Training skills and assessing performance in simulator-based learning environments

Charlott Sellberg, PhD Student in Education[a]

Olle Lindmark, Lecturer in Cargo and Maritime Management[b]

Hans Rystedt, Professor in Education[a]

a. Department of Education, Communication and Learning, University of Gothenburg, 405 30 Gothenburg, Sweden

b. Department of Mechanics and Maritime Sciences, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Email: charlott.sellberg@gu.se

Abstract: This article reports the results from a research project on the use of simulator technologies in the training and assessment of professional performance in maritime training. The research draws on ethnographic fieldwork and analyses of video-recorded data to examine how maritime instructors make use of simulator technologies during instruction. Our results reveal an instructional practice where the need to account for general principles of good seamanship and international regulations is at the core of the basic maritime training. The meanings of good seamanship and the rules of the sea are hard to teach in abstraction, since their application relies on an infinite number of contingencies that have to be accounted for in every specific case. Based on this premise, we are stressing the importance of both in-scenario instruction and post-simulation debriefing in order for the instructor to bridge theory and practice in ways that develop the students' professional competences. Moreover, our results highlight how simulator technologies enable unique ways of displaying and assessing such competences by enabling instructors to continuously monitor, assess and provide feedback to the students throughout training sessions. Our results imply that training models advocating isolating and targeting technical and non-technical skills during training conflict with training for rule-governed maritime operations where such skills are intricately entwined. Furthermore, our results show that debriefing models that recommend a linear chronological order of discrete phases could be misleading. Although this structure might provide an overall resource, processes of connecting principles and rules to a multitude of specific circumstances in the training scenarios are at play throughout the debriefings.

Keywords: Maritime training; Simulator-based training; Instruction; Assessment; Debriefing

Introduction

In maritime education, simulators have been used for navigation training since the 1950s (Hanzu-Pazara *et al* 2008). Simulators provide opportunities to train for high-risk professions such as shipping, aviation and health care in a risk-free manner, providing opportunities to train skills that are time-consuming and costly to practice on board a real vessel (Dahlstrom *et al* 2009). The controlled simulator environment also has pedagogical advantages, as exercises can be designed to train and assess specific learning outcomes in a way that is adjusted to the level of the students' developing competency (Maran & Glavin 2003). Today, the use of simulators is mandatory for certain parts of the curriculum for maritime training and is regulated by international standards, that is, by the *Standards of Training, Certification and Watchkeeping for Seafarers* (STCW). In order to ensure that future mariners are able to act properly and safely, the STCW Convention stresses that simulators are to be used for both training and assessment. The latest update of the STCW Convention—the 2010 Manila amendments—has a greater focus on technical proficiency and so-called non-technical skills compared to previous Conventions. The former skills are related to handling the equipment of the ship, while the latter are often described as cognitive and communicative skills, such as situation awareness and decision making, as well as skills involved in teamwork, such as leadership and communication (Flin 2008).

When much of the training of maritime skills and practices are conducted in simulation-based learning environments, theoretical knowledge and written knowledge tests have been deemed irrelevant for developing and testing certain types of competencies. As a result, there is a need for upgraded forms of training and assessment that, on the one hand, acknowledge the multifaceted nature of the performance in simulation-based training and, on the other hand, meet the criteria for training and certification set up by the Convention (Emad 2010). A recent literature review on the use of simulators in bridge operation training showed that although the use of simulators is both well established and well regulated in maritime education, few empirical studies have addressed the pedagogical aspects of simulator-based training in this domain (Sellberg 2017). In regard to this, the research project draws on ethnographic fieldwork and analyses of video-recorded data to examine the pedagogical matter of how maritime instructors make use of simulator technologies for instruction in order to develop the students' professional competences (cf Heath *et al* 2010).

Background

Several studies on maritime simulations have been grounded in human factor perspectives (Sellberg 2017). Research in this tradition regularly draws on classical cognitive theories for describing processes of work and learning. In previous studies on simulator-based training, the cognitive approach is seen through research designs that strive to isolate skills for training and reflect an interest in underlying cognitive models during learning activities. Moreover, there is often a focus on the technical fidelity of the simulator (Sellberg 2017). Instead of taking a classic cognitive approach, the current research project draws on theories that situate work and learning in the social, material and cultural context (Goodwin 1994; Hutchins 1995; Suchman 2007). This approach implies an interest in the specific details of educational activity in terms of the interactions between instructors, students and the simulator environment, with a focus on how the students develop their perception and understanding of professional practice. In maritime educational research, few studies can be found that take a situated perspective on simulator-based training. However, initial results show promise of being fruitful for understanding how participants are learning the professional knowledge of a mariner (Hontvedt 2015a; 2015b; Hontvedt & Arnseth 2013).

For example, in a study on students training together with professional pilots on a full mission simulator, Hontvedt and Arnseth (2013) found that the practices trained in the simulator are closely entwined with the maritime profession's hierarchy and work roles. Moreover, they found that expert feedback is crucial in order to structure simulator training in a way that enhances professional knowledge. The importance of professional guidance during simulator-based training is seen in results from studies on simulations in other domains, such as healthcare and dentistry (Hindmarsh *et al* 2014; Rystedt & Sjöblom 2012. In a study on professional pilots' continuous training, results revealed that the pilots' professional vision of the work environment was in conflict with an instructional strategy that isolates skills for learning from the experienced exercise (Hontvedt 2015b). While the potential for simulator-based learning is that professional knowledge and expertise can be taken into account and developed, specific skills are not easily separated from maritime work practice and cultural notions of what constitutes good seamanship. In line with these results, the classical cognitive division between technical and so-called non-technical skills is problematic in practical training. Instead, the different skills are increasingly intertwined in the different work tasks. This, in turn, requires an analytical framework that takes into account the practical and contextual aspects of learning on the ship's bridge (Hontvedt 2015a; 2015b).

An almost unanimous conclusion in the research across domains highlights the importance of post-simulation debriefing (Dieckmann et al 2008; Fanning & Gaba 2007; Wickers 2010). Allowing for retrospective feedback and reflection is necessary for participants to learn from their experiences in a way that forms the basis for prospective strategies on how to manage future situations. In general, a structure is suggested involving three phases: a description of what happened, an analysis of what should be done differently and a concluding part to summarize the lessons learned (Fanning & Gaba 2007). In debriefing, it is common to use different technologies for feedback. In teamwork training in healthcare, for instance, the use of video is recommended to assist debriefings (Dieckmann *et al* 2008). A pedagogical rationale for using video is that it provides a record of the actions taken during a scenario that allows for the participants to view their prior actions from an observer's perspective. The main idea is that gaining an observer's perspective on one's own conduct allows the participants to see how they performed, instead of how they thought they performed, which is expected to reduce 'hindsight bias' in debriefing (Fanning & Gaba 2007). Further, different forms of visualization have been used in military and maritime training to revisit and learn from the exercises.

A common technology for debriefing in navigation courses is the use of an electronic map with a replay of the simulated scenario displaying the actions of multiple crews from a birds-eye view (Hontvedt & Arnseth 2013). While empirical studies on the use of playback technologies in navigation training are still lacking, results from studies of simulations in healthcare show that the use of video has pedagogical potential because, among other things, it provides a third-person perspective on one's own conduct and makes it possible to reconceptualise prior events in professionally relevant ways (Johansson *et al* 2017). Such outcomes, however, regularly demand substantial efforts by facilitators to highlight critical aspects of what is shown and to demonstrate how the situation should be understood (Goodwin 1994). This conclusion concurs with studies in other educational fields, pointing to the need for systematic instruction if students are to be able to make sense of film clips of their own conduct (Erickson 2007). Although video as a playback technology is quite different from visualization tools in navigation training, it points to the fact that visualizations are far from self-explanatory and there is a need to scrutinize instructors' practical use of playback for instructional purposes.

To summarize, the results seen so far highlight three aspects of training in simulators as especially important for learning for the maritime profession: the role and importance of professional guidance during simulations, the close relationships between technical and non-technical skills and the role and importance of debriefing for learning from the practical exercises. This research project adds to these results with knowledge on *how* instructions in a simulator environment are carried out, but also *why* instructions should be designed in certain ways.

Methods

The research design is based on three well-tested principles for video-based research (Heath *et al* 2010). The first principle is to explore human-technology interactions as they naturally occur in the setting under study. This implies that instructional activities at the simulator centre were studied with no intention to manipulate the activities taking place during training. Second, when studying highly technical workplaces in complex domains, such as maritime navigation training, ethnographic fieldwork is considered essential for developing an understanding of the practice and the context where interactions take place (Heath *et al* 2010). Since 2013, the first author has spent hundreds of hours on observations and informal interviews with instructors in order to be able to analyse the activities that take place in simulation-based maritime training sessions. Observations included several different simulators and types of training, such as cargo operations, engine control operations and radio communication, as well as field trips to different simulator centres across Europe. The third principle puts emphasis on the complex relationship between the temporal, technical and social environments in simulation-based training (Heath *et al* 2010). This makes video data an important source for analysis, since video creates stable records for analysis of the interactions that take place during training. Approximately 75 hours of simulation-based training in a bachelor level navigation course were video recorded in 2013–2014. When using multiple cameras to capture instructions that were distributed in time and space during exercises, close to 400 hours of film was recorded. When narrowing down the selection of video data for further analysis, six different scenarios and their subsequent debriefings emerged as analytically interesting. In the next step, instructions between the instructor and students were transcribed and analysed both individually and collaboratively, drawing on competencies from professional mariners, educational sciences and human factors.

Results

Although simulator-based training in maritime education might encounter challenges similar to those in other domains, our results reveal that there are also some crucial differences. While simulation training in other realms often focuses on technical and non-technical skills, the need to account for general principles of good seamanship and international regulations is at the core of basic maritime training (Sellberg & Lundin 2017). The meanings of good seamanship and the rules of the sea are hard to teach in abstraction, since their application relies on an infinite number of contingencies that have to be accounted for in every specific case (Sellberg & Rystedt 2015). During simulator-based training, this premise poses different instructional challenges for the maritime instructor in the different phases of training.

Briefing is commonly focused on practical information regarding the upcoming scenario and the learning objectives and takes place in a classroom in close proximity to the simulators (Fig. 1). The spatial layout of the classroom sets the frame for instruction, and the technologies used for instruction in this phase are common classroom technologies, such as documents, PowerPoint presentations and overhead sheets, which are prepared by the instructor beforehand. In this phase of training, the instructions given to the students were rather open and straightforward (Sellberg & Rystedt 2015). Examples of such open instructions are directives to 'follow COLREG' or to use the TRAIL-function in a particular scenario. Before the scenario is played out, all the specific contingencies of the scenario are yet unknown. For the instructor, the openness of the instructions is a necessity in order to handle an infinite number of possible courses of events that may occur in the upcoming scenario. For the students, this is a classical problem of following instructions: of turning open and partial descriptions into practical action towards a desired outcome (Suchman 2007).

Fig. 1. From briefing, through scenario, to debriefing in simulator-based maritime training.

After briefing, a *scenario* plays out in the simulator. In the scenarios chosen for further analyses, the exercises take place in the dense traffic of the Dover Strait and in the confined waters of Great Belt Strait, where the students are training in teams of two (as officer-of-the-watch and lookout) in bridge operations simulators. These kinds of exercises are used to train proficiency in handling the instruments on the ship's bridge, as well as in bridge teamwork and application of the rules that regulate traffic at sea (COLREG). During scenarios, the instructor monitors the students' on-going teamwork on the different bridges from the instructor's room. Our results show a close relationship between assessment and instruction in the midst of the action (Sellberg & Lundin 2017).

During scenarios, *assessment* is a continuous and on-going process that reflects the instructor's ability to recognize the fit or the gap between the learning objectives and the students' activities in the simulator, as they unfold (Sellberg & Lundin 2017). These assessments rely both on technology, that is, on the monitoring technologies in the instructor's room and the radar technologies in the simulator, as well as on questions to the students. Moreover, when the interactions between instructor and students are taking place in the simulators, the instructor can use a variety of navigational technologies in a maritime context as a basis for his or her instructions (Sellberg & Lundin 2017; Sellberg & Rystedt 2015). For the instructor, being there, in the midst of the action enables him or her to attend to specific details of the students' conduct, such as how they are managing their gaze and attention when integrating information from different sources on the bridge (Sellberg & Rystedt 2015). The students' actions as well as their understandings of the situation that are shown in their answers to questions are then used to continue the instructions in a way that supports each student bridge team (Sellberg & Lundin 2017). For example, the instructor can choose to clarify or correct the students' actions as necessary, or just to ratify their actions as correct behaviour. What is interesting with these instructions, in relation to the instructions in the briefing phase is that they can be delivered in a way that takes the contingencies of specific situations into account (Sellberg & Rystedt 2015). In this way, instructions during scenarios take the initial partial and open instructions and show how they apply to the specifics of a concrete situation. Such immediate and detailed instruction is known to 'keep the roof up', addressing skill acquisition issues that are difficult to address anywhere else, at any other point in time (Suchman 2007).

Lastly, in the *debriefing* phase, the use of the playback of the prior scenario is at the core of recreating a shared view of how all students navigate, and provides a basis for revisiting critical events. The playback forms a shared point of reference for demonstrating alternative solutions by contrasting what was done in the scenario and what should be done differently in order to follow the rules of the sea and maintain safe conduct in similar situations. A range of different instructional resources can be combined in this process. The overview and dynamic playback of the scenarios can function as an essential background on which gestures, pointing, drawings and discussion can be directed to create a common view of typical problems and how these should be addressed. In this process, issues such as where to look, which instruments to use, when to turn and when to adjust speed, can be elaborated to demonstrate how to keep a safe distance and how to show clear intentions to other ships. In this way, the application of the rules of the sea can be addressed in terms of practical and timely actions in relation to the ever-changing and situation-dependent character of navigation practice. Accordingly, the use of dynamic playbacks during debriefings offers opportunities to portray rules in a context in which their meanings can be tied to situations as they were actually carried out and to demonstrate more preferable alternatives. Most important, the use of tools for navigation can represent a learning objective, that is something for students to master, and can also work as an instructional device of crucial importance in exhibiting nautical problems and demonstrating good seamanship in all its intricate details.

What is clearly illustrated in all of our studies is the role and importance of professional guidance, from briefing, through scenario, to debriefing. The instructional work accomplished in the simulator environment connects the simulated events with the students' experiences of the work practice encountered during on-board training, as well as showing the relevance of theoretical and abstract principles in practical situations.

Conclusions

Based on results from the research project, the following guidelines for maritime instruction are provided:

1. Highlighting the details of the students' performance together with explanations on general principles and formal rules at the core of good seamanship are key to developing the students' understanding of professional competency.
2. Following this, the results stress the role and importance of providing students with specific instructions both during scenarios and in debriefing, which is crucial for the process of bridging theory and practice in ways that develop the students' professional understanding.
3. During scenarios, the timing of instructions is crucial. In order to be able to provide immediate instructions, there is a need to closely monitor the students' actions in the simulator. For this purpose, simulator technologies that offer monitoring opportunities are of great use for the maritime instructor.
4. During scenarios, instructions draw strength from the specific details that are at play in the midst of the action. To use the navigational instruments, for example, the radar display, together with artefacts such as nautical paper charts as a basis for highlighting and explaining the specific details makes the lessons concrete and grounds them in practices of good seamanship.
5. The debriefing phase is decisive for deepening the analysis and synthesising the lessons to be learned from the scenarios. The use of playback technologies for visualizing the prior scenario is essential for recreating prior events on a sufficiently detailed level where specific details of the students' performance can be highlighted and explained.

Acknowledgements

This study is financed by four parties: The University of Gothenburg Learning and Media Technology Studio (LETStudio); The Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society (LinCS); Department of Mechanics and Maritime Sciences at Chalmers University of Technology; and Department of Education, Communication and Learning at University of Gothenburg. We are also most grateful to the instructors and students at the simulator centre for their participation in the project.

References

DAHLSTROM, N., DEKKER, S., VAN WINSEN, R., NYCE, J., 2009. Fidelity and validity of simulator training. *Theoretical Issues in Ergonomics Science*, 10(4), 305-314. Available from: http://www.tandfonline.com/doi/abs/10.1080/14639220802368864

DIECKMANN, P., REDDERSEN, S., ZIEGER, J., RALL, M., 2008. A structure for video-assisted debriefs in simulator-based training of crisis recourse management. In: R. Kyle & B.W. Murray (Eds.) *Clinical simulation: Operations, Engineering, and Management,* (pp. 667-676). Burlington, VT: Academic Press.

EMAD, G. R., 2010. Introduction of technology into workplace and the need for change in pedagogy. *Procedia-Social and Behavioral Sciences*, 2(2), 875-879. Available from: http://www.sciencedirect.com/science/article/pii/S187704281000159X

ERICKSON, F., 2007. Ways of seeing video: Toward a phenomenology of viewing minimally edited footage. In: R. Goldman R, Pea, B. Barron, S. Derry (Eds.) *Video research in the learning sciences*, pp. 145-155.

FANNING, R.M., GABA, D.M., 2007. The role of debriefing in simulation-based learning. *Simulations in Healthcare*, 2(2), 115-125. Available from: http://journals.lww.com/simulationinhealthcare/Fulltext/2007/00220/The_Role_of_Debriefing_in_Simulation_Based.7.aspx

FLIN, R., 2008. *Safety at the sharp end: A guide to non-technical skills*. Abingdon, UK: Taylor & Francis Group Ltd.

GOODWIN, C.,1994. Professional vision. *American anthropologist*, 96(3), 606-633. Available from: http://onlinelibrary.wiley.com/doi/10.1525/aa.1994.96.3.02a00100/full

HANZU-PAZARA, R., BARSAN, E., ARSENIE, P., CHIOTOROIU, L., RAICU, G., 2008. Reducing of maritime accidents caused by human factors using simulators in training process. *Journal of Maritime Research*, 5(1), 3-18. Available from: http://www.jmr.unican.es/index.php/jmr/article/view/32

HEATH, C., HINDMARSH, J. & LUFF, P., 2010. *Video in qualitative research: Analysing social interaction in everyday life*. London, UK: SAGE Publications Ltd.

HINDMARSH, J., HYLAND, L., BANERJEE, A., 2014. Work to make simulation work: 'Realism', instructional correction and the body in training. *Discourse Studies*, 16(2), 247-269. Available from: http://journals.sagepub.com/doi/abs/10.1177/1461445613514670

HONTVEDT, M., 2015a. *Simulations in Maritime Training: A video study of the socio-technical organisation of ship simulator training*. Doctoral thesis, Faculty of Educational Sciences, University of Oslo, 234. Oslo: Akademika Publishing.

HONTVEDT, M., 2015b. Professional vision in simulated environments-Examining professional maritime pilots' performance of work tasks in a full-mission ship simulator. *Learning, Culture and Social Interaction*, 7, 71-84. Available from: http://www.sciencedirect.com/science/article/pii/S2210656115000367

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. Available from: https://link.springer.com/article/10.1007%2Fs11412-013-9166-3

HUTCHINS, E., 1995. *Cognition in the wild*. Cambridge, MA: MIT Press.

JOHANSSON, E., LINDWALL, O., RYSTEDT, H., 2017. Experiences, Appearances, and Interprofessional Training: The Instructional Use of Video in Post-Simulation Debriefings. *Computer Supported Collaborative Learning*, 12, 91-112.

MARAN, N. J., GLAVIN, R., 2003. Low- to high- fidelity simulation - A continuum of medical education? *Medical Education*, 37(1), 22-28. Available from: http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2923.37.s1.9.x/full

RYSTEDT, H., SJÖBLOM, B., 2012. Realism, authenticity, and learning in healthcare simulations: rules of relevance and irrelevance as interactive achievements. *Instructional Science*, 40, 785-798. Available from: https://link.springer.com/article/10.1007%2Fs11251-012-9213-x?LI=true

SELLBERG, C., 2016. Representing and enacting movement: The body as an instructional resource in a simulator-based environment. *Education and Information Technologies*, 2016, Online ahead of print. Available from: https://link.springer.com/article/10.1007/s10639-016-9546-1

SELLBERG, C., 2017. Simulators in bridge operation training and assessment: A systematic review and qualitative synthesis. *WMU Journal of Maritime Affairs*, 16(2), 247–263. Available from: https://link.springer.com/article/10.1007/s13437-016-0114-8

SELLBERG, C., LUNDIN, M., 2017. Demonstrating professional intersubjectivity: The instructor's work in simulator-based learning environments. *Learning, Culture and Social Interaction*, 13, 60-74. Available from: http://www.sciencedirect.com/science/article/pii/S2210656116301714

SELLBERG, C., RYSTEDT, H., 2015. Temporal and material conditions for instruction in simulation-based maritime training. Presented at *Computer Supported Collaborative Learning* (CSCL2015), June 7-11, 2015, Gothenburg, Sweden. Available from: https://www.isls.org/cscl2015/papers/MC-0207-Poster-Sellberg.pdf

SUCHMAN, L., 2007. *Human-machine reconfigurations: plans and situated actions*. (2nd Edn.) Cambridge, MA: Cambridge University Press.

WICKERS, M.P., 2010. Establishing the climate for a successful debriefing. *Clinical Simulation in Nursing*, 6(3), e83-e86. Available from: http://www.sciencedirect.com/science/article/pii/S1876139909004964