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Way-finding on-board training for maritime vessels

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ABSTRACT

In the maritime industry, it is of vital importance that personnel onboard ships are familiarized with the ship's layout, along with safety equipment and processes for safeguarding of the individual seafarer and the ship's crew. In fact, international maritime regulations require that all personnel employed or engaged on a seagoing ship receive proper familiarization training. However, several studies have identified lack of familiarization as a contributing factor to maritime incidents. There are several challenges associated with the current familiarization practices: cost, difficulty in optimizing planning, variation in practices in familiarization and the experience of the facilitator of familiarization process. This paper presents a study consisting of 58 students comparing traditional and virtual familiarization. No overall difference was found between real and virtual familiarization overall, although some differences were found for single waypoints. Individual differences were more important than treatment, indicating that virtual familiarization can perform on par with traditional approaches.

1. Introduction

In the maritime industry, namely regarding logistics and transport, seafarers are exposed to a high diversity of safety and security risks, such as potential occupational accidents, disasters and piracy [1]. In many of these incidents, the response time often plays a critical role in making the optimal decision, with limited information and short timeliness, towards achieving a successful outcome. A key contributing factor to the decision-making process is adequate familiarization of the vessel's design, equipment and outfitting. In fact, international maritime regulations require that all personnel employed or engaged on a seagoing ship receive proper familiarization training [2,3]. However, there is a lack of standardization of vessel design, which leads to significant amount of diversity in layouts and structure, making familiarization a tailored process applied to each vessel. It is also important to denote that on certain types of vessels, such as offshore support vessels, a great number of people may not be part of the ordinary marine crew. However, this does not exempt them from receiving basic familiarization training. The importance of familiarization cannot be overemphasized as demonstrated through the additional statutory requirements for familiarization through industry standards such as the Common Marine Inspection Document (CMID) and Offshore Vessel Inspection Database (OVID) [4–6].

When analysing existing familiarization practices amongst different shipping companies, one can distil a common approach which is based on the provision of a guided tour throughout key relevant safety locations within the vessel. The familiarization practices also include the demonstration of particular safety equipment. Typically, the familiarization tour is conducted by a qualified person, such as the safety officer of the vessel.

The analysis of current familiarization practices as performed today [7,8] have identified common challenges that compromise the effectiveness of the training:

- **Cost.** The familiarization is a simple enough task, but it still requires a significant amount of time to be adequately carried out, which disrupts other tasks and operations, meaning that work by the security officer is not carried out;
- **Scale.** As a result of the vessels' indoor environment, it is necessary to conduct the tours with relatively small number of seafarers. This implies considerable inefficiency, in particular when considering that personnel often arrive at different times, which invalidates any attempt to optimize the tours and also contributes to the cost;
- **Practice.** The personal ability of the safety officer has significant impact in conveying the necessary relevant information, in an effective and engaging manner, so all individuals within the group have equal potential of acquiring the imparted knowledge;
- **Context.** The positioning of the individuals within the group and

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their distance from the officer delivering the familiarization of the vessel has an impact on the effectiveness of the familiarization.

So even though the statutory requirements and procedures for ship familiarization are met, recent research indicates that defective familiarization is an explanatory factor in many accidents [9,10].

In the attempt of addressing these challenges, the Norwegian shipping company Østensjø ASA engaged in a research project to study the impact of gaming technologies, namely the use of Virtual Reality (VR) in familiarization. As such, a familiarization simulator was developed based on a real Inspection, Maintenance and Repair (IMR) vessel currently involved with petroleum-related deep-sea operations in the North Sea - the Edda Fauna. This paper reports on the exploratory research in the use of a serious game as a potential viable alternative, involving a total of 58 participants. The main aim of the study was to compare the effectiveness of a serious game compared to real-world familiarization. Consequently, an experimental design involving two groups was used, with half of the participants being exposed to the current familiarization practice, whilst the remainder half being exposed to the virtual familiarization facilitated by a serious game modelled on the Edda Fauna. After the initial exposure, all participants were tested in their knowledge of the vessel by the time taken to find particular waypoints onboard.

The paper is structured into a further 5 sections, starting with an overview of the relevant principles in cognitive psychology and virtual reality underpinning the study on way finding training using a serious game. Section 3 describes the simulator environment of the serious game and the study methodology, along with the hypothesis, is covered in Section 4. The key results are presented in Section 5, with an in-depth analysis, discussion and conclusion in the final Section 6.

2. Background

The essence of the familiarization process of a maritime vessel is to facilitate seafarers in their understanding of the vessel's layout, thus enabling them to identify key waypoints and learn appropriate routes between the most critical waypoints. The main aim for familiarization is to ensure personal safety and safe operation of the ship.

A relevant study of the impact of familiarization within a maritime vessel is found in a feasibility study on the use of virtual environments in the training of fire-fighting [11] where there were two phases to the study. The first phase, and most relevant to this paper, consisted of the research of the use of the virtual environment in reducing both the time in navigating a fictitious vessel and the number of errors along a single path. The study focused on the comparative analysis of the two chosen performance indicators, without assessing the impact of the individual waypoints along the route. Additionally, the study did not research the impact of prior gaming experience on the spatial memory of the study participants and the subsequent impact on their performance.

There are two fields of study relevant for understanding the individual's familiarization process of their surrounding spatial environment:

- Cognitive Psychology with regards to how individuals process their surroundings from a cognitive perspective;
- Virtual Reality with regards to how individuals navigate within virtual environments.

2.1. Cognitive psychology

The individual's processing of their surrounding environment relies on the use of spatial memory [12], which consists of a cognitive process where individuals build and update their mental representation of space otherwise designated as cognitive maps [13]. These maps are based on an individual's spatial position and orientation in relation to their environment and the objects contained therein (see [14], for review). However, according to [15] it is more likely that people do not construct accurate structural representations of reality, but rather collations of spatial information in recognisable clumps, similar to cognitive collages.

Nevertheless, the three-stage development of the cognitive representation of large-scale navigational space has a strong foothold in cognitive psychology [16]: Initially, a person will focus on important locations in the environment. The knowledge at this stage consists of sets of disconnected landmarks. More exposure to the environment will enable a person to link the landmarks together into routes. This knowledge is termed route representation. With additional exposure, some people develop a map-like representation of the environment that is flexible and allows people to infer new routes and short cuts. This knowledge is called survey representation. In [17], a mediating level called "graph knowledge" between route and survey knowledge, is introduced. This graph knowledge contains the topological information and the connectivity of the environment, but not the metric information about distances contained in survey knowledge.

2.2. Active and passive contributions to spatial learning

In their review of research on active and passive learning, [18] point out that despite the intuitiveness and anecdotal evidence of the value of active spatial learning, the research literature has yielded mixed results. They go on to argue that this has to do with confounding different aspects of activeness, which warrants a more sophisticated treatment of activeness. They then go on to distinguish five components of active learning associated with differing results:

1. idiothetic information, acquired by physical movement in space;
2. decision making about turns during exploration;
3. attention to place-actions and relevant spatial relations;
4. the different encoding subunits of working memory involved in encoding of route- and survey information;
5. the facilitation of mental manipulation for spatial learning.

Idiothetic information has been shown to contribute to metric survey knowledge – that is awareness of distances in a landscape [18]. Decision making has generally not been shown to matter – passive explorers that tag along learn just as much. This might be explained by demand characteristics in the experiment prompting passive explorers to also pay attention. However, new insights also point to benefits of decision making for graph knowledge [17]. Attention to place-actions and spatial relations have been shown to help route and survey information, although landmarks and spatial boundaries are learned without special attention (at least in experiments) [17]. There's also increasing evidence that route- and survey learning are more dependent on the working memory, and interference studies show that verbal- and executive memory plays a role in encoding, but that visuo-spatial working memory is crucial for both encoding and retrieving spatial memory [17]. For wayfinding this means that verbal, executive, and visuo-spatial distractors during encoding will be detrimental in acquiring route- and survey knowledge. Although more research is needed, it has been shown that explorers actively using a map to find a route performed better than explorers given the same map with auditory instructions about which way to turn [19].

There is an extensive body of research in wayfinding which is highly relevant to the present study, although the field has paid little attention to wayfinding onboard ships. Hölscher et al. [20] focus on a point of direct interest for any familiarization training onboard ships – that of the special case of multilevel buildings. The rapid direction changes involved in climbing stairs are thought to be a central problem here. Also, [21] identifies a common error affecting wayfinders due to their assumption concerning the topology of the floor plans of different levels being identical.

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