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e-Navigation Journal

Original article

Maritime Simulator-based Training in Sri Lanka: Tolerance Limits for Freeze Probes during Open Sea Scenario Phase

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Abstract

This study introduces the Three-Memory-Model (Cherry, 2019) in education into Maritime Simulator- based training in Sri Lanka and conducts empirical research. In simulator-based education what is disseminated as knowledge during the Briefing, Scenario and Debriefing phases must be transferred from short-term, across working memory to long-term-memory. Working memory gained during the scenario phase, could be encoded into long-term-memory through rehearsal probes. But the number of probes which could be tolerated by the participants of simulator-based training has not undergone empirical investigation. Thus, selecting the Open Sea scenario phase as its setting the research questions aim to identify tolerance limits in the participants for the number of freezes and the number of probes introduced during each freeze. The methodology selects a population of seafarers (n = 60). Through stratified random sampling this population was subdivided based on experience at sea as Group A (n = 30): Mean of 2 years and Group B (n = 30): Mean of 13.6 years of sea experience. The duration of the open sea scenario phase is 35 minutes with freezes at 10-minute intervals. The number of probes were given a range of 7 to. Data analysis utilized SPSS. The highest percentage mean value was obtained for three freezes for the Open Sea scenario phase while two freezes had the next highest percentage mean value. The mean value of the tolerance limits for questions during one freeze is approximately 9 and 6 probes for Group A and B respectively. Citing prior research on working memory, visuo-spatial vs. verbal working memory, reaction time and age this study raises a counter argument against the findings: the self-declared tolerance limits of the number of questions the participants feel comfortable to answer during each freeze. The findings of this research are valuable to maritime Simulator-based instructional designers outside and within Sri Lanka.

Keywords: Three-Memory-Model, open sea scenario phase, freeze probes, reaction time, age

https://doi.org/10.52820/j.enavi.2022.18.018

1. Introduction

1.1 Simulator Based Training and Education

Currently, in the maritime domain, simulator-based training and education is a significant, integrated component. Several aspects of the maritime industry, from offshore operation training on vessels and oilrigs to onshore training of crane operations and Vessel Traffic Services, offer possibilities for professional training in tertiary educational settings (Crichton 2016). Wilson et al. (1998) identify the benefits obtained from the use of simulators in training as follows:

• Provision of an environment where learners practice the theoretical concepts that have been taught and show the consequences of actions in a very immediate and visual manner.

• Instructors have a controlled environment where a large amount of data can be recorded and analyzed to evaluate the trainee's evolution/ performances.

• Experience is gained in handling real machines to avoid danger situations.

• Reduces costs associated with training operations.

• Provide trainees with the possibility of working in any arbitrary weather conditions.

Agreement comes from Lützhöft at al. (2017) who state that Simulator Studies are risk-free, repeatable, controllabl e, conducive towards data assimilation and efficient. Literature identifies three main phases in Simulator instruction.

Briefing phase: This is the introduction and is commonly focused on practical information regarding the upcomin g scenario and the learning objectives (Wickers, 2010).

Scenario phase: During the scenario, instructions are prompted by observing students actions on a screen in the instructors' room. When it is evident that the students display lack of understanding of how to continue, a closer inspection of their performance is done. Instructions that maintain the activity or for straightforward directives on what to do next are provided. Instruction based on sensitivity to the material enhance skill acquisition and "draws pedagogical strength from exploitation of the unique details of particular situations" (Suchman 2007, p.45). Additionally, instructions in the course of actions are frequently designed as a series of corrections (Lindwall et al. 2015).

O'Brien and Meadows(2013). identify two fundamet al and inter-related skill requirements during the scenario phase:

• Situation assessment – "what's the problem"

• Decision making – "what shall I do".

Barnett (2004) stated that the use of simulation in providing solutions to the problems of risk and crisis management and the optimal use of crew resources. Barnett (2004: 8) further claims that the nature of crisis situations suggests that there are at least two specific training requirements for the development of situation al awareness and decision making skills:

• To develop a general critical thinking skill which resolves conflicting information and tests the assumpti ons on which decisions are based.

• To provide exercise scenarios in which the individual's mental models of systems, situations and the cues by which they recognize them, may be tested and enriched.

Debriefing phase – In the debriefing phase, the prospective instructions in the briefing are revisited, connecting the particular scenario back to the general learning objectives of the exercise. In this phase, instructions take the form of assessment, providing feedback that is connecting the practical actions to the theoretical content of the course and to professional concerns.

Debriefing "transforms experience into learning" (Hontvedt and Arnseth, 2013: 92). This consists of a post-experience analysis and group reflection of the scenario where learners understand, analyze and synthesize their experiences, thoughts and feelings during the scenario (Fanning and Gaba 2007). Playback of prior actions makes learners accountable and instruction and assessment of specific details of the students' prior conduct is possible.

In simulation-based training, it is a common practice to use different technologies that reconstruct the scenario to enable post-simulation feedback and reflection. Ontvedt and Arnseth (2013) state that the ship simulator shows great potential as an educational tool. Castells et al. (2015) stresses on appropriate assessment methods which measure the mariner's competencies quantitatively and continuous ly during the training period. But what is absent is theory based instructional design within the genre of Maritime Simulator-based Education.

In light of these considerations, the purpose of this research is to examine whether two selected theories in education: Three-Memory-Model van den Berg, & Ma(2014) and Cognitive Load Theory on Instructiona l Design (Sweller, 1988) can be applied to maritime simulator training. In this respect this research paper is organized as follows: first, in the introduction the background of educating seamen and the use of ship simulators is conducted. Then an account of the theoretical and analytical perspectives that informed the study is provided. Next a discussion of the methodological issues is presented. Finally, analysis of the data is followed by a discussion with some final remarks regarding the conclusions.

1.2 Theoretical Framework

The research methodology of this investigation is informed by the following theories.

1.2.1 Three-Memory-Model

In simulator based education what is disseminated as knowledge has to be transferred from short-term across working memory to long-term-memory to be used during seafaring. Atkinson & Shiffrin in 1968 developed the Three-Memory-Model and since then it has had many adaptations and gained recognition as an important component in the process of gaining and accumulating information. The Three levels of Memory are: Sensory-Memory, Working Memory and Long-Term-Memory.

As illustrated in Figure 1 below the short- and long-term memory stores differ in duration, and in capacity. Items in short-term storage decay as a function of time.

Long-term memory (LTM) is linked to the creation of mental models. Jones et al (2011) state that Mental models are personal, internal representations of external reality that people use to interact with the world around them. They are constructed by individuals based on their unique life experiences, perceptions, and understandings of the world. Because our working memory capacities are limited, we rely on information stored in our long-term memory in the form of particular mental models (Endsley, 1995b). Long term memory has an almost limitless capacity to retain information, but it could never be measured as it would take too long.

Cherry(2019) claims that memories that are frequently accessed strengthen the neural networks in which the information is encoded. Thus, they become much stronger and easier to recall, leading to the easier recollection of the information. On the other hand,

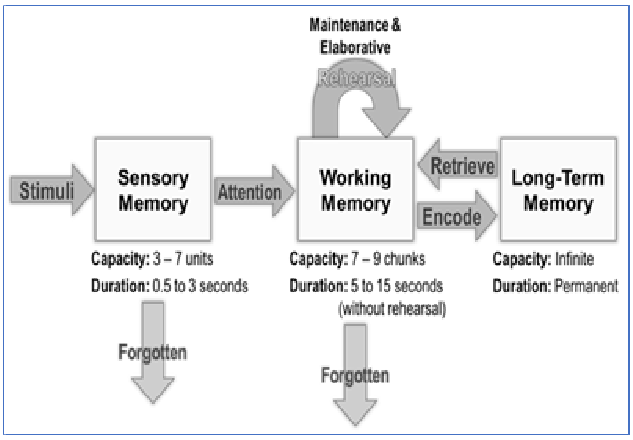

Figure 1:Information Processing Model ((Dataworks Curriculum, 2014).

memories that are not recalled often can sometimes weaken or even be lost or replaced by other information. Thus as illustrated in Figure 1 above elaborative rehearsal attach meaning to ideas presented, making students efficiently encode new information.

Information processing model of this study is based on the Three-Memory-Model identifies the need for Working memory activating many areas of the brain that include LTM. According to Baddeley(2000), working memory manipulates information storage for greater and more complex cognitive utility. Working memory is closely linked to LTM, and its contents consist primarily of currently activated LTM representations.

1.2.2 Working Memory, Reaction Time and Age

Shalby (2014) after studying 3,305 people ages from 16 to, found that the brain's response time begins to decline at age 24. The descent is a slow, but nonetheless, steady one. The results suggest that the age-related slowing in visual choice reaction time tasks latencies is largely due to delays in response selection and production.

Agreement comes from other scholars (Knight and

Nigam, 2017; Wyss-Coray, 2016) who state that with increasing age cognitive performance slows down including cognitive processes essential for motor performance. Tasks become less automatic with increasing age (Heuninckx et al., 2005; Wu and Hallett,2005) and especially complex motor tasks require increased cortical control with increasing age (Heuninckx et al., 2005).

Analyzing crewing demographics Bergeron (2018) states that the average age of a Master in the Maritime field is 47 years and the percentage of seafarers aged 55 and older has grown. In 2000 they represented 4% of the work force – by 2015, they were 11%. The Certificate of Competency (COC) ensures that the person has the sufficient knowledge and skills to sail on ocean going vessels.

When seafarers who apply for COC undergo simulator training, during the scenario phase many factors predicting work ability are identified as it entails the location for generating working memory. Numerous studies recognize that working memory declines with age (Ziaei et al., 2017). Hence, older seafarers are expected to perform poorer on a working memory task when making comparison with relatively younger task takers. Such decline has been shown with different paradigms like the delayed recognition task (McNab, 2015) or the so called n- back task where a currently presented stimulus should be compared with previously presented stimuli(Nyberg et al., 2009). According to Schmiedek et al.,(2009) functional decline in working memory can be already observed in middle-aged participants (i.e., between 40 and 65).

This bears practical relevance to this study as middle-aged sea farers such as Group B participants are still active in working life. Wild-Wall et al (2011) claim that the performance of the middle-aged vs. young participants in their study was characterized by a general decline of performance under high working memory load. Wild-Wall, Falkenstein and Gajewski (2010) identify a generally slower response times (RT) in the middle-aged compared to the young participants in their study.

Furthermore, during the scenario phase visuo-spatial information is presented along with verbal queries. According to Bradford and Atri (2014) visuospatial function refers to cognitive processes necessary to identify, integrate, and analyze space and visual form, details, structure and spatial relations in more than one dimension. Visuospatial skills are needed for move ment, depth and distance perception, and spatial navigation. Thus, a scenario phase generates visuo-spatial working memory and verbal working memory which is responsible for temporarily storing verbalizab le information.

Klencklen et al (2017) claim that visuo-spatial working memory has been shown to exhibit a greater age-related decline than verbal working memory which is responsible for temporarily storing verbalizab le information.

In light of the above, this study selects Seafarers with an average of 2 years sea experience on ocean going vessels following operational level (Group A; n = 30) and Group B: seafarers with an average of 13.6 years of sea experience following Managerial level courses at CINEC with a Simulator module (n = 30).

1.2.2.5 Research Questions

Selecting the Open Sea scenario phase as its setting the research questions given below aim to identify tolerance limits in the participants for freeze probes and the number of questions within a freeze.

1. Given a range of 1-5 how many freezes will seafarers be comfortable with during a simulator exercise?

2. Given a range of 7 to 19 what is the number of Freeze probes which could be tolerated by the participants with less than two years' experience within one freeze during a simulator exercise?

3. Given a range of 7 to 19 what is the number of Freeze probes which could be tolerated by the participants with more than 6 years of experience within one freeze during a simulator exercise?

The working definitions for the purpose of this research:

Freeze: Pausing the simulation at a given moment of time during a simulator exercise Freeze probes: Pausing the simulation and questioning the candidate to analyze the level of awareness of a situation.

The duration of the open sea scenario phase is 35 minutes with freezes at 10-minute intervals.

2. Methodology

2.1 Population

This study utilized two populations of seafarers following course work for COC.

Group A: Seafarers with an average of 2 years sea experience on ocean going vessels following operation al level (n = 30). They were less than 35 years old.

Group B: seafarers with an average of 13.6 years of sea experience following Managerial level courses at CINEC with a Simulator module (n = 30). Their age was between 35 – 55 years.

The groups consisted of numbers ranging from 3-12 while for each Open Sea scenario phase number of participants accommodated within the simulator per session were <4.

Group A and Group B were formed according to their level of Certificate of competency. Operational level COC holders included under group A and manage ment-level COC holders included in group B; the average sea experience observed was 2 and 13.6 years within groups respectively.

2.2 Sampling mode

Electic and included stratified random sampling or/and Convenience sampling.

2.3 Instruments:

a.Questionnaire for Tolerance limit identification of freeze probes.

b.Data sheets for recording Tolerance limit identification of freeze probes of individual participants during the Scenario phase.

2.4 Procedure:

The research took place in a full-mission bridge simulator where a physical replication of a ship bridge is placed in front of a 180 degrees projection.

Baseline data collection through a Questionnaire from experienced seafarers following operational level and Managerial level courses at CINEC to build a database to identify tolerance limits for freeze probes through the time frame indicated in Figure 1.

2.5 Sample simulated Activity

A basic learning activity is developed by the maritime navigation experts in the Department of marine simulation at CINEC.

Scenario Title: Navigation and collision avoidance in open sea

Ship Models: One out of the following list of Own ship models in the simulator.

1. Bulk carrier (Two ships)
2. Container ship (Six ships)
3. Very large Crude oil carrier
4. Car carrier
5. LPG Tanker
6. LNG tanker

Ship particulars: Provided according to the ship model used

Sea State: Beaufort Sea state 3

Present geographical location: open sea southwest of British Isles

Mission: Manage the safe Navigation of the vessel and Collision avoidance while following the planned route for 30 minutes.

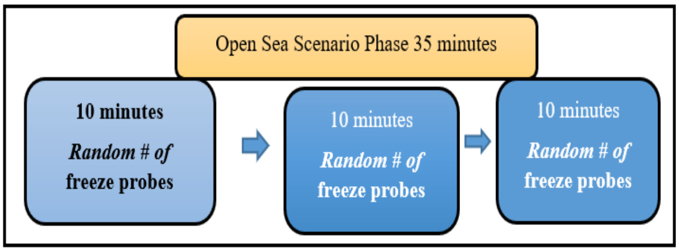

Figure 2: Time frame for freeze probes

Suggested example questions (a short selection) for each of the three freezes.

First freeze

1. What is your current course?
2. What is your charted course?
3. What is your current speed?
4. What is your planned speed for ETA.?
5. What is the visibility at present?

Second freeze

6. Do you experience wind? If yes, then state the

wind force and direction?

7. Do you experience any current? If yes,

then state the rate and set of current?

8. What is the current stabilization mode of your X-band radar?

9. What is the current stabilization mode of your S-band radar?

10. What are the targets which you have a risk of collision?

11. What are the targets on a collision course with you.?

Third freeze

13. Explain the traffic situation around your ship.

14. What are the targets that you are supposed to take collision avoidance actions?

15. What is the first target you are planning to take action for collision avoidance and why?

16. What is the nearest danger to navigation at present?

17. What is the distance to the nearest danger to navigation?

2.6 Data Collection

For the simulator session portrayed in this article, a professional maritime simulator trainer, a member of the research team, collected the data from the November 2019 to July 2020. Each simulator course has a duration of 5 days. The first day the briefing session was conducted. On the second day within the duration of 35 minutes, during Open Sea Scenario Phases the participants were randomly subjected to 1-5 freeze probes.

Within each freeze probe a range of 7 to 19 questions were asked. The next day the participants were given the questionnaire. The main aim of the questionnaire was to collect data to ascertain the following.

- If three freezes are given the number of questions the participants would feel comfortable answering during ea ch freeze.
- The number of freezes the participants felt comfortable during the simulator exercise.

2.7 Ethical Considerations

In the process of this study, ethical considerations will be put in place as per ethics of World Maritime University Committee to ensure respect for the rights, privacy, dignity, and sensitivities of our research populations and also the integrity of the institution.

3. Results and analysis

Research question 1:

Table 1: Percentage mean values # of freezes comfortable during a simulator exercise (n = 60).

Percentage mean value: # of freezes comfortable during a simulator exercise					
# of freezes	1	2	3	4	5
Percentage mean value of the participants	16.7	38.9	44.4	0	0

The analysis in Table 1 above indicates that the highest percentage mean value was obtained for three freezes while two freezes had the next highest percentage mean value. The findings further indicated more than three freezes exceed the comfort zone of the participants during a simulator exercise.

Research question 2:

Table 2 below tabulates the Percentage mean value of number of questions Operational level participants with an average of 2 years sea experience felt comfortable to answer during each freeze. Within a range of 7 – 19 the all three freezes recorded a comfort zone of approximately 9 questions. A minor trend indicated only one additional question for the two final freezes. This sums up as an average of 9 questions per freeze.

Table 2: Percentage mean values: # of questions do you feel comfortable to answer during each freeze: Group A: Operational level with a Mean of 2 years of sea experience (Standard Deviation = 0.91) (n = 30).

<u>If we have three freezes</u>, how many questions do you feel comfortable to answer during each freeze? (Please

note that the minimum number is 7 and maximum

Freeze	Percentage mean value of number of questions	Standard Deviation	Coefficient of variation	Mean Average
1	8.9	2.6	0.29	
2	9.4	2.7	0.29	9.3
3	9.6	4.3	0.45	

Research question 3:

Table 3 below denotes the percentage mean value of number of questions Managerial level participants who had a mean of 13.6 years of sea experience (Standard Deviation = 9.27) felt comfortable to answer during each freeze. Within a range of 7 – 19 the all three freezes recorded a comfort zone of approximate ly 6 questions.

Table 3: Percentage mean values: # of questions do you feel comfortable to answer during each freeze: Group B: Management level (n = 30).

If we have three freezes, how many questions do you feel comfortable to answer during each freeze?

(Please note that Minimum number is

Free z e	Percentage mean value of Number of	Standar d Deviati o n	Coeffici e nt of variation	Mean Avera g e
1	5.7	2.7	0.47	
2	6.6	3.4	0.52	6.1
3	6.0	3.7	0.62	

Observations: An interesting element which wa s observed in the completed questionnaires is that all participants other than 2 had completed the grids which collected data for the research questions 1 and 2. Two participants, Captains X and Y, who had 20 and 28 years of experience and were 42 and 54 years old respectively stated the following in their questionnaire s.

X: No freezing required during exercises. Prefer only debriefing after exercises.

Y: Prefer no freezes. Briefing and debriefing are preferred.

4. Discussion

The finding of research questions 1-3 indicate the following. Given a range of 1-5 freezes within a scenario phase with a duration of 30 minutes the majority 44.4% of the seafarers state that they would be comfortable with three freezes during a simulator exercise.

The analysis of percentage mean values of the comfortable number of questions to answer during each freeze had two diverse results for the Management and the Operational level.

While the operational level seafarers (Group A) who had an average experience of 2 years, declared that they were comfortable to answer an average of 9 questions during each freeze the much more experienc ed management level seafarers (Group B) with an average of 13.6 years of sea experience felt comfortab le with an average of 6 questions to answer during each freeze was their comfort zone.

At this juncture attention is requested to the lower average of 6 questions to answer during each freeze was the comfort zone of Seafarers with an average of 13.6 years of sea experience following Managerial level courses at CINEC with a Simulator module.

Also note that two participants in Group B, Captains X and Y, who had 20 and 28 years of experience and were 42 and 58 years old respectively requested for 'no freeze probes' during the scenario phase.

It is interesting to note that the management level seafarers with long experience have shown that they are comfortable with both fewer freezes and probs than operational level seafarers. Reasons may be the feeling that a freeze itself can disturb the attention of a person and the realism of the simulation where senior officers are used to be. Management level officers with experience and high confidence in the industry might feel asking more questions during the freeze is indirectly questioning their competence which will eventually convert into a negative attitude. However, these implications can be minimized by giving a proper briefing which includes the number of freezes and probs and reasons for selecting those numbers in the simulation exercise so that they can face the exercise without developing a negative attitude. It is worthwhile noting that the limitation on the number of participants and their cultural background being dominantly Indian subcontinental could be another reason for this implication. There is much room exists for further research on this aspect.

While respecting experience and the dignity of the rank of the participant populations, recall the following findings of prior research.

• Working memory declines with age. (Ziaei et al., 2017)

• A generally slower Reaction Times in the middle-aged compared to the young(Wild- Wall, Falkenstein and Gajewski, 2010) .

• The brain's Reaction Time begins to decline at age 24. The results suggest that the age- related slowing in visual choice Reaction Time tasks latencies is largely due to delays in response selection and production (Shalby,2014) .

• Visuo-spatial working memory, as in the scenario phase, exhibit a greater age-related decline than which is responsible for temporarily storing verbalizable information(Klencklen et al.,2017).

• The scenario phase should provide verbal exercises in which the individual's mental models of systems, situations and the cues by which they recognize them, may be tested and enriched (Barnett, 2004).

Based on the above findings of prior research, this study though its findings stipulate a lower number of probes per freeze as the comfort zone for the older more experienced Group B, argues for more probes. Information Processing Model(Dataworks Curriculum, 2014) too argues for rehearsal for working knowledge. Additionally, the certificate of competency (COC) is a form of license every mariner is granted to work on ships. The certificate ensures that the concerned person has the sufficient knowledge and skills to sail on ocean going vessels(Raunek, 2019). It is the main paper evidence you have on hand to prove the seafarer's level of maritime education and training meets STCW standards of competence relevant to their particular functions and level of responsibility on-board. the amended 2010 STCW Convention has made substantial changes in regulation I/2 to tighten up on the endorsement process. It is now required that all endorsements are only issued by the administration after fully verifying the authenticity of any certificates and documentary evidence, and the candidate has fulfilled all requirements and has the standard of competence for the capacity identified in the endorse ment(STCW: A Guide For Seafarers, 2010). With such requirements the providers of the training for the COC should take stringent steps to guarantee that competen ce relevant to their particular functions and level of responsibility on-board are tested prior to issuing such certification.

Acknowledgement

This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education funded by the World Bank.

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Received **16 February 2022**

Revised **28 June 2022**

Accepted **28 June 2022**