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Enhancing Maritime Education and Training (MET) through Virtual and Augmented Reality: A Voyage into Immersive Learning

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ABSTRACT

This study examines the effectiveness of virtual reality (VR) in maritime education, with a focus on firefighting training. While academic education values cognitive skills, such as critical thinking, maritime education has always placed a strong emphasis on the development of practical skills. Immersion technologies, such as VR and AR, have opened up new avenues for improving marine training methods and simulations. The purpose of this study was to fill the knowledge gap regarding the efficacy of VR in maritime education. This study aimed to understand the concept of VR, examine how students utilize VR in maritime education, and determine the advantages of VR using cost-benefit analysis (CBA) are the goals of this study. Methodologically, SPSS was used to analyze the survey questionnaire administered to students studying nautical studies. A cost-benefit analysis was also performed to evaluate the observable advantages of VR training over standard physical training. The results showed that after VR training, knowledge and skills significantly increased; however, because physical training involved more hands-on experience, skill enhancement was greater. VR training, on the other hand, provides benefits in terms of learning and time efficiency, enabling numerous lessons in a shorter amount of time. The conclusion emphasizes that VR firefighting training offers a cheaper option that improves equipment familiarity and fundamental firefighting skills. VR training guarantees accessibility, adaptability, and lower accident costs, whereas physical training provides priceless hands-on experience and team-building opportunities. The decision between the two approaches is based on organizational needs. Physical training promotes endurance and team development, whereas VR training emphasizes cost-effectiveness and safety. This study provides critical assessment information from students receiving both virtual and in-person firefighting training, assisting maritime education in identifying the most effective teaching strategies for improving student performance. Additionally, it provides students with a forum to express ideas and encourages teamwork to enhance maritime training and teaching procedures.

1. Introduction.

1.1. Research Background.

The development and application of practical skills have traditionally been emphasized in seafarer training. While this technique addresses some cognitive abilities, the consensus is that it emphasizes and concentrates considerably more on the development of practical hands-on skills for performing particular activities. In contrast, academic education has been seen to be significantly more focused on the development of in-depth analytical and critical thinking skills and cognitive skills that are less dependent on hands-on task-oriented training, but emphasize critical reading and discussion (Manuel, 2017). Simulators are a crucial part of maritime education and training and play a crucial role in the development of seafarer skills. Virtual reality (VR), augmented reality (AR), and mixed reality (MR), three emerging immersive technologies, have opened

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up new and diverse possibilities for maritime simulations and simulators. A new generation and category of simulators and simulation-based experiences for professional education, training, and operations have been made possible by the increasing technological advancements and readiness of these systems. These experiences are more affordable, immersive, portable, and accessible than those of traditional configurations. (Mallam et al., 2019). Maritime is one of the largest and most important sectors in the world. This entails the movement of cargo and people over land, sea, and air. Intensive training for marine professionals is essential to ensure the safety of ships, crews, and cargo. Classroom lectures, on-the-job training, and simulator exercises are traditional modes of maritime education. Asad et al., (2021) indicated that virtual-based learning helps students experience opportunities that they would not obtain in the actual world due to various factors such as danger, high cost, and the wrong time. However, with advancements in technology, virtual reality (VR) and augmented reality (AR) have emerged as effective tools in maritime education and training. The core value of the best academic education today is the growth of a scientific inquiry mindset, whether for career goals or just ”ivory tower goals.” Learners should be optimally challenged to question the status quo and develop critical skills that are primarily cognitive, while also satisfying the demands of specific competencies related to specific professional standards in this new university paradigm of fusing inquiry and task-focused, outcome-based educational approaches. (Manuel, 2017). Different types of technologies can be used for learning in the modern era. This includes virtual reality (VR). A computer-produced environment, known as virtual reality (VR), enables the user to feel completely immersed in the generated object in their surroundings. (Ifanov et al., 2023). However, no evidence shows and precisely acknowledges the effectiveness of virtual reality (VR) for maritime education training, as it does not have any quantitative data proving that VR learning is efficient for the maritime sector. This proposal aims to explore the application of VR in maritime education and training.

1.2. Research Question.

1. How does reality work function?
2. What is the experience of using virtual reality in maritime education training?
3. What is the benefit of using virtual reality in the maritime education sector?

1.3. Objectives of Research.

1. Study the working concept of virtual reality (VR).
2. To analyze the experiences of students using virtual reality in maritime education training.
3. To determine the benefits of VR for maritime education training using cost-benefit analysis (CBA).

1.4. Scope of Research.

1. Comparing between physical training and virtual training of firefighting by nautical students
2. Evaluate training criteria in terms of skills and knowledge gains and evaluate the experience of time consumption and learning.
3. Consulting data with experts to conduct cost-benefit analysis (CBA)

1.5. Justification for Conducting Research.

This research will provide information on virtual reality and augmented reality working principles and also identify the experience of using virtual and augmented reality in maritime education training, providing data on end-user experience in handling virtual reality for learning and training purposes. End-user experience data is crucial, as virtual reality (VR) itself is costly to set up; thus, feedback and outcomes are needed from the end user to provide the data needed to enhance the cost-efficiency of using VR. The outcome highlights the benefits of virtual and augmented reality in maritime education training, which will help in designing significant training for future training.

In the introduction, authors should be able to describe an adequate research background by highlighting the problem statement / issue of the research, research questions raised, purpose / objectives of the study, scope of the research, and justifications for conducting the research. However, the authors should avoid including a detailed literature survey or summary of the results.

2. Literature Review.

2.1. Virtual Reality (VR) Concepts.

For a user to feel fully immersed in a simulation (virtual environment), an interactive computer simulation that senses the user's state and operation must replace or enhance sensory feedback information to one or more senses. (Mihelj et al. 2014).

Kumar et al. (2023) indicate that virtual reality is the idea of creating simulated environments that can be viewed in 360 degrees utilizing computer technology. Virtual reality, in contrast to traditional interfaces, immerses the user in a virtual setting and offers an immersive experience using a headset.

2.2. Type of Virtual Reality (VR).

According to Mandal (2013), we can be grouped the VR systems according on the level of immersion offered to the user.

1. Non-Immersive System (Desktop VR): Desktop VR is a more basic type of immersive VR that may be used in various applications without the use of specialized equipment. Through one or more computer screens, a desktop VR user can view the virtual environment. However, despite being able to interact, the user is not completely submerged. It presents a worldview that is often monoscopic on a typical monitor. Different sensory outputs were not supported.
2. Semi-Immersive System: Desktop VR is in a better version. Due to the motion parallax effect, these systems support head tracking, which enhances the sensation of

"being there." Although it still employs a traditional monitor, it typically does not provide sensory output. LCD shutter glasses are frequently used in stereoscopic viewing.

3. Immersive System: This is the peak of the VR technology. The use of head-mounted devices (HMD), which support a stereoscopic view of the scene according to the user's position and orientation, enables the user to fully immerse themselves in a computer-generated environment. The use of audio, haptic, and sensory interfaces can improve these systems.

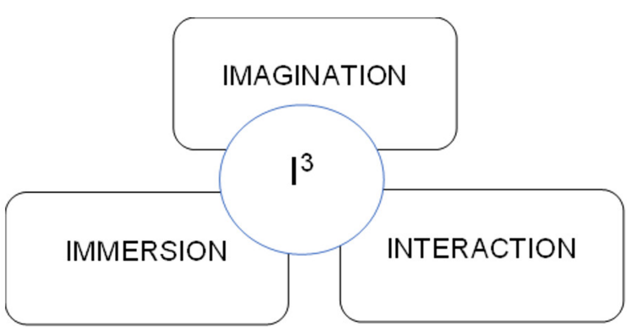
2.3. *Virtual Reality (VR) Working Principle.*

Users can explore and interact with an immersive computer-generated environment using virtual reality (VR) technology. It combines powerful computers, specialized VR glasses, and software to generate a realistic illusion of presence in the virtual world.

According to William and Alan (2018), three main elements are required for VR: a computer, VR headset, and software. Running the software that creates the VR world and renders the images is the responsibility of the computer. The head-mounted VR headgear features sensors that capture head movements and a visual display that immerses the wearer in the virtual world. The immersive experience is made possible by the software, which also generates the images, audio, and other sensory inputs of the virtual environment.

Burdea and Coiffet (2003) stated the triple I's immersion, interactivity, and imagination aspects of virtual reality. This element must be present for virtual reality to function properly. In Figure 1, this involvement describes the triple I's.

Figure 1: Illustration of Triple I's.



Source: Burdea and Coiffet (2003).

This technology has been deployed in several industries including gaming, healthcare, education, and military training. It can completely change the way we perceive the world by providing a new and intriguing method to explore and engage with virtual surroundings. Three essential elements are required for VR to function: the headset, input devices, and software.

The main piece of hardware used for VR technology is the headset. To provide the user with an immersive experience, it often contains a display screen, lenses, and sensors that track their head motions. The photos were enlarged and given a 3D appearance owing to the optics. The sensors aid in tracking the user's head movements, giving them a sensation of presence in the virtual setting.

Input devices are another crucial component of the VR technology. These gadgets include motion trackers, haptic feedback gadgets, and portable controllers. Users can engage with a virtual world by picking up objects, pressing buttons, or changing their surroundings.

2.4. *Effectiveness of Virtual Reality (VR).*

By including virtual reality technology in the practical teaching of navigation students and creating a platform for virtual ship equipment operation training, it can compensate for a variety of real-world shortcomings by allowing students to perform virtual equipment disassembly training, operation training, and troubleshooting. Training can expand the meaning of practical teaching, further enhance and improve the practical operational ability of maritime students, and train qualified global international seafarers without being constrained by time, space, expensive hardware resources, and venues of real equipment. (Bi & Zhao, 2020).

The ability to change the virtual environment easily creates new opportunities in the field of experimentation, because digital prototypes can be copied, modified, and tested without the financial and time costs required to create and test physical prototypes. VR aids a better understanding of abstract concepts through visualization and the possibility of virtual testing of the majority of educational materials. (Miyusov et al., 2022).

2.5. *Virtual Reality (VR): New Alternative in Changing Teaching Method.*

Bi and Zhao (2020) stated that numerous factors limit how navigation is taught. Students do not have sufficient time or opportunities to examine the equipment, which can affect how well practical teaching works. By including virtual reality technology in the practical teaching of navigation students and creating a platform for virtual ship equipment operation training, it can make up for a variety of real-world shortcomings by allowing students to perform virtual equipment disassembly training, operation training, and troubleshooting.

Gandhi and Patel (2018), owing to greater technological advancement and the requirement to meet client demand. Virtual reality is one of the most effective and immersive technologies available, surpassing the limitations of augmented reality while also making life easier and more convenient. Some of the growing needs of virtual reality are as follows:

1. Computer hardware, software, and virtual world integration technologies were utilized to dynamically simulate the real world.
2. They can act as though they are physically present in both fictional and actual settings.
3. We can participate in the action in a virtual, safe atmosphere without any actual risks.
4. Through the use of computer graphics software, headsets, gloves, and other accessories, virtual reality can help visualize working environments where humans cannot travel,

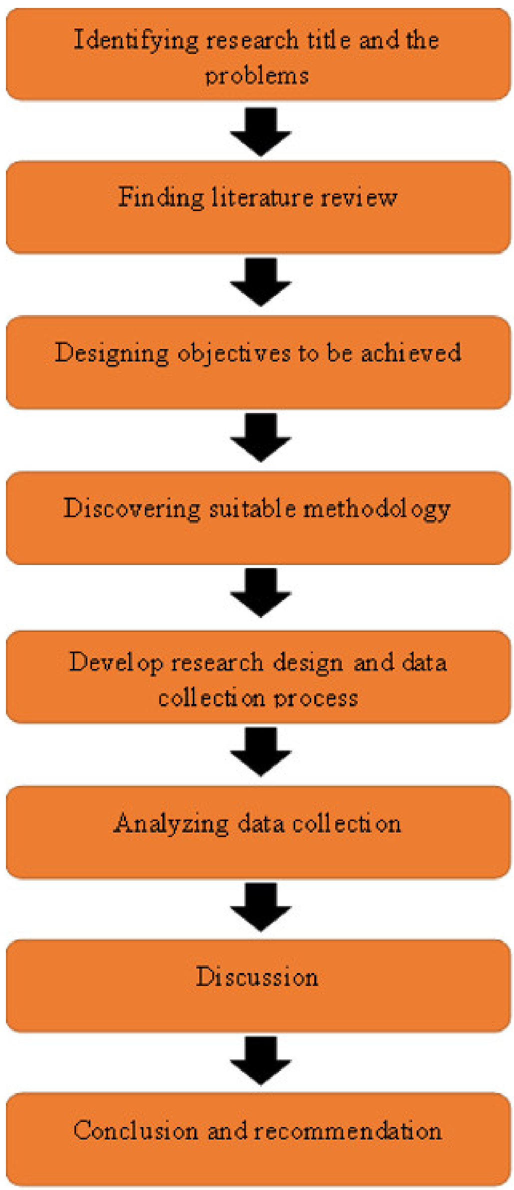
such as Mars or low-temperature environments, and give them the impression that they are physically present there.

3. Methodology.

3.1. Research Framework.

As shown in Figure 2, this conceptual framework satisfied the needs of this study.

Figure 2: Research Framework.



Source: Authors.

This research framework helps to understand and show a clear flow during the research from the beginning to the end. The first step is to identify the research problem and titles related to this research. The problem that was found in this research is to evaluate the level of knowledge and experience about virtual reality training and physical practicals of firefighting training for nautical students. The second step was to find a literature review related to the research problem and study. The third step was to develop the research objectives. Objectives are important aspects that need to be addressed in the research. The fourth step was to determine a suitable methodology. This is an important step to achieve the objective of the research, and this is how the data were collected and analyzed. The fifth step was to develop a research design and data collection process. This step helped collect the data.

The next step was to analyze the data collection. Primary and secondary data were collected. Primary data were collected from questionnaires and interview experts, while secondary data were from literature reviews, such as journals, articles, and case studies. After collecting the data, the data analysis step was performed using the statistical analysis method and its software. From this data analysis, the next step, which is a discussion about the research, has been made, and finally, the conclusion and recommendations have been made for future use.

3.2. Data Collection Strategy.

The major technique of data collection for this research was the quantitative approach of constructing the research question according to the research purpose. The primary data will be collected based on a survey questionnaire to find out opinions and changes after nautical students have been going through before and after virtual reality and physical firefighting training. The information obtained in the literature review was used to create a set of questionnaire surveys. The questionnaire was distributed using a Likert Scale. The Likert Scale was chosen because it is a universal data collection tool that is easily accessible to the respondents. The research question covered six main criteria: the importance of virtual reality training to enhance the knowledge of nautical students, the skill and attitude of students in firefighting training before and after using virtual reality training, and suggestions to improve virtual reality to be more efficient and effective.

Next, literature research, which includes books, notes, journals, official websites, and certifications, is used to supplement and enhance the main data. Furthermore, respondents were not compelled to use this method to convey their views. The tools utilized for this research are charts and table presentation, Microsoft Excel and Word, Google Forms (Likert Scale), and Statistical Package for the Social Science (SPSS) software. A pilot study was conducted before the main study to configure misappropriate sentences or words. The questionnaire used a 9-point Likert scale ranging from strongly disagree to strongly agree.

3.3. Sampling Strategy.

To gather the data, purposeful sampling was used. Palinkas et al., (2015) stated that it is widely used in quantitative research for the identification and selection of information-rich cases for the most effective use of limited resources. This involves gathering individuals or groups of individuals who are especially knowledgeable about or experienced in the phenomenon of interest. Forty students of Nautical Science from year two and year four were selected as candidates to participate in this research.

The candidates will participate in the research to achieve the second objective by undergoing two different types of firefighting training: physical training in firefighting and virtual reality (VR) simulation training. After the candidates undergo both trainings, the questionnaire will be distributed, and they will give the answers based on the training that has undergone. A comparison between the two types of training was then analyzed.

3.4. Types of Analysis Methods Applied.

3.4.1. Statistical Package for the Social Sciences (SPSS).

Statistical analysis was performed to analyze the questionnaire data. The Statistical Package for the Social Sciences (SPSS) is a popular software for statistical analysis. It offers researchers a full range of features and tools for carrying out different data analysis tasks, from straightforward descriptive statistics to sophisticated statistical modeling. Large datasets can be handled by SPSS, and it has an easy-to-use interface that makes it usable for users with different degrees of statistical knowledge.

The key features of SPSS are as follows.

1. Data Management: Researchers can effectively import, arrange, and manage their data using SPSS. It supports a broad variety of file formats including databases, Excel, and CSV. With SPSS, missing values, merged datasets, and clean and recorded data were used.
2. Descriptive Statistics SPSS offers a range of descriptive statistical methods for exploring and summarizing data. These consisted of frequencies, cross-tabulations, measures of variability (such as standard deviation and range), and measures of central tendency (such as mean and median).
3. Data Visualization: SPSS offers a variety of graphical tools to visualize data, such as bar charts, histograms, scatter plots, and box plots. Understanding patterns, trends, and correlations in the data is facilitated by these visualizations.
4. Output and Reporting: Tables, charts, and statistical summaries are among the outputs produced by SPSS, which are both straightforward and thorough. For additional research, reporting, and publication, the output is easily exportable to several formats (e.g., Word, Excel, PDF).
5. Integration with Other Software: Microsoft Excel is one of the programs from which SPSS can smoothly import and export data. Additionally, it enables an interface with other statistical programs, such as R and Python, enabling users to use the advantages of several tools in their investigations.

SPSS is widely utilized in many different industries, including business, healthcare, education, market research, and the social sciences. It is favored for its user-friendly interface, wide variety of statistical methods, and effective data management features. Researchers can use SPSS to analyze difficult data, obtain new perspectives, and arrive at well-informed judgments supported by statistical evidence.

- **How The SPSS Works:** IBM created The Statistical Package for the Social Sciences (SPSS) program, which is frequently used to analyze data and generate predictions based on certain datasets. With the use of a few keystrokes, SPSS makes the results easy to obtain for both professors and students. The ramifications of these findings were statistically sound and obvious. The software allows for quick and efficient completion of several investigations.

  Because of its user-friendly interface, both novice and expert researchers can easily utilize it. SPSS is commonly employed for data analysis in a variety of disciplines, including social sciences, medicine, marketing, and economics.

- **Step To Do Data Entry on SPSS:** To use SPSS accurately, the data that are being inserted must be precise and concise. Open the new data file and collect data from the survey. Then, the variables are defined by entering the name accordingly in the variable view and defining the type of variable. In the data view, the data are input into the corresponding columns for each variable. Each row represents a case or observation and each column represents a variable.

- **Compute The Variables into Mean in SPSS:** After the data are already keyed in, the variables can be computed into any intended data. However, ensure that all columns are filled in, and no blanks are left behind to prevent errors in the data. The data collected by the survey will be analyzed to evaluate their skills, knowledge, time consumption, and learning experience when undergoing firefighting with the two different types of training. The data were computed in a mean form to evaluate the average experience.

  Navigate to the analyze from the top menu, under "Analyze," select "Descriptive Statistics" and then click on "Descriptives." In the "Descriptives" dialog box, move the variables (skills, knowledge, time consumption, and learning experience) to compute the mean from the left box to the right box. Click on the "Options" button to specify additional statistics for computing SPSS. Ensure that "Mean" is checked. Click "OK" to conduct the analysis. SPSS generates an output that includes various descriptive statistics for the selected variables, including the mean. Look for the "Mean" value in the output table corresponding to the variables. This value represents the average or mean of the selected data.

3.4.2. Cost-Benefits Analysis (CBA).

(Weller 2016) stated that organizations can use cost-benefit analysis, sometimes referred to as benefit-cost analysis, to evaluate decisions, systems, or projects, or to provide value to intangibles. The model is created by determining the costs and benefits of a course of action, and then deducting the costs from the benefits. When completed, a cost-benefit analysis will produce quantifiable findings that can be utilized to draw fair judgments about the viability and/or appropriateness of a choice or circumstance.

This analysis method will be carried out with expert interviews to obtain opinions and enhance suitable and profitable training that would benefit more maritime education training.

4. Results and Discussions.

4.1. Introduction.

This section describes the results of this study. All results were analyzed to achieve the objectives of this study. According to the general aims and nature of the study, the target respondents were 60 nautical students from Batches 14 and 16 of the University of Malaysia Terengganu. Thirty respondents underwent virtual reality firefighting training and 30 respondents underwent physical firefighting training.

4.2. Results and Analysis from Questionnaires.

The results from the questionnaire were analyzed using the Statistical Package for the Social Sciences (SPSS) software, and the results were used to evaluate the most important element of the firefighting training criteria. All the data that all the respondents answered had to be entered into this software so that we could know the evaluation of each element. The second objective is to compare the performance knowledge, skills, time consumption, and training experience of firefighting training performed by nautical students before and after virtual reality training and physical firefighting training will be achieved using this method.

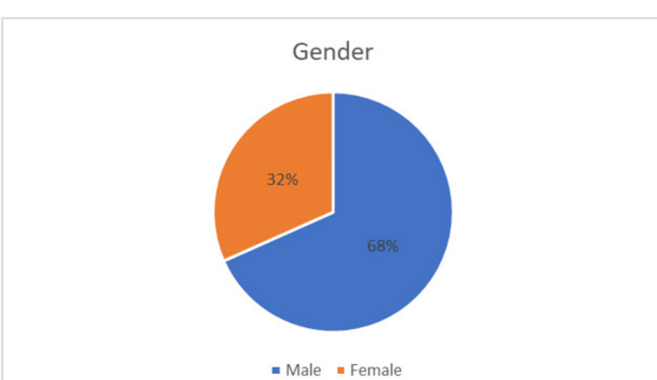
4.2.1. Gender of Students.

Table 1: Gender of Students.

Gender	Number of Students
Male	41
Female	19
Total	60

Source: Authors.

Figure 3: Gender of Student.



Source: Authors.

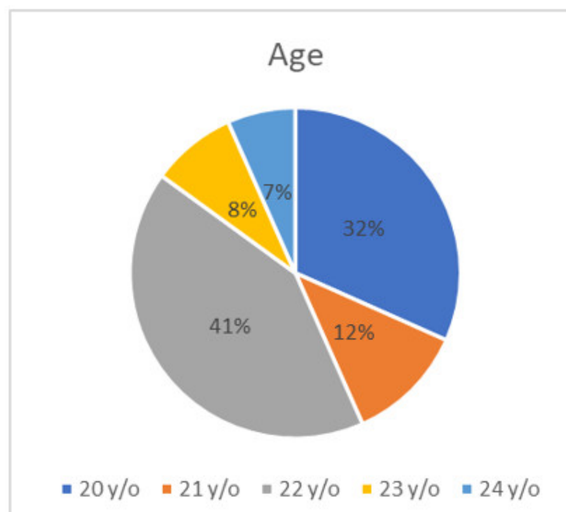
The Nautical students involved in this study were from Batches 14 and 16, who had already undergone virtual reality and physical training in firefighting. In Figure 3, 41 male students represented 68%, and 13 female students represented 32% of the pie chart. Sixty nautical students completed the questionnaire is 60 students.

Table 2: Age of Students.

Age	Number of Students
20 years old	19
21 years old	7
22 years old	25
23 years old	5
24 years old	4
Total	60

Source: Authors.

Figure 4: Age of Students.



Source: Authors.

Figure 4 shows a pie chart representing the overall Batch of Nautical students from batches 14 and 16. 41% of the pie charts show that 25 students were 22 years old, 32% showed that 19 students were 20 years old, and 7 students were 12% of the age 21 years old. Lastly, 8% and 7% of the pie charts show that five and four students are 23 and 24 years old, respectively.

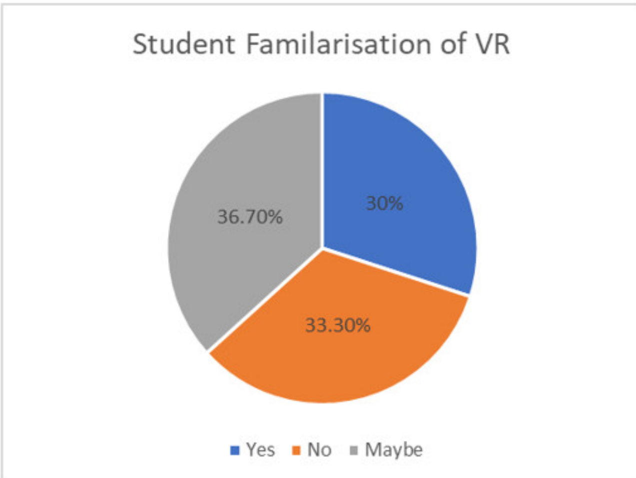
4.2.2. Student Familiarisation of Virtual Reality.

Table 3: Student Familiarisation.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	9	30.0	30.0	30.0
	No	10	33.3	33.3	63.3
	Maybe	11	36.7	36.7	100.0
	Total	30	100.0	100.0	

Source: Authors.

Figure 5: Student Familiarisation.



Source: Authors.

Figure 5 shows a pie chart representing the overall student familiarization with the virtual reality environment. Only 30% of the students stated that they knew and were familiar with the virtual reality environment, whereas 33.3% stated that they did not know anything about virtual reality. Lastly, 36.7% of students stated that they may know little about virtual reality and its environment.

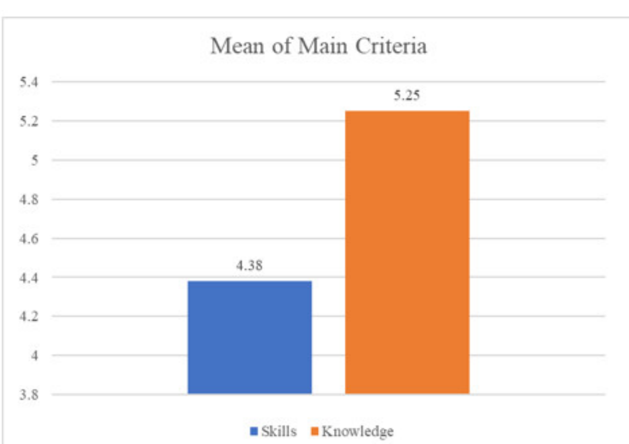
4.2.3. Main Element Analysis of VR Firefighting Training.

Table 4: Main Element Analysis of Before VR Firefighting Training.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SKILLS	30	2.71	7.86	4.3810	1.12193	1.420	.427
KNOWLEDGE	30	3.50	8.13	5.2458	1.12307	.940	.427
Valid N (listwise)	30						

Source: Authors.

Figure 6: Mean of Main Criteria Before VR Training.



Source: Authors.

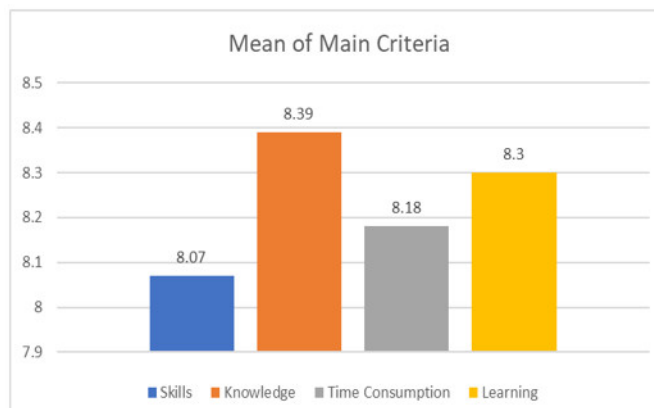
Figure 6 shows a summary of the main criteria before training for virtual reality firefighting training. The value of skewness is between -1.96 and 1.96, which is normal; hence, the data are valid. It concludes that the students before undergoing virtual reality training have skills with a statistical mean of 4.38 and a knowledge statistic mean of 5.25 in basic firefighting.

Table 5: Main Element Analysis of After VR Firefighting Training.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SKILLS	30	6.86	9.00	8.0762	.50714	-.037	.427
KNOWLEDGE	30	7.13	9.00	8.3917	.37100	-1.038	.427
TIME CONSUMPTION	30	6.67	9.00	8.1889	.71483	-.334	.427
LEARNING	30	6.00	9.00	8.3000	.71304	-1.446	.427
Valid N (listwise)	30						

Source: Authors.

Figure 7: Mean of Main Criteria After VR Firefighting Training.



Source: Authors.

Figure 7 shows a summary of the main criteria after training for virtual reality firefighting training. The value of skewness is between -1.96 and 1.96, which is normal; hence, the data are valid. It concludes that after undergoing virtual reality training, the students have skills with a statistical mean of 8.07 and a knowledge statistic mean of 8.39. The student also stated that the time consumption of the training statistic mean was 8.18 and the learning experience statistic mean was 8.3 in basic firefighting.

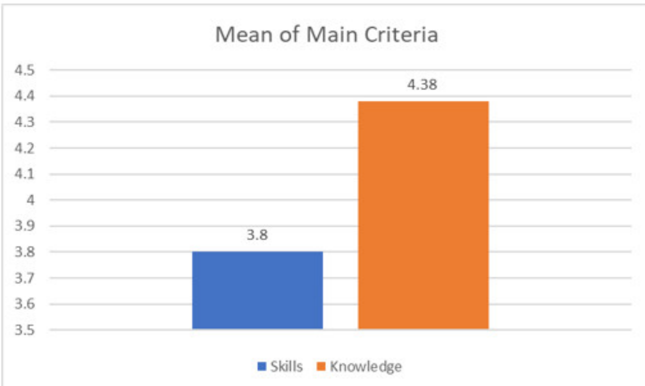
4.2.4. Main Element Analysis of Physical Firefighting Training.

Table 6: Main Element Analysis of Before Physical Firefighting Training.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SKILLS	30	1.86	6.29	3.8000	.83266	.581	.427
KNOWLEDGE	30	2.75	7.88	4.3833	.95420	1.557	.427
Valid N (listwise)	30						

Source: Authors.

Figure 8: Mean of Main Criteria Before Physical Firefighting Training.



Source: Authors.

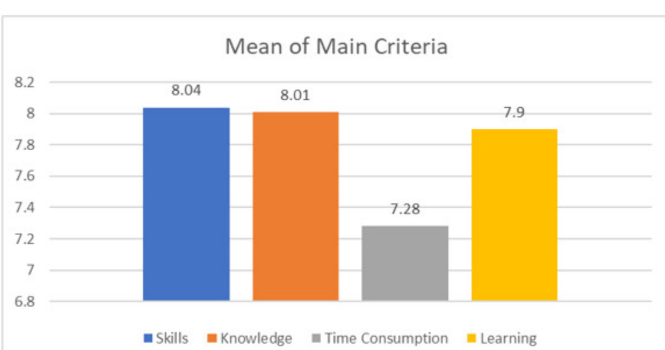
Figure 8 shows a summary of the main elements before physical firefighting training. The value of skewness is between -1.96 and 1.96, which is normal; hence, the data are valid. It concludes that the students before undergoing physical training have skills with a statistical mean of 3.8 and a knowledge statistic mean of 4.38 in basic firefighting.

Table 7: Main Element Analysis of After-Physical Firefighting Training.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
KNOWLEDGE	30	6.38	9.00	8.0125	.44571	-1.071	.427
TIME CONSUMPTION	30	5.33	9.00	7.2889	.74655	.001	.427
LEARNING	30	6.00	9.00	7.9000	.60108	-1.331	.427
SKILLS	30	7.57	8.71	8.0429	.30513	.217	.427
Valid N (listwise)	30						

Source: Authors.

Figure 9: Mean of Main Criteria After Physical Firefighting Training.



Source: Authors.

Figure 9 shows a summary of the main elements after physical firefighting training. The value of skewness is between -1.96 and 1.96, which is normal; hence, the data are valid. It concludes that after undergoing physical firefighting training, the student has skills with a statistical mean of 8.04 and a knowledge statistic mean of 8.01. The students also stated that the time consumption of the training statistic mean was 7.28 and the learning experience statistic mean was 7.9 in basic firefighting.

4.2.5. Overall Criteria of Virtual Reality and Physical Training in Basic Firefighting.

From the results in the table above, the rating of each criterion was used to compare the performance knowledge, skills, time consumption, and learning experience of basic firefighting training. The method to identify the percentage growth level of the element is using

$$\boldsymbol{Percentage\ Growth} = \left(\frac{\boldsymbol{new\ mean - old\ mean}}{\boldsymbol{old\ mean}} \right) \boldsymbol{x\ 100} \quad (1)$$

Table 8: Overall criteria of VR and Physical Training.

Type of Training	Criteria	Mean		Percentage Growth/Mean of Experience
		Before	After	
Virtual Reality	Knowledge	5.25	8.39	59%
	Skills	4.38	8.07	84%
	Time Consumption	-	8.18	8.18
	Learning	-	8.3	8.13
Physical	Knowledge	4.38	8.01	82%
	Skills	3.8	8.04	89%
	Time Consumption	-	7.28	7.28
	Learning	-	7.9	7.9

Source: Authors.

As shown in Table 8, before attending virtual reality training, the elements of knowledge (5.25) and skills (4.38). After attending the virtual reality training the element of knowledge (8.39) and skills (8.07) which indicate the growth of 59% (knowledge) and 84% (skills). The experience of learning shows a mean of 8.13 and 8.18 for time consumption. Before attending physical training, the elements of knowledge (4.38) and skills (3.8) were assessed. After attending physical training, the elements of knowledge (8.01) and skills (8.04) indicated a growth of 82% (knowledge) and 89% (skills), respectively. The experience of learning shows a mean of 7.28 and 7.9 for time consumption. The data indicate that knowledge and skills increase significantly after undergoing physical firefighting training rather than virtual reality firefighting training. This is because respondents had more opportunities and hands-on practices on the ground. However, the learning experience and time consumption used for training favor the virtual reality firefighting training. This is because in virtual, respondents can repeat the training, and the time consumed for the virtual training only takes about 15 to 20 minutes to finish, while physical firefighting training requires at least two consecutive days to finish the training. The two days needed to finish the training are stated in the IMO Class 1.20 book on fire prevention and firefighting as a guideline for the maritime institute to run the basic firefighting course (refer to Appendix 4).

4.3. Results and Analysis from Cost-Benefit Analysis (CBA).

Breakdown of the cost-benefit analysis between the virtual reality firefighting training and physical firefighting training using the cost provided.

4.3.1. Virtual Reality Firefighting Training.

Table 9: VR Firefighting Cost.

Virtual Training Cost	Description	Monetary Value (RM)
Initial Expense	VR software development, VR headset, sensor, and computer equipment purchases.	10,000
Maintenance	Updating software regularly and possibly fixing broken equipment	1500
Total		11,500

Source: Authors.

Table 10: VR Firefighting Benefits.

Virtual Training Benefits	Description	Monetary Value (RM)
Safety	Provides a controlled atmosphere while lowering the risks connected with live firefighting drills.	10
Repeatability	Enables skill development through repeated scenarios without requiring actual resources.	1500
Accessibility	Training sessions can be completed more quickly and with less expense by being accessed remotely.	Difficult to quantify in direct monetary terms.
Adaptability	Various firefighting scenarios, even uncommon or dangerous ones, can be simulated by using different scenarios.	Difficult to quantify in direct monetary terms.
Data collection	It is possible to monitor performance indicators, which can help pinpoint areas in need of development.	Difficult to quantify in direct monetary terms.
Total		1510

Source: Authors.

4.3.2. Physical Firefighting Training.

Table 11: Physical Firefighting Training Cost.

Physical Training Cost	Description	Monetary Value (RM)
Equipment and Buildings	Investing in safety precautions, training facilities, firefighting equipment, and props.	300,000
Instructor cost (min 2 person)	The cost of hiring qualified instructors and staff to run in-person training programs.	1000 per person
Resource Utilisation	During drills, actual resources like fuel, water, and infrastructure are used.	60 per session
Total		301,060

Source: Authors.

Table 12: Physical Firefighting Benefits.

Physical Training Benefits	Description	Monetary Value (RM)
Real-world Experience	Offers hands-on training using real firefighting tools and situations.	Difficult to quantify in direct monetary terms.
Team building	Improves communication and collaboration among the team under high-pressure situations.	Difficult to quantify in direct monetary terms.
Physical Endurance	Builds the strength and endurance necessary for battling fires.	Difficult to quantify in direct monetary terms.
Course Revenue (min 5 person)	Revenue gains from a participant who joins the training course	1500 per person
Tangible Experience	A more realistic experience is obtained by sensory involvement with heat, smoke, and physical impediments.	Difficult to quantify in direct monetary terms.
Total		1500

Source: Authors.

4.3.3. Cost-Benefit Analysis Ratio.

Table 13: Cost-Benefit Analysis Ratio.

VR Firefighting Training	**Calculation**	**Total (RM)**
Benefits		
Safety	10	10
Repeatability	1500	1500
Accessibility	N/A	-
Adaptability	N/A	-
Data collection	N/A	-
Total Benefits		1510
Cost		
Initial Expense	10,000	10,000
Maintenance	1500	1500
Total Cost		11,500
Cost Benefit Ratio		0.13

Physical Firefighting Training	**Calculation**	**Total (RM)**
Benefits		
Real-world Experience	N/A	-
Team building	N/A	-
Physical Endurance	N/A	-
Course Revenue	1500*5	7500
Tangible Experience	N/A	-
Total Benefits		7500
Cost		
Equipment and Buildings	300,000	300,000
Instructor cost	1000*2	2000
Resource Utilisation	60	60
Total Cost		302,060
Cost Benefit Ratio		0.024

Source: Authors.

VR Firefighting Training is more feasible with a high cost-benefit ratio.

4.3.4. Conclusion of CBA.

This analysis can be divided into the following three terms:

- Cost Efficiency: Virtual Reality Training has lower initial and maintenance costs than the substantial upfront investment and ongoing expenses of physical training.
- Safety and Repeatability: Because VR training increases safety and allows for repetition, it can reduce costs by lowering the likelihood of accidents and the accompanying costs of retraining.
- Resource Utilization: Compared to virtual reality, physical training is less expensive in terms of both equipment and instructor fees but offers no demonstrable advantages.

Virtual reality firefighting training is beneficial for both safety and cost-effectiveness. Physical training provides intangible advantages, such as practical experience and team development, but it can be difficult to put these advantages into monetary terms.

Virtual reality (VR) training offers accessibility and adaptability that traditional training does not, reduces the cost of accidents, and permits low-cost recurrent training at a cheap cost. However, physical training may still be beneficial for building teamwork and physical endurance, both of which are essential in firefighting situations.

The organization's priorities would decide which of the two options to go with. VR training is advantageous if cost - effectiveness, safety, and frequent training opportunities are prioritized. However, a well-rounded strategy that might incorporate components from both training approaches could offer a whole firefighting training curriculum, guaranteeing a mix of safety, skill development, and real-world experience.

Conclusions.

Recommendations and Suggestions for Future Research.

The following recommendations are some ways to improve this study: IT knowledge is the most important element for conducting this type of research. Future researchers should provide themselves with adequate knowledge to gain a better understanding of this research.

Research Contribution.

This research is mainly aimed at providing evaluation data from students who undergo virtual reality firefighting training and physical firefighting training. This will provide data on maritime education training, of which training will provide more benefits for the student outcome. In addition, this study provides opportunities for students to voice their opinions.

Conclusion.

In conclusion, virtual reality firefighting training is another alternative that should be considered in the future, which can lower the costs of preparing a good deck cadet who can contribute to a team during firefighting onboard. Virtual reality firefighting training can aid a person in acquiring the knowledge and skills of basic firefighting. In addition, it can help a person familiarize themselves with firefighting equipment. They can rectify the mistakes that occur during virtual training as they can be repeated.

Virtual reality firefighting training is beneficial for both safety and cost-effectiveness. Physical training provides intangible advantages, such as practical experience and team development, but it can be difficult to put these advantages into monetary terms. Virtual reality (VR) training offers accessibility and adaptability that traditional training does not, reduces the cost of accidents, and permits low-cost recurrent training at a cheap cost. However, physical training may still be beneficial for building teamwork and physical endurance, both of which are essential in firefighting situations.

The organization's priorities would decide which of the two options to go with. VR training is advantageous if cost - effectiveness, safety, and frequent training opportunities are prioritized. However, a well-rounded strategy that might incorporate components from both training approaches could offer a complete firefighting training curriculum, guaranteeing a mix of safety, skill development, and real-world experience.

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