Safety in Extreme Environments (2022) 4:277–290
https://doi.org/10.1007/s42797-022-00066-0

RESEARCH ARTICLE

Computer-assisted management training for emergency response professionals in challenging environments

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Received: 13 June 2022 / Revised: 26 August 2022 / Accepted: 6 September 2022 / Published online: 17 September 2022

Abstract

Coordinating complex crisis responses generally requires comprehensive skills. When operating in the High Arctic, extreme environments make this task even more challenging. Training for these situations is thus of utmost importance, but such training requires extensive resources for full-scale exercises. Simulation is an alternative that can yield an effective learning process and learning outcomes. In this study, we explored how simulator-based accident training in high-risk, highly sensitive environments can be optimised. To do this, Exercise Isfjord was designed for students in the master's Preparedness and Emergency Management programme at NORDLAB at Nord University. This exercise involved a grounded cruise ship from which passengers needed to be evacuated, in addition to a severe oil spill. Interviews with students, mentors, facilitators, and academic staff were conducted, and thematic analysis was used for analysing the data. Our findings indicate that a pedagogical wheel consisting of the six factors preparations, psychological safety, mentors, learning objectives, context realism, and evaluations promotes an optimal learning process in simulated-accident exercises in high-risk and highly sensitive environments. Thus, we recommend tailor-made simulated exercises for crisis management and emergency preparedness.

Keywords Simulation · Training · Learning process · Adult learning · Experiential learning · Crisis management · Arctic · Situation awareness

Introduction

To coordinate complex crisis response operations, crisis management and emergency preparedness professionals require comprehensive competence. This applies in particular for challenging environments such as the Arctic, a highly sensitive and remote area characterised by harsh weather, a cold climate, and a dispersed population with long distances to emergency response centres. Thus, a large-scale accident here may create additional challenges, for instance, for search and rescue (SAR) operations and can potentially be incredibly destructive for the vulnerable environment and the people involved (Kruke and Auestad 2021). Moreover, maritime activity in the Arctic has increased over the past decade (Stocker et al. 2020), giving rise to increased environmental hazards, such as oil spills, and risk to human life. Further, cruise tourism is increasing, causing a risk of accidents in the Arctic, which may strain the preparesdness system (Borch et al. 2016; Melia et al. 2016).

Crisis management and emergency preparedness concern creating a safety culture for preparedness (Weick and Sutcliffe 2015) and responding to unwanted incidents that threaten to harm an organisation or society, often with limited resources (Borch and Andreassen 2020; Bundy et al. 2017; Shrivastava et al. 1988). This calls for a special focus on emergency preparedness resources, and specialised competence may be in demand among the management of emergency responders in the Arctic.

Simulation-based education is a common discipline that can provide safe and effective learning environments (e.g., Ziv et al. 2003), and over the last decades, it has become part of standardised training in different safety–critical sectors, such as medicine (Jeffries 2005; McGaghie et al. 2010; Morrison and Cantazaro 2010), aviation (Jentsch et al. 2017; Salas et al. 1998), and nuclear (Bye et al. 2011). Additionally, in recent years it has also been introduced to high-risk industries, such as driver training (Sætren et al. 2021), firefighting (Saghafian et al. 2020), maritime search and rescue

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(Andreassen et al. 2021) and operating heavy machinery in challenging environments (Saghafian et al. 2021).

Simulation-based emergency response training in safety critical contexts is becoming increasingly common in several industries. When looking at the scientific research literature of the past five years, we found emergency response training based on simulation in areas such as medicine (Abulebda et al. 2021; Kalidindi et al. 2018), firefighting (Kwegyir-Afful et al. 2022), maritime navigation, and offshore industry operations (Moreno et al. 2022; Musharraf et al. 2019; Sharma et al. 2019). However, it is mostly related to the learning of certain functions within operational responses from front-line operators and the operational management level, like communication, situational awareness, safety behaviour, or decision-making, rather than understanding the capability of an organisation and functions of strategic management. In addition, the pedagogical aspect is often limited in research on simulation training in emergency response to a discussion of teaching strategies. Thus, the learning process for adult learners and the management of the response to an emergency situation are the main focus of this study.

Even though hands-on experience through full-scale, large-accident emergency exercises yields real-life experience and learning outcomes from mobilising many actors, this type of exercise is expensive, usually focuses on specific tasks or skills, and is difficult to organise (Tena-Chollet et al. 2017). Simulation alternatives are required because of the cost of resources, danger for both people and the environment, and the absence of time pressure under the simulated response (Laffitte and Howe 1997); computer-assisted simulation may provide a realistic and less expensive option. However, to justify the cost of high-fidelity simulation and maximise the output of computer-based simulation exercises, educators must ensure that the simulation training is effective according to the desired outcomes. Thus, our research question was the following: How can simulator-based emergency management training in high-risk, highly sensitive environments be optimised?

In the following section, we present the theory of situational awareness, followed by the adult learning and experiential learning theories. After this, we explain the method and then present the results before the discussion. Finally, a conclusion summarises the research questions and findings.

Theoretical framework

Adult learning – andragogy

Effective simulated learning for adults requires a thorough understanding of both adult learning theories, which is also known as andragogy (e.g., King 2017; Loeng 2018; Zigmont et al. 2011), and experiential learning (Kolb 1984, 2014). Effective practice-based learning requires a focus on three areas: the individual, the learning environment, and the students' experience (Zigmont et al. 2011). Adult students are probably more intrinsically rewarded (Knowles 1985; Ryan and Deci 2000), are often more self-regulated in learning situations (Knowles 1985), and have experience that usually benefits the learning process for themselves and the group (King 2011; Kolb 1984). In addition, adult learners who feel competent and a respected part of the environment through, for instance, psychological safety, increase their self-efficacy (Bandura 1993; Edmondson 1999; Ryan and Deci 2000).

Psychological safety is an important aspect of learning and relates to a perception of being able to take risks by, for instance, asking questions or contributing to discussions without fear of negative consequences on a group level (Edmonson and Lei 2014). Focusing on team building and effective communication through psychological safety stimulates student participation, which leads to advanced learning processes (Edmondson 1999). Additionally, increased self-efficacy contributes to increased motivation for learning (Kolb 1984). As simulation is a hands-on experience and at the same time has the capacity to enhance autonomy and competence, it could increase the motivation of adult learners (Kolb 2014).

Learning outcomes are often measured through testing. However, according to Bloom's taxonomy of learning, comprehension and knowledge are basic skills that are easier to test (Anderson et al. 2000). This taxonomy consists of a hierarchy, in which comprehension and knowledge are basic skills. The next levels are application, analysis, synthesis, and the final level, evaluation. Complexity increases beyond the basic levels, complicating the ability to measure learners' ability to, for example, apply and analyse existing and new competencies in the assimilation of knowledge. Application and analysis are the levels desired for emergency management training outcomes. This is why we, in this study, explore the process of learning rather than testing skills or comprehension of a learning outcome.

Learning by simulation – experiential learning

Simulation-based education has been widely used in experiential learning, and the educational context is of great importance. As, for instance, medicine has a long tradition in the use of and research on simulators in an educational setting, research, for instance, focuses on a critical review of 12 general features and best practices (McGaghie et al. 2010) that are most likely to be generally applicable to simulation-based education. These 12 are feedback on performance, deliberate practice, curriculum integration, outcome measurement, simulation fidelity, skills acquisition and maintenance, mastery learning, transfer to practice, team training,

high-stakes testing, instructor training, and educational and professional context. Simulation as a pedagogical methodology is based on the premise that hands-on experience plays a central role in learning, often drawing upon theories of experiential learning (Kolb 1984, 2014), situated learning (Lave and Wenger 1991), and social learning theory (Bandura and Walters 1977).

Kolb (1984, 2014) contended that knowledge is crafted through understanding and transforming experience. As experience can be described as a catalyst for learning, well-designed experiences are important in learning processes and for enhancing mental models (Eckert and Bell 2005; Kolb 2014). Reflections – through, for instance, a debriefing after a simulated exercise – contribute to allowing the student to test previous knowledge regarding new experiences and thus to revise their mental models. This aligns with Kolb's (2014) experiential learning cycle, which states that having (a) a concrete experience (partaking in an exercise) and (b) reflecting on the observations (debriefing afterwards) leads to (c) abstract conceptualisation (making new mental models) and further develops into (d) active experimentation (testing existing mental models).

By using simulation as a tool for learning, direct experience provides an opportunity to learn about situations that could be difficult to encounter in real-life settings but are still important to learn. With the use of simulation, the process of experiential learning is enhanced through the possibility of testing different behaviours and skills while generating new mental models. Further, simulation in learning provides a tool that allows students to learn and experience important processes in a hazard-free environment (Sætren et al. 2021).

Situational awareness (SA)

In order to make good decisions for crisis management in crucial occurrences, the understanding of the situation for the management team is of crucial importance. Situation awareness is often defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley 1995, p. 36). In other words, it can be said to be a person's understanding of the situation throughout an event. SA consists of three levels, perception of the current situation, comprehension of the current situation, and prediction of future occurrences. Humans have a natural tendency to search for order, for which we use, for instance, cognitive structures, such as perception and memory, to create mental models (Weick 2001). This is essential for SA, which Endsley (2015) points out, describing how Q-morphisms in mental models provide defaults that give a reasonable SA even with missing or limited information about the context. Thus, as we create a full understanding of the context based on our previous knowledge and what we perceive in the current situation even though the information is limited, SA can be used in relation to errors, such as failing to interpret signals correctly.

Even though research on SA has been conducted in a variety of settings, and many variations and developments of the term have been used (e.g., Endsley 1995; Fracker 1988, 1991; Salmon et al. 2009; Smith and Hancock 1995; Weick 2001), Endsley's is still today one of the most used theories on how to create awareness of a context. SA is also important on a group level. In regard to the management of crises situations, there is most likely to be a management group making the decisions together. Shared SA consists of the individual attention towards one's responsibility within the team and the ability to share this information in order to achieve a shared understanding of the contextual factors. Shared understanding is of importance in order to coordinate team tasks. Thus, it is not sufficient for one person in the team to have knowledge about the context of their responsibility while others on the team do not have knowledge of this at all (Endsley 1995). However, in order to provide the necessary information to the others on the team, an optimal level of psychological safety has been found to be highly relevant (Edmondson and Lei 2014).

Method

An inductive qualitative approach was chosen for this explorative study of context-adapted tailor-made training schemes for emergency response leaders. Both individual and group semistructured interviews were conducted. Because training outcomes become more complex and more difficult as one moves up Bloom's learning hierarchy (Anderson et al. 2000), we chose a qualitative explorative approach to map the perceptions of several actors to the factors important for the optimal learning process of the exercise. These actors represented students, facilitators, mentors, and academic staff.

Description of the researchers

The researchers have relevant and varied backgrounds. One holds a PhD in safety psychology, specialising in human–machine interaction, and has several years of experience in human factors and the use of simulation in adult teaching; another has broad pedagogical experience, including facilitating simulation in training. Further, one researcher holds a PhD in emergency management and preparedness organisation and for several years was responsible for planning and conducting large-scale emergency management exercises. Additionally, one researcher is a professor

specialising in emergency preparedness systems, strategic management, and safety in maritime contexts.

Participants

The participants in this study were three students, three facilitators, two mentors, and two academic staff in the Preparedness and Emergency Management master's degree programme. The participants were recruited by email and selected with the inclusion criteria being their experience with participation in exercises related to the master's degree programme at Nord University and in particular Exercise Isfjord. The sample size was based on availability, convenience, and subjective assessment of data saturation (Braun and Clarke 2022; Kvale 1997).

The facilitators and academic staff planned, organised, and coordinated the exercise, and the mentors were an active part of the exercise in the sense that they were available for students and reflected with them during the exercise. To be admitted as a student in this programme, one must have at least two years of paid relevant practical experience in work related to risk and emergency preparedness in a high-risk sector, such as the police, military, health, fire, or other private industry sector. Hence, all students were experienced with practical high-risk work before undertaking the exercises.

Data collection

Two interviewers were present during the interviews. The main interviewer did not have experience with exercises in the master's programme and had no previous knowledge of the students or mentors interviewed. Both interviewers had professional relationships with the academic staff and facilitators.

Interviews

Ten informants took part in qualitative semistructured interviews that we conducted one week to four months after the exercise was completed. Five individual interviews were conducted with students, mentors, and academic staff, and two group interviews were conducted with students and facilitators. The informants had differing experiences with the exercises at NORDLAB, ranging from being responsible for planning and coordinating several exercises to being a student participating in one exercise.

The semistructured interviews (Kvale 1997) were conducted digitally using Microsoft Teams. Ten informants were interviewed in seven interviews, which all lasted approximately 60 min. All the interviews were recorded and transcribed. An interview guide was prepared before the interviews were conducted and was adjusted during the data collection process according to aspects that were found important to explore further. It consisted of questions covering the informants' backgrounds, daily work, perceptions of exercises at NORDLAB and during educational programmes in general, perceptions of Exercise Isfjord, relationships with other students, and the study context. For academic and professional staff, it included, for instance, questions concerning the process of conducting an exercise in general and Exercise Isfjord in particular, their part in exercises, and their perceptions of what works and what could be improved.

Analysis

Thematic analysis (Braun and Clarke 2006, 2022) with a reflexive approach (Braun and Clarke 2019) was used to interpret the data, and QSR NVivo (2022) was used to organise the analysis of the written data into categories. The main reason for choosing reflexive thematic analysis is that it is a flexible process of analysis suitable for an inductive explorative approach to discovering themes and categories in the qualitative data collected. The overall process of thematic analysis consists of coding the data and developing themes by analysing and interpreting patterns within our qualitative data set. Thus, we used an open approach with subjective constructions of the relevant themes. By choosing the reflexive approach, we included reflection on our roles as researchers and our backgrounds, valued in qualitative research paradigms (APA 7, 2020; Braun and Clarke 2019; Elliot et al. 1999).

The process of reflexive thematic analysis, often referred to as reflexive TA, consists of six phases (Braun and Clarke 2006). These are as follows: (1) familiarising oneself with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the scientific research report. According to the first phase, we familiarised ourselves with the data, as we collected and transcribed the data before reading it thoroughly. While transcribing the interviews, ideas were noted as the start of memo writing. After the completion of the transcriptions, the interviews were thoroughly read through, and these ideas were elaborated as well as new codes were made. For the transcribed material, we took each part we found to be important and coded it into relevant codes that were more concrete rather than abstract. This was to get an in-depth knowledge of our data set.

Second, we generated initial codes of the written material of the interviews according to phase 2 of conducting thematic analysis. Examples of codes from this phase were "active talking in the groups", "good possibilities for preparation of roles", "can stop and reflect during the exercise". During this phase, we also started an in-depth literature search based on the themes of adult learning, simulated training, higher education, and learning processes. This

resulted in the inclusion of theory-based literature in the categories found. During this preliminary analysis, ideas for initial categories emerged. As the process of reflexive TA is not linear, these phases were undertaken somewhat back and forth, and one interview could be completely coded prior to transcribing the next.

Third, we organised the data into meaningful groups, and during this process we discovered themes. Examples of themes were "trust other participants", "physical gatherings", "active participation", "mentoring", "learning roles", "dialogue and cooperation", "planning prior to exercise", "know what we are training for", "feeling of safety prior to exercise", "good with pizza evenings to know each other", "must be realistic scenario", and "ensure evaluation". In phase 4, we reviewed the themes and ended up with the final six themes of "preparations", "psychological safety", "mentors", "learning objectives", "context realism", and "evaluations". During phase 5, these themes were subjected to a more in-depth analysis by creating thick descriptions through memo writing and grounding the themes to the data by using quotes (Braun and Clarke 2006, 2022). The final phase 6 consisted of writing this paper.

Ontology and epistemology

Regarding the theory of reality, or in other words, the ontology of the methodology of this study, we place our research within the post-positivistic paradigm (Guba and Lincoln 1994). Within this paradigm, there is an idea that there are some points of the world that represent an objective reality but that there is also room for interpretation based on the culture and what is known as the truth at the time, often called zeitgeist. Thus, there are hints of a pragmatic worldview of which a reality is set which is the truth for the time being (Corbin and Strauss 2008). What is known now is known as the truth.

In regard to the theory of knowledge, or epistemology, we state that our research is of a direction called interactionism, which is largely inherited from John Dewey and his pedagogical research. This view states that knowledge is created through both action and interaction. We as human beings in our self-reflectiveness develop our understanding of the world through the way we act as individuals and the feedback we get from our actions in our interactions with others in a society (Corbin and Strauss 2008).

Methodological integrity and ethics

From several different approaches that exist for establishing quality through the validity of qualitative research (e.g., Elliott et al. 1999; Hayashi et al. 2019; Kvale 1997; Yardley 2000), we chose Yardley's four principles for this study. Her first principle, sensitivity to context, concerns contexts that include theoretical, scientific, and social contexts. For us to provide these contexts, we presented a theoretical context to establish the scientific framework within which we worked while conducting this research. Further, we presented our own background as researchers and the social context in which the research was conducted. This included the context of the research situation and exercise and a description of the informants and the recruitment process. Yardley's second principle, commitment and rigor, concerns the researchers' commitment to the research process. In this regard, the researchers planned the research, collected the data, analysed the data, and were a part of the whole research process. The third principle, transparency and coherence, includes explaining how the data collection was conducted, describing the data analysis process, and noting how the researchers engaged in reflexivity. Every step of the research was conducted by two or more members of the author group at all stages, from planning to writing. The fourth principle is impact and importance. This is presented in the Discussion.

The study project was approved by the Norwegian Centre for Research Data. The participants were all informed about the project in writing and verbally before the interviews. They were told that they could withdraw at any time, and they consented to both participating in and to the recording of the interviews. Additionally, the students were informed that participating in or declining to participate in the study would not affect their study progress or other educational aspects. The topic and content of the study were not assumed to cause any harm to the participants.

Results

First we will present the context prior to the categories found from the analysis.

The context

Nord University's emergency preparedness management lab (NORDLAB) provides an arena for education, research, exercises, and testing of management tools and collaboration processes related to sea, land, and air-based emergency responses. It uses top emergency preparedness software, modelling and simulation systems, and decision-making support solutions. Computer-based simulation capacities are integrated with crisis management decision-support tools, and command and control support systems. A wide spectrum of exercises, including international collaboration, maritime rescue coordination, and hybrid threats, is conducted at NORDLAB, and the institution is experienced in both full-scale and simulated exercises.

The current study is based on a computer-assisted simulator exercise, called Exercise Isfjord. The simulation was

initially created by researchers and NORDLAB advisors in cooperation with the Joint Rescue Coordination Centre North Norway, based on the recommendations and best practices for exercise and education concepts within maritime emergency management in the Arctic (Andreassen et al. 2021) and an overview of the demands on the emergency management educational programmes in the Arctic (Borch and Roud 2021). The exercise was presented at two international conferences: the High North Dialogue 2018 (Ikonen et al. 2018) and the 8th MARPART conference in 2019 in Bodø (Andreassen et al. 2019). The training was later used for master's students at NORDLAB as an emergency preparedness exercise focusing on different parts of the maritime strategic level of SAR operations, forming part of the master's degree course Emergency Preparedness Organisation and Crisis Management.

One of the learning outcomes in this course was learning about coordination and collaboration between different management levels and between sectors. One of the exercise objectives was thus to examine how different management-level collaborators and different emergency preparedness organisations are involved in maritime SAR operations. The aim was for students to increase their understanding of how the organisations are involved in maritime SAR, what their different responsibilities are, and how they coordinate the work. In addition, the students were also to increase their understanding of the mechanisms of collaboration and technological solutions that were used. For instance, another learning outcome was to learn about different communication, coordination, and control methods. Therefore, similar tools to those that are used in crisis response, (CIM – Crisis Information Management) and the mobile command and control system, named NORA), communication, coordination, and control tools were used during the exercise as well. The students had received training in using those programmes in advance, as a learning outcome included knowing how these programmes can be used in practice.

The scenario of this simulator-assisted exercise begins with a cruise ship accident in Norwegian waters, at Isfjord, outside Longyearbyen on the west coast of Spitsbergen, which requires a mass evacuation and oil spill response and builds upon the decisions made by key crisis management personnel. The students were in Bodø at NORDLAB as the accident was simulated. They were grouped to represent different functions of the emergency response teams of the coordinating organisations, including the rescue subcentre and later the Norwegian Coastal Administration during the oil spill response. They were seated in a simulator room with screens on the desktops and the walls showing the accident using advanced simulators, the location of the resources, and a map with relevant information. During the exercise, mentors and facilitators were available for the students, who walked between the different student groups.

Before the exercise, the students had attended lectures covering the theoretical basis of the learning outcomes, had received relevant documents from the organisations they were representing, knew which roles they were to play during the exercise, and were present during a panel debate consisting of experienced rescue workers, management, and scientific staff regarding the theme. The exercise lasted approximately two hours. This exercise was conducted three times for students during the period 2017–2019, with some adjustments for each session.

The categories

With the adult learning process for management training as the main subject of the thematic analysis, the interpretation of the interviews resulted in six categories necessary for an optimal simulated safety learning process: (a) preparations, (b) psychological safety, (c) mentors, (d) learning objectives, (e) context realism, and (f) evaluations (Table 1).

Preparations

The category of preparations relates to setting the stage for a well-conducted exercise. This includes the full aspect of planning, coordinating relevant information for those involved, ensuring practical facilities, ensuring theoretical and practical learning, social preparation for participants, creating the scenario, and executing meetings with the organisations and agencies involved to ensure authentic roles.

According to our findings, the coordinator of the exercise was responsible for preparing every participant, including students, facilitators, and mentors, for the exercise. This could be through practical information, theoretical lectures, or panel debates with relevant expertise. The coordinator further was found to align practical exercises with learning objectives. This included letting participants get to know each other in formal and informal arenas.

> We prepared … what the students were going to read in advance. They were given background material and they were given discussion assignments … and started reflecting on the issues and dilemmas. So they knew what to do.

In addition, preparations were social (e.g., meeting informally face to face) and theoretical (e.g., providing documents and other background materials regarding the roles of organisations and management; organising panel debates, theory lectures, mentors; and planning scenarios with experienced practitioners for a high degree of realism).

> We have had gatherings in advance where they [students] have been in the lab and become familiar with the equipment that is there. And get to try a little and

Table 1 Explanation of the six categories found to promote simulated learning processes

Category	Explanation
Preparations	Concerns organising for a well-conducted exercise. This includes planning, coordinating information and practical facilities, ensuring theoretical, strategic and operational learning objectives, socialising, creating the scenario, and executing meetings with the organisations and agencies involved to ensure authentic roles
Psychological safety	This concerns the social climate of the work environment. There should be an atmosphere fit for sharing information and asking questions openly. Psychological safety was found to be important for good communication to gain optimal information in order to execute the decision- making for the management teams
Mentors	Mentors were highly skilled external staff from relevant agencies and organisations involved in the crises management of the exercises. The mentors provided real-life authenticity to the exercise through all stages, from the planning through being present during the exercise and right after the exercise for reflections
Learning objectives	Learning objectives refer to the goals set for the exercises. In order to make functional exercises, it was found that having explicit points regarding strategic and operative goals was important
Context realism	Context realism concerns the scenario being a situation that could possibly occur in real life. This includes the context, the organisations and agencies involved, their roles, as well as the technology used, and so forth
Evaluation	Evaluation is about the actions conducted after an exercise as an conclusion to the current exercise as well as a preparation for the next. Elements from evaluations should be to decide what to continue with from the exercise and what to adjust to continuously make exercises better. This was thus seen as part of a continuous improvement phase

> discussed, and that they got the plan and procedures and what roles they will play in advance. So much of the benefit of the exercise is related to the fact that they are well prepared. That they conduct self-learning and that we ensure that they are educated. But it is also time consuming for both them and us.

Preparations for the actual exercise could start up to more than a year before it was conducted due to the need for extensive planning for a well-conducted exercise. These preparations were viewed as part of continuous and ongoing processes in parts of the master's programme.

Psychological safety

Psychological safety refers to the work climate for the participants being fit for sharing information and asking questions openly. With psychological safety, we found a category that was of importance for communication and gaining optimal information in order to execute the decision-making for the management teams. That means the atmosphere among the student group as well as the staff should be included and have a feeling of safety for everyone. This is relevant for the whole master's programme, and it was found that the staff starts off from day one of the study making sure that the student group has a feeling of connectedness and providing good communication.

To reach the full potential of the exercise, trust among the participants is important, as it allows them to fulfil their roles and know they can make mistakes and ask questions. Participants must feel safe to interact with others.

> Take several steps [for the students to] get to know each other. First, there were several presentations from academic staff at the actual kick-off [of the study programme]. And then we had a get-to-know-you round with the students.

Building psychological safety and trust before the exercise was found to be preferable so that it is well established for the actual cooperation and role play to take place. Thus, it was interpreted as an important part of the preparations.

> I like the team feeling that everyone is involved and contributes, from academic staff to facilitator and students and mentor, and you should ensure both subject teacher and student and facilitator and that you should go out and eat pizza. There is a lot of team building. The sky is the limit I get a sense of.

Mentors

The role of the mentors during exercises provided a real-life factor that had an impact on the learning process for the students. Mentors were external staff from agencies and organisations involved in the crises management of the exercises. That means they were chosen based on the theme of the exercises. Maritime SAR operations would have other agencies and organisations involved than a tunnel accident including a heavy vehicle with dangerous cargo, or an avalanche in inhabited areas for instance. By having mentors who are experienced and highly skilled within their field taking part in planning the exercise as well as joining in to reflect with the students and make sure their actions were in accord with their roles, mentors were relevant for gaining required skills.

Mentors were found to have an important practical role before the exercise in the planning process, in

guiding the students through the actual exercise, and for evaluation afterwards. Mentors were external staff from relevant organisations chosen based on their experience and mentoring skills. However, as they work externally, they are often busy, so it is important to use their competence wisely and clarify for which tasks their expertise is preferred.

> We look at the scenario together. They are very busy. So first we do the work with the others at NORDLAB, and then we send it to them for a quality check, so that we do not write something that does not agree with practice.
> During the exercise, it is very important that we have mentors from the involved organisations. Mentors are experts in their field.
> They go from group to group and give feedback to the students so they get feedback on their discussions, and they can also be asked [questions].

Learning objectives

The term learning objectives refers to the goals that were set for the exercises. In order to make good exercises that were functional, the point of the exercise was preferably to be clear to all participants. These learning objectives were both overall, as well as being more concrete.

Specific and explicit learning objectives were found to be important for the coordinator, facilitators, and students to know what the main focus was for the exercise.

> Learning objectives for the exercise could [for instance] be that they increase their understanding of how the organisations involved in maritime search and rescue and how they coordinate the work together and how they coordinate between management levels up and down and across sectors.

Context realism

Context realism refers to the notion that the scenario must be relatable and something that could possibly occur in real life. Further, it was viewed as beneficial to have access to and training in how to use relevant software for crisis coordination, such as CIM. However, it is not a necessity that everything be completely like real life as long as the immersiveness allows the students to have a sense of doing something that is real-life like. The degree of needed fidelity in order to increase knowledge for the students was found to depend on how the exercise is conducted based upon the learning objectives of the exercises.

The analysis showed that it was important for the students to perceive realism in the scenario they were role playing and that what was occurring could have been real-life incidents. This includes the technological equipment used.

> First, we make the scenario with the others at NORDLAB, and then we send it to [the mentors] for a quality check so that we do not write something that does not agree with practice.
> We have been very concerned about realism in northern labs and that it should be recognisable, by using, for example, the existing plans that one has access to and that play relevant roles.

Evaluation

Evaluation refers to the actions taken after an exercise as preparation for the next. Elements of evaluations will be taken into consideration so as to continue with the things that work well and adjust the things that were found challenging in order to continuously make the exercises better. This was thus seen as part of a continuous improvement phase. Evaluations were found to be relevant both for the students to reflect upon their own learning from the experience and for the NORDLAB crew to further improve the next exercise.

> They [students] also had debrief and reflection together and then they had the evaluation form.

Various evaluations were used at different times, including after-action reviews right after the exercises, written surveys with closed and open questions after exercises, discussions internally among the staff working with exercises, and input from mentors on their perceptions of how the exercise went. This resulted in new exercises and materials and formed the foundation for a continuous improvement process.

> We also build on the cutting-edge competence we have and the learning … where the exercise will contribute. That's very important. We have further worked in parallel with building learning materials including book production. … builds our own learning portfolio in parallel with doing exercises, then you take the competence there in books and build on it for the students and get a synergy effect from it.

Discussion

Understanding how different management-level collaborators and different emergency preparedness organisations collaborate with different sectors and levels of management during a large-scale accident is crucial should an accident occur (Andreassen et al. 2020). In addition, emergency responders must be prepared for operations

in different and challenging environments, as the Arctic is harsh and remote. Thus, training for managing crisis operations in the Arctic is of utmost importance. However, access to training facilities in real-life settings is both resource intensive and potentially dangerous for people and the environment. Therefore, simulation training could be beneficial. Thus, our research question was the following: How can simulator-based emergency management training in high-risk, highly sensitive environments be optimised?

Our findings indicate six interconnected factors relevant for an optimal simulated preparedness and crisis management training learning process (Fig. 1).

Preparations

The findings revealed the importance of proper preparation of the participant group and the process of building trust among the participants to create temporary shared situational awareness (Endsley 1995). Through a variety of preparation activities, including lectures delivered by staff and professionals, reading assignments, group work, and panel debates, the students were exposed to a broad spectrum of methods for preparing for the simulated training exercise. This is in accordance with learning styles and offering different inputs for a broader learning perspective (Kolb 2014).

The highest levels of Bloom's taxonomy of learning, which include applying and assimilating existing and new competence (Anderson et al. 2000), are harder to measure, as complexity increases. Nevertheless, this is the level desired for managerial training outcomes. Therefore, the students underwent a broad range of training before the actual simulated exercise. In addition, they reflected on their own experience with risk in their daily work tasks. This is in accordance with the learning outcome model of Zigmont et al. (2011), who emphasised the inclusion of the individual, their experience, and the learning environment when designing simulation-based training.

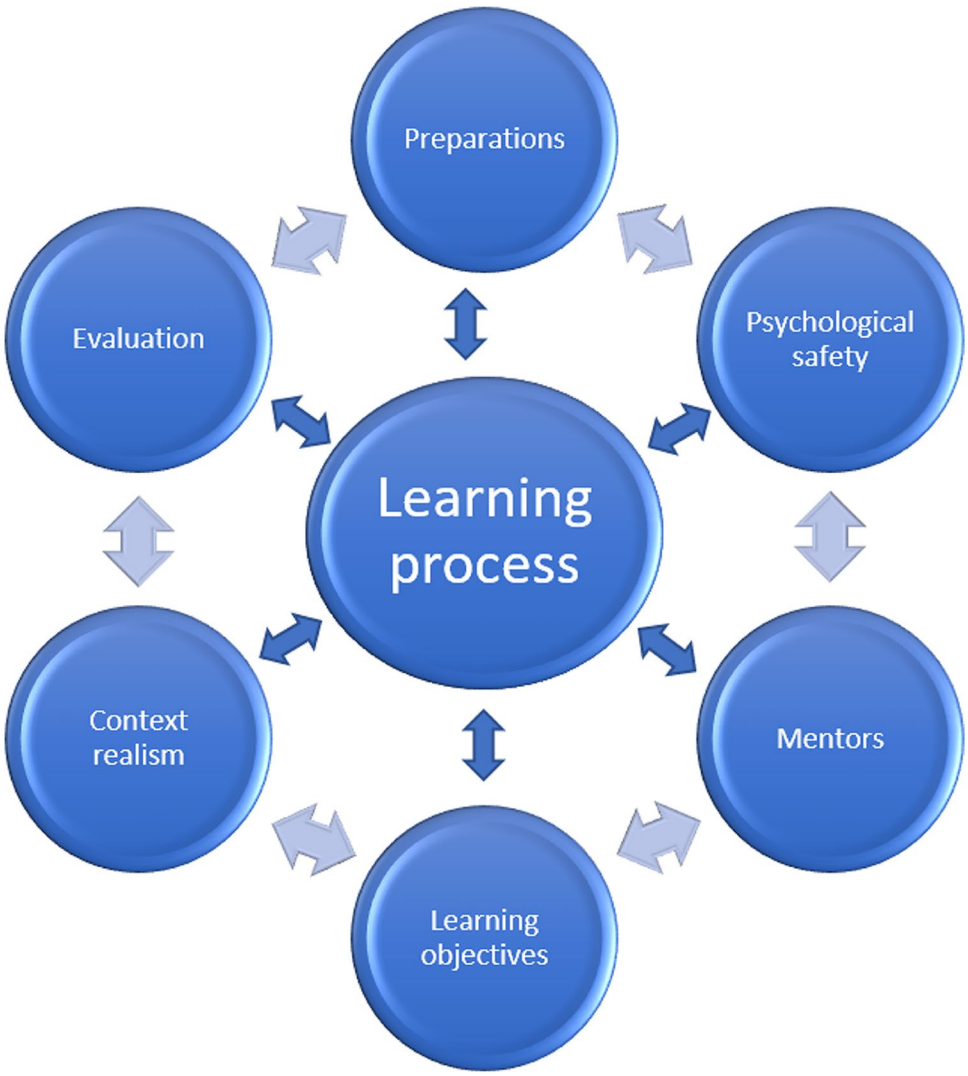

Fig. 1 Model 1. NORDLAB's pedagogical wheel: factors promoting an optimal simulated learning process in emergency exercises in high-risk and high-sensitivity environments

Psychological safety

Our findings on the importance of psychological safety align with Zigmont et al.'s (2011) recommendation that educators in simulation situations should use strategies to create respectful and supportive learning environments that protect each individual's confidentiality. Participants who are interested in each other's competence listen to each other and do not fear rejection promote effective learning within teams (Edmondson 1999). Further, participants feeling safe to interact with others with open and trustful communication based on good intentions makes a solid foundation for establishing shared situational awareness (Endsley 1995), which is important in emergency management training where participants come from different sectors and organisations.

According to Zigmont et al. (2011), strategies to create respect and support include defining goals for students before the exercise, introducing facilitators to the students, outlining expectations of the students' input, and providing debriefings after completion. We found that the preparations and the trust building and evaluations aligned with these recommendations. Working on a trustful and respectful environment within the group of students starts the very first day of the master's study programme and includes arranging both formal and informal interactions (Stenhammer and Sætren 2021). This further promotes a shared belief amongst individuals about whether it is safe to engage in interpersonal risk-taking in the workplace, or more precise, psychological safety (Edmondson 1999; Edmondson et al. 2007).

Mentors

Mentors were used before, during, and after the exercise. The use of mentors was found to be of specific importance to provide realism both for the facilitators in the scenario building and for the students during and after the exercise. This is in accord with Zigmont et al.'s (2011) learning outcome model, which specifically mentions mentors as a part of the learning environment for effective practice-based learning. The importance of the knowledge being created through the transfer of experience is the main aspect of Kolb's (1984) learning cycle. To be able to provide an experience that is adjusted and explained by experienced mentors is thus important in this transfer of knowledge.

Learning objectives

To know what to train for, the learning objectives must be articulated. The learning objectives should be clear before planning an exercise, as the preparations, degree of realism, and choice of scenario and mentors are based on the foundation of what the students are supposed to learn. Here, the learning objectives were the basis for developing the exercise.

Depending on what students are supposed to learn, the background of the students matters. Here, the students were all experienced in risk-related work, but the levels varied greatly, from hands-on operations to management. For this exercise, the management level and collaboration between sectors and management levels were of the essence. For adult learning, building on the experience of others is important, and including students in the steps was found to be of great value. This significantly influenced the learning process, creating new mental models (Eckert and Bell 2005; Endsley 2015; Kolb 2014), and the students had a sense of owning the exercise and partaking in a serious way.

Realism

Increased context realism and simulator-assisted exercises were found to positively affect the safety training process, which is in line with Zigmont et al.'s (2011) theory of learning. This might be of particular importance for rescue operations in the High Arctic, working in conditions that are more extreme than those in other areas (Khan et al. 2015; Lauta et al. 2017; Sydnes et al. 2021) and with potential outcomes that are incredibly destructive for the vulnerable environment and the people involved (Kruke and Auestad 2021). The simulated exercise created realism, and the mentors added knowledge about the system and best practices. Previous knowledge and trust among the actors were found to be important as was adapting the exercise to previous knowledge of both the operational context and the emergency response system. This underlines the need for meeting arenas and tailor-made training schemes, including the right composition of the groups training together.

Additionally, the seriousness with which the participants approached the exercise further emphasised the sense of realism in the exercise, as the students could build on their experience and the mentors and facilitators provided realistic scenarios and outcomes. The simulation exercise activated relevant prior knowledge and experience for students and provided an opportunity for them to learn from each other. For instance, if one knew the practice of establishing main priorities, they would do this in the group and let the others partake in the strategic process used. The participants' experience would then allow them to compare new strategies and tools with those they knew, enabling the students to reflect upon different practices (Eckert and Bell 2005) and increasing the margin for making human errors (Reason 1990) during the exercise and learning from them.

The learning outcomes from hands-on learning through full-scale emergency exercises are substantial. However, large full-scale emergency exercises on large accidents are expensive, time consuming, and resource intensive. In Arctic

conditions, they could also be dangerous for both people and the environment. Being able to provide exercises at the management level with a high degree of realism is thus beneficial from both a risk and a resource perspective. Even though the simulation equipment is expensive and requires competence on the part of the facilitators and staff, it has a longer lifespan, can be used for different exercises, and is situated in a safe context.

Evaluation

It is important that the learning process does not end once the exercise is completed. To achieve a continuous improvement process, learning from the experience is of great value for transferring knowledge (Kolb 1984). Evaluations of disaster exercises are important on several levels, including the individual, group, and organisational levels (Beerens and Tehler 2016). First, it is important for the student's learning process that they take part in the evaluation process. For the evaluation to be as broad as possible, several methods of evaluation were used for the exercise. The students participated in an after-action review immediately after the exercise was completed, during which all students and staff met in a classroom to discuss elements from the exercise they found important, including discussions concerning the learning objectives. This type of immediate reaction promotes different views and different perspectives, helps clarify misunderstandings, and is important for allowing the students to learn from each other (Eckert and Bell 2005). Additionally, the students were given a survey some weeks later, which included both closed- and open-ended questions concerning the exercise and their perceptions of it. This was an individual task that was conducted a few weeks after the first impression of the exercise.

Second, evaluation is important for the staff preparing for the next exercise for the exercises to undergo a continuous process of improvement. This is also linked to the preparations, as part of preparing for a new exercise is to consider past evaluations. Hence, the mentors and coordinating and academic staff took notes during the exercises and after-action reviews as well as from the written evaluation forms. In addition, they worked on their subjects of expertise between exercises, with some, for instance, writing books which were used later in lectures. This continuity of establishing, trying out, and transferring knowledge seemed to form the basis for a process of continual learning for both the students and the NORDLAB staff.

Challenges of simulation training of emergency management

Training with the use of simulation is resource effective and provides learning for those involved. However, there is a need to look at the challenges regarding such training, as it can never fully replace full-scale exercises. First of all, it depends on what it is to be trained and the technology used for training. For instance, VR training or simulators you step into, such as driving simulators, are known to potentially cause simulator sickness (De Winter et al. 2012; Sætren et al. 2018; Saghafian et al. 2020). Another challenge could be the technology itself. If the technology stops functioning optimally, technical staff is needed. Further, a delay of the exercise could result in less motivation for the students, and stopping during the exercise could hinder the flow of the training. Additionally, the students need to have basic skills related to the technological tools used for management and collaboration, such as CIM. Thus, preparations are often time-consuming for large-scale simulated management training sessions.

Further, the immersiveness of the situation is of importance (Kolb 1984). For emergency management training, the students are not present at the scene of any accident but rather are situated further away from the situation, just like in real life. However, the collaboration between different organisations, such as the police, community, and health services for instance, needs to be trained. Thus, the role play between different sectors and agencies conducted by students needs to be close to reality. This also necessitates thorough preparations in order for the students to be able to play the role sufficiently and know which responsibility each role entails. The computer-assisted training provides, for instance, images of the accident that the students can watch on a screen on the wall that resemble TV images. This improves the immersiveness.

Impact and further research

Research on simulated exercises in higher education for emergency management training during, for instance, SAR operations influences how knowledge transfer regarding how to conduct such exercises can be optimised for a broader audience. From a societal perspective, this is important, as well-conducted simulated exercises are far cheaper and less resource intensive than full-scale exercises. To know which factors influence an effective training process will thus affect several industries responsible for conducting and managing rescue operations in Arctic conditions. Additionally, this knowledge is useful for gaining knowledge on how to conduct exercises during crisis management training in challenging environments in general.

Because this training was conducted as a part of a master's level higher education programme by practitioners who conducted the study part-time while working in related occupations, knowledge transfer to the industry has

occurred. However, research on the long-term effects and the effects of this transferability is needed.

Last, even though student involvement is an important aspect of any learning process, exploring aspects of where and how student involvement in conducting exercises brings benefits would make an important contribution to the research on learning outcomes in the future.

Conclusion

To save lives and protect the environment in demanding conditions, providing training on emergency management during large-scale accidents is important. Our findings indicate that a pedagogical wheel consisting of six factors – preparations, psychological safety, mentors, learning objectives, context realism, and evaluations – promotes an optimal learning process in simulated-accident exercises in high-risk and highly sensitive environments. Simulation realism combined with proper knowledge and learning objectives may improve context-specific learning. The adult learning perspective helps to explain the importance of preparations, mentors, and evaluation as it allows learners to apply existing and new competences in the assimilation of knowledge. Considering the perspective of learning by simulation, psychological safety and mentors are the factors that contribute to experiential learning and reflection during a simulator-based exercise.

Thus, we recommend simulation-based exercises with a high degree of context realism for the physical actions during the incident and for human actions and interactions. In addition, tailor-made simulator-assisted exercises, which could address a broad range of crises, are recommended for an efficient learning process.

Funding Open access funding provided by Nord University

Data availability statement The data in this article cannot be made available because the data are based on qualitative interviews where indirect personal information can identify the informants. We do not have ethical approval for this distribution prior to data collection.

Declarations

Conflict of interest The author declares no competing interests

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