as bodily alignment, gestures and the use of specific artefacts. There are several frameworks for transcribing video that facilitate different types of detail (e.g. Du Bois, et.al 1993; Jefferson 2004; Streeck, Goodwin & LeBaron, 2011).

Two differing rationales for using transcriptions for reporting research findings can be identified. The first has a radical stance as the goal is a level of detail that will allow outside readers to do independent analyses and ultimately different analyses than the authors. The second rationale can be considered a more pragmatic stance as it treats transcriptions as renderings of key issues for a specific analysis (Jordan & Henderson, 1995, p. 48). This thesis follows the latter conception of the function of transcriptions, and I have aimed to present truthful representations of actual interactions, transcribed at the level of detail necessary for demonstrating particular analytical findings. Accordingly, the necessary level of detail changed between studies. For example, Study I focused on overlapping and joint constructions of meaning, but Study III merely described participants' solving of tasks without using specialised transcription symbols. However, it is important to note that the represented talk within the each study follows the same level of detail, so the signs are not used to support my particular interpretation. The use of gestures and movement, however, is not commented on exhaustively, but those made relevant to particular talk activities are explained.

Even if the faithful presentation of events is the goal of high-quality transcriptions, it is important to note that transcribing is a textual practice that does not depict actual events but versions of them. According to Ochs (1979), a selective rendering of the data is created in what can be conceived as trivial matters. For instance, the organisation of text creates cultural expectations that certain items will be discussed before others. Correspondingly, different transcription formats encourage the reader to notice specific instances (Ochs, 1979, p. 47). Moreover, transcriptions can portray bodily conduct and what goes on in the physical environment in several ways. I began by describing what participants did in a separate column

of the transcription, but to increase the readability, I decided to remark on relevant doings and events in double brackets. The transcriptions are on a less detailed level than the Jefferson (2004) system affords, but I found it satisfactory for demonstrating the issues I addressed in the analyses. Also, I perceive maritime simulations as very complex professional settings; therefore, the current thesis should also have relevance for readers who do not have a specific interest in the maritime profession and believe that an exhaustive level of detail in the transcriptions could blur the reading.

Table 2

Transcription symbols from Studies I and II

[ ]	Square brackets mark the start and end of overlapping speech. They are aligned to mark the precise position of overlap.
Under<u>lin</u>ing	Underlining indicates emphasis; the extent of underlining within individual words locates emphasis and also indicates how heavy it is.
CAPITALS	Capitals mark speech that is audibly louder than surrounding speech. This is beyond the increase in volume that comes as a by-product of emphasis.
°-I know it	'Degree' signs enclose audibly quieter speech.
(0.4)	Numbers in round brackets measure pauses in seconds (in this case, 4 tenths of a second).
(.)	A micro pause, audible but too short to measure.
(( ))	Additional comments from the transcriber, e.g. about features of context or delivery.
she wa::nted	Colons show degrees of elongation of the prior sound; the more colons, the more elongation.
Yeh,	'Continuation' marker—speaker has not finished; marked by fall-rise or weak rising intonation, as when delivering a list.
>he said<	'Greater than' and 'lesser than' signs enclose speeded-up talk. Occasionally, they are used the other way around for slower talk.
solid.= =We had	'Equals' signs mark the immediate 'latching' of successive talk, whether of one or more speakers, with no interval.
heh heh	Voiced laughter. Can have other symbols added, such as underlining, pitch movement, extra aspiration, etc.
sto(h)p i(h)t	Laughter within speech is signalled by h's in round brackets.

y'know?	Question marks signal stronger, 'questioning' intonation, irrespective of grammar.
Yeh.	Full stops mark falling, stopping intonation ('final contour'), irrespective of grammar, and not necessarily followed by a pause.
(xx) or (blrf)	Un-gotten material. Nonsense syllables are sometimes provided, to give at least an indication of various features of the un-gotten materials.

The symbols used in this thesis are selected from Jefferson's (2004) influential guide for transcribing in CA. These symbols offer rich opportunities for representing different aspects of talk and were shared among the members of my research group. As mentioned, however, my transcriptions do not provide the detail that this system allows. The final transcriptions presented in each article correspond to my analytical interests. These are a result of practical compromises between the ideals of transparency, faithfulness and readability and the affordances of the video material in regards to what is visible and audible.

Another issue with the function of transcripts for reporting findings is the function of transcribing as part of the analytical work. Some researchers have their material transcribed by assistants or specialised companies, whilst others claim that the act of transcribing is an important part of the analytical process.. Furthermore, scholars have taken different stances on whether all materials should be transcribed and to what detail.

Jordan and Henderson's (1995, p. 48) framework for interaction analysis recommends the use of content logs to map the data material before expanding logs into transcripts when particular tape segments emerge. I tried different ways of working with the tapes, but I typically reviewed videotapes directly after observing training and assessed their relevance to further investigations. Some videos were discarded before close analyses. For example, some tapes were considered less interesting because of technical problems; for instance, videos of night sailings were much too dark to allow for analysis of the team activity. Usually, I mapped the tapes for different themes and work tasks the teams encountered and possible areas of interest. I took on a more targeted practice of transcription than if the whole material were to be transcribed. Repeated viewings and examinations were the basis for selecting data. When specific centres of attention emerged in the analytic work, I looked for ways to pursue these themes and transcribed different parts of the material. For example, one issue on which I worked quite extensively was the ways students enacted the simulated environment and took on a certain professional identity. Another issue was that of debriefing and how the

reconstruction of events was concerned with participants' meaning making and negotiation. These issues are still in a sketching stage but illustrate the way transcriptions were done in the analytical work. The two sessions that provided data for Study I and II were transcribed—and the particular extracts presented in studies I and II were scrutinised and transcribed verbatim.

The level of detail in transcriptions, and the range of data being transcribed, puts constrains on opportunities for doing analysis. When body position and gestures are not transcribed, they cannot support an analysis in which those elements play a role. Likewise, if generalizable patterns of behaviour are of key interest, it may be essential to transcribe the whole material for coding purposes. In this thesis, the ways of treating the video materials in terms of content logs and transcription was adequate for the purposes of the analysis and enabled one researcher to analyse a larger amount material and to substantiate and identify key issues in maritime simulation for further investigation.

Analytical centres of attention

From the outset of the fieldwork, I had an interest in learning the coordinating and communicative practices of a bridge team. I was interested in the simulators' affordances for training collaboration, in the handling of specific tools and in how simulators provided an environment for connecting the theoretical and practical levels of navigation. Therefore, the simulator training design and how various groups enacted professional positions of a bridge team became an overarching frame of interest. However, during data collection and preliminary analysis, more specific centres of attention became salient. One such centre of attention emerged during the preliminary analyses during the first semester of filming: It was striking that, by role playing, some groups, although not the majority, took on professional roles and enacted the work tasks as on an actual ship. This role playing included using professional terminology and institutional structures for participation, such as the hierarchical positions of captain, helmsman and first officer. Further, during this phase, it became apparent that the ways participants handled the interactional work in the simulator was somehow connected to their opportunities to learn.

This theme seemed especially interesting for detailed analysis in a particular training, when a professional pilot visited and participated in an exercise together with students. The pilot put on his uniformed jacket and spoke English when he entered the bridge. This prompted the bridge crew to use English as their work language throughout the exercise. An interesting aspect was that students tended to talk in Norwegian when they stepped out of the functional roles as a bridge team; therefore, the shifts between languages made the role

playing particularly accessible for analysis. This specific exercise was transcribed and coded to indicate whether talk activity was in role or out of role. Sometimes, this orientation was unclear and so was coded as ambiguous. I scrutinised the instances in which the role play created opportunities for solving tasks in situated manners and the transitions of the improvised role play, zooming in on instances in which the role play encountered problems. These instances of trouble became especially interesting when investigating the social practices of simulating and the sequential constitution of a simulated work context. Within interaction analysis, such investigations of trouble in normal streams of activity are considered a potential analytical focus. Such breaches in interaction might make visible the unspoken rules by which people organise activity (Jordan & Henderson, 1995, p. 69). My primary focus in Study I was to investigate the sociocultural constitution of the simulations and how opportunities for learning were constructed in this environment. Inspired by Linell and Persson Thunqvist's (2003) identification of *activity contexts* as interactional achievements, Study I examined the construction of context as a meaning making activity between participants in simulator training.

A second centre of attention was that the professionals using the simulators seemed to treat the simulations differently than students. The professionals tended to take a more critical stance towards the simulators and were disturbed by differences between the simulators and the actual work settings. This different attitude became especially visible in a training session during the fourth semester of filming. A group of professional maritime pilots participated in a one-day training session on teamwork and close manoeuvring using a relatively new type of rotatable propellers for cruise ships called Azipods. The training session was analysed, and the sequences in which the pilots indicated a mismatch between the simulated and the real work setting were scrutinised. For the pilots, an especial concern was the lack of visual fidelity in the simulators display, that is, the simulators' windows. A mismatch between the electronic map and the visual lookout made the electronic map a more accurate source of information than the windows. The pilots expressed unease with being forced to navigate using the electronic equipment as the main source of information, instead of by visual lookout, which is the appropriate professional strategy. As well, other inconsistencies between the simulated waters and their real counterparts drew the pilots' attention, although it did not have any noticeable significance for the work performance. By detailing this trouble in the training activity through the use of interaction analysis, Study II investigated what seemed to be a discrepancy between the professionals' ways of enacting work tasks in the actual work setting and the simulated work setting.

A third issue that became apparent in the first phase of the project was not an empirical one but, rather, a problem of contextualising the studies to the existing body of research. I found it difficult to position my focus on participants' interactional achievements to previous studies. Accordingly, Study III examines different notions of simulator fidelity and recommends the notion of interactional fidelity for describing accuracy in the re-creation of collaborative work activity. Analyses of data extracts and the physical setting are presented to illustrate different types of fidelity, namely *technical fidelity*, *psychological fidelity* and *interactional fidelity*. In Study III, it was important to outline the different approaches to simulator fidelity, especially to frame our conception of interactional fidelity and provide a conceptual framework that might aid trainers in designing simulator training.

Reliability

Providing qualitative empirical investigations with high levels of transparency and reliability has been an aim of this thesis. Reliability is often considered to describe whether a study will provide the same result if it is reproduced under the same conditions. However, in qualitative research, matters of reliability relate to the degree of transparency and rigour of the inferences that are drawn (Silverman, 2011). Accordingly, some choices were made to ensure a high level of reliability in this thesis.

In a video study, reliability is closely connected to the quality of recordings and transcripts. In the current study, I strove to keep the findings on a level that matched the affordances of the data. Even if the quality of my video recordings put some constrains on what types of analysis were possible, the transcriptions of video clips are displayed in the articles—and these sequences of talk provide reliable data compared to traditional sources for qualitative research, such as field notes (Peräkylä, 2004, p. 285).

The reliability of interaction analytical studies is connected to data selection. According to Derry et al. (2010, p. 8), video studies typically build on transcripts from social interaction, and the inquiry process follows phases, including planning, filming, choosing and analysing video clips and presenting the data. Issues of data selection are present in all these stages, and the degree to which the video clips are rigorously developed influences the reliability of research. There is a serious threat to reliability in qualitative studies if data are presented anecdotally—that is, rhetorically and subjectively—instead of as a result of methodical rigour (Silverman, 2011, p. 47). Articulating the analytical strategies can increase the reliability of these processes; therefore, I have attempted to explain the logic of the

cyclical questioning of data, theoretical implications and hypothesis in the studies, as well as in this extended abstract. The use of video increases reliability as it allows other researchers to consider the analytic processes from video film to results.

Validity

The term *validity* refers to whether a study measures what it is supposed to measure and whether the strategies for examining a phenomenon are relevant to the examination of this phenomenon (Silverman, 2011). In this study, validity involves the credibility of analytical claims and the analytical strategies used for drawing inferences between the data and conclusions. Conceptions of validity touch upon various aspects of the quality, rigidity and transparency of data collection; the organisation and analysis of data materials; and how the conclusions were reached based on the research. Thus, validity does not describe a quality of the data but, rather, the inferences drawn from data in analytical processes. I shed light on three choices made to increase the level of validity in this thesis.

First, the fact that the study was conducted in a naturalistic setting is grounds for claiming a high degree of ecological validity—that is, relevance to real-world training practices (Hood, McDermott & Cole, 1980; Silverman, 2011). I observed simulator training in naturalistic settings and strove to understand the training practices without disturbing the practices I have studied. In such real-life settings, there is always the possibility that the presence of the researcher and the video equipment will affect the practices being observed. My impression was that the participants mostly appeared to be unaffected by the presence of the cameras. This impression is also supported in the recordings, in which students tended to mention the cameras at the start of the session but seemingly disregarded them by the end. During training, the maritime pilots appeared even less concerned with the cameras than the students. I believe that this lack of concern about being filmed and evaluated is connected to the facts that I explained thoroughly for what the films would be used and that the participants were accustomed to being closely evaluated and tested in their professional lives.

Second, I analysed several different groups in training. I observed both nautical students and maritime pilots utilising the same simulator facility. This can increase the validity of the study as it allowed for comparing the training of novices and professionals when the majority of other factors, such as the simulator tools, instructors and instructional design, were similar. In this thesis, the observation of divergent groups helped distinguish the variances and complexity of the simulator training and how different groups might require varied forms of instructional support. I also observed debriefings, which allowed me to gain

insight into participants' and instructors' accounts of their actions. During debriefings, participants and instructors shared their thoughts on the exercise and examined in detail both the reasons and consequences of actions. A replay of the exercise on an electronic map guided the debriefings. In the analyses, the video materials from the debriefings provided participants' accounts and elaborations on appropriate actions. The debriefings, therefore, offer opportunities for increasing validity in the analytic processes, as well as material for independent examinations.

Third, I compared my interpretations with other members of the research community and tried to validate the inferences drawn from the data by participating in a network of interaction analysts. Throughout my PhD studies, I have, as suggested by Jordan and Henderson (1995, pp. 43–46), participated in discussions with a group of analysts who regularly meet to assess data and analytical opportunities and challenges when working with video data. Another way of validating research findings in the scholarly community is through peer review. At the time of publication of this thesis, I have published one of the three studies in an international research journal which practises blind peer review, the *International Journal of Computer-Supported Collaborative Learning*. During the review rounds, I received valuable comments for improving the manuscript in terms of theoretical clarifications, as well as strategies for meeting data saturation and interpretation.

Generalisability

Generalisability is a much-debated dimension of qualitative research. Generalisability is often defined as the extent to which findings can be expected to hold true for the population from which a sample is observed (Silverman, 2011). The simulator trainings scrutinised in this thesis depend on a range of situational contingencies, and the analysis sheds light on both specific and general factors. Generalisability is often used to imply causal relationships between factors in the world, and it is especially problematic when the studied outcome also depends on factors other than those upon which the research focuses. In this thesis, the degree to which my studies estimate how future training will develop should be regarded with caution. However, this lack of causal connection to future practices does not imply that the findings do not affect theory, training and future practices. Unlike statistical generalisations, such generalisations can be termed *analytical generalisation* (Yin, 2009, pp. 43–44) and describe how empirical findings can be used for confronting and developing theory, which again becomes a resource for examining other cases and developing new practices.

I would like to point out three relevant ways of considering the generalisability in interaction analytical research. First, the generalisability of interaction analytical studies might be connected to providing consistent accounts of cultural and linguistic patterns in a specific type of social practice. Such accounts are often confirmed through analysing an interaction of a specific sort, for example, by uncovering specific patterns of classroom discourse (Nystrand, Gamoran, Kachur, & Prendergast, 1997). Often, declaring general patterns from a specific set of observations requires a significant amount of observation and systematical treatment. However, it is difficult to set a specific limit for when an interaction study meets data saturation, as this depends on the nature of the phenomena studied (Ercikan & Roth, 2006).

Second, one might consider generalisability as present in a single case in terms of providing cases for what *can* happen as opposed to what *usually* happens (Peräkylä, 2004, p. 297). A premise in interaction analysis is that artefacts and technologies set up a social field, such as simulated ship travel, within which certain activities become very likely, some possible, and others improbable (Jordan & Henderson, 1995, p. 41). Analyses of specific situations and smaller corpuses of data can be considered generalisable, to a certain extent, as they indicate a range of possible activities within a specific sphere (Ercikan & Roth, 2006, p. 15).

Third, generalisability can be considered based on theoretical impact. Jordan and Henderson (1995) point out that verifiable observation provides a firm foundation for analytical knowledge, which allows 'building generalizations from records of particular, naturally occurring activities, and steadfastly holding our theories accountable to that evidence' (p. 41).

The findings of this thesis touch upon all three types of generalisation. Some instructional patterns are displayed across exercises, and the findings might be integrated with those of other studies to provide more consistent accounts of instructional strategies in simulators. These studies also provide accounts for possible actions within a simulator environment. The three studies interact and contribute to sociocultural learning theory and research on simulator training in ways that can develop theory and future practices. However, the three studies focus on highly relevant aspects of training in simulated contexts, rather than the most usual. Such mapping of especially interesting instances is often relevant to research on learning and instruction as these studies tend to have a more normative outset than, for example, studies that have communication as their primary concern of the analysis.

Ethical considerations

In this section, I describe the ethical considerations and procedures related to the research design, observations and writing of the studies. At the outset of the study, I filed a request with the Norwegian Social Science Data Services (NSD), which was approved. The request contained detailed descriptions of the routines for data storage data, a letter of consent and the purpose of the study.

Unlike some of my colleagues who work with children, I have studied the actions of adults, who were well equipped to judge the consequences of participating in this study. However, some potential issues, such as the quite hierarchical culture of the maritime domain, required attention. One might envision situations in which people agreed to participate in a study as they felt obligated by their superiors, or the maritime domain has a tradition for external checks and the formal measurement of expertise, so participants might become worried about the use of my videotapes for purposes other than research. The extent of such worries was difficult for me to judge, but one example that caught my attention was when the instructor joked in front of the students during a briefing that, after the exercise, he would look through the tapes to see how students were doing. Few students, though, seemed to understand the joke. In addition, one pilot rejected the request to be filmed, because he did not want his professional judgments videotaped. This is an understandable concern due to pilots' great responsibility for environmental damage, material cost and human safety. Given the specific demands for competence among maritime pilots, one can imagine that there would be an interest in videos of a pilot's training if he were involved in an accident.

I dealt with these issues by thoroughly explaining to study participants my objectives and the routines for storing and analysing the videos before participants signed a confirmation form. I also expressly stated that participants could withdraw their consent and that I would delete the films after the exercise if they wanted me to. Such a request was never made, and overall the participants met me with an open, positive attitude.

6. DEVELOPMENT AND SUMMARY OF THE THREE STUDIES

In this chapter, I detail the writing process for collaborating with co-authors and orienting the manuscripts to specific journals and then present summaries of the three studies. When the analyses began to form concrete findings, I screened a range of scientific journals with a relevant scope and readers in the scholarly community. Along with my co-authors, I oriented the studies to meet three journals' standards for quality and relevance.

The conclusions of Study I emerged from analysing the ways in which participants created relevant activity contexts for enacting professional tasks through improvised role plays. Sociocultural and situated approaches guided this empirical study, especially by paying attention to the ways in which social and physical environments combine to shape understanding. Along with my supervisor Hans Christian Arnseth, I oriented the findings to core issues of interest within CSCL, namely, meaning making through discursive and technological tools. The paper was submitted to the *International Journal of Computer-Supported Collaborative Learning*, published by Springer. The paper underwent peer review and was published in March 2013 in volume 8, issue 1 of the journal.

Study II describes the instructional design of a simulator session for professional maritime pilots and details a mismatch between simulator fidelity and the planned learning activity. This empirical analysis was also guided by sociocultural theory, which directed attention towards the situated contingencies for participating in activity systems at work. Study II investigates how technical work and routines are entwined in cultural practices and configured in social interaction, which made it suitable for the journal *Learning, Culture and Social Interaction*, published by Elsevier. The paper was submitted in the summer of 2014 and received suggestions for minor revisions after the initial review.

Study III, which it is not primarily empirically, differs from the first two. In Study III, Øvergård and I pragmatically map a cross-disciplinary basis for the field of simulator training and propose a conceptual model of simulator fidelity that relates to research findings from a broad theoretical background. In my collaboration with Øvergård, it became an aim to position our separate research agendas in relation to each other in a pragmatic framework that could guide practitioners in the research field and to create training designs. We looked for an international journal that had a broad, applied orientation. *Education + Training*, published by Emerald, appeals policy makers, educators and academics working in a wide range of fields,

including education, learning and skills development. We saw *Education + Training* as oriented to the transitions between education, training and employment and an emphasis on creating links between research and practice. Study III was submitted to *Education + Training* in the summer of 2014 and is under initial review.

Study I

Hontvedt, M. & Arnseth, H.C. (2013). On the bridge to learn: Analysing the social organization of nautical instruction in a ship simulator. *International Journal of Computer-Supported Collaborative Learning, 8*(1), 89–112. doi:10.1007/s11412-013-9166-3

Objective

This study explores how role play and the use of institutional language can become important resources for creating simulations. Research on ship simulator training has rarely focused on the ways in which simulated contexts are socially constructed in the interplay with the physical simulator setting. Such aspects of training are especially relevant in maritime training. Ship handling demands efficient teamwork for safe navigation and, consequently, follows a strict division of labour based on the maritime profession's hierarchical system of professions and ranks. Accordingly, introducing newcomers to participating in the communicative system of a ship's bridge is the key to full-mission simulator training.

These issues are examined empirically in this study, which is guided by the following research question: *How do students' enactment of professional roles and their construction of relevant activity contexts in a ship simulator environment offer opportunities for learning and instruction?*

Methods

Drawing on a larger amount video material of ship simulator training, a training course for bachelor students in nautical science was analysed in detail. Interaction analysis was used as a tool to examine how a simulated context for learning navigation was socially co-created and how opportunities for learning were entwined in this collaborative activity. It was especially relevant to scrutinise the use of role play for enacting future professional roles and responsibilities.

Results

The study describes how a group of students, along with a professional maritime pilot, enacted professional roles and collaboratively solved tasks as part of a larger scenario of a cruise ship entering the Oslofjord. Their activities on the bridge were framed within the maritime profession's hierarchical system of captain and officers, and Arnseth and I examined in detail how these institutionally defined positions become important resources for meaning making during role play. The analysis explains how two competing activity contexts were constructed and how the role play provided opportunities for enacting professional roles and work tasks.

It is demonstrated that the crew's enactment of professional roles became a resource for situating collaborative actions in a work-like setting and socialising students into such work practices. However, this study also shows that it was challenging for participants to notice and adopt professional actions performed by the experienced pilot in the evolving scenario and to confront these situated experiences later in the debriefing.

The simulated environment emerged as a possible resource for creating authentic experiences for participants, but this strive for authenticity sometimes came into conflict with other objectives for training, such as providing instruction and asking for help. The findings show that the simulated context provided opportunities for learners to participate in situated actions important for the nautical profession, such as emergency anchoring. However, it is also evident that the simulation differed from the real situation and, as such, should not be confused with reality.

Conclusions

The study concludes that participants' role-playing became an important part of creating the simulation and that these collaborative activities were controllable units important for trainers to address. Based on the empirical demonstrations of students' collaborative and meaning-making activities, the article recommends paying increased attention to the interactional level of training for research and design.

Study II

Hontvedt, M. (Under revision). Professional vision in simulated environments: Examining maritime pilots' performance of work tasks in a full-mission ship simulator. *Learning, Culture and Social Interaction*

Objective

This study reports on an exercise in which professional maritime pilots used a ship simulator to train for cruise ship navigation in high winds using Azipod propellers. The instructional design of the exercise involved participants experiencing work-like situations in the simulators before reflecting on these situations in debriefings. This study aims to focus on the technical facilitation of professional practice in simulators and how these technological tools meet sociocultural and functional demands. The following research question is examined: *How are work tasks re-created and trained for in a ship simulator exercise for maritime pilots, and how is simulator fidelity related to training objectives and to participants' professional ways of performing work tasks?*

Methods

Interaction analysis was used to examine a training session for maritime pilots. Drawing on a larger corpus of video materials, five extracts from this training were chosen for interaction analysis (Jordan & Henderson, 1995). The analysis consisted of two parts. The first part examined the typical training situations selected to demonstrate the instructional design, while the second part focused specifically on problematic issues which illuminate important aspects of the ways in which the social and technical requirements of training must be coordinated.

Results

The analysis shows that, to re-create work tasks, very specific requirements must be adhered to in order to match institutional, social and technological factors. Through the analysis, it is demonstrated that fidelity should not be considered a stable aspect of the simulator; rather, it is an element that varies as it interacts with other elements of the training, such as the scenario, crew and learning objectives. Three main findings are pointed out.

First, efficient training requires technological fidelity that specifically corresponds to the training objectives for instrument response, visual replication of environments and activity facilitation. High and low fidelity is an insufficient measure of efficiency. The extracts show that the requirements for fidelity are closely linked to the training scenarios.

Second, fidelity, participants' professional vision and the scenario are interconnected. Isolating targeted skills from the total experience was problematic for participants. Episodes from training illustrate that fidelity, training scenarios and participants' professional vision are interconnected and that the complexity of full-mission simulators can sometimes cause problems in focusing and supervising exercise. The analysis implies that the targeted skills should either be more effectively isolated or that the training scenarios must be supported by more accurate technology.

Third, a lack of fidelity might harm the logic of the actual work task and cause participants in training to shift from performing within a simulated work environment to simply manipulating the simulated model. An important outcome from observing this training was the pilots' own highlighting of an imbalance in the accuracy and trustworthiness of the electronic equipment and the windows. It was shown that the visual lookout for close manoeuvrings was not sufficiently supported by the projection, so pilots had to either solve tasks less accurately by visual lookout or adapt their strategies to match the simulator environment and navigate using the ECDIS. Such imbalance between the tools and visual representation might tempt training participants to change their professional strategies to fit the simulator environment, instead of their work setting. This incident reveals a potential problem in viewing low-fidelity simulators as simpler versions of high-fidelity simulators: The work practices that are re-created might not remain consistent.

Conclusions

The manuscript concludes that ship simulators afford instructional designs for training situated actions in a work-like environment but also give rise to problems related to scaffolding the full complexity of professional practices. The study concludes that the organisation of simulator trainings should take into account whether the degree of fidelity meets the requirements of the situated work tasks and learning objectives while attending to the specific nature of professionals' expertise.

Study III

Hontvedt, M & Øvergård, K. I. (In review). Simulations at work: A framework for configuring simulator fidelity into training objectives. *Education + Training*

Objective

The level of physical and visual similarity with real work settings is often characterised as simulator fidelity. This study aims to provide a practical framework for considering fidelity in the design of simulator training. The importance of simulator fidelity in the creation of learning activities has been extensively debated, particularly with regard to the degree of similarity and complexity that simulators should provide in order to facilitate specific types of training. However, little research-based advice has been provided to guide the organisation of ship simulator training.

Methods

Based on a selected literature review, this study provides a conceptual discussion of developing a conceptual framework for fidelity requirements in simulator training. Throughout the manuscript, the framework is applied to an empirical example from a case of ship simulator training using interaction analysis (Jordan & Henderson, 1995).

Results

The study identifies three types of simulator fidelity that might be useful from a trainer's perspective. By introducing a framework of *technical*, *psychological* and *interactional fidelity* and linking these concepts to different levels of training and learning outcomes, the study aims to describe how simulators might relate to learning objectives at different levels of professional training.

Technical, psychological and interactional fidelity are suggested to be different aspects of simulated training scenarios and to have specific relevance to skills training, adaptive problem solving and situated participation in socio-technical work environments. This framework could aid trainers in their efforts to configure requirements for fidelity to tasks and objectives in training. Through the use of an empirical example from ship simulator training, I demonstrate that the fidelity of the simulation might profit from being regarded in light of the level of expertise targeted in training.

Conclusions

The study demonstrates that technological, psychological and interactional fidelity might provide useful foci for targeting accuracy and truthfulness in different entities of simulator training. This suggests that a useful conceptualisation of fidelity should provide distinctions for considering accuracy in the qualities of work activities, instead of describing how immersive or detailed simulators are. This framework adds to the body of knowledge on simulator training by providing guidelines for the different ways in which simulators can increase professional expertise within simulator training.

7. DISCUSSION OF THE MAIN FINDINGS

This chapter points out the three studies' contributions. The first section explicates the *empirical contributions*, whilst the second section explains the *methodological contributions to the study of simulations*. In the third section, I discuss the studies' *theoretical contributions*.

Empirical contributions

The empirical findings of this doctoral work contribute on several levels to an increased understanding of the practices and instructional design of ship simulator training. In this section, I refer mostly to studies I and II as these are empirical studies that portray how simulators provide contexts for performing work tasks. The studies uncover the dominant training design in this ship simulator environment; that is variations of instructional designs in which participants are briefed on a specific topic, then enact navigational tasks in the simulators and reflect on these performances in a debriefing session.

Together, these two studies reveal the distributed character of professional work in a simulator setting. These studies focus primarily on the activity of simulating as a condition for learning and on simulation as a learning activity in itself. Different than, for example, the work of Hutchins and Klausen (1996) who analysed flight simulator activities as if they were observing an actual work-setting, the ship simulator training in this study was positioned as a socio-technically constituted simulation, operating under other conditions and with a different purpose than the actual work setting. I detail four aspects of the simulator training that became visible during the empirical analysis.

Firstly, participants' social construction of the simulation is described. Study I focuses on participants' way of communicating and enacting work tasks in accordance with the maritime profession's conventions and shows that simulations can be formed by participants' enactment of professional roles through improvised role playing. In the overall data, far from all groups took on professional roles by role playing during training. However, by detailing the interactions of one professional maritime pilot and a group of students, Study I sheds light on the potential learning opportunities that emerge from role playing. The study demonstrates that enactments of the formal roles of captain, pilot and helmsman are intertwined with communicative and coordinating actions. Study I describes subtle strategies, such as providing small hints and signals to orient others to the tasks at hand in a professional manner. Many learning opportunities are created in this enactment of the institutional relationships,

language constructs, tools and tasks of the maritime profession. It is shown that the practices of handling a ship require high discursive, communicative and coordinating skills, and a full-mission simulation not only makes the physical and virtual surroundings work-like but also determines whether participants simulate professional interactions. Throughout Studies I and II, the interactional level of training is seen as a significant aspect of simulator training, which is assessable and controllable by trainers.

However, the studies also reveal potential pitfalls when simulating contexts for training. Sometimes, there seemed to be different requirements for creating authenticity than for providing instruction in the learning environment. Participants' endeavours to engage in authentic role playing might come into conflict with their need for instruction. In Study I, students' reluctance to question the pilot's decisions—even in role as the captain of the ship—shows that, even if professional roles are assigned in the simulator scenarios, actual positions and authority also influence collaboration. Therefore, Study I questions participants' ability to simulate the intricate relations of power and the goal-orientation that reflect actual practices.

Secondly, the studies shed light on the technical requirements for facilitating different types of ship simulator training. Study II scrutinises the technical requirements for simulating ship navigation. Examining instances in which crews' signalled inaccuracies in the simulated environment demonstrate that the simulator mediated other strategies than the preferred professional strategy for solving the simulator assignment. More specifically, in training on close manoeuvring, the lack of fidelity in the crew's view from the windows made learners' training more successful when they steered using the electronic map, instead of enacting the proper professional routines and using visual lookout as the primary source of information. This analysis in Study II reveals the risk in simulator training of entering a mode of manipulating the simulator, rather than enacting professional work tasks.

Thirdly, the studies portray the practical pedagogical organisation of ship simulator training by detailing how the different entities of training interact. Study II shows that the functions of navigational tools are inseparable from participants' professional conduct. Consequently, a simulator's level of fidelity does not have a set role in the socio-technical constitution of a ship simulation but creates preconditions for facilitating different instructional designs. Moreover, Study II are portrays difficulties of re-creating all situated aspects of navigating a ship. Therefore, the work tasks encountered in simulators should not be seen as static features of the physical and technological environment but as opportunities enacted by the participants. This distinction moves the focus of attention from shaping the setting to supporting the learning process. In Study II, the maritime pilots were distracted by

inaccuracies in the landscape—even when the inaccuracies were irrelevant to the learning objective of close manoeuvring and pilots were requested to disregard them. The pilots kept focusing on inaccuracies between the simulated and real waters and even requested that instructors edit them. This issue might have become such a strong focus as the harbour with which pilots were presented in the simulation was the same as which they were certified and knew exceptionally well. Consequently, presenting manoeuvring tasks in a different harbour could have decreased the problems with lack of accuracy in the simulated landscape.

Fourthly, the studies shed light on the function of debriefing. In the observed simulator trainings, the situated actions of participants customarily were discussed in debriefings. In the situated training activity, the underlying principles for action were often tacit. However, these situated actions could be confronted, evaluated and made visible as meta-reflections when debriefing. For example, in Study I, students lowered anchor at the maritime pilot's request, but in the following debriefing, it became clear that the students had not picked up on the nuances of the maritime pilot's request—to *lower*, not *drop* the anchor. This differentiation was important because the ship was in deep waters, and dropping the anchor without enough rope to reach the seabed might have caused damage or the loss of the anchor. In this case, the complexity of the pilot's request was not made evident—or learnable—before it was questioned in the debriefing. This incident highlighted the importance of sharing the underlying reasons for action. This support prior studies' emphasis on participants challenging each others' ideas and positions (Van den Bossche et al., 2011)— as well as connecting feedback to situated actions and providing clear measures for performance in skills training (Silvennoinen et al., 2012).

In particular, the debriefings seldom facilitated professional action at a dialogic level. The pilot's attention to lowering, not dropping, anchor in Study I was an exception to this pattern and provides an example of how small, apparently insignificant variations at the dialogical level can have substantial impact. This incident demonstrates a persistent challenge for debriefing bridge team management in simulators: to relate debriefings and assessment of bridge team management to the situated activities of the team.

Methodological contributions to the study of ship simulations

After the preceding section, the most important empirical contributions of the current thesis were made possible by zooming in on the interactional level of simulator training. Unlike prior research on learning in ship simulators, I grounded the findings in video observations. Even if this thesis only addresses parts of this complex training, Studies I and II demonstrate

the potential for using interaction analysis to show how the training is done *in situ*. I have not developed new methods as such, but through this novel approach to ship simulator training, it is shown that the interactional work of training participants is the key to the learning outcomes. Understanding the ways in which tasks and instructional features are socially organised in the simulator is key for providing technical and social support to facilitate learning activities. Consequently, the interactional level of training could become a key issue for future studies and for creating instructional designs.

Learning is a broad, multifaceted concept that is difficult to pinpoint as an observable action in interactional studies (Suthers, 2006, p. 320). Accordingly, a major methodological concern for investigating learning in simulations on an interactional level is to develop concepts that identify processes which provide learning opportunities. Suthers (2006) developed his notion of *intersubjective meaning making* in response to the methodological challenges in studying learning in CSCL. In Suthers's reasoning, repositioning to reach a common understanding in joint meaning making is a productive way of conceiving learning *in situ*. Suthers (2006) defines intersubjective meaning making as the 'joint composition of interpretations of a dynamically evolving context' (p. 315). Study I contributes in this respect. By pursuing Suthers's notion of intersubjective meaning making and connecting this notion to training participants' social construction of a simulated context, Study I argues that the social construction of context is closely related to learning opportunities. This argument adds to the complexity of Suthers's (2006) description of intersubjective meaning making by portraying how students' joint creation of a simulated context can be considered a meaning-making activity in itself.

Both Studies I and II demonstrate the ability of interaction analysis to pay close attention to learning processes as they unfold, without depending on participants' to be aware of their doings—as, for example, does a survey study that relies on participants' self-reports of learning. A rare example of research on ship simulator training from this perspective, this thesis also offers implications for further research on an interactional level within this domain. Study I shows that role playing had potential for learning bridge teamwork and that future research should more effectively address this interactional level of training. A suitable follow-up could be to create and try out different instructional designs and monitor them on an interactional level, for example, through the use of design experiments (Brown, 1992). Additionally, Study II shows that simulations can incite different strategies for solving tasks than the actual work setting. This is an important finding that demonstrates a generic aspect of simulating. However, Study II does not imply the generalisability and transfer of this potential

issue across simulated and actual work-settings. I believe that future research could benefit from mapping how bridge teams solve tasks across simulators and actual participation on ships at an interactional level.

Theoretical contributions to the study of simulator training

This thesis aimed to contribute to knowledge about simulator training. Here, I point out theoretical contributions to the analysis and construction of simulated learning environments and also considerations for fidelity in the design of simulator training

Constructing simulated learning environments

Studies I and II offer implications for building sociocultural accounts of simulator training in several regards.

Firstly, Study I examines participants' shaping of the simulations through enacting professional roles. Based on prior studies positioning context as socially constructed, Study I employed Linell and Persson Thunqvist's (2003) notion of *activity context* to understand participants' creation of a simulated context. One specific case of training proved especially suitable for such an analysis because of the consistent use of English as the professional language while students were in their roles during the exercise. The conception of activity contexts was employed to distinguish the simulated context from the training context, which both were found to have relatively stable bearings in participants' collaborative work. Interaction analysis of participants' use of institutional language in Study I enabled me to delineate context, as actively co-constructed by participants *in situ*. The analysis shows that participants moved in and out of their roles and negotiated between the two activity contexts. It also demonstrates that the interactional effort needed for achieving and sustaining the simulation both creates a context for situated learning and is a learning activity in itself. The study presents the simulation as a moment-to-moment construction dependent on active co-construction by participants, a different position than seeing a simulation as a stable modus that can be appropriated.

Also, Study II focuses on the interactive constitution of the simulation context and investigates the function of social and technological entities for constructing the simulation. The study sheds light on the importance of the technical fidelity of the visual display—the simulator's windows—to supporting maritime professional pilots' practice of making visual lookout primary to technological tools. Interaction analysis demonstrates how the pilots sustained a focus on inaccuracies in the simulator environment, even if they were unimportant

to the learning objective. This attitude towards inaccuracies was explained by the notion of *professional vision*, which is a way of conceptualising professional enactment (Goodwin, 1994). In my research, Goodwin's (1994) notion of professional vision functions as a way of conceiving professionalism interactionally as the notion comprises maritime pilots' way of categorising and jointly orienting to their surroundings. Essentially, the notion serves the purpose of linking interactions to professionalism, thereby connecting immediate action to the sociocultural practices of a profession.

In relation to creating simulated contexts for learning, Studies I and II confirm that simulations are ambiguous communicative settings, as explicated by Linell and Thunqvist (2003). Moreover, in line with Rystedt and Sjöblom's (2012) analysis of simulations in healthcare, these two studies view learning opportunities as emerging from the joint use of cultural and physical tools, not as technologically predesigned. Also, Rystedt and Lindwall (2004) portrayed how the dynamics of an anaesthesia simulation became an inseparable part of the participants' interactions, and that students created a hybrid activity entailing multiple connections to both education and work. These studies imply that research on the social construction of simulated learning environments is a pertinent area of interest for several domains. However, in this study, it is shown that the requirements for technological support and fidelity are linked to the maritime profession's specific way of organising and perceiving work tasks, which suggests the need for further studies specific to the maritime domain.

Secondly, the studies shed light on the trade-off between focusing training by isolating learning objectives and maintaining a high level of ecological validity in training. At the institution I studied, students systematically shifted between training skills and knowledge in isolation and training as part of complex work situations and in theoretically oriented discussions and lessons. For example, the concrete activity of positioning was frequently trained in isolation from the larger activity navigation. Initially, the students trained triangulation using PC-based simulation programmes without the complexities of the real situation before proceeding to triangulation as part of complex scenarios in full-mission simulators. A sociocultural approach differs from cognitive psychology in its view of learning and thinking as situated in social contexts, not in the individual, and in the rejection of a split between mind and behaviour (Vygotsky, 1978). However, that skills and knowledge are regarded as situated accomplishments does not mean that all formal learning activities must be taking place in an authentic, holistic setting. Instead, participants need to reconceptualise learning in one setting—such as the practice of positioning in nautical education—and put it to use in a particular practice (Greeno, 1996, p.7).

The practical pedagogical organisation of training that I observed intends to create specific learning designs for participants to undertake different types of tasks and over time connect these specific types of skills and knowledge to a larger body of expertise. This process requires creating a balance between wishes for focused training and the maintenance of a high level of ecological validity. However, that not all learning objectives seemed easy to train in isolation affected the training practices. For example, watchkeeping and situation awareness include the concrete practices of seeing, interpreting and communicating and have a longitudinal aspect that is key to safety. Well-known challenges to watchkeeping and situation awareness, such as fatigue and miscommunication (Hetherington et al., 2006), are difficult to re-create within the timescale and contextual circumstances of simulator training.

At times, the analyses in Study I and II show different concerns in focusing on specific learning objectives and maintaining the full work context. Difficulties in isolating and addressing specific abilities in scenario-based training are especially evident in how participants' professional visions affected the training design in Study II. This suggests that the technological aspects of the simulator are fundamentally connected to instructional design. Study II shows the demands for instructors to match the capabilities of the simulator, the scenario and participants' professional ways of enacting work tasks. In this regard, the distinct ways professionals perceive and solve work tasks are both resources and challenges for trainers.

Thirdly, the findings relate to the explanations for using debriefings as a resource for revealing the underlying principles of the simulator experience. Earlier studies pointed out that debriefings are a key to successful simulator training (Fanning & Gaba, 2007; Shinnick et al., 2011). However, an underlying assumption of simulator training is the advantage for learners to meet specific situations that require certain located actions. Simulator scenarios seem to have strengths in uncovering the complexity of tasks and training participants in putting knowledge to use, rather than obtaining an overarching joint model of how all tasks should be carried out. This tendency creates a challenge in using very specific simulator scenarios for training generality, as for example, in the theories of shared mental models (e.g. Mathieu et al., 2000). Different types of teaching and debriefing are often employed in meeting this instructional challenge.

In the training I observed, debriefing sessions evaluated and discussed each simulator operation. An electronic map replaying all of the ship's movements aided and organised the debriefing, during which the instructors encouraged reflection and knowledge sharing amongst participants. The debriefings observed stood out as highly useful for finding different

solutions to the same problem, supporting participants' ability to reflect on action and paying joint attention to a shared professional language. However, this practice should not be considered to be an effect of mental models per se but could be reconceptualised in a sociocultural perspective.

To my knowledge, debriefings have not been extensively researched from a sociocultural point of view. Doing so, in my view, could be a productive endeavour for future research, which might explain debriefings as a new, separate learning activity from the actual simulator activity. In such a perspective, thinking and learning are not regarded as stable characteristics of the individual but as interactionally constituted. I believe that future research could shed light on debriefings as a specific communicative situation in which participants acquire a qualitatively new type of reflective competence, more than they adapt or maintain previously achieved mental models.

Considerations for fidelity in the design of simulator training

Many expectations for the development of professional expertise in simulators concern whether simulated experiences resemble the real work setting. In this thesis, *fidelity* has been identified as a key concept for describing the correspondence between the training environment and the actual work setting.

When reviewing prior studies of simulator fidelity, I sometimes found it difficult to decide whether simulator fidelity was used to conceptualise the immersiveness of the physical/technical environment or the accuracy of the interactionally constituted simulation. Additionally, the literature review on fidelity and learning made it clear that scholars representing different theoretical backgrounds have emphasised the importance of different aspects of fidelity in the simulation. Conducting studies I and II convinced me that fidelity should not be considered a stable aspect of the simulator but, rather, an element that varies as it interacts with other entities of the system. Therefore, I found it important to distinguish between the *simulator*, on one hand, and the *simulation*, on the other. Treating fidelity as a descriptive term for describing accuracy in the simulation, not the simulator, enabled identifying fidelity as an emerging property of the simulation, in contrast to a descriptive term for technology.

In Study III, my co-author Øvergård and I present a selected review of research on the function of fidelity in simulator training. We argue that such an expanded notion of fidelity is productive for considering simulators as resources for simulating and that it is necessary to keep questions of fidelity closely connected to other entities of simulator training rather than

only to the technological aspect. Study III suggests a model of *technical*, *psychological* and *interactional fidelity*. These are suggested as possible focuses of attention in the design of simulator training. In this study, the notion of *interactional fidelity*, which is suggested to be complementary of other types of fidelity in the design of simulator training, is introduced. This new concept is proposed for describing accuracy in the socio-technical patterns of collaboration, which I found to be an underreported type of fidelity. To demonstrate how these conceptualisations might provide a lens for assessing training situations, we analysed data extracts from a maritime pilot course.

The concept of interactional fidelity corresponds with studies I and II of this thesis, which show that separating the socially from the technically created aspects of the simulation is not meaningful. Therefore, I argue that conceptualisations of fidelity are most useful when they encompass accuracy in the re-creation of specific elements of the simulated environment, independent of whether these elements are technical or social. This can be seen as part of an endeavour to coordinate technical and social requirements in simulator training by developing a concept that grasps the accuracy of the re-created elements in the simulation regardless of human or technological actors. In such a perspective, the fidelity of these tools is undoubtedly relevant to facilitating learning opportunities. However, as Study I describes, it is problematic to claim that the degree of fidelity supports causal relationships to learning at a general level.

The learning sciences have a dual commitment to seeking understanding of the nature of learning and to shaping future learning practices (Sawyer, 2006). A practical outcome of Study III is the formation of a framework for aligning learning objectives with simulator fidelity requirements and learning outcomes. This framework provides a practical table that easily enables trainers to make notes and conceptualise different types of instructional designs. I believe that conceptualising such elements of simulator activities might increase the level of sensitivity to the learning processes that are initiated and enhance collaboration among trainers, learners and designers. The framework should not be conceived as a classification of different types of learning but simply as the presentation of prior research on simulator training which emphasise different types of accuracy in the simulation. I believe the framework can be useful for designing different types of simulator training designs directed at different aspects of professional practice in manners grounded in empirical research.

8. CONCLUDING REMARKS

This thesis presents empirical investigations of how ship simulators are utilised as tools for learning in the maritime domain. These investigations contribute insights to the growing body of knowledge that demonstrates how simulators can provide work-like learning environments that bridge the practices of schooling and work.

As well, the analyses demonstrated the potential of a seldom-used research strategy in maritime simulation. A detailed video study shows how simulators allow learners to meet work-like situations in a safe setting and train students' ability to partake in the sociotechnical work system of a ship bridge. Especially in studies I and II, I attempt to analyse issues of simulator training without extracting training practices from the contextual contingencies within which they are embedded. In Study III, I attempt to position studies on the interactional level of training within a larger body of research on simulations.

The main findings provide support for simulators' potential to facilitate learning experiences in work-like contexts. Through three separate studies, this thesis zooms in on the situated aspects of how simulators are interactionally constituted and socially organised as learning environments.

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