Incorporating Virtual Reality into Maritime Safety Training for Enhanced Competency-Based Learning Methodology

Hossam Gadalla[1a], Hesham Helal[2a], Sameh Rashed[3a]
Head of Quality and International Accreditation Unit, Maritime Safety Institute[1]
Dean of Maritime Postgraduate Studies Institute[2]
Vice Dean of, Maritime Postgraduate Studies Institute[3]
[a] Arab Academy for Science, Technology & Maritime Transport (AASTMT)
Miami, Alexandria, P.O. Box 1029, Egypt
(+20) 1202061618[1], 1001674351[2], 1000836897[3]
hossam.gadalla@aast.edu[1] hesham.helal@aast.edu[2], redmahi@aast.edu[3] ,

Abstract

The potential of using immersive technologies like Virtual Reality (VR) in education is endorsed by several research studies indicating an expected increase in its use within the foreseeable future. Owing to its capacity to provide a highly interactive and immersive experience, the adoption and integration of VR into maritime safety training can create new opportunities for competency-based learning and teaching methods. In a safety-critical domain such as the maritime industry, safety training is crucial for ensuring trainees' competency in emergency response and survival skills. This is accomplished through a range of training programs that were specifically tailored to address emergency events. However, during training exercises, fear and anxiety can have a substantial influence on trainees performance, especially if the activity is stressful as the "Helicopter Under Water Escape Training" (HUET). To address this problem, it is essential to psychologically prepare the trainees before executing the exercise. Driven by this aim, this applied research claims that incorporating VR technology into the classroom prior to practical exercises might contribute to achieving the best feasible results of the preparation by improving skill acquisition while mitigating fear and disorientation.

The methodology followed in the study consists of two stages; the first comprises a 3D-Camera recording the training exercises from the trainee's seats view, and examples of commonly committed faults. The trainees watch these recordings in VR headsets before practicing the exercises. The second stage entails conducting, collecting and analyzing trainees' questionnaire, as well as observations raised by training instructors to distinguish viable elevations in trainees' performance. Based on the outcomes of this study, it can be concluded that VR technology considerably enhances learning by enabling trainees to anticipate difficulties of the exercises, hence contributing to improved training performance.

Key Words: Virtual Reality - Training - HUET - Competency

1. Introduction

Digital technology has become a part of the daily present life. It imposes a need for more growth and development in all aspects of life so that the individual can coexist and participate in the modern lifestyle. The use of VR technology in various fields is an inevitable necessity as almost many recent studies are moving towards the technology of VR in a challenge to link the data systems with multiple interactions and communications as well. VR is one of the innovative technologies that have been used in various scientific and practical fields, in particular those that require imagination, creativity, and a transition to the real world. The basics of VR depend on making experiences not related to place, time, or individuals, so the experience is a continuous and evolving subjectivity with the development of the era and its inventions.

The effectiveness of VR applications in education and training has been embraced by several research studies pointing at a predicted growth in demand for VR utilization in education and training. Pantelidis conducted a comprehensive bibliography on the application of VR in education and training, listing over 800 printed research articles and reports on its use of it [1]. According to a study by Freeman regarding the trends and technologies that will drive educational reform in the future, VR technology, in particular, is expected to have increasingly widespread adoption in classrooms within the coming few years [2].

In another empirical research on innovative maritime training simulators, Sathiya reveals that VR is the future training medium for seafarers [3]. This was firmly agreed by Bi & Zhiqiang, who demonstrate that 3D Virtual Learning is going to reshape the future of Navigation Education [4]. Driven by these findings, training providers must swiftly expand in the fields of information technology and communications in order to keep up with what contemporary education provides in all aspects of life. Dealing with these developments has become an imperative for striving to achieve success as it is a real reflection of a major factor in the quality of institutions.

One of the areas in question is the "Competency-Based Safety Training" which is designed to allow learners to demonstrate their ability to perform a task, activity or exercise successfully to be assessed as "competent". Similar types of training equip learners with the essential skills required to respond timely and adequately in real situations where hazards are mostly encountered [5]. The HUET is an example of highly recognized a safety training program that adopt a competency-based learning methodology to ensure trainees have an adequate level of emergency response performance.

However, similar to other maritime competency-based safety training programs, the HUET exercise can place intense mental and psychological challenges on trainees who may experience varying degrees of fear and anxiety affecting their performance and leading to incompetency outcomes. In many cases, this might be owing to the lack of effective preparation in classes, where teaching methodologies are exclusively relying on textbooks and PowerPoint presentations.

To address this problem, the authors of this study argue that incorporating VR technology into a preparation process before commencing the practical exercise could significantly improve training performance by improving skill acquisition, reducing fear, and overcoming disorientation to increase time-saving awareness of situational characteristics.

To test the hypothesis held by the authors, the study sample of trainees is offered the opportunity to participate in an immersive experience involving a 3D-video demonstration displayed via VR display headsets of the same training egress simulator's configuration in actual training exercises. Additionally, to help reinforce the learning outcomes being taught, trainees are offered another set of VR videos depicting frequent behavioural mistakes consistently noticed across a wide range of past HUET programs delivered by the Maritime Safety Institute (MSI) of the Arab Academy for Science, Technology & Maritime Transport (AASTMT).

To evaluate the experiment, and also to verify the hypothesis of the study, the results of a questionnaire submitted to participants, in addition to observations raised by the training instructors are collected and analyzed to distinguish possible elevation in trainees' performance .

1.1 **The Concept of Virtual Reality**

VR systems are computer systems in which users are immersed in a virtual, computer-generated world. It is a multi-use and collaborative computing environment that enables the individual to be more interactive with its content. It also enables the user involved in the activities to be offered dynamic participation through the freedom of walking around and interacting. These environments provide life experience realism with different degrees of handling and performance available for the task to be completed. VR systems consist of one or two visual display units together with optically compensated systems that form a prospectively correct virtual image, even though the display is very close to the user's eyes. Moreover, it is a man-made technological world to deal with, using the computer, so that a person can interrelate with any task environment directly as it interacts with real life. The third dimension plays an important role in VR technology as it allows seeing the 3D output as in physical reality, by involving the auditory, visual, and tactile senses to achieve an experience similar to proximity to reality [6].

The VR technique is designed to give its users the illusion that digital objects are in the same space as physical ones, involving the merging of real and virtual worlds. Therefore, it has an important role in preparing and completing the training for maritime safety courses, which are of a very hazardous nature. HUET is one of the significant exercises that need adequate preparation before commencing the training, especially the preparation of the trainees. The pre-training concept ommitted the mental stress when trainees are challenged with unfamiliar topics as individuals learn more profoundly from a multimedia message provided that they are familiar with the names and characteristics of the main concepts [7]. In this context, maritime safety training processes must not only accomplish a high rate of safety measures for trainees but also increase their capacity and self-efficacy to overcome their apprehension or anxiety when performing competency-based training activities.

1.2 **The Helicopter Underwater Escape Training: Overview**

According to the Civil Aviation Authority (CAA), helicopter transportation has become an integral aspect of maritime and offshore operations and is widely used for carrying personnel to offshore installations such as drilling Ships/Rigs, oil platforms, survey and research ships. Even though it's a fast transportation method, it is carried out in a hazardous open sea environment [8].

Furthermore, helicopters like other means of transport, are vulnerable to a wide range of common incidents related to mechanical, electrical, and electronic failures. All of which can disrupt the flying capability leading to a helicopter crash in water, posing a major risk to the passengers [9]. If the helicopter had to ditch (crash on water), it would certainly invert and rabidly submerge as water rushed into its structure [10].

In this scenario, being trapped inside an inverted helicopter that is submerged in water is an extremely difficult challenge for its occupants to survive as they must carry out several emergency response procedures in a very short time. These procedures include protection from impact, locating emergency exits, using breathing systems, operating jesting mechanisms and eventually escaping through windows to find a way to surface outside the sunken helicopter.

As a response, the HUET training program was established to provide participants with fundamental emergency response knowledge and skills needed in case of a helicopter emergency, with a particular emphasis on escaping from a helicopter after ditching [11]. Trainees will practice bracing for impact, locating primary and secondary exit points, and evacuating through exit windows underwater then surfacing for air. The HUET simulator, as depicted in Figure (1), consists of a submerged helicopter cabin revolving along a single axis, commonly lengthwise.

One of the most critical complications that instructors face during training is the loss of trainees' self-confidence as a result of a severe fear of being trapped inside the helicopter training simulator when flipped and quickly submerged into water [12]. Some trainees suffer fear and loss of confidence even before the training assignment starts. To address this issue, adopting VR technology to prepare the trainees can be beneficial in mitigating their fear, promoting knowledge transmission and decreasing the chances of panic during training.

Figure (1): Helicopter Under Water Escape Training Simulator

Source: [13]

2. The Methodology

2.1 The Creation of VR Video Recordings

The VR videos are designed to provide a professional demonstration of each exercise specified by the OPITO standard using the same training simulator's configuration present in the real training sessions.

2.1.1 Identifying the Training Criteria

As per section (C.5) of the OPITO HUET Standard (Code 5095), Revision 5, amendment 9, January 2020, the training program includes fourteen learning outcomes that must be acquired by trainees to demonstrate their competency [11]. It can be observed that most challenging tasks are indicated by learning outcomes (7, 8, 9, 10, 11, 12) where learners have to practice escaping from a flooded helicopter structure in both upright and inverted positions. For this reason, the researchers choose these 6 exercises to be video recorded for demonstration.

2.1.2 Identifying/Preparing Technical, Physical, and Staff Resources

The HUET simulator and the training facility site including a swimming pool and all involved training equipment, with related activity risk assessments, were provided for the purpose of this study by the MSI of the AASTMT. A well-recognized OPITO approved training provider within the Middle East and Africa region, that maintains a high level of commitment to OPITO standards [13].

2.1.2.1 VR Technology-related Technical System

Selecting the required equipment related to VR technology display units, a water-proof high-resolution camera appropriate for underwater video recording, and a Computer set for video editing and technical adjustment. The system contains a set of technical requirements and tools that are used to create simulations in practice for practical training, in addition to a set of specifications that must be met to allow a hardware product to be fully operatable. These specifications are required to optimize the performance as well as the integration of system content.

1. A camera with the ability to capture every angle 360° in 4K "underwater"

2. A "Video Solo Video Converter Ultimate" software

This software is needed for converting image and video files to very high resolution with the use of live audio. The program converts video clips from two-dimensional into three-dimensional. The video is divided into two halves that are completely similar in movement, quality, and at the same time to be displayed on the projectors designated for that.

3. Pro Show Producer Software

This program is one of the simplest newly developed applications to help computer users create a distinct set of videos, publish them on the internet and add many effects as the researchers need to montage the video images to reach the best video compiled for all stages of training, and use some effects in editing the incoming error clips underwater.

• The first method is to use a smartphone: At this method, the videos are sent to the phone and then download and install VR viewing software, examples of which are on the Google Play Store (Cardboard-VR Video Player-3D Video Player) which enables the user to merge the video divided into two parts and see it in one interface only.

• The second method is to use a computer: Before the user can watch through a computer screen, the setup process must be completed which includes installing (The VIVE and SteamVR software) on the user's computer and it is recommended that the computer is of this specifications. In this method, the trainee must take into account the type of VR goggles that must be equipped to be connected to the computers with the USB port on the device used for the viewing process.

2.1.2.2. The Training Exercise Equipment

The specification and quantity of the equipment used for both the 3D video recording and the real execution of the training exercises are indicated in Table (1). The referred equipment including the HUET simulator and relevant supporting training equipment is certified and valid to be utilized for conducting an OPITO approved HUET training.

Table (1): Training Exercise Equipment

s	Equipment	Quantity	Type	Manufacturer
1	Helicopter Egress Simulator	one	METS M5 c/w Jib 6000 4Seat configuration	Survival Systems
2	Emergency Breathing System	Four	EBS Air-Pocket Plus Rebreather type Nose-clip	SURVTECH
3	Survival Suit	Four	Helicopter Transit Suit "Survival One" model	Survival Systems
4	Life Jackets	Four	Aviation lifejacket Inflatable type/spray visor	Survival Systems
5	Safety Helmets	Four	Colour-coded HUET training crash helmets	Survival Systems
6	Diving Equipment	Two	Full-gear Scuba Diving Set	Scuba One

2.1.3 Identifying and Preparing Staff Resources

Both the recording and the demonstration of the escaping exercises were executed by approved and qualified HUET instructors. All supporting staff for ensuring the safety measures identified by OPITO standard including qualified safety divers, competent simulator operators, and pool safety guards are certified for delivering HUET course. Moreover, for safety reasons, the Medical Emergency Response (MER) requirements as specified by OPITO were implemented during the period of the video recording including medical staff presented at the training site [14].

2.1.4 Recording Escape Exercises and common errors

2.1.4.1. Part A: The escape training exercises criteria as specified by OPITO HUET standard in learning outcomes (7) to (12) were recorded in 6 videos. The relevant OPITO reference and the description of each exercise is demonstrated in Table (2).

Table (2): Escape exercise Video description

Recording	OPITO Reference	Description
Video (1)	Learning outcome (7)	Escaping out from a partially flooded helicopter through an underwater window, without operating “EBS” nor “push-out window”.
Video (2)	Learning outcome (8)	Escaping out from a partially flooded helicopter through an underwater window, with deployment, operation, and breathing from “EBS”, but without operating “push-out window”.
Video (3)	Learning outcome (9)	Escaping out from a partially flooded helicopter through an underwater window, with deployment, operation, and breathing from “EBS”, and operating “push-out window”.
Video (4)	Learning outcome (10)	Escaping out from an inverted helicopter through an underwater window, without operating “EBS” nor “push-out window”.
Video (5)	Learning outcome (11)	Escaping out from an inverted helicopter through an underwater window, with deployment and operation of “EBS” on the surface before inverting, but without operating “push-out window”.
Video (6)	Learning outcome (12)	Escaping out from an inverted helicopter through an underwater window, with deployment and operation of “EBS” on the surface before inverting, and operating “push-out window”.

2.1.4.2 Part B: Recording demonstrations for common errors during the underwater escape exercise. Table (3) illustrates 6 behavioural mistakes and their description which were frequently observed by authors during previously delivered HUET programs.

2.1.4.3 Technical Video Editing

This step included all the video editing technical aspects related to video time, video contrast, and brightness to ensure the quality of a high-resolution 3D video.

Table (3): Behavioural Mistakes Video description

Recording	Cause	Mistake Description
Video (7)	Unprepared	The seat belt is not tightly fastened with buckle location not adjusted in the middle while the belt has a loose end.
Video (8)	Disoriented	losing physical reference related to window exits due to inadequate performance of "Locate position"
Video (9)	Confused	Unbuckling seat belt before jettisoning window exits.
Video (10)	Unfocused	Pushing out windows from inaccurate locations
Video (11)	Panicked	Escaping window during the inversion sequence
Video (12)	Rushed	Wrong escape from the stern of the training module

2.1.5 Training Delivery with Demonstration of Pre-Exercise VR Videos

The delegates' physical conditions were assessed to confirm their medical fitness for training, then they were given an orientation regarding the training sequence including instructions on how to use VR headsets. Before participating in the exercise, delegates watched via VR headsets the 6 videos related to the learning outcomes and how the exercises should be performed. Then they were given another explanation of wrong acts to be avoided followed by presenting the other 6 videos related to the commonly committed mistakes.

2.1.5.1 Observations by Training Instructors

To measure the effectiveness of the training, reports of observation by instructors were gathered to determine any difference in trainees' performance after watching the videos compared to the usual performance during this type of training. The questionnaire was filled out by the trainees to determine the value of the VR briefing they received before their actual training in the HUET simulator.

2.2 Population, Sample Size and Data Analysis

A meta-analysis of trainees' data was conducted to examine the relationship between the specified HUET course and the use of VR prior to the training. A questionnaire was designed as an effective tool to collect data and assess the importance of using VR in the training provided by AASTMT**.** The questionnaire was distributed to the trainees who attended the HUET course in AASTMT within the period the study was carried out.

The population for this study was all trainees who attended the HUET course at AASTMT. The total enrolled trainees' population was 114 trainees within the period of this study. The total population of this study is the sample size, as all participants responded to the questionnaires. All returned questionnaires were reviewed for stray marks and other damages. Response files were created by entering data into an EXCEL sheet, then transferred for further advanced statistical analysis package "SPSS". Statistical measures such as means and standard deviations were computed as well as frequencies, tabulation, correlation, regression and t-test analysis.

2.2.1 Questionnaire Validity and Reliability Testing

To fulfil the validity procedures, the content validity check was performed; the questionnaire was validated by a panel of experts (pilot study) consisting of three academic staff members and seven senior trainees. Based on expert suggestions, changes were made to improve the content and the clarity of the questionnaire. After collecting pilot study data, statistical analysis was employed to ensure the validity of the questionnaire by calculating Pearson's correlation coefficient independent between each statement and the total statements of the questionnaire and between the total of each dimension and the total statements of the whole questionnaire.

3. Results and Discussion

3.1 Data Reliability Testing

Reliability of data was carried out by using Cronbach's Alpha. Table (4) showed that all the variables have a reliability (> 0.70). It was also found that the overall questionnaire reliability was 0.957 confirming the high reliability of the questionnaire, i.e. the internal consistency among the statements and the studied variables of the questionnaire has high reliability.

Table (4): Reliability Statistics and value of Cronbach's Alpha

Variable	Cronbach's alpha
VR videos and simulation	0.843
Adapting and self-control	0.867
Interaction	0.794
Teamwork and Collaboration	0.798
Quality of the training process	0.895
The questionnaire	0.957

3.2 The Hypothesis Testing

Statistical tools such as correlation analysis, regression analysis and pair-wise T-test using the SPSS program V25 were used to figure out which research hypotheses could be accepted for trainees responses' data. The correlation analysis, as well as simple and multiple regression analysis were employed to test the relationship between the four adopted variables; VR videos and simulation, adapting and self-control, Interaction and teamwork and Collaboration (Independent variables) from one side and also their impact on the quality of the training process (Dependant variable).

3.2.1 Correlation analysis between the study variables

The correlation between the four main variables is shown in Table (5). All correlation Coefficients between each two variable are significant, positive and varied from 0.590 moderate correlation between Interaction and Teamwork and Collaboration to a strong correlation 0.811 between VR videos and simulation and Adapting and self-control.

Table (5): Correlation between the four main variables

Variable	VR videos and simulation	Adapting and self-control	Interaction	Teamwork and Collaboration	Quality of the training process
VR videos and simulation	1				
Adapting and self-control	0.811	1			
Interaction	0.695	0.660	1		
Teamwork and Collaboration	0.746	0.723	0.590	1	
Quality of the training process	0.677	0.716	0.593	0.733	1

3.2.2 Testing the impact of the study variables on the quality of the training process

Simple and multiple regression analysis were carried out for the trainees' responses to test the study hypotheses.

First Hypothesis H1:

H1: VR videos and simulation has a significant impact on the quality of the training process. This hypothesis was tested by using a simple regression test, and Table (6) shows the following results.

Table (6): Simple Regression test for the impact of "VR videos and simulation"

		Unstandardized Coefficients		Standardized Coefficients	t	r	R^2	P-value Sig.
		B	Std. Error	Beta				
1	(Constant)	2.791	0.403		6.918	0.677	0.459	0.000
	VR videos and simulation	0.401	0.089	0.376	4.521			

The impact of "VR videos and simulation" on the quality of the training process is given in Table (6) where the coefficient of determination (R^2) equals 45.9%. This means that 45.9% of the variance in quality of the training process can be explained by the independent variable "VR videos and simulation". The observed significancy P-value is (0.000 < 0.05) that means "VR videos and simulation" has a positive significant impact on quality of the training process at 95% confidence level.

Second Hypothesis H2:

H2: Adapting and self-control has a significant impact on the quality of the training process. This hypothesis was tested by using simple regression test, and Table (7) shows the following results:

Table (7): Simple Regression test for the impact of "Adapting and self-control"

Model		Unstandardized Coefficients		Standardized Coefficients	t	r	R^2	P- value Sig.
		B	Std. Error	Beta				
1	(Constant)	2.350	0.378		6.214	0.716	0.512	0.000
	Adapting and self-control	0.499	0.083	0.474	6.001			

The impact of "Adapting and self-control" on quality of the training process is given in Table (7) where the coefficient of determination (R^2) equals 51.2%. This means that 51.2% of the variance in quality of the training process can be explained by the independent variable "Adapting and self-control". The observed significancy P-value is (0.000 < 0.05) that means "Adapting and self-control" has a positive significant impact on quality of the training process at 95% confidence level.

Third Hypothesis H3:

H3: Interaction has a significant impact on the quality of the training process. This hypothesis was tested by using simple regression test, and Table (8) shows the following results:

Table (8): Simple Regression test for the impact of "Interaction"

Model		Unstandardized Coefficients		Standardized Coefficients	t	r	R^2	P-value Sig.
		B	Std. Error	Beta				
1	(Constant)	2.705	0.381		7.094	0.593	0.352	0.000
	Interaction	0.428	0.085	0.411	5.014			

The impact of "Interaction" on quality of the training process is given in Table (8) where the coefficient of determination (R^2) equals 35.2%. This means that 35.2% of the variance in quality of the training process can be explained by the independent variable "Interaction". The observed significancy P-value is (0.000 < 0.05) that means "Interaction" has a positive significant impact on quality of the training process at 95% confidence level.

Fourth Hypothesis H4:

H4: Teamwork and Collaboration has a significant impact on quality of the training process. This hypothesis was tested by using simple regression test, and Table (9) shows the following results:

Table (9): Simple Regression test for the impact of "Teamwork and Collaboration"

Model		Unstandardized Coefficients		Standardized Coefficients	t	r	R^2	P-value Sig.
		B	Std. Error	Beta				
1	(Constant)	3.391	0.449		7.550	0.733	0.537	0.000
	Teamwork and Collaboration	0.274	0.101	0.237	2.716			

The impact of "Teamwork and Collaboration" on quality of the training process is given in Table (9) where the coefficient of determination (R^2) equals 53.7%. This means that 53.7% of the variance in quality of the training process can be explained by the independent variable "Teamwork and Collaboration". The observed significance P-value is (0.000 < 0.05) that means "Teamwork and Collaboration" has a positive significant impact on quality of the training process at 95% confidence level.

Testing Normality

A data set should be normal or well-modeled by a normal distribution. A normality test is used to determine if a data set is normal and to compute how likely it is for a random variable underlying the data set to be normally distributed. An assessment of the normality of data is a prerequisite for many statistical tests because normal data is an underlying assumption in parametric testing and it is proved by Normality Test of Kolmogorov, as p –values > 0.05.

Table (10): Normality test for variables under study

Variable	p-value
VR videos and simulation	0.158
Adapting and self-control	0.741
Interaction	0.904
Teamwork and Collaboration	0.937

From Table (10), the variables data of the trainees proved to be normally distributed as long as p-value is larger than 0.05.

Table (11): Multiple regression test for the four variables

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.994	.281		3.539	.001
	VR videos and simulation	.090	.083	.101	1.075	.014
	Adapting and self-control	.150	.087	.161	1.715	.521
	Interaction	.174	.094	.172	1.855	.006
	Teamwork and Collaboration	.354	.087	.387	4.073	.000

Table (11) showed the multiple regression analysis for the impact of all the 4-variables under study together on quality of the training process. It was found out that Teamwork and Collaboration has the most significant positive impact on quality of the training process followed by Interaction and VR videos and simulation in the presence of other variables (P-value < 0.05). While Adapting and self-control has insignificant positive impact on quality of the training process in the presence of other variables (P-value > 0.05).

4. Conclusion

Digital technology passes through all lifestyles and it is a significant means in the field of education and training such as using modern devices for VR technology. In the field of the maritime transport industry, there are some training tasks classified as very hazardous tasks and need to prepare the trainee before carrying them out. Critical tasks such as maritime safety training operations, including the HUET. Therefore, VR is the technology that provides a lot of support to achieve efficiency in completing such dangerous training operations.

This study contributes to the effectiveness and safety of the HUET training by providing an opportunity to prepare delegates to face their fear and to overcome disorientation that otherwise is a challenging barrier for them in acquiring the needed skills to survive a helicopter ditching. This experience will be remembered by trainees as the sensation of which safety measures they should follow and the consequences if they respond wrong. After participating the questionnaire form was distributed to delegates to measure how the VR videos have contributed to their fear and disorientation during the performed exercises.

The data had been collected and analyzed to evaluate the experiment, and also to verify the hypothesis of the study. Observation had been carried out by the team members, Lecturers from the MSI, and the instructors who shared in the training implementation to distinguish between the trainee's performance in relation to the trainees for other traditional courses without using the VR.

References

[1] Pantelidis, V. Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. *Themes in Science and Technology Education* [online]. 2009, vol. 2, no. 1-2, p. 59-70. [Accessed 1 February 2022]. Available at: <https://www.researchgate.net/publication/268002587_Reasons_to_Use_Virtual_Reality_in_Education_and_Training_Courses_and_a_Model_to_Determine_When_to_Use_Virtual_Reality>.

[2] Freeman, A.; Adams Becker, S.; Cummins, M. *NMC/CoSN Horizon Report: 2017 K-12 edition* [online]. Austin, Texas: The New Media Consortium, 2017. ISBN 9780998865034 [Accessed November 2021]. Available at: <https://www.learntechlib.org/p/182003/>. [Accessed 13 June 2022]. Available at:<https://eric.ed.gov/?id=ED588803>.

[3] Renganayagalu, S.K. Virtual Reality as a future training medium for seafarers: potential and challenges. In: *Proceedings of Ergoship 2019: Haugesund, 24-25 September* [online]. Haugesund: HVL, 2019, p. 79-86. ISBN 9788293677048. [Accessed January 2022]. Available at:<https://www.researchgate.net/publication/348233163_Virtual_Reality_as_a_future_training_medium_for_seafarers_potential_and_challenges>. [Accessed 13 June 2022]. Available at:<https://www.hvl.no/en/about/centre-for-safety-at-sea/ergoship-conference-papers/>.

[4] Bi, Y.; Zhao, Z. Application of VR virtual reality in navigation teaching. *Journal of Physics: conference series*. 2020, vol. 1648, no. 032156. [Accessed October 2021]. Available at: <https://www.researchgate.net/publication/346492147_Application_of_VR_Virtual_Reality_in_Navigation_Teaching>.[Accessed 13 June 2022]. Available at: <https://iopscience.iop.org/article/10.1088/1742-6596/1648/3/032156>.

[5] Berg, N.; Storgård, J.; Lappalainen, J. *The impact of ship crews on maritime safety* [online].Turku: University of Turku, Publications of the Centre for Maritime Studies, 2013, A 64. eISNB 978-951-29-5308-0. [Accessed 13 June 2022]. Available at: <https://tuit.cat/I4Sak>.

[6] Makransky, G.; Lilleholt, L. A structural equation modelling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development* [online]. 2018, no. 66, p. 1141–1164. [Accessed November 2021]. Available at:<https://doi.org/10.1007/s11423-018-9581-2>.

[7] Mayer, R.E.; Pilegard, C. Principles for managing essential processing in multimedia learning: segmenting, pre-training and modality principles. In: Mayer, R.E. (ed). *The Cambridge handbook of multimedia learning* [online]. 2nd ed. New York: Cambridge University Press, 2014, p. 316 – 344. eISBN 9781139547369. [Accessed 13 June 2022]. Available at: <https://doi.org/10.1017/CBO9781139547369.016>.

[8] Civil Aviation Authority. *Safety review of offshore public transport helicopter operations in support of the exploitation of oil and cas: Progress report 2019: CAP 1877* [online]. West Sussex: CAA, 2020. [Accessed 13 June 2022]. Available at: <https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=9364>.

[9] European Helicopter Safety Team. *Training, and testing of emergency and abnormal procedures in helicopters* [online]. Köln: European Aviation Safety Agency, November 2015. [EHEST Leaflet HE 11]. [Accessed 13 June 2022]. Available at: <https://www.easa.europa.eu/sites/default/files/dfu/EASA_EHEST_HE_11.pdf>. Available at:

<https://www.easa.europa.eu/document-library/general-publications/ehest-leaflet-he-11-training-and-testing-emergency-and> [in several languages].

[10] European Union Aviation Safety Agency. *Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Annex III Organisation requirements for air operations [Part-ORO] of Commission Regulation (EU) 965/2012 on-air operations*. Consolidated version including Issue 2, Amendment 12. December 2017.

[11] Offshore Petroleum Industry Training Organization. Helicopter Underwater Escape Training (HUET) with Emergency Breathing System (EBS). In: *Basic Offshore Safety Induction & Emergency Training (with Emergency Breathing System), Helicopter Underwater Escape Training (with Emergency Breathing System) and Further Offshore Emergency Training (with Emergency Breathing System)* [online]. Revision 5, Amendment 9. OPITO, January 2020, p. 37-67. [Accessed October 2021]. Available at: <https://downloads.opito.com/downloads/Standards/basic-emergency-response/BOSIET_FOET_HUET-with-EBS-Revision-5-Amendment-9-January-2020.pdf?mtime=20200513030643&focal=none>.

[12] Taber, M.J. Use and implications of fidelity in helicopter underwater egress training. In: *Handbook of offshore helicopter transport safety: essentials of underwater egress and survival* [onlilne]. Elsevier, 2016, p. 125-150, ISBN 9781782421870. [Accessed 13 June 2022]. Available at: <https://www.sciencedirect.com/science/article/pii/B9781782421870000079#>. Available at: <https://doi.org/10.1016/B978-1-78242-187-0.00007-9>.

[13] The Maritime Safety Institute. *Maritime Safety Institute: Arab Academy for Science Technology & Maritime Transport* [online]. Alexandria: MET, 2022. [Accessed October 2021]. Available at: <http://www.aast.edu/en/institutes/msi/contenttemp.php?page_id=6900005>.

[14] Offshore Petroleum Industry Training Organization. *Medical emergency response and planning requirements* [online]. OPITO, 2019. [Accessed December 2021]. Available at: <https://downloads.opito.com/downloads/OPITO-Medical-Emergency-Response-Requirements-06082019-002.pdf?mtime=20190807112105>.