Exploring the Perceived Ease of Use of an Immersive VR Engine Room Simulator among Maritime Students: A Segmentation Approach

Bačnar, David; Barić, Demir; Ogrizović, Dario

Source / Izvornik: **Applied Sciences, 2024, 14**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.3390/app14188208

applied sciences

MDPI

Article

Exploring the Perceived Ease of Use of an Immersive VR Engine Room Simulator among Maritime Students: A Segmentation Approach

David Bačnar, **Demir Barić** and **Dario Ogrizović** *

Faculty of Maritime Studies, University of Rijeka, Studentska ulica 2, HR-51000 Rijeka, Croatia;
david.bacnar@pfri.uniri.hr (D.B.); demir.baric@pfri.uniri.hr (D.B.)
* Correspondence: dario@pfri.uniri.hr

Featured Application: The findings of this study have important implications for educators and software developers looking to implement VR technology in maritime education. Educators can use the insights from the study to better customize VR technology to meet the specific needs of students, thus improving the effectiveness and learning experience of VR-based education. Similarly, software developers can use the study's findings to improve the design and functionality of VR engine room simulators for maritime training. This collaborative effort is essential for advancing the application of VR technology in maritime education, ensuring that it aligns with educational objectives and the practical needs of future maritime professionals.

Abstract: The integration of innovative technologies, such as Virtual Reality (VR), into maritime education presents a substantial challenge but also offers significant potential for enhancing training and knowledge transmission. This study aims to contribute to the existing body of knowledge by providing segmented insights into maritime students' Perceived Ease of Use (PEU) of an immersive engine room VR simulator. The study analysed a sample of 58 students from the Faculty of Maritime Studies at the University of Rijeka, covering undergraduate, graduate, and specialized maritime education programs. Through hierarchical and non-hierarchical cluster analyses, two distinct segments were identified and named Proactivists and Moderates. The findings reveal significant differences between extracted sub-groups regarding (i) perceived benefits of using the VR engine room simulator in learning and education, (ii) future intention to use the technology, and (iii) overall experience. Study insights can directly aid educators and software developers in enhancing the further implementation of VR technology in maritime education.

Keywords: virtual reality; engine room simulator; segmentation; maritime education; serious game; perceived ease of use

check for updates

Citation: Bačnar, D.; Barić, D.; Ogrizović, D. Exploring the Perceived Ease of Use of an Immersive VR Engine Room Simulator among Maritime Students: A Segmentation Approach. *Appl. Sci.* **2024**, *14*, 8208. https://doi.org/10.3390/app14188208

Academic Editors: Chrysostomos Stylios, Athanasios Christopoulos and Stylianos Mystakidis

Received: 18 August 2024
Revised: 6 September 2024
Accepted: 10 September 2024
Published: 12 September 2024

1. Introduction

Despite occasional fluctuations, the shipping industry continues to propel the global economy [1]. The ongoing investment in innovative technologies in maritime education, training, and knowledge transmission is considered a fundamental challenge not only in order to sustain a position as global economy leader but also to continue enhancing maritime safety and risk mitigation [2,3]. Traditionally, conventional maritime simulators, among other knowledge transfer tools, have been recognized as an effective training means that allows trainees to comprehend, evaluate, and practice critical situations at sea effectively in a risk-free environment [4]. However, due to their relatively high cost, time and space restrictions, and limited immersion capacity, recently, there has been a significant focus on integrating Virtual Reality (VR) technology into maritime education and training curricula [2,5–7].

VR can be described as a computer-simulated environment that allows users to interact with and modify their perceptions by delivering a combination of 3D sensory information to the human brain via isolated screens or a wearable display, e.g., a Head-Mounted Display (HMD) [8–11]. VR can be divided into three distinct categories: non-immersive, semi-immersive, and immersive. Non-immersive VR employs a conventional computer screen on which the user can indirectly interact with the digital 3D environment by utilizing a mouse, keyboard, or controller. Semi-immersive VR uses a combination of concave monitors and/or wall projectors surrounding the user to display virtual information such as a flight or maritime simulators. Immersive VR is the term used to describe the process of tracking a user's movement and presenting VR information based on their position using an HMD [4,11,12]. The primary advantage of immersive VR is the ability to transport individuals to specific VR environments (e.g., a ship's engine room) with a high degree of psychological fidelity, thereby facilitating an interactive and experiential training experience and encouraging the transfer of knowledge regardless of location or time.

According to recent Statista Search Department estimates (2024) [13], the prevalence of VR technology and its associated industry is rapidly increasing, with the global VR market size expected to rise from less than 12 billion U.S. dollars in 2022 to over 22 billion U.S. dollars by 2025. The constant reduction in VR costs, leaps in computer processing power, and improvements in the technology have boosted the use of VR technology in a variety of domains, including entertainment [14,15], medicine [16], tourism and hospitality [17,18], engineering, logistics, and the maritime industry [6,19,20], as well as in education and professional training [21–25].

Academic endeavors to investigate the potential of VR technology's implementation in the corporate sector have been extensively documented to date. VR simulation training is being utilized in a variety of fields, such as construction training [26], medical training [16], fire and rescue training [27], and aviation inspection training [28]. Though the maritime sector has often been regarded as conservative [29] due to its high-risk environments and the need for rigorous training, it presents a unique opportunity for the adoption of VR technology. In accordance with the worldwide movement towards digitalization and innovation in the shipping sector [5], there has been a rise in research into the application of VR technology in the maritime industry (e.g., [30–32]). The majority of studies have primarily concentrated on various aspects of maritime safety, such as firefighting and evacuation training in the engine room [7], operational procedures on the deck [25], and navigation [2].

While there have been ongoing academic efforts to explore the benefits of the implementation of VR technology in the maritime industry, there remains a lack of studies specifically examining its potential in higher maritime education. Numerous studies have demonstrated that incorporating VR technology in different educational and learning settings can offer multiple benefits to students, such as enhancing engagement, providing greater flexibility and control over the learning process, supporting self-directed learning, improving knowledge transfer, and deepening understanding of previously learned concepts [10,11,33,34]. However, to date, these learning outcomes have been insufficiently explored in maritime higher education (e.g., [12]). Furthermore, studies suggest that users' (e.g., students) perceptions of the adoption and perceived benefits of VR technology in education and learning are influenced not only by its technical features (e.g., fidelity) but also by its level of intuitiveness and simplicity to use [35,36]. The term perceived ease of use denotes the extent to which an individual perceives an innovation as being easy to comprehend or/and utilize [37,38]. To date, the results of different studies that have explored the user's experience with VR technology in the field of industry and education have highlighted that PEU may have direct or indirect positive impacts on user engagement in VR-based learning [20,36], its acceptance, and intention for future use [21,27].

Despite the considerable attention given to understanding how the PEU of VR technology influences users' attitudes towards its educational benefits and their willingness to adopt it in the future, this relationship has not been thoroughly explored within the context of maritime higher education. By focusing specifically on maritime students, the main motivation of this study is to address this gap by exploring relationships between PEU and (i) the perceived benefits of using a VR engine room simulator in maritime learning and education, (ii) the intention to use it in the future, and (iii) the overall experience. To gain deeper insights, the study employs segmentation analysis using PEU as a segmentation basis. By categorizing students into different segments, the study intends to delve deeper into the specific dynamics at play within each group, offering novelty in the understanding of mutual relationships between PEU and the aforementioned constructs.

2. Theoretical Framework and Literature Review

2.1. VR Engine Room Simulators in Maritime Training and Education

Real systems aboard ships provide a genuine experience; however, they are also extremely expensive to operate, have spatial and temporal restrictions, and pose safety risks and consequences. In the domain of Maritime Education and Training (MET), Marine Engine Room Simulators (MERSs) have been utilized for nearly thirty years for the purpose of educating and training marine engineers. Nowadays, MERSs are widely employed in maritime universities and seafarer training institutions around the world; meanwhile, the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW 78/95) also makes mandatory requirements for training marine engineers by using an MERS, which presents the significant importance of MERSs in training marine engineers [32,39]. While conventional MERSs have achieved satisfactory training effects, they come with limitations, including high costs, limited immersive experiences, and dependency on physical infrastructure and instructor involvement [12,31,40]. In response to the limitations of conventional MERS training methods, the concept of fully immersive and interactive VR engine room simulators has been recently developed, highlighting the growing interest in leveraging advanced technology for maritime education. One prominent example is the VR—Ship Engine Room simulator developed by the company Adriacom in cooperation with the Faculty of Maritime Studies at the University of Rijeka, Croatia. This fully immersive VR engine room simulation was specifically developed to assist maritime engineering students not only in acquiring hands-on experience but also in performing diagnostic procedures and managing simulated engine room operations as they would on a real vessel [41]. Another example is from Dalian Maritime University, China, where researchers developed a head-mounted, display-based Immersive Virtual Reality (IVR) marine engine training system based on HTC Vive Pro hardware [42]. Despite the growing interest of the scientific community towards exploring the potential of the integration of VR technology into seafarer training programs (e.g., [2,5,25,43–47]), studies that have specifically investigated the potential of fully immersive VR engine room simulators in maritime engineer training are relatively scarce and are mainly focused on maritime safety training, including topics related to firefighting and evacuation training [7,41,42,48–50].

The educational value of the VR technology in the field of engineering is well established. Scoping reviews conducted by [10,33,51,52] reported a variety of evidence supporting the advantages of incorporating VR technology into higher engineering education. The main findings of these investigations revealed that implementing VR activities in learning processes promotes students' engagement, responsiveness and active control over the learning process, self-paced learning, and overall effectiveness and enhances the holistic comprehension of previously acquired knowledge.

However, there is a scarcity of research that specifically investigates the educational benefits of immersive VR technology in maritime higher education. Ogrizović (2024) [12] conducted one such study that offers valuable insights into this emerging field. He surveyed maritime students during immersive VR engine room trials and found that respondents who had never used the immersive VR technology held a positive view of its potential to improve their learning outcomes. In addition, the research demonstrated that these students were of the opinion that the immersive VR engine room simulator could substantially enhance the effectiveness of their training by providing a more interactive learning environment than traditional MERSs. These findings indicate a strong potential for the inclusion of immersive VR simulators in maritime higher education, though more comprehensive research is needed to fully understand the educational outcomes of VR-based training in this field.

2.2. Perceived Ease of Use (PEU)

The effective integration and utilization of VR in learning and educational environments are contingent upon the users' acceptance and attitudes, including their PEU of this emerging technology [23,36,53]. The PEU constitutes an integral component of Davis's Technology Acceptance Model (TAM), which is grounded in the Theory of Reasoned Action [37,54]. According to the TAM, PEU, along with Perceived Usefulness (PU), is considered a key factor (often termed as Usability construct) in impacting user attitudes towards technology acceptance and future usage [21,55]. Moreover, the results from distinct studies revealed positive relationships between PU/PEU and a diverse array of affective and cognitive factors, including the state of presence, enjoyment, cognitive benefits, and reflective thinking [56,57]. Dhingra and Mudgal [35] stated that although individuals may perceive a given technology as useful, they can simultaneously feel that it is difficult to use. Consequently, the effort required to utilize the technology may outweigh the performance benefits derived from its use. To date, the results of numerous studies that have explored the user experience with VR technology in the field of industry and education have highlighted that PEU, when regarded as an independent construct, may have direct or indirect positive impacts on users' perceived usefulness [58,59], engagement in VR-based learning [20,36], and attitudes towards VR use [21,59]. In addition, several studies (e.g., [58,60,61]) have identified positive correlations between PEU and future behavioural intentions (e.g., the degree to which an individual intends to use or recommend VR as a learning tool to others). Other studies in the fields of hospitality, marketing, and e-learning found a positive relationship between PEU and overall satisfaction [62,63].

2.3. Segmentation

Segmentation involves the process of dividing the set of consumers (e.g., in this case, maritime students) into distinct homogeneous sub-groups based on various socio-demographic traits, needs, attitudes, or behavioural patterns [64,65]. In order for segmentation to be effective, the extracted sub-groups must be measurable, durable, and characterized by a high level of homogeneity [65]. There are two fundamental segmentation approaches, a priori/common sense and a posteriori/data driven [66,67]. The former pertains to the description and characterization of grouping criteria that are either known or specified beforehand (e.g., socio-demographics). The latter approach is used when there are no prior insights about a distinct group in advance. In order to discover homogeneous and mutually distinct sub-groups, statistical techniques (such as factor and/or cluster analysis) are implemented using the empirical survey data. The segments that are generated are subsequently profiled using variables that are deemed pertinent to the objectives of the study [66,68]. In the context of the current study, the initial step involved the selection of students from a maritime university as a special interest group, following the common-sense approach. During the second stage, a data-driven approach was implemented in accordance with the ratings of the PEU of the VR engine room simulator.

3. Materials and Methods

3.1. Hardware and Software

For this trial, we used a Meta Quest 2 (256 GB) VR headset and four equivalent VR headset devices with touch controllers, which is developed by the company Meta, formerly known as Facebook, based in Menlo Park, CA, USA. However, the VR simulator cannot be supported by the headset alone due to its limited hardware resources and the requirements of the simulator. Therefore, each of the four VR headsets was wirelessly connected to its own computer with a dedicated graphics card to run the VR simulator while receiving controls and sending rendered video from the VR headset wirelessly. Each computer had its own dedicated wireless connectivity card, allowing it to create a wireless hotspot for each VR headset to connect to, minimizing lag and maximizing bandwidth to maintain satisfactory video and response quality. The VR laboratory, the used equipment, and the familiarization of the trial participants can be seen in Figure 1.

Figure 1. Depiction of the VR laboratory, equipment, and the familiarization of the participants.

Two of the computers used had an identical configuration, including a 13th Gen Intel Core i7-13700F (2.10 GHz) CPU, 32 GB DDR5-4800 (2400 MHz) RAM, and a NVIDIA GeForce RTX 4070 Ti 12 GB VRAM GPU. The third computer was equipped with a 13th Gen Intel Core i7-13700F (2.10 GHz) CPU, 32 GB DDR5-4800 (2400 MHz) RAM, and a NVIDIA GeForce RTX 3080 10 GB VRAM GPU. The fourth computer featured a 12th Gen Intel Core i7-12700F (2.10 GHz) CPU, 8 GB DDR4-2400 (1200 MHz) RAM, and a NVIDIA GeForce RTX 4070 Ti 12 GB VRAM GPU. All computers ran 64-bit Windows 10 Pro Version 22H2 and were equipped with an Intel Wi-Fi 6E AX210 160 MHz wireless card.

The VR simulator, called VR engine room, is created using 3D modelling software Blender 4.2 and Unreal Engine 5.4. It is specifically designed for use with Windows computers and it is compatible with a variety of VR HMDs, both wired and wireless.

Some of the features of the VR simulator are X-ray vision, which allows users to peer inside equipment by moving the housing; realistic object manipulation; and interaction with various objects such as starting engines, measuring cylinder pressure, manipulating valves, and using a fire extinguisher, as seen in Figure 2.

Figure 2. Some of the possible interactions possible in the simulator (e.g., engine start, fire extinguisher use, blackout flashlight).

The simulator also includes simulation scenarios for fire, flood, blackout, and evacuation. Participants in the simulation are tasked with performing several activities, including using X-ray vision to inspect equipment interiors (by moving the housing), manually operating equipment and interacting with objects, using a fire extinguisher, and navigating through the virtual environment, as seen in Figures 3–5.

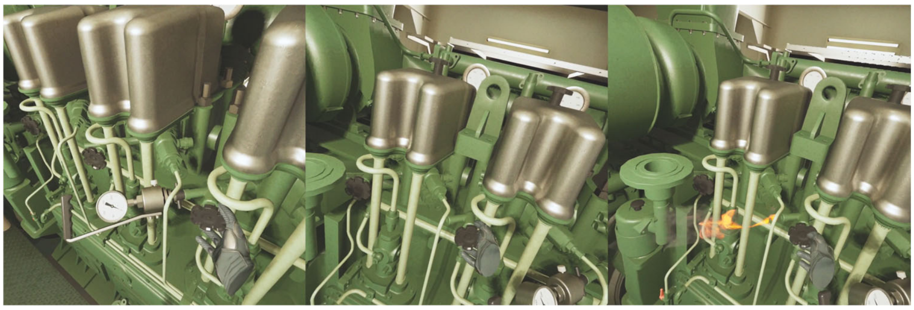

Figure 3. Main engine cylinder pressure measurement procedure using a pressure gauge.

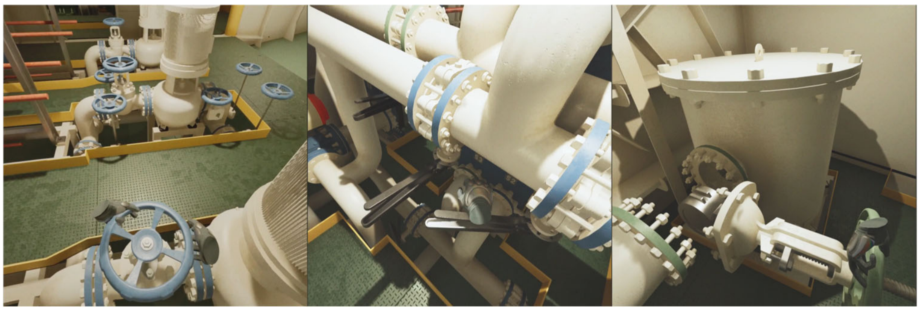

Figure 4. Valve operation procedures, including one-handed and two-handed (last with X-ray vision).

Figure 5. Fire extinguisher priming and subsequent use on a fire (successful fire extinguishment).

A ship engine room model was created based on actual blueprints of an RO-RO ship; it is double-decked and measures 16.1 × 19.6 m. On the bottom deck, it has two main four-stroke diesel engines with shaft generators, three diesel generators, propeller shafts, cooling systems for sea and fresh water, pumps, valves, and pipelines. The upper deck has two heavy fuel oil purifiers, one diesel oil purifier, one service air compressor and two start air compressors, fuel and lubricating oil tanks, valves, and pipelines.

3.2. Sample

The population in the study consisted of 58 students from the Faculty of Maritime Studies at the University of Rijeka, covering undergraduate, graduate, and special education maritime programs. Most of the sample (75.9%) were marine engineering students, followed by trainees enrolled in a special education program for attaining the rank of second engineer officer (17.2%). The remaining participants included students from Logistics and Management in the Maritime Industry and Transport (5.2%) and Marine Electronic Engineering and Information Technology (1.7%) study programs, respectively. All participants were male and aged between 18 and 46 (Mdn = 22). Regarding VR use, 74.1% of the participants had never used a VR headset for educational purposes, 24.1% reported using one 1 to 5 times in their lifetime, and 1.7% had used it on a monthly basis.

3.3. Data Collection and Procedure

The sampling was conducted in a newly equipped VR laboratory at the Faculty of Maritime Studies, University of Rijeka, between 15 May and 15 June 2024. Students were approached before and/or after classes and asked to voluntarily participate in the VR engine room simulator familiarization, trials, and post-use survey. To respondents willing to participate, the lab personnel delivered a 25 min oral introduction including the study aim and brief familiarization with the VR engine room simulator features, where a lab staff member showcased the VR engine room features and controls using a wall projector, as depicted in Figure 1. They explained the process in real time so that participants could follow along. After the introductory part, participants were guided through a tutorial to test the VR engine room simulator under the observation and guidance of the survey team members. Finally, the students participated in a series of trial exercises, independently using the VR engine room simulator. On average, each participant completed the trials in 20 min.

Lastly, each participant was asked to complete a post-use questionnaire that measured their experience using the VR engine room simulator. Data were collected through a self-administered computer-based questionnaire with the Lime Survey tool. On average, each respondent took approximately 10 min to complete the questionnaire. Respondents showed a significantly high willingness to collaborate, as all 58 collected questionnaires were usable for further analysis. An overview of the procedure is given in Figure 6.

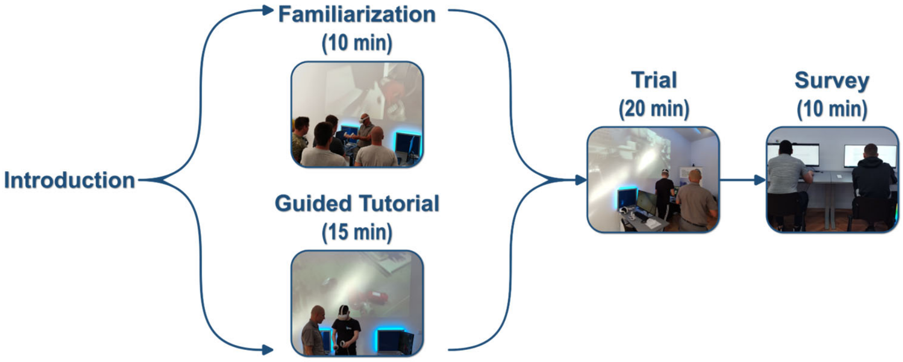

Figure 6. Depiction of the research design procedure containing the introduction consisting of familiarization and user manual training, followed by the trial and survey.

3.4. Instrument Design

As depicted in Figure 7, the questionnaire was partitioned into six main parts: 1. previous experience with VR technology in education, 2. perceived ease of use of the VR engine room simulator, 3. perceived benefits of using the VR simulator in learning and education, 4. future behavioural intention, 5. overall satisfaction, and 6. socio-demographic information. In section one, participants rated their previous experience with VR technology in education on a 5-point Likert scale from 1 (never) to 5 (always/weekly). For sections two (4 items), three (6 items), and four (3 items), students were asked to respond on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) for each statement provided. Overall satisfaction was measured using a single item on a 5-point Likert scale, from 1 (very unsatisfied) to 5 (very satisfied). The final section of the survey gathered information about participants' socio-demographic characteristics, including age, degree level, and program title. Measurement items in sections two, three, and four were drawn from different authors [20,53,56,57,69] and adapted to align with the current research context.

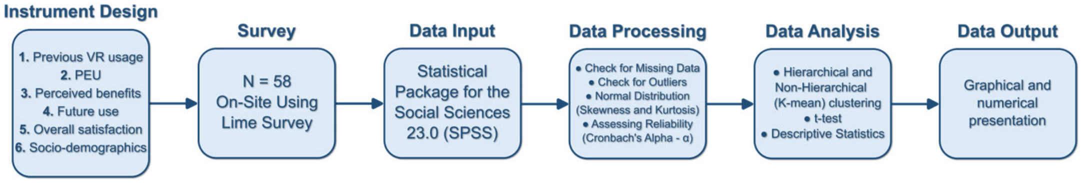

Figure 7. Instrument design, data collection process, and analysis procedure flowchart.

3.5. Data Analysis

As shown in Figure 7, the collected data were processed and analysed using the IBM Statistical Package for the Social Sciences 23.0 (SPSS). Firstly, hierarchical (Ward's method) and non-hierarchical (K-means) clustering procedures were utilized to identify target segments. Subsequently, an independent sample *t*-test was conducted to examine the internal consistency of segments and their differences in perceived benefits, future behavioural intention, and overall satisfaction. In cases where the assumption of variable homogeneity was not met (Levene's test; $p > 0.05$), Welch's *t*-test was accordingly reported. For normality, values of skewness and kurtosis were used. The values satisfied the cut-off level of ±2.58 [70,71]. There were no outliers in the data, as assessed by the inspection of a boxplot for values greater than 1.5 [70]. Perceived ease of use was assessed using four items (e.g., "My interaction with the VR simulator was clear and understandable") and demonstrated a Cronbach's alpha of 0.734. The perceived benefits of VR learning were evaluated through six items (e.g., "Using the VR simulator facilitates the comprehension of my previously acquired knowledge") and yielded a Cronbach's alpha of 0.910. Behavioural intention was gauged using three items (e.g., "I would study more if I had access to VR simulations in my field") and showed a Cronbach's alpha of 0.852.

4. Results

4.1. Segmentation Procedure

A cluster analysis was conducted to segment the maritime students according to their rating of the PEU of the VR engine room simulator (Figure 8). Since the number of segments was not known in advance, Ward's hierarchical cluster procedure with squared Euclidian distance was first used to determine the most appropriate number of clusters. The results of group membership, agglomeration coefficient, and associated dendrograms suggested two and three clusters. Consequently, a non-hierarchical K-means cluster method was employed to additionally test grouping alternatives. A solution with two clusters was deemed appropriate because the obtained segments displayed the most satisfactory characteristics regarding interpretability and measurability. An independent sample *t*-test and Welch's *t*-test result revealed that the segments' mean scores significantly differed on all four measurement items at the probability level $p < 0.001$ (Table 1). The first segment, labelled Proactivists, accounted for 65.5% of the total sample and was composed of students who mostly perceived the VR engine room's simulator PEU as positive ($M > 4$). The second segment, which comprised 34.5% of the total sample, was designated as Moderates because the average rating scores for all examined PEU items were between three and four (Figure 8).

Table 1. Characterization of the PEU-based segments.

	Segments				**df**	**t**	***p*-Value**
	Proactivists		**Moderates**				
	M	**SD**	**M**	**SD**			
Understandable [a]	4.37	0.54	3.40	0.88	26.7	4.48	**<0.001**
Effortless	4.47	0.65	3.00	0.73	56	7.91	**<0.001**
Easy to use	4.29	0.52	3.20	0.77	56	6.43	**<0.001**
User friendly [a]	3.97	0.59	3.20	0.84	29.3	3.70	**<0.001**

Note: [a] A Welch test was reported, as the assumption of homogeneity of variables has not been met.

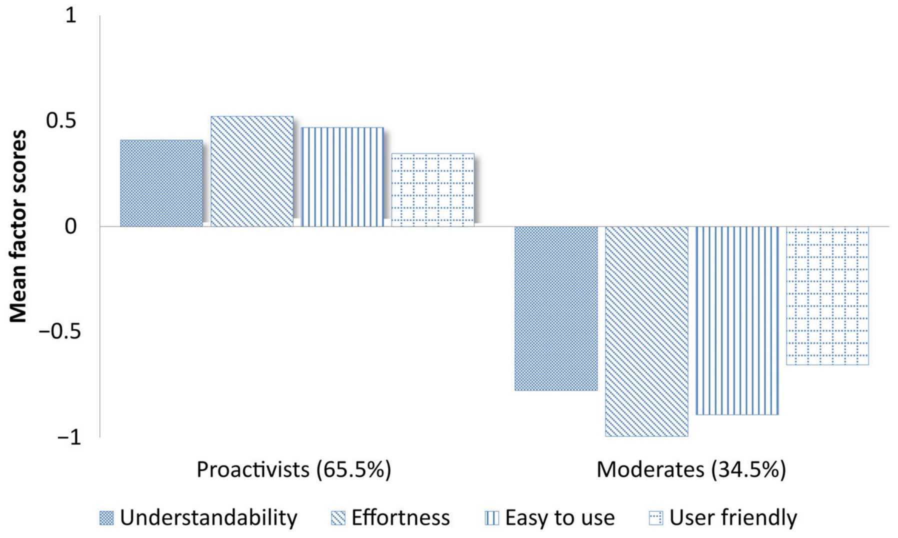

Figure 8. Distribution of mean scores by segments.

4.2. Segment Differences in Perceived Benefits of VR in Learning, Future Behavioural Intention, and Overall Satisfaction

Segment differences in perceived VR engine room learning benefits, future behavioural intention, and overall satisfaction are presented in Tables 2–4, respectively.

Table 2. Differences between segments in perceived benefits.

	Segments						
	Proactivists		**Moderates**		**df**	**t**	***p*-Value**
Perceived VR Learning Benefits	**M**	**SD**	**M**	**SD**			
Comprehending the previously acquired knowledge [a]	4.00	0.57	3.35	0.81	29.1	3.19	**<0.001**
Controlling the learning process	3.97	0.75	3.35	0.93	56	2.76	**0.008**
Promoting self-paced learning	3.87	0.81	3.7	0.98	56	0.70	0.487
Improving the effectiveness of learning [a]	4.13	0.58	3.45	1.05	25.2	3.20	**0.012**
Stimulating responsiveness and active learning	4.16	0.59	3.70	0.92	56	2.29	**0.026**
Enhancing self-engagement in the learning activity	4.05	0.66	3.65	0.99	56	1.86	0.068

Note: [a] A Welch test was reported, as the assumption of homogeneity of variables has not been met.

Table 3. Differences between segments in future behavioural intention.

	Segments						
	Proactivists		**Moderates**		**df**	**t**	***p*-Value**
Future Behavioural Intention	**M**	**SD**	**M**	**SD**			
Using the VR technology frequently in the future [a]	4.18	0.70	3.70	1.13	26.7	1.75	0.091
Studying more if I had access to VR simulations in my field of study [a]	4.11	0.73	3.35	1.09	28.2	3.15	**0.009**
Recommending the use of VR simulations as learning tools to others	4.47	0.60	3.95	1.01	56	2.35	**0.022**

Note: [a] A Welch test was reported, as the assumption of homogeneity of variables has not been met.

Table 4. Differences between segments in overall satisfaction.

	Segments						
	Proactivists		**Moderates**		**df**	**t**	***p*-Value**
Overall Satisfaction	**M**	**SD**	**M**	**SD**			
In general, how satisfied are you with your VR trial experience?	4.68	0.53	4.15	0.88	56	2.91	**0.005**

A statistically significant difference between the two segments was recorded for perceived benefits of VR in learning for four out of six measurement items: comprehending the previously acquired knowledge, t(29.1) = 3.19, $p < 0.001$; controlling the learning process t(56) = 2.76, $p = 0.008$; improving learning effectiveness t(56) = 3.20, $p = 0.012$; and stimulating responsiveness and active learning, t(56) = 2.29, $p = 0.026$.

As displayed in Table 2, Proactivists provided statistically significant higher mean scores for the intention to include the VR engine room simulator as a part of their learning activities, t(28.2) = 3.15, $p = 0.009$, and recommend it to others, t(56) = 2.35, $p = 0.022$. Compared to Moderates (M = 4.15), Proactivists expressed a higher level of overall satisfaction with the VR trial experience (M = 4.68); t(56) = 2.91, $p = 0.005$.

5. Discussion

The primary idea of this applied research was to broaden the current body of knowledge by examining the utility of data-driven segmentation analysis based on PEU in exploring the differences among maritime students in regard to (i) their attitudes towards the benefits of the immersive engine room VR simulator for learning and education, (ii) future behavioural intentions, and (iii) overall VR experience.

The primary discovery provides compelling evidence that maritime students do not respond homogeneously when it comes to the PEU of the VR engine room simulator. Namely, the segmentation analysis demonstrated that the two extracted sub-groups (i.e., Proactivists and Moderates) exhibited a high level of homogeneity and comparability (see Figure 6 and Table 1), which is indeed considered a key characteristic of an efficient market segmentation [65]. The students who had a positive experience with the VR engine room simulator, e.g., finding it user friendly, easy to understand, intuitive, and not too demanding (M > 4), were labelled as Proactivists. This term was chosen because their responses mirrored the definition of proactive behaviour described as one who is self-starting and change or future oriented [72,73]. Those students who rated the PEU items moderately (3 < mean < 4) were simply named as Moderates. Despite the fact more than one-third of the respondents were classified as Moderates, it is important to consider the fact that the majority of the students had no prior experience with VR technology in education and that the research was conducted during the trial use of the VR engine room simulator. Therefore, these findings should be viewed from a positivist perspective, as they offer valuable guidance for enhancing students' assimilation to the VR engine room simulator in the future. The authors of this study propose that educators should give more priority to the familiarization procedures. For instance, during the initial phase, students can be progressively introduced and systematically guided through a series of elementary training exercises to acquire proficiency in fundamental movement and develop a comprehension of spatial perception in the virtual environment. This strategy will enable users to enhance their comprehension of the VR environment, hence enabling them to efficiently complete more sophisticated tasks in subsequent training phases, including executing emergency protocols in a flooded engine room or managing a fire. Additionally, educators and software developers may consider the integration of a series of interactively guided tutorials, which would allow students to independently familiarize themselves with all the features and capabilities of the VR engine room simulator.

Regarding the perceived benefits of using a VR engine room simulator in learning and education, the findings revealed that segments differed significantly with respect to four of the six benefit variables. The results suggest that the perceived benefits of a VR-based learning environment are contingent upon the quality of the interaction experience (i.e., PEU) that an individual has while engaging with the given VR setting. Consequently, the findings provide a captivating foundation for further discussion.

The most significant discrepancy among the segments was found for the benefit item "Comprehending the previously acquired knowledge" in favour of the Proactivists group. The findings imply that interaction factors like the perceived understandability and intuitiveness of the VR engine room simulator, if viewed favourably, may play a significant role in influencing perceived advantages of using the VR environment for the assessment and application of previously learned theoretical knowledge. In addition to educators, these study findings can also provide software developers with valuable insights and new perspectives on how to improve the end-user experience in order to maximize learning benefits, as the software features have a significant impact on factors such as the perceived ease of use [53]. Interestingly, a consistent pattern of ranking was noticed regarding the VR benefits related to self-paced learning and self-engagement. This finding is intriguing because it essentially suggests that, despite differing attitudes towards other perceived benefits, both sub-groups equally regard the use of the VR engine room simulator as a prominent tool that allows them to have control over their engagement and the pace at which they can learn.

Ultimately, the research demonstrated that Proactivists were more satisfied with the overall experience of the VR trials and were more likely to recommend the VR engine room simulator to others and use it in the future for educational functions. These results were somewhat anticipated, as they echo the findings of [60,63,64,73], who discovered that when VR learning environments are perceived as intrinsically interesting, understandable, and intuitive, this perception may have positive impact on overall satisfaction and the development of a positive attitude towards future use.

The use of VR technology, although beneficial, can also have some potential risks associated with it. Therefore, the authors of this study believe its worthy to shed some light on some of these risks. Namely, based on our qualifications and research, we provide our subjective observations and the feedback we received from test subjects regarding the potential risks of using VR technology. The symptoms primarily consist of physical discomfort and are categorized as "cybersickness" or Virtual Reality-Induced Symptoms and Effects (VRISEs) [74,75]. These include motion sickness (disorientation, dizziness, and nausea), eye strain or fatigue, physical injuries, and repetitive strain injuries. During the trials, some participants experienced collisions with real-world objects due to limited space. This suggests that even if a VR user remains mostly stationary, they may still move slightly, which could result in collisions with nearby objects. One participant with claustrophobia initially struggled with using VR, as per [76]; however they eventually adjusted and completed the experiment. Extended use or exposure to dynamic scenarios seemed to exacerbate symptoms or prolong their effects. Additionally, individuals required varying amounts of time to adapt to VR, which could be influenced by their past VR experience and other factors. However, the side effects are generally temporary and mild, varying from person to person. Nonetheless, we must acknowledge that some individuals may experience more adverse reactions, though such cases are rare. As for mitigating the cybersickness, perhaps it would be beneficial to employ a whole-body controller or treadmill, such as in [77], thus alleviating some of the symptoms due to a more natural interaction while walking or interacting with the virtual world. However, the type of content displayed, or rather its level of dynamics, can also affect the level of symptoms experienced, as per [78]. Regarding education, we believe that VR technology complements traditional learning but has not advanced enough to replace it entirely, especially in maritime education. The VR simulator can be a useful training tool; however, its implementation in education curricula should be introduced gradually given that VR technology still under development.

6. Conclusions

The results indicated that segmentation based on the perceived ease of use may be considered a reliable and stable approach to exploring the differences in maritime students' attitudes towards the benefits of VR engine room simulators in learning and education, their future behavioural intentions, and overall experiences. Furthermore, the research underscores the importance of incorporating user feedback to ensure the optimal performance and usability of innovative VR technologies in the future education of maritime students.

As mentioned in the previous section, there is a general lack of research on the potential implementation of VR technology in maritime education, particularly concerning specialized immersive VR engine room simulators. Consequently, this study makes several significant contributions to the current body of knowledge. These contributions include (i) providing a novel approach to exploring the potential of segmentation analysis based on PEU; (ii) validating the stability of extracted segments by examining maritime students' attitudes towards the benefits of using VR engine room simulators in learning and education, future intentions for use, and overall experience; and (iii) offering new perspectives on the importance of understanding the demand side for the further development and implementation of VR technology in maritime education.

Based on the findings, it is evident that just over 30% of students (i.e., Moderates) did not fully integrate with the VR engine room simulator. Therefore, educators should prioritize the development and implementation of specialized introductory protocols to ensure more students can become well acquainted with the interaction features of the VR simulator. Moreover, the benefits of creating introductory protocols could have significant impacts on students' perception of the possibilities and advantages of the usage VR technology for maritime education in the future.

However, it is imperative to recognize some study limitations. As the survey was conducted in a recently opened VR laboratory, which is still in the developmental phase, the sampling was conducted during a relatively restricted period (one month) at the end of the academic year. Thus, the results, while valuable and reliable, should not be generalized, despite the acceptable sample size (n = 58). In this context, we suggest implementing a long-term sampling protocol to verify not only the stability of the identified PEU segments and but also to further detect their variances using different socio-demographic, attitudinal, and behavioural variables. Another possible limitation of this study is again associated with the sample size, which indirectly impeded the application of more sophisticated statistical procedures, including CFA and Structural Equation Modelling (SEM). With a larger sample size, it would be possible to establish and validate an appropriate model based upon which the direct and indirect relationships between PEU and different affective and cognitive constructs could be empirically determined to obtain deeper understanding of the potential of using the VR engine room simulator as a learning tool in maritime education.

Finally, the rationale behind the utilization of a combined approach of segmentation methods should be outlined. Initially, hierarchical clustering was employed to obtain an understanding of the potential number of cluster solutions, as it can disclose the nested structure of the data without necessitating a predetermined number of clusters. However, it is not particularly robust, as even a minor alteration in the data can result in a completely different clustering outcome, which is especially problematic when considering a small sample, as in the case of the present study. To address this limitation, the K-means clustering method was subsequently implemented to resolve this constraint. K-means is less sensitive to small samples and produces well-separated, convex clusters that are simpler to group, visualize, and interpret. Considering the relatively small sample size, by combining hierarchical and non-hierarchical methods, the analysis benefits from the flexibility of hierarchical clustering while also leveraging the simplicity and interpretability of non-hierarchical approaches.

Author Contributions: Conceptualization, D.B. (David Bačnar), D.B. (Demir Barić), and D.O.; methodology, D.B. (David Bačnar); validation, D.B. (David Bačnar) and D.B. (Demir Barić); formal analysis, D.B. (David Bačnar); investigation, D.B. (David Bačnar) and D.O.; resources, D.O.; data curation, D.B. (David Bačnar); writing—original draft preparation, D.B. (David Bačnar) and D.B. (Demir Barić); writing—review and editing, D.B. (David Bačnar), D.B. (Demir Barić), and D.O.; visualization, D.B. (David Bačnar) and D.B. (Demir Barić); supervision, D.O.; project administration, D.O.; funding acquisition, D.O. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the European Union's Horizon Europe research and innovation program under Grant Agreement No. 101087348 "INNO2MARE" project, University of Rijeka project line ZIP UNIRI for the project UNIRI-ZIP-2103-11-22, and by the European Regional Development Fund, under Interreg VI A Italy—Croatia 2021–2027 Programme, project ID: ITHR0200326 (BEST4.0).

Institutional Review Board Statement: The study was conducted after being approved by the University of Rijeka, Faculty of Maritime Studies Ethical Committee (AC:217013702410, May 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data in this article will be provided by the authors upon request.

Acknowledgments: Our thanks go to Darko Glujić and Srđan Žuškin for lending us some of their students, as well as the Maritime Training Centre and Life-long Learning for lending us some of their course participants. Our thanks also go to the total of 58 students and maritime course participants that partook in our study for their time and effort.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

VR	Virtual Reality
HMD	Head-Mounted Display
3D	Three Dimensional
PEU	Perceived Ease of Use
TAM	Technology Acceptance Model
PU	Perceived Usefulness
GB	Gigabyte
GHz	Gigahertz
CPU	Central Processing Unit
DDR	Double Data Rate
MHz	Megahertz
RAM	Random-Access Memory
VRAM	Video Random-Access Memory
GPU	Graphics Processing Unit
Mdn	Median
M	Mean
SD	Standard Deviation
df	Degrees of Freedom
t	T-score
p	*p*-value
CFA	Confirmatory Factor Analysis
SEM	Structural Equation Modelling

References

1. Economist Group. *Global Maritime Trends 2050*; Economist Group: London, UK, 2023.
2. Markopoulos, E.; Lauronen, J.; Luimula, M.; Lehto, P.; Laukkanen, S. "Maritime safety education with VR technology (MarSEVR)", Maritime safety education with VR technology (MarSEVR). In Proceedings of the 2019 10th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Naples, Italy, 23–25 October 2019; pp. 283–288.
3. Koukaki, T.; Tei, A. Innovation and maritime transport: A systematic review. *Case Stud. Transp. Policy* **2020**, *8*, 700–710. [CrossRef]
4. De Oliveira, R.P.; Junior, G.C.; Pereira, B.; Hunter, D.; Drummond, J. Andre Systematic Literature Review on the Fidelity of Maritime Simulator Training. *Educ. Sci.* **2022**, *12*, 817. [CrossRef]
5. Markopoulos, E.; Luimula, M. Immersive safe oceans technology: Developing virtual onboard training episodes for maritime safety. *Futur. Internet* **2020**, *12*, 80. [CrossRef]
6. Markopoulos, E.; Markopoulos, P.; Laivuori, N.; Moridis, C.; Luimula, M. Finger tracking and hand recognition technologies in virtual reality maritime safety training applications. In Proceedings of the 11th IEEE International Conference on Cognitive Infocommunications, CogInfoCom 2020—Proceedings, Online, 23–25 September 2020; pp. 251–258.
7. Vukelic, G.; Ogrizovic, D.; Bernecic, D.; Glujic, D.; Vizentin, G. Application of VR Technology for Maritime Firefighting and Evacuation Training—A Review. *J. Mar. Sci. Eng.* **2023**, *11*, 1732. [CrossRef]
8. Freina, L.; Ott, M. A Literature Review on Immersive Virtual Reality in Education: State of the Art and Perspectives. In Proceedings of the 11th International Conference eLearning and Software for Education, Bucharest, Romania, 25–26 April 2015; Volume 1, pp. 133–141.
9. Bailenson, J.N.; Yee, N.; Blascovich, J.; Beall, A.C.; Lundblad, N.; Jin, M. The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *J. Learn. Sci.* **2008**, *17*, 102–141. [CrossRef]

10. Soliman, M.; Pesyridis, A.; Dalaymani-Zad, D.; Gronfula, M.; Kourmpetis, M. The application of virtual reality in engineering education. *Appl. Sci.* **2021**, *11*, 2879. [CrossRef]
11. Hamad; Jia, B. How Virtual Reality Technology Has Changed Our Lives: An Overview of the Current and Potential Applications and Limitations. *Int. J. Environ. Res. Public Heal.* **2022**, *19*, 11278. [CrossRef]
12. Ogrizovic, D. Computer simulation of a marine engine room using fully immersive and interactive virtual reality. In Proceedings of the International Conference on Artificial Intelligence, Computer, Data Sciences, and Applications, ACDSA 2024, Victoria, Seychelles, 1–2 February 2024; pp. 1–4.
13. Statista. *Virtual Reality (VR)—Statistics & Facts*. 2024. Available online: https://www.statista.com/topics/2532/virtual-reality-vr/ (accessed on 6 September 2024).
14. Kishor; Kala, D.; Jain, D.; Arora, A.; Student, F.Y. Analysis of the Gaming Industry: Embracing Virtual Reality Experiences. *Int. J. Res. Anal. Rev.* **2023**, *10*, 155–159.
15. Kari, T.; Kosa, M. Acceptance and use of virtual reality games: An extension of HMSAM. *Virtual Real.* **2023**, *27*, 1585–1605. [CrossRef]
16. Kouijzer, M.M.T.E.; Kip, H.; Bouman, Y.H.A.; Kelders, S.M. Implementation of virtual reality in healthcare: A scoping review on the implementation process of virtual reality in various healthcare settings. *Implement. Sci. Commun.* **2023**, *4*, 1–29. [CrossRef]
17. Chung, N.; Han, H.; Joun, Y. Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site. *Comput. Hum. Behav.* **2015**, *50*, 588–599. [CrossRef]
18. Han, D.I.; Dieck, M.C.T.; Jung, T. User experience model for augmented reality applications in urban heritage tourism. *J. Herit. Tour.* **2018**, *13*, 46–61. [CrossRef]
19. Kuncoro, T.; Ichwanto, M.A.; Muhammad, D.F. VR-Based Learning Media of Earthquake-Resistant Construction for Civil Engineering Students. *Sustainability* **2023**, *15*, 4282. [CrossRef]
20. Masiello, I.; Herault, R.; Mansfeld, M.; Skogqvist, M. Simulation-Based VR Training for the Nuclear Sector—A Pilot Study. *Sustainability* **2022**, *14*, 7984. [CrossRef]
21. Patricia, E.; Louis, E.N.; Sartono, E.S.; Gui, A.; Shaharudin, M.S.; Pitchay, A.A. Analysis of Factors Affecting Students Intention to Use Virtual Reality in Education. In Proceedings of the 2023 8th International Conference on Business and Industrial Research, ICBIR 2023—Proceedings, Bangkok, Thailand, 18–19 May 2023; pp. 1222–1227.
22. Zhao, J.; LaFemina, P.; Carr, J.; Sajjadi, P.; Wallgrün, J.O.; Klippel, A. Learning in the Field: Comparison of Desktop, Immersive Virtual Reality, and Actual Field Trips for Place-Based STEM Education. In Proceedings of the 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), Atlanta, GA, USA, 22–26 March 2020; pp. 893–902.
23. Song, H.; Kim, T.; Kim, J.; Ahn, D.; Kang, Y. Effectiveness of VR crane training with head-mounted display: Double mediation of presence and perceived usefulness. *Autom. Constr.* **2021**, *122*, 103506. [CrossRef]
24. Strojny, P.; Dużmańska-Misiarczyk, N. Measuring the effectiveness of virtual training: A systematic review. *Comput. Educ. X Real.* **2023**, *2*, 100006. [CrossRef]
25. Makransky, G.; Klingenberg, S. Virtual reality enhances safety training in the maritime industry: An organizational training experiment with a non-WEIRD sample. *J. Comput. Assist. Learn.* **2022**, *38*, 1127–1140. [CrossRef]
26. Rokooei, S.; Shojaei, A.; Alvanchi, A.; Azad, R.; Didehvar, N. Virtual reality application for construction safety training. *Saf. Sci.* **2023**, *157*, 105925. [CrossRef]
27. Braun, P.; Grafelmann, M.; Gill, F.; Stolz, H.; Hinckeldeyn, J.; Lange, A.-K. Virtual reality for immersive multi-user firefighter-training scenarios. *Virtual Real. Intell. Hardw.* **2022**, *4*, 406–417. [CrossRef]
28. Eschen, H.; Kötter, T.; Rodeck, R.; Harnisch, M.; Schüppstuhl, T. Augmented and Virtual Reality for Inspection and Maintenance Processes in the Aviation Industry. *Procedia Manuf.* **2018**, *19*, 156–163. [CrossRef]
29. Acciaro, M.; Ferrari, C.; Lam, J.S.; Macario, R.; Roumboutsos, A.; Sys, C.; Tei, A.; Vanelslander, T. Are the innovation processes in seaport terminal operations successful? *Marit. Policy Manag.* **2018**, *45*, 787–802. [CrossRef]
30. Dewan, M.H.; Godina, R.; Chowdhury, M.R.K.; Noor, C.W.M.; Nik, W.M.N.W.; Man, M. Immersive and Non-Immersive Simulators for the Education and Training in Maritime Domain—A Review. *J. Mar. Sci. Eng.* **2023**, *11*, 147. [CrossRef]
31. Shen, H.; Zhang, J.; Cao, H. Research of marine engine room 3-D visual simulation system for the training of marine engineers. *J. Appl. Sci. Eng.* **2017**, *20*, 229–242.
32. Shen, H.; Zhang, J.; Yang, B.; Jia, B. Development of an educational virtual reality training system for marine engineers. *Comput. Appl. Eng. Educ.* **2019**, *27*, 580–602. [CrossRef]
33. Radianti, J.; Majchrzak, T.A.; Fromm, J.; Wohlgenannt, I. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Comput. Educ.* **2020**, *147*, 103778. [CrossRef]
34. Leißau, M.; Hellbach, S.; Laroque, C. Self-paced learning in virtual worlds: Opportunities of an immersive learning environment. In Proceedings of the European Conference on e-Learning, ECEL, Berlin, Germany, 28–29 October 2021; pp. 257–265.
35. Dhingra, M.; Mudgal, R.K. Applications of Perceived Usefulness and Perceived Ease of Use: A Review. In Proceedings of the 2019 8th International Conference on System Modeling and Advancement in Research Trends, SMART 2019, Moradabad, India, 22–23 November 2019; pp. 293–298.
36. Wong, E.Y.C.; Hui, R.T.Y.; Kong, H. Perceived usefulness of, engagement with, and effectiveness of virtual reality environments in learning industrial operations: The moderating role of openness to experience. *Virtual Real.* **2023**, *27*, 2149–2165. [CrossRef]

37. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q. Manag. Inf. Syst.* **1989**, *13*, 319–339. [CrossRef]
38. Zeithaml, V.A.; Parasuraman, A.; Malhotra, A. Service Quality Delivery through Web Sites: A Critical Review of Extant Knowledge. *J. Acad. Mark. Sci.* **2002**, *30*, 362–375. [CrossRef]
39. International Maritime Organization (IMO). *STCW: Including 2010 Manila Amendments: STCW Convention and STCW Code: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers*; International Maritime Organization: London, UK, 2011.
40. Mangga, C.; Tibo-oc, P.; Montaño, R. Impact of Engine Room Simulator As A Tool for Training and Assessing Bsmare Students' Performance in Engine Watchkeeping. *Pedagogika-Pedagogy* **2021**, *93*, 88–100. [CrossRef]
41. Glujić, D. Advanced Model of Fire Spread in Ship Engine Room Based on Virtual Reality. Ph.D. Thesis, University of Rijeka, Rijeka, Croatia, 2024.
42. Tan, Y.; Niu, C.; Zhang, J. Head-Mounted, Display-Based Immersive Virtual Reality Marine-Engine Training System: A Fully Immersive and Interactive Virtual Reality Environment. *IEEE Syst. Man Cybern. Mag.* **2020**, *6*, 46–51. [CrossRef]
43. Chae, C.-J.; Kim, D.; Lee, H.-T. A Study on the Analysis of the Effects of Passenger Ship Abandonment Training Using VR. *Appl. Sci.* **2021**, *11*, 5919. [CrossRef]
44. Qiu, S.; Ren, H.; Wang, D.; Qu, Y.; Sun, J. Research on an educational virtual training system for ship life-saving appliances. *Comput. Appl. Eng. Educ.* **2024**, *32*, e22708. [CrossRef]
45. Frydenberg, S.G.; Nordby, K. Virtual fieldwork on a ship's bridge: Virtual reality-reconstructed operation scenarios as contextual substitutes for fieldwork in design education. *Virtual Real.* **2022**, *27*, 3333–3344. [CrossRef] [PubMed]
46. Shang, L.; Gao, Q.; Chen, J.; Hu, F. Research of Virtual Simulation Experiment Platform for Marine Auxiliary Machinery Based on VR/AR. In Proceedings of the 3rd International Conference on Computer Science and Application Engineering, Sanya, China, 22–24 October 2019.
47. Bassano, C.; Chessa, M.; Fengone, L.; Isgró, L.; Solari, F.; Spallarossa, G.; Zini, A. Evaluation of a Virtual Reality System for Ship Handling Simulations. In Proceedings of the 14th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, Prague, Czech Republic, 25–27 February 2019.
48. Hjellvik, S.; Renganayagalu, S.K.; Mallam, S.; Nazir, S. Immersive Virtual Reality in Marine Engineer Education. In Proceedings of the Ergoship, Haugesund, Norway, 24–25 September 2019.
49. Niu, C.; Tan, Y.; Jiang, R.; Tian, H.; Lin, Y.; Zhang, J. Enhancement of Telepresence and Collaboration in a 3D Virtual Marine Engine Room as a Complement to the Traditional Semi Physical Marine Engine Room Simulator. In Proceedings of the International Conference on Mechanical, Aerospace and Automotive Engineering, Changsha, China, 3–5 December 2021.
50. Deng, J.; Gong, M.; Du, Z.; Zhou, Z.; Chen, H.; Xiao, W.; Guan, C. Design and implementation of immersive interactive simulation system for ship engine room. *Chin. J. Ship Res.* **2023**, *18*, 31–39.
51. Oje, A.V.; Hunsu, N.J.; May, D. Virtual reality assisted engineering education: A multimedia learning perspective. *Comput. Educ. X Real.* **2023**, *3*, 100033. [CrossRef]
52. Wang, P.; Wu, P.; Wang, J.; Chi, H.-L.; Wang, X. A Critical Review of the Use of Virtual Reality in Construction Engineering Education and Training. *Int. J. Environ. Res. Public Heal.* **2018**, *15*, 1204. [CrossRef]
53. Makransky, G.; Petersen, G.B. Investigating the process of learning with desktop virtual reality: A structural equation modeling approach. *Comput. Educ.* **2019**, *134*, 15–30. [CrossRef]
54. Fishbein, M.; Ajzen, I. *Beliefs, Attitudes, Intention, and Behaviour: An Introduction to the Theory and Research*; Addison-Wesley: Reading, MA, USA, 1975; p. 578.
55. Karahanna, E.; Straub, D.W. The psychological origins of perceived usefulness and ease-of-use. *Inf. Manag.* **1999**, *35*, 237–250. [CrossRef]
56. Makransky, G.; Lilleholt, L. A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educ. Technol. Res. Dev.* **2018**, *66*, 1141–1164. [CrossRef]
57. Lee, E.A.-L.; Wong, K.W.; Fung, C.C. How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. *Comput. Educ.* **2010**, *55*, 1424–1442.
58. Fagan, M.; Kilmon, C.; Pandey, V. Exploring the adoption of a virtual reality simulation: The role of perceived ease of use, perceived usefulness and personal innovativeness. *Campus-Wide Inf. Syst.* **2012**, *29*, 117–127. [CrossRef]
59. Brown, T.J. Individual and Technological Factors Affecting Perceived Ease of Use of Web-based Learning Technologies in a Developing Country. *Electron. J. Inf. Syst. Dev. Ctries.* **2002**, *9*, 1–15. [CrossRef]
60. Huang, H.M.; Liaw, S.S. An analysis of learners' intentions toward virtual reality learning based on constructivist and technology acceptance approaches. *Int. Rev. Res. Open Distrib. Learn.* **2018**, *19*, 91–115. [CrossRef]
61. Hornsey, R.L.; Hibbard, P.B. Current Perceptions of Virtual Reality Technology. *Appl. Sci.* **2024**, *14*, 4222. [CrossRef]
62. Baki, R.; Birgoren, B.; Aktepe, A. A meta analysis of factors affecting perceived usefulness and perceived ease of use in the adoption of E-Learning systems. *Turk. Online J. Distance Educ.* **2018**, *19*, 4–42. [CrossRef]
63. Lim, W.M.; Jasim, K.M.; Das, M. Augmented and virtual reality in hotels: Impact on tourist satisfaction and intention to stay and return. *Int. J. Hosp. Manag.* **2024**, *116*, 103631. [CrossRef]
64. Goyat, S. The basis of market segmentation: A critical review of literature. *Eur. J. Bus. Manag.* **2011**, *3*, 45–55.

65. Wedel, M.; Kamakura, A. *Market Segmentation-Conceptual and Methodological Foundations*; Kluwer Academic Publishers: Dordrecht, The Netherlands, 2000; p. 206.
66. Dolničar, S. Beyond "Commonsense Segmentation": A Systematics of Segmentation Approaches in Tourism. *J. Travel Res.* **2004**, *42*, 244–250. [CrossRef]
67. Mazanec, A. *Market Segmentation*; Jafari, H.X.J., Ed.; Routledge: London, UK, 2000; pp. 125–126.
68. Dolnicar, S. A Review of Data-Driven Market Segmentation in Tourism. *J. Travel Tour. Mark.* **2002**, *12*, 1–22. [CrossRef]
69. Renganayagalu, S.K.; Mallam, S.C.; Nazir, S.; Ernstsen, J.; Haavardtun, P. Impact of simulation fidelity on student self-efficacy and perceived skill development in maritime training. *TransNav* **2019**, *13*, 663–669. [CrossRef]
70. Pallant, J. SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS. In *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS*, 4th ed.; Allen & Unwin: Crows Nest, QLD, Australia, 2013.
71. Field, P. *Discovering Statistics Using SPSS*, 2nd ed.; SAGE Publications: London, UK, 2005; p. 821.
72. Crant, M. Proactive behavior in organizations. *J. Manag.* **2000**, *26*, 435–462. [CrossRef]
73. Ohly, S.; Fritz, C. Work characteristics, challenge appraisal, creativity, and proactive behavior: A multi-level study. *J. Organ. Behav.* **2009**, *31*, 543–565. [CrossRef]
74. Chang, E.; Kim, H.T.; Yoo, B. Virtual Reality Sickness: A Review of Causes and Measurements. *Int. J. Hum. Comput. Interact.* **2020**, *36*, 1658–1682. [CrossRef]
75. Stanney, K.; Lawson, B.D.; Rokers, B.; Dennison, M.; Fidopiastis, C.; Stoffregen, T.; Weech, S.; Fulvio, J.M. Identifying Causes of and Solutions for Cybersickness in Immersive Technology: Reformulation of a Research and Development Agenda. *Int. J. Human–Computer Interact.* **2020**, *36*, 1783–1803. [CrossRef]
76. Howard, C.; Van Zandt, E.C. A meta-analysis of the virtual reality problem: Unequal effects of virtual reality sickness across individual differences. *Virtual Real.* **2021**, *25*, 1221–1246. [CrossRef]
77. Dopsaj, M.; Tan, W.; Perovic, V.; Stajic, Z.; Milosavljevic, N.; Paessler, S.; Makishima, T. Novel neurodigital interface reduces motion sickness in virtual reality. *Neurosci. Lett.* **2024**, *825*, 137692. [CrossRef]
78. Saredakis, D.; Szpak, A.; Birckhead, B.; Keage, H.A.D.; Rizzo, A.; Loetscher, T. Factors Associated With Virtual Reality Sickness in Head-Mounted Displays: A Systematic Review and Meta-Analysis. *Front. Hum. Neurosci.* **2020**, *14*, 96. [CrossRef]