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Simulator Training for Offshore Oil and Gas Emergency Preparedness

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Abstract

Lifeboats are essential life-saving equipment for many types of vessels and offshore platforms, such as oil rigs. Although their purpose is for an emergency escape, possibly in rough seas, coxswains usually learn to launch and maneuver the lifeboat on calm waters to avoid risks during training. Simulators have been created specifically for offshore oil and gas personnel to practice in conditions that are normally prohibitive. A human factors study was performed to investigate learning and skill acquisition of new coxswains as they completed training over a year, emulating industry practice of performing quarterly drills. On completion of training, participants were evaluated in a plausible emergency scenario. Exercises were performed in a simulator to provide consistent training conditions and to provide exposure to moderate wave conditions and hazards during assessment. Results indicate several practice sessions are needed to prepare trainees for an emergency lifeboat launch.

1.0 Introduction

The retention of knowledge and skills obtained through training is important for the successful launch of a lifeboat in an emergency. As the launch of a lifeboat is not a routine event, participants are required to practice regularly to maintain the requisite skills. In the event of an emergency, lifeboat coxswains are expected to be able to successfully launch and operate a lifeboat in environmental conditions that prevail in the location of their operation. As an example, for operations in the North Atlantic Ocean, annual average winds speeds range from 12-20 knots, and mean annual wave heights are 3-5 meters (C-Core, 2015). It is also plausible that an emergency event will involve hazards such as fire and smoke.

Lifeboat coxswains are typically required to complete an initial training session at an onshore facility, followed by regular recurrency training. Initial training typically consists of a 3-5 day course that includes a combination of classroom training, followed by hands-on training on the launch of the lifeboat. Recurrency training is normally conducted quarterly (every 3 months) and involves launching the vessel and performing simple maneuvering tasks in the water. To minimize the risk to people and assets, quarterly lifeboat exercises are performed in calm water.

Coxswains are expected to be competent in the launch of the lifeboat in an emergency at any point following initial training. It is assumed that their training and practice provide enough experiential learning to achieve and retain competence.

2.0 Research Objectives

The study presented here investigated the amount of training needed to achieve a targeted level of competence. The research had two primary objectives: a) to assess skill acquisition and retention as trainees progress through a yearlong training program, and b) assess how the skills acquired in the training program transfer to a plausible emergency scenario. The amount of skill acquisition and retention achieved with practice at planned intervals allows us to determine if the training is sufficient. The transfer of skills from quarterly drills practice to an emergency scenario is an indicator of the effectiveness of the training that has been applied.

A secondary objective was to observe how different types of skills are learned in training emulating industry practice of performing regular drills to maintain competence. The task of launching a lifeboat includes sequential cognitive tasks with some physical operation of equipment to complete skill-based tasks. The study measured how skills are acquired for different task types and how these skills transferred to an emergency scenario.

3.0 Skill acquisition and retention

Scientific literature and experience indicate several factors that can affect skill acquisition and retention. These include the frequency and amount of training that is received, the type of task, variability and fidelity of the training exercises, and individual differences between trainees. Skill decay is known to be problematic in situations where individuals receive initial training and are not required to use the skills over extended periods of time (Arthur et al., 1998). The effects of practice are expected to weaken as the time between practice increases. The longer the delay between skill acquisition and retrieval, the more will be forgotten (Driskell, 1992).

Lifeboat practice is normally conducted as a straightforward launch in benign weather conditions, with little variability between practice events. Research has emphasized the importance of gaining experience in scenarios with similar cues and stressors as the operational environment to develop mental models and improve decision making (Klein, 2008). Repeated exposure to the same scenario may decrease stress and cognitive difficulties on that scenario, but the effect does not necessarily generalize to new scenarios (Baumann et al. 2011). Research has indicated variability in training encourages learners to focus on the structure of problems, providing beneficial results in training transfer (van Merriënboer et al., 2002). Some research has debated that variability in practice scenarios is not as important as the amount of practice performed, or the structure of the learning events (Van Rossum, 1990).

Complex tasks involving a variety of tasks, such as a lifeboat launch, is of interest as different skill types have different lengths of skill retention. Cognitive closed-loop tasks involving discrete responses and fixed sequences (e.g. pre-flight checks) are not as easily retained as continuous open-loop tasks involving tracking and problem solving (Arthur et al., 1998, Schendel, 1992, Wickens et al., 2013). Some tasks in a lifeboat launch are sequential and procedural closed-loop tasks requiring mental checks and recall of information. Other tasks are more physical and require application of motor skills to complete the tasks (i.e. opening a hook release, applying a throttle, steering). Retention of cognitive and physical skills is dependent on the type of practice performed and the amount of mental practice between assessment events (Arthur et al., 1998). Considering the type of tasks being performed, there is expected to be an establishment of both procedural memory and declarative memory as participants practice. For complex tasks involving both procedural and declarative components, it is suggested to train the procedural components first (Wickens et al., 2013).

Simulators have been widely used to assess performance in operational conditions using scenario-based training exercises. Both high and low fidelity simulators have been used to investigate human performance in flight (Tran & Hernandez, 2004, Hoffman et al., 2010) as well as medical (Stefanidis et al., 2007) and marine operations (Sellberg, 2017). This study provides an additional case of how a simulator can be used to measure performance in an exercise that would otherwise be prohibitive due to risks and logistics.

4.0 Methodology

A test program was developed to emulate industry practice of receiving initial lifeboat training at a shore-based facility, followed by performing a practice lifeboat launch every quarter. The study was performed using naïve participants with no previous lifeboat experience. At the end of one year, following the quarterly practice sessions, an assessment exercise measured how the skills acquired by the participants transferred to a plausible emergency event that required the launch of the lifeboat in weather conditions typical of offshore operations. Figure 1 illustrates the elements of the study. A lifeboat simulator was used to provide consistent training at planned training intervals. The simulator provided a means to measure performance in a scenario that was too risky for a live exercise.

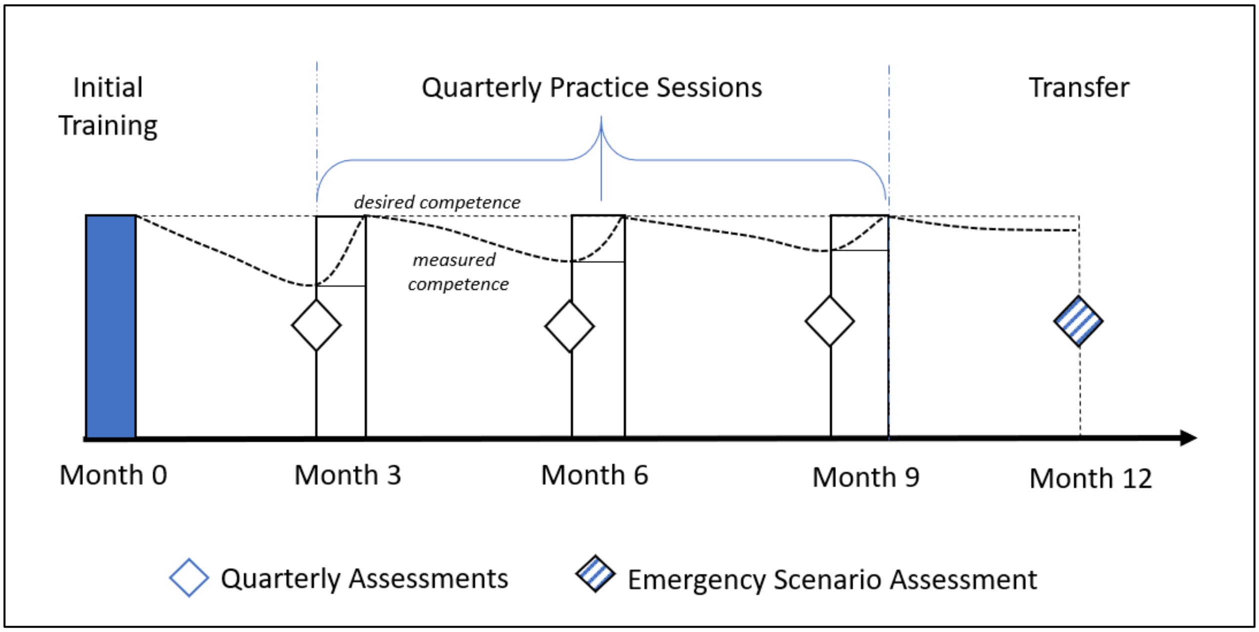

Figure 1: Study Timelines

Phase I - Initial Training

Initial training of naïve participants consisted of a combination of classroom training from an instructor and familiarization exercises with the simulator. Participants were taught the sequence of actions needed to safely launch a lifeboat from the davits using training derived from competencies identified in the Standards of Training, Certification and Watchkeeping for Seafarers (IMO, 2010). A guided tour of a lifeboat was also given to familiarize the participants with the appearance and location of equipment in the lifeboat, thereby providing knowledge needed to inspect the lifeboat prior to launch. Participants were given a fifteen minute simulator exercise to become familiar with the lifeboat simulator.

Participants then completed a simulator scenario that required them to demonstrate the fundamental skills to inspect and launch the lifeboat. To ensure a baseline competence was achieved, participants repeated the scenario until they were able to complete all tasks.

Phase II – Quarterly Assessment and Training

Quarterly sessions were performed approximately 3 months, 6 months, and 9 months after initial training. Participants performed the same launch task scenario in the simulator at each session. The scenario included completing a Pre-Launch Inspection (PLI), lowering the boat to the water, and driving to a safe zone. To emulate industry practice, the launch conditions were calm weather and there were no equipment faults. The first practice attempt was used to assess the trainee's ability to launch the lifeboat three month's following their previous training session. Trainees repeated the scenario, if necessary, until they could complete all launching tasks, thereby returning to the baseline competence.

Phase III – Transfer to an emergency scenario

After completion of three quarterly training sessions, and following an additional 3 months without practice, participants performed a lifeboat launch in a plausible emergency scenario that included more adverse weather conditions than they had experienced in training, as well as hazards. The assessment was performed in the same simulator used in the quarterly practice sessions.

The scenario comprised of an emergency event in weather conditions that were representative of common operating conditions in the North Atlantic. The parameters of the scenario were set to night time with clear visibility, 13 knot winds, and a 3 m wave height. A scenario briefing was provided to give context for the emergency event and to differentiate the exercise from a practice drill. The briefing indicated that an explosion on the platform had been heard, followed by a fire alarm. The Offshore Installation Manager (OIM) had ordered evacuation from the platform by lifeboat, and the duty of the participant was to launch the lifeboat and assist in a search and rescue exercise once in the water. Figure 2 provides an overview of the emergency scenario. This image was also provided to the trainees in the briefing.

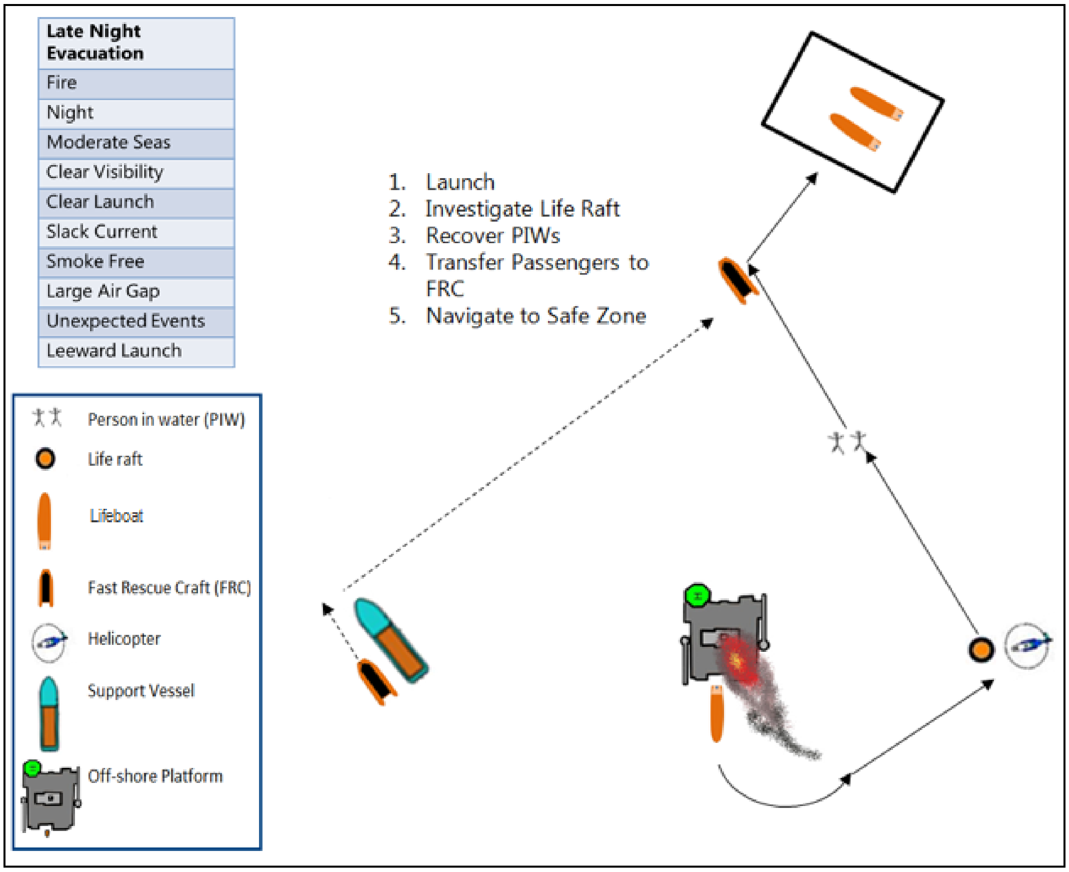

Figure 2: Emergency Scenario

Performance was measured using the same rubric used in the quarterly practice drills. In the emergency exercise, the participant had to take additional actions for conditions not present in the quarterly practice scenarios, such as turning on the air system and sprinkler to deal with fire in the scenario. The visibility was reduced (night scenario) and weather conditions made some tasks more difficult.

4.1 Launch Task

The launch of a lifeboat involves a series of cognitive and physical tasks that have to be completed in a specific order. Tasks include inspecting the lifeboat and emergency equipment prior to the launch, performing a series of actions to lower the lifeboat to the water surface, releasing the lifeboat from fall wires, and maneuvering to a safe zone away from the platform.

The launching system modeled a twin fall gravity davit, which is commonly used on oil and gas platforms. Coxswains are required to inspect the vessel prior to launching. A PLI is performed prior to entering the boat to ensure there is no fault with the lifeboat or launching system that could hinder the launch of the lifeboat (e.g. maintenance pendants are in place). To lower the lifeboat, the lifeboat operator pulls on a brake release wire from inside the lifeboat, thereby activating a hydraulic system to make the lifeboat lower at a constant rate. Once in the water, a hydrostatic indicator indicates the boat is buoyant. The operator moves a mechanical arm to open up the fore and aft hooks simultaneously. The vessel is then released from fall wires and can maneuver freely. The coxswain then must drive the vessel away from the platform and away from any hazards (e.g. debris or fire on the water) to complete the launch.

The presence of waves makes the release of the boat more difficult. The coxswain must make sure the boat is completely buoyant before releasing the lifeboat hooks. The rising and falling of the waves can create temporary buoyancy on the crest of the wave, which vanishes when the wave falls. In this case, the release task requires the participant to pay closer attention to the hydrostatic indicator to ensure the vessel is completely in the water and not just touching a wave crest.

4.2 Performance Measurements

The scoring criteria for all launch tasks were identified by a subject matter expert to reflect a standard of proficiency as identified in recognized training standards, including the Standards of Training, Certification and Watchkeeping for Seafarers, and model lifeboat courses (IMO, 2010). A scoring rubric was established to identify measures of task performance. Table 1 provides a list of performance measures used in the study. Tasks are categorized as cognitive or physical tasks based on the type of action required to complete the task.

Table 1: Performance Measures

	Task Name	Task Objective	Expected Performance
Cognitive Tasks	**PLI – Critical Errors**	Perform visual Inspection of lifeboat in-preparation for launch and ensure no equipment is stopping vessel launch	No critical errors made in equipment inspection to prohibit launch
	Permission to Launch	Obtain permission to launch from OIM	Communicate with instructor (as OIM) requesting permission to launch
	Inform Crew Prior Launch	Inform Crew prior to Launch – “Launching,	Verbal order given to instructor

		Launching”	(as crew member)
	Lower w/o stopping	Pull brake release, lower lifeboat without stopping by keeping tension on release	Vessel lowered continuously without stop
	Sprinkler and Air	The student orders the use of sprinkler and air system after being informed of gas, smoke or fire.	If hazard present, verbal order to instructor (as crew member) to turn on air and sprinkler
	Engine Started	Ensure engine is started before lowering/splashdown using engine turn key	Engine on before water entry
Physical Tasks	**# of re-entries**	Ensure lifeboat completely enters water and is fully buoyant before releasing hooks by looking at hydrostatic indicator on hook release or visual cue.	Vessel is lowered to become buoyant on first attempt with no weight returning to falls
	Splashdown zone	Promptly Release Hooks using hook handle release and apply throttle	Release hooks within 10s, apply throttle within 5s
	Contact with platform	Maneuver vessel and do not make contact with platform after release of hooks	No collisions detected
	Clear Away Zone	Safely leave clear away zone by moving away from rig quickly and avoid hazard.	Clear platform within 45 seconds and move away from rig and any hazards

Actions are expected to be performed in sequence, except for operation the sprinkler system, which can occur any time before entering water. A total of 9 tasks were required to be completed in the quarterly scenarios. In the emergency scenario, an additional task of turning on the sprinkler and gas was tracked as the participants needed to respond to a fire hazard in the scenario. This task was identified in initial training, but was not practiced in the following quarterly sessions.

In the study, all parts of the launch task were completed in the simulator, except for the PLI, which was conducted prior to starting the lifeboat launch. A PLI normally involves visual examination of the lifeboat’s exterior on deck and internal checks. In the study, PLI pictures were used instead and the trainee had to determine if a given picture represented a correct or incorrect equipment state. Identification of correct state of equipment was needed to allow for a safe launch (i.e. removal of maintenance pendants, brake cable present).

In each of the assessment scenarios, an instructor managed and evaluated each participant. The instructor identified all errors made based on the rubric. The practice exercises in the study used interactive scenarios that required the participants to perform voice commands and use lifeboat equipment as needed. The instructor role-played as an OIM or crew member in specific tasks (e.g. receiving command to turn on sprinkler system) and acknowledged receipt of voice commands. If the student requested assistance from the instructor, the task was considered to be incomplete. All measurements made during a training session were made by the same instructor.

4.3 Simulator

Participants completed lifeboat launching tasks in a simulator with a representative layout and equipment of a real lifeboat. The simulator used in the study is certified by Det Norske Veritas Germanischer Lloyd (DNV-GL) and Transport Canada as a simulator capable of representing realistic situations needed for training. The simulator provides a visual mockup of the lifeboat and is equipped with real lifeboat equipment (e.g. steering wheel, throttle, brake release, compass) allowing participants to operate the controls needed to launch the lifeboat. The visual environment is displayed using Liquid Crystal Displays providing virtual models of the waves, weather conditions, and floating objects as seen through the windows of a lifeboat. The simulator cabin provides a seat and viewpoint corresponding to the real lifeboat. Sound effects are provided by surround audio system. A picture of the simulator is shown in Figure 3. This simulator was used previously in research studies to measure skill transfer associated with training to maneuver a vessel (Magee et al., 2016).

Figure 3: VMT Lifeboat Simulator Interior and Modelled Lifeboat

The simulator's vessel motion and propulsion was modeled based on an actual lifeboat that is approximately 9.4 m long, 3.5 m high with a draft of 2.9 m. The vessel is able to carry up to 72 people with a loaded weight of 11506 kg.

4.4 Participants

The study used participants who had no previous lifeboat experience. Sixteen volunteers between the ages of 18 and 65 were recruited. Four participants dropped out of the study due to time commitment and scheduling conflicts, as the experiment was carried out over a year. Recruits were expected to be unfamiliar with the lifeboat operation and launch procedure and were not allowed to participate if they had previous lifeboat experience.

5.0 Results and Discussion

The primary indicator of retention was the ability to complete all launch tasks on the first attempt in each of the quarterly assessment exercises. The analysis of first attempts is a measure of skills retained from former practice. A secondary measure was the number of attempts, or trials to criterion, taken by the participant to reach competence following assessment.

Performance in the emergency scenario in the final session of the experiment is an indicator of skills transfer from training to a plausible emergency event. For this scenario, the ability to complete all tasks on the first attempt provides an indicator of performance in a situation where a second attempt would not be possible.

The frequency of errors made by the group in completing individual tasks during assessment was also investigated. The study assessed how effectively cognitive and physical skills were acquired in the quarterly training sessions and how skills transferred to the emergency scenario.

5.1 Quarterly Retention – First Attempt

The results indicate a progressive increase in the number of successful task completions on the first assessment exercise, as indicated in Figure 4. On completion of initial training, participants were able to complete the 9 tasks that constituted the baseline competence level. The retention results in Figure 4 show evidence of skill fade in the first assessment exercise performed 3 months following initial training, followed by improved performance in assessments performed at month 6 and month 9. In the first assessment (month 3), trainees completed an average of 6.92 of 9 tasks successfully (mode 8, standard deviation of 1.88). This increased to an average of 7.92 (mode 8, standard deviation of 0.9) at month 6. At the third session, this average increased to 8.67 (mode 9, with standard deviation of 0.78).

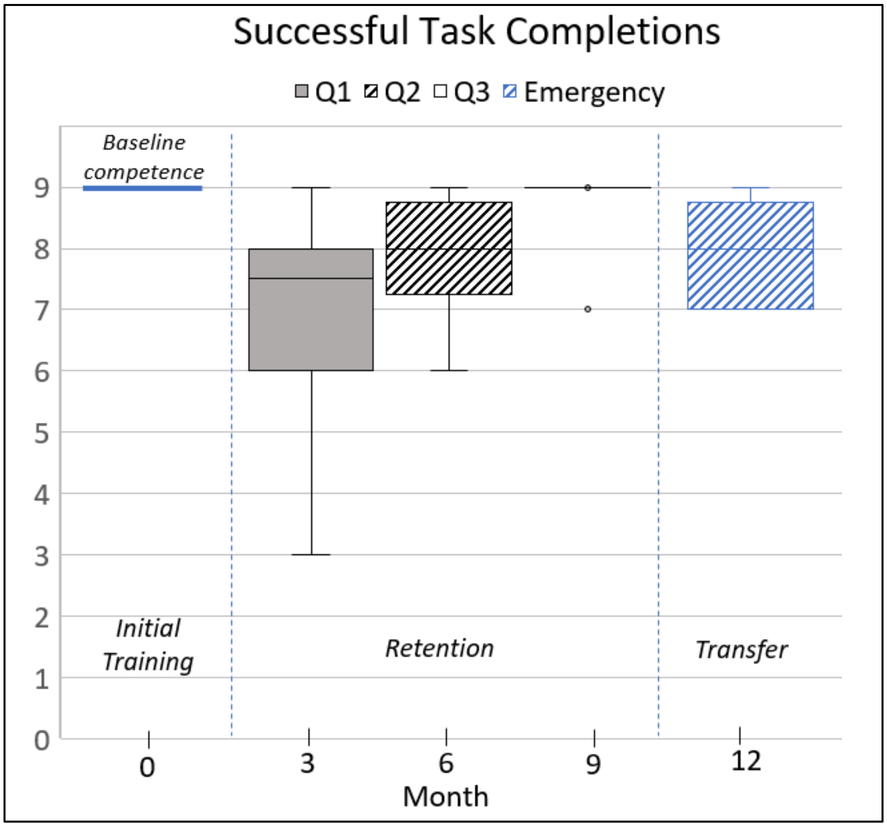

Figure 4: Task Completions - Retention and Transfer

A Friedman test for repeated measures (a non-parametric version of an ANOVA for repeated measures) yielded a value of χ2 (2 degree of freedom) of 12.7, probability (p) < 0.0053, indicating a significant difference among the medians measured in each quarter. In order to determine which sessions were significantly different from each other, pair-wise comparisons using the Wilcoxon T-test were made. The analyses found reliable difference between 3 and 6 months, but no reliable difference between 6 and 9 months (p < 0.05). There was also a significant difference found between the assessment performed in month 9 and the emergency evaluation assessment in month 12.

5.2 Quarterly Retention – Trials to Criterion

Figure 5 shows the number of trials required by the participants (n = 12) to successfully launch the lifeboat in the simulator each quarter after initial training.

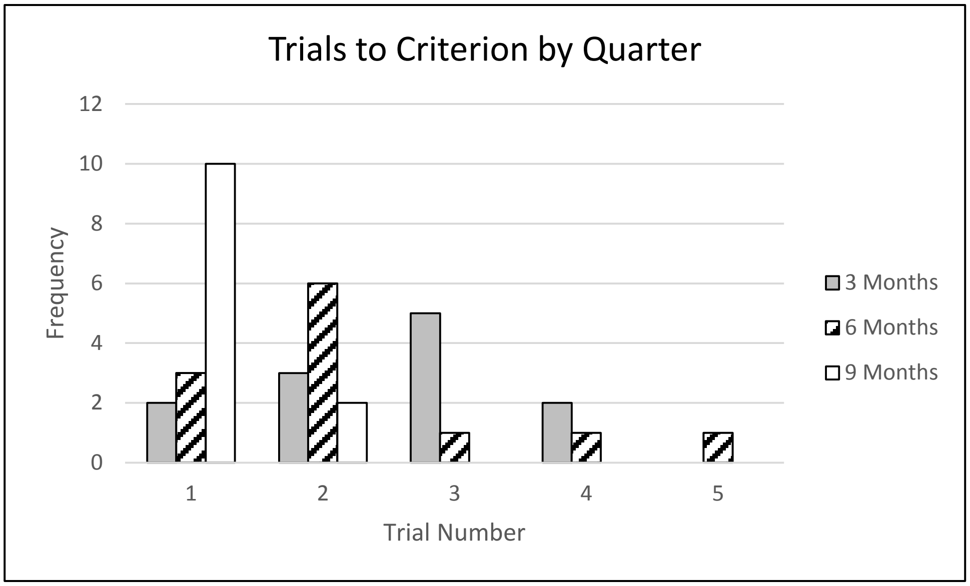

Figure 5: Number of Trials Needed to Achieve Competence

The bar graph for the first quarter shows that 2 participants were able to complete all launch tasks on their first attempt after initial training, even though all 12 members of the group had previously achieved competence by the end of initial training. Three members of the group achieved success on their first attempt at 6 months, and 10 members achieved success on their first attempt at 9 months. The medians of the number of attempts needed to achieve criterion for these quarters are 3.0, 2.0, and 1.0 respectively.

A Friedman test of the medians yielded a value of $\chi 2$ (2 degree of freedom) of 10.8, probability (p) < 0.0045, indicating a significant difference among the quarterly medians. Wilcoxon T-tests found no reliable difference between 3 and 6 months, but reliable differences between 3 and 9 months and between 6 and 9 months.

5.3 Skills Transfer to Emergency Scenario

The assessment exercise performed at month 12 measured transfer of the skills acquired through 9 months of repeated training to an emergency scenario. Referring again to Figure 4, a comparison of the performance in the transfer session indicates a reduction compared to performance at the month 9 assessment. In the final emergency scenario, the average number of completed tasks dropped to 7.92 (from 8.67) with a standard deviation of 0.79. Three of the twelve participants (25%) were able to complete all tasks on their first attempt when tested in the final emergency scenario, compared to ten of twelve (83%) who were able to complete the tasks on their first attempt in the third quarterly practice session. Pair-wise comparisons using the Wilcoxon T-test found reliable difference between the assessment performed in month 9 and the emergency evaluation assessment ($p < 0.05$).

5.4 Individual Task Analysis

Analysis of the individual tasks provides further insights into the performance of the group. Figure 6 shows the frequency of errors made in the assessment scenarios.

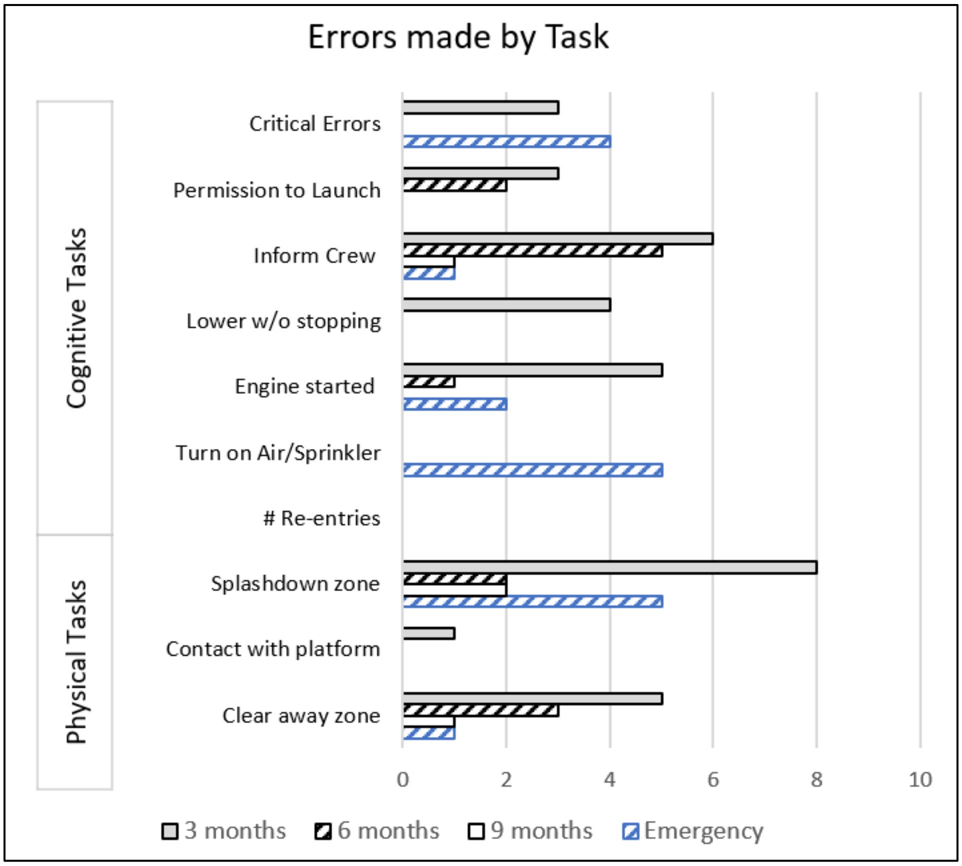

Figure 6: Errors Made During Launch on First Attempt

Errors related to cognitive closed-loop tasks, including inspection (PLI), tasks involving voice commands (i.e. permission to launch), and lowering tasks (lowering and starting engine), were not evident in the third quarterly practice session at 9 months. Errors related to physical tasks, including the release of the lifeboat and maneuvering to a safe zone, were reduced with more practice sessions, but not eliminated. This result indicates participants were becoming more proficient on these skill-based tasks through quarterly practice.

The number of errors made by the group on tasks common to the third quarterly session and the emergency scenario increased from 4 to 13. There was an increase in errors made during the pre-launch inspection and remembering to turn on the lifeboat engine. Performance on procedural tasks involving voice commands and lowering the lifeboat did not deteriorate. A hazard condition was introduced in the emergency scenario that required participants to draw on their initial training to remember to turn on air and sprinkler. 5 of 12 participants did not take action to deal with the hazard. Participants also had more difficulty in releasing the lifeboat, as evident in the increase of errors from

Q3 (8%) to the emergency scenario (42%). The waves in the emergency conditions were worse than the conditions in which the participants had trained.

6.0 Discussion

The study presented here provides a profile of the learning achieved by naïve participants as they progressed through a year of simulator-based training. The simulator provided a consistent and repeatable means to measure trainee performance. It also provided the only means to safely assess performance in a dangerous scenario.

The study was designed to investigate the retention and transfer of specific skills after an initial training protocol that ended once the participants demonstrated competence in the same skills. Memory decay for launch procedures was found to occur between quarterly practice sessions, despite prior training to criterion. We found that accumulated practice with quarterly intervals improved retention. Following initial training, two quarterly practice sessions were needed before more than half of the participants were able to complete all tasks on their first attempt three months following practice (month 9). Training to competence at quarterly intervals did not ensure success at nine months as two members of the group were unable to perform the task successfully despite having reached competence on three previous occasions. Errors made during the first launch attempt were reduced with additional quarterly practice sessions. Most cognitive skills and physical skills were successfully demonstrated after three practice sessions.

The accumulated benefit of quarterly practice did not fully prepare trainees to deal with the novel emergency scenario that was presented in the final session. Errors made in the emergency scenario indicate that the hazard and environmental conditions had an impact on performance of cognitive tasks. Tasks involving voice commands showed effective transfer to the new scenario. Performance of the physical task of releasing the lifeboat worsened. This is likely due to the unfamiliar motion of the vessel as it entered waves. Most participants were able to clear the platform successfully once in the water.

tThere are ways to improve skill retention and performance of procedural and motor tasks. In the study, trainees used a repeated scenario and practiced until they were able to successfully complete all launch tasks in the same exercise once, and they were considered competence based on this criterion. Other pedagogical approaches, such as overtraining, could be employed to improve retention between practice sessions. Providing variability in training scenarios can increase the trainee’s ability to relate tasks to new problems (van Merriënboer et al., 2002). Allowing the user to practice in scenarios that are representative of the operational conditions where they will most likely have to apply their skills can help improve skill transfer and performance (Klein, 2008). Allowing trainees to practice in stressful environments has been shown to improve performance in stressful operations (Mclernon, 2011).

Future studies are planned to determine the impact of increased training frequency, additional training time, and use of representative scenarios on time to competence and retention of skills. These studies will evaluate how simulation can be used to continually assess performance and create tailored training programs to obtain and retain skills. Tailored training can include more frequent practice on specific skills, and application of skills in novel scenarios to improve skill transfer.

Acknowledgments

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