The necessity of cloud-based simulator for Indonesia's maritime education and training institutions

Stevian Geerbel Adrianes Rakka

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THE NECESSITY OF CLOUD-BASED SIMULATOR FOR INDONESIA’S MARITIME EDUCATION AND TRAINING INSTITUTIONS

By

STEVIAN GEERBEL ADRIANES RAKKA
Indonesia

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE
in
MARITIME AFFAIRS

MARITIME EDUCATION AND TRAINING

2022

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature) : ..................................................
(Date) : 20th September 2022

Supervised by : Dr. Johan Bolmsten
Supervisor’s affiliation : World Maritime University
Acknowledgements

I would first like to thank God for granting me the opportunity and strength to carry out my studies and complete this dissertation successfully. And I would like to thank my family and a special one for their endless support throughout my study.

I am also grateful to International Maritime Organization for sponsoring and providing me with the opportunity to pursue MSc at World Maritime University.

I would like to express my sincere gratitude to my supervisor, Dr. Johan Bolmsten, for his patience in guiding and supporting me constantly throughout the dissertation. Also, I sincerely thank all members of the MET faculty for their guidance and encouragement during the specialization term.

To my WMU friends, thank you for making this experience worthwhile. To my Bistro friends, thank you for your support with a cup of tea every morning. I appreciate your friendship and appreciation towards me. Last but not least, I thank the maritime experts and MET institutions under the Ministry of Transportation Indonesia who helped me with the interview and questionnaire survey.
Abstract

Title of Dissertation : The Necessity of Cloud-based Simulator for Indonesia’s Maritime Education and Training Institutions

Degree : Master of Science

During COVID-19, several institutions have made some efforts to adopt cloud-based simulators. This is because, after the pandemic, they see that cloud-based simulators could be the solution for their issues in delivering practical training. Especially the institutions that are located in remote areas and are difficult to reach. However, it is still a question of whether cloud-based simulators can fulfill their need or need more development or there are other alternatives to solve the issues.

This study is conducted in three stages, where each stage is designed to answer its related research question: What are the main factors that affect the selection of simulators in a MET institution? Are the existing training simulators appropriate and capable of accommodating the training and assessment activities in Indonesia’s MET institutions? Are cloud-based simulators needed to be adopted by MET institutions in Indonesia?

The thematic analysis and Analytical Hierarchy Process (AHP) method are the analytical frameworks in this study. The primary data was collected through interviews, questionnaires and document reviews. The literature review supports the analysis process and serves as the secondary data of this study. The first stage of the study is designed to answer the first research question, which becomes the foundation for subsequent stages in answering the other questions.

The data analysis and discussion found that cloud-based simulators are necessary for MET institutions in Indonesia. Cloud-based simulators gained the highest weight value between alternatives of training simulators. This conclusion is supported by the analysis result that revealed the instructor’s capability in operating the simulator and high degree of flexibility are two most needed factors by MET institutions should be available immediately. Being one of the largest suppliers for seafarer, the variety of training simulator technology used by MET institutions in Indonesia is quite behind other supplier countries, such as the Philippines. Therefore, any publications related to cloud-based simulators are hardly found. This opens up an opportunity to investigate cloud-based simulators, especially their implementation in Indonesia, and learn about their benefits.

KEYWORDS: Cloud-based simulator; Cloud computing; Training simulator; Analytical Hierarchy Process (AHP); Simulation-based training; Weight value; Criteria; Alternatives
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<th>Full Form</th>
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<tr>
<td>MET</td>
<td>Maritime Education and Training</td>
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<td>METIs</td>
<td>Maritime Education and Training Institutions</td>
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<tr>
<td>STCW</td>
<td>International Convention on Standards of Training, Certification and Watchkeeping for Seafarers</td>
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<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>AHP</td>
<td>Analytic Hierarchy Process</td>
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<td>IMO</td>
<td>International Maritime Organization</td>
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<td>DP</td>
<td>Dynamic Positioning</td>
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<td>GMDSS</td>
<td>Global Maritime Distress and Safety System</td>
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<td>VR</td>
<td>Virtual Reality</td>
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<tr>
<td>HMD</td>
<td>Head-mounted Display</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>CBS</td>
<td>Cloud-based Simulation/ Simulator</td>
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<tr>
<td>WBS</td>
<td>Web-based Simulation</td>
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<tr>
<td>IaaS</td>
<td>Infrastructure-as-a-Service</td>
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<tr>
<td>PaaS</td>
<td>Platform-as-a-Service</td>
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<tr>
<td>SaaS</td>
<td>Software-as-a-Service</td>
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<tr>
<td>CloudDNSE</td>
<td>Cloud-based Distributed Network Simulation Environment</td>
</tr>
<tr>
<td>DNV</td>
<td>Det Norske Veritas</td>
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<tr>
<td>MCDM</td>
<td>Multi-Criteria Decision Making</td>
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<tr>
<td>CR</td>
<td>Consistency Ratio</td>
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<td>TLAs</td>
<td>Teaching and Learning Activities</td>
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Chapter 1: Introduction

1.1. Background and Context

“Indonesia as the world’s largest archipelagic state consisted of 18,108 islands, scattered between the island of Breueh in the west, Sibir island in the east, Miangas in the north and Dana in the south” (Cribb & Ford, 2009). For this reason, Maritime Education and Training (MET) Institutions were built across the country to accommodate the existing and new seafarers by reducing the travel cost by just visiting the nearest Institutions. These MET Institutions come from the government and private sectors in secondary and tertiary education. Therefore, only twelve (12) institutions are owned and managed by the Ministry of Transportation Indonesia (MoT, 2020), located on the five main islands of Indonesia. Most of them are considered to have complete training courses approved by the Administrator and facilitated by the latest equipment (simulators and laboratories) aligned with a handful of qualified instructors.

However, several institutions were established in remote locations quite far from the nearest city. This significant distance has made the trainees’ reluctance to enrol in those institutions despite the convenience. The issues related to the cost they must incur for accommodation during the training process could take days, weeks, or even months. Although those Institutions tried to address the issue by providing free accommodation for trainees, they tend to choose the near-city institutions, especially ones located in the nation’s capital. Another thing is that most shipping companies from the national and international branches are located in the nation’s capital. Some trainees argue that they could look for crew vacancies in the capital, which provides more opportunities while completing their training. Based on the author’s observation, these phenomena heavily affect the Institutions located in remote locations, which means the government’s initial goal of accommodating all the seafarers by providing the MET institutions across the country is hardy accomplished.

The situation worsened significantly when Covid-19 cases rose, and most education and training activities ceased due to quarantine and health protocols. This condition has pushed all the MET Institutions to change their learning method to
distance learning if they still want to continue their activities. Since on-site learning is a learning method that is commonly used in all of Indonesia's MET institutions, changing to distance learning certainly will not run as smoothly as expected. Various challenges have emerged in adapting to this new distance learning, such as the low engagement exhibited by students/trainees during the learning process or situations where students/trainees do not achieve the intended outcome from a course/learning subject, especially when delivering a 'practical' training course that requires a simulator. Training simulators have been used in various industries for many years to prepare their personnel for the job roles resulting in optimal performance in highly stressful situations (Chrichton, 2017, as cited in Kim et al., 2021). Additionally, a training simulator is a mandatory requirement in delivering the material and assessing the candidates for some courses as regulated in the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978*, as amended. Moreover, MET institutions have difficulty accommodating the trainees in confined simulators’ environments where physical contact during training activities can hardly avoided in line with imposed restrictions.

Therefore, MET institutions are trying to adopt another kind of simulator known as a cloud-based simulator that utilises cloud computing to run the simulation program, just like a physical-based simulator that uses local hardware. This cloud-based system could complement the learning activities of a training course for its ‘practical’ aspect through distance learning in the Learning Management System of MET institutions. Besides providing a solution to address this challenge, this effort is also a response of MET institutions in Indonesia to the significant change in the globalization era, according to the author’s observation. As part of the Industrial Revolution 4.0, the cloud-based system, also called the “Internet of Things” or “Cloud Computing”, which focuses on automation and real-time data connection, has provided considerable benefits to various fields of industry. As a result, all the stakeholders could increase their production levels resulting in the rapid growth of the world's economy. The maritime industry became one of the industry fields that obtained many advantages from this growth. Furthermore, as part of the Maritime Industry's framework, MET Institutions could utilise this technology to pursue their purpose of accommodating the seafarers' training and development.
However, before implementing the cloud-based simulators, there are many factors that should be considered. Since this simulator is newly developed, resulting in a minimum application by MET in the world, it is necessary to investigate the characteristics, benefits and disadvantages of this simulator, for MET in Indonesia. The other alternatives for training simulators should be identified and investigated on their merits and demerits. Then these characteristics will be collected and analyzed on their similarities which are beneficial and needed by institutions to facilitate the simulation-based training.

1.2. Problem Statement

Indonesia, as the third-largest supplier country of seafarers on foreign ships in the world after China and the Philippines (Handayani, M., Kurniawan, D., 2021, para. 1), needs the continuance of MET Institutions to accommodate this considerable number of seafarers and future candidates in their education and training. Thus, the establishment of MET institutions across regions in Indonesia has initially intended for seafarers located in some remote areas due to the nature of Indonesia, which consists of thousands of islands. Based on the author’s observation, these seafarers unexpectedly prefer to stay in areas where the establishment of shipping companies or crewing agencies is highly concentrated, such as the nation’s capital city, Jakarta. Furthermore, while they were looking for a job opportunity in those areas or waiting for the sign-on schedule, they used it as a chance to upgrade their qualification or revalidate their certificate. This situation has led to the accumulation of trainees in certain MET institutions and other institutions becoming unproductive. It is also shown that the government’s effort to accommodate seafarers was unsuccessful.

This unfavourable situation became worse when Covid-19 cases emerged in Indonesia. The government must restrict physical contact between people in every sector, which undoubtedly affects the activities in each MET institution within the country. Then, the concept of distance learning is introduced through national policy and subsequently will be applied in all MET institutions to accommodate the students and trainees. Therefore, some institutions are trying to adopt cloud-based simulation technology to assist the lecturers and instructors in delivering the training material that requires a simulator. They also want to gain benefits from this technology with the
expectation of solving the problem relating to the accumulation of trainees in certain institutions.

Implementing a cloud-based simulator could present many challenges either in its effectiveness in delivering the materials or the readiness of MET institutions’ resources to operate this simulator. As part of the human elements that will operate the training simulators, including Cloud-based simulators, Instructors in a MET institution must be able to handle the simulators and utilise their features in delivering the training materials to the trainees. Meanwhile, the trainees also must have enough appropriate Information Technology (IT) knowledge or skill to collaborate in the training process through these new simulators. However, other than IT knowledge and skills, there are still many factors that affect the decision of Indonesia’s MET Institutions to implement cloud-based simulators as their training instruments. Therefore, questions arise in the author’s mind: Will this technology be able to solve the issues faced by these institutions, or could there be other ways to solve these issues without adopting this technology?

1.3. Aims

This study aims to assess the necessity of cloud-based simulators to be adopted and implemented by MET institutions in Indonesia. To achieve the research aims, this study has the following objectives:

- To identify the factors of a training simulator that Met institutions need in conducting simulation-based training
- To determine whether the existing training simulators are appropriate and capable of meeting the MET institutions’ needed factors of a training simulator
- To investigate the alignment of cloud-based simulators with the needed factor

1.4. Research Questions
The author has formulated the following research questions to achieve the objectives of this study:

- What are the main factors that affect the selection of simulators in a MET Institution?
- Are the existing training simulators appropriate and capable of accommodating the training and assessment activities in Indonesia’s MET Institutions?
- Are cloud-based simulators needed to be adopted by MET Institutions in Indonesia?

1.5. **Research Methodology and Methods**

The data used in this study will be collected through a mixed method between qualitative and quantitative approaches. Hence, this mixed method will maximise the strength of both approaches and reduce their limitations (Truscott et al., 2010, as cited in Kuada, 2012). First, semi-structured interviews will be undertaken as part of the qualitative method to define critical factors of the appropriate simulator selection in a MET institution. Then these key factors will be used as the foundation for building the questionnaire. Additionally, the participants of these interviews are simulation experts with different backgrounds who have already engaged with training simulators for a desirable amount of time, including cloud-based simulators, during their professional carrier.

Furthermore, quantitative data will be collected through a close-ended questionnaire which can be answered by a single word or short phrase (Kuada, 2012) with space for clarification if the research’s participants are deemed necessary. This questionnaire will be distributed to the research’s participants consisting of six (6) simulator instructors and six (6) trainees from the deck and engine course from twelve (12) MET Institutions respectively in Indonesia. Then the results will be analysed using Analytic Hierarchy Process (AHP) to calculate the priority weights for each factor. By then, the existing condition could be understood from the discussion, and a conclusion can be drawn.
1.6. **Structure of the Dissertation**

This dissertation is structured into six chapters, as follows:

- Chapter 1 shows the background, problem statement, aims and objectives, research questions, and a short brief on the research methodology of this study, along with the methods.
- Chapter 2 shows the collection of literature that will become the foundation or comparison of the result of data collection.
- Chapter 3 discusses the research design that will be used to conduct this study in detail, including how to collect the data, how to analyse the data, and so on.
- Chapter 4 presents the findings, analysis and discussion of data collected through the qualitative methods.
- Chapter 5 presents the findings, analysis and discussion of data collected through the quantitative methods.
- Chapter 6 delivers the study’s conclusion, limitations, the possibility for future studies and recommendations for MET Institutions regarding the implementation of cloud-based simulators.
Chapter 2: Literature Review

Through this chapter, the author will primarily be focused on explaining theoretical discussion and previous studies on related topics to the cloud-based simulator. It will be started with the roles of a simulator for MET, its international regulation and different types of training simulators developed until now. Then, the author will provide more elaboration on the cloud-based simulator itself. Furthermore, the current condition of MET in Indonesia will be the last theme in this literature review. Finally, the author will summarise all themes that have been explained previously. The following section will explore the findings based on the three themes mentioned before to support the objectives of this study.

2.1. Training Simulator

According to Merriam-Webster (n.d., para. 1), a simulator means "a device that enables the operator to reproduce or represent under test conditions phenomena likely to occur in actual performance". Meanwhile, a simulation means "a model of a set of problems or events that can be used to teach someone how to do something or the process of making such a model" (Cambridge Dictionary, n.d., para. 1). From both terminologies, one can conclude that a simulator is a device that can be used to generate a specific set of events with the purpose of 'informing'. Simulators have been through so much improvement as technology advances, especially in their functions for many purposes. Many types of simulators have been created and brought many advantages for decades to safety-required industries such as outer space-related, aviation, medical, maritime, rail and many more. The simulator can provide an environment where the individuals can exercise their skills with a high level of freedom without inflicting damage from aspects of cost, environmental pollution and fatalities that come from their errors during exercise (Sharma et al., 2019; Håvold et al., 2015, as cited in Kim et al., 2021). Therefore, Industries can prepare their human resources for their perspective roles in the system to perform optimally to achieve expected results in a highly stressful situation (Crichton, 2017, as cited in Kim et al., 2021).
2.1.1. Simulation-based Training

For every kind of profession, training can not be separated from the development of individuals in their job. Training is the systematic acquisition of attitudes, concepts, knowledge, rules, or skills that should result in improved performance (Goldstein, 1991, as cited in Salas et al., 2009). It has been known that simulation can be an effective tool for training complex skills in many sectors of industries. The medical field, which is vital for the world's society, has facilitated studies regarding the application of simulators as training tools. The result shows that many professionals have improved performance after simulator training (Sturm et al., 2008; Salas & Burke, 2002). Simulation can provide many benefits in the medical community by training individuals and teams to reduce human error and promote patient safety (Salas & Burke, 2002). According to prior studies, simulation-based training does result in skills transfer to the operative setting, for instance, the surgical skills, which are crucial for trainees, therefore, provide a safe, effective, and ethical way for trainees to acquire the skills before entering operation room (Sturm et al., 2008). Currently, simulation-based training has assisted the individual or team training in many sectors of industries, which in this context for MET.

Simulation-based training essentially encompasses a continuum of technology intended for training purposes which happened in any artificial (synthetic) environment created to manage an individual's or team's experiences with reality (Bell et al., 2008, as cited in Salas et al., 2009). According to Summers (2004), today's simulation-based training can generally be categorised into three primary categories: computer-based simulation, physical-based simulation (board games), and role-playing simulation (behavioural simulations). The simplest form of simulation role-playing simulation can be generated without any computer program, technology, or equipment but requires participants to engage in fictional scenarios. At the next level, physically-based simulations require the participant to interact with some physical representation of the profession's environment related to the skill. Finally, computer-based simulations involve some level of computer technology which is the most commonly used category of simulation-based training and varies in simulation technologies, ranging from basic PC-based simulations to full-motion simulators, VR
and the newly developed cloud-based simulations (Salas et al., 2009). All three categories within MET are equally important due to the nature of professions within this industry that require cooperation and teamwork in addressing a particular situation. For instance, the seafarers’ organisational structure onboard the vessel is complemented by their respective roles, which could be very complex in practice due to their different behaviours.

2.1.2. Roles of Training Simulators for MET

As previously mentioned, simulation-based training is one of many methods to deliver training for the population of trainees. Especially for the maritime industry, MET is part of the maritime industry that benefited most from the availability of this method. The importance of simulation-based training for MET was proven when the International Maritime Organization (IMO), as one of the United Nation’s specialised agencies, included simulation-based training as one of the minimum standards for training requirements at the international level and applied it to all maritime educational institutions through a convention. This Convention, known as the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, prescribes the minimum standards for seafarers’ training, certification and watchkeeping, which countries are obliged to meet (IMO, 2019). Moreover, this Convention has adopted “performance standards” as the proper standard to use simulators in MET, which is dominated by the application of computer-based simulation in various kinds and levels of technology. The simulator’s ability to present credibility and dependability during the training process has added to the merits of the simulator in MET.

Today, simulators can simulate multiple scenarios and situations in various ship types, adjusting to the learning objectives, which are hardly encountered in real life (Ali, 2006). Moreover, some studies argue there is a possibility that simulators can be used to facilitate the training for soft skills such as leadership, communication, and decision-making, to the extent as a substitute for onboard training to a limited degree and under certain circumstances (IMO, 2011). Prior studies have concluded several advantages from various aspects of using a simulator for maritime training and assessment purposes (Kim et al., 2021), including:
• Safety; It could provide a safe environment to practice and rehearse high-risk tasks without dangerous implications and allow the trainees to simulate accident scenarios.

• Flexibility; It allows playback of task performance, which enables detailed feedback and discussions; simulator is potentially available at all hours, which provides time flexibility for designing training programs and facilitating proficiency; simulator facilitates the controllability of different scenarios, determining metrological conditions as well as allowing the trainees for repeated exercise at their own pace.

• Skill acquisition; Support transfer of training and skill acquisition allows for a tailored delivery of training content and enables the trainees to understand the consequences of actions and learn from errors.

• Skill utilisation; Provide opportunities for trainees to apply and utilise the existing and newly acquired knowledge and skills and allow trainees to practice non-technical skills such as leadership, communication, and decision-making skills.

• Efficiency; Highly efficient training, for instance, trainees can change between any scenario from low speed to high speed, or from narrow channel to open sea navigation without any delay.

• Cost-effectiveness; Lower operating costs compared to onboard training or training ship.

• Assessment; Data can be generated through recordings, improved training practices, and pedagogical approaches.

These advantages shown above make a strong argument for IMO to adopt the usage of a simulator in the Convention for training standard requirements, which emphasises the value of this method as a supplement to the other educational methods in developing the competencies at a deeper level and validating the essential skills of seafarers in practice. However, it must be put into attention that there are still many additional factors that could determine the transfer of skills, including the simulator design and functionality and the way that it is used as training equipment,
including pre-learning, the nature and type of proximate and summative feedback, and opportunities for reinforcement of learning (Sturm et al., 2008).

### 2.1.3. Regulation I/12 of STCW 1978 as amended

In maritime education, simulators have been used for navigation training since the 1950s (Hanzu-Pazara et al., 2008, as cited in Sellberg et al., 2017). They have become mandatory for certain parts of the curriculum for maritime training, which is regulated by STCW 1978. Through its implementation, STCW 1978 has through a significant amendment in 1995. A significant change could be observed in the convention structure, where three attachments have been added to the Convention. This structure has still been adopted until a recent amendment in 2016. Attachment I contains resolution I, which established the adoption of amendments to the Annex of the Convention. Furthermore, the Annex consisted of chapters, starting from Chapter I until Chapter VIII, where regulation I/12 in Chapter I is one of the new additions to the Convention. Meanwhile, the standards and guidelines for regulation I/12 are explained in parts A and B of the Seafarers’ Training, Certification and Watchkeeping (STCW) Code, which cannot be disparate.

Entitled “Use of simulators”, Regulation I/12 has mandated that simulators for all mandatory simulator-based training and any use for competency assessment or demonstration of continued proficiency are obliged to meet or exceed the performance standards requirements, which are explicitly prescribed in Section A-I/12 of STCW Code. Furthermore, this section also covers operating procedures regarding training and assessment through a simulator alongside the qualifications for its instructors and assessors. Moreover, Section B-I/12 offers specific guidelines on how training and assessment in the simulator are conducted, which can be used as a recommendation for parties to adopt into their national law.

As might be noticed, the provision of regulation I/12 stated that this regulation could be applied to all mandatory simulator-based training. Meanwhile, the text clearly says the standards apply to all mandatory simulator-based training, which could refer to all training mandated by the Convention or the Code or training required nationally under a Party’s legislation to prevent the application of regulation I/12 to training
mandated only by a Party. At the same time, the standards are made of a generic nature with the flexibility sufficient to be applied to all known types of simulator-based maritime training.

Therefore, the Parties may decide to apply the provisions of regulation I/12 to all simulator-based training and assessment activities on matters falling within the scope of the Convention. This regulation has a different degree in terms of assessment or demonstration of proficiency. This regulation could only be applied to the exercises mandated by the Convention and the Code, even if the Party itself demands the assessment (Morrison, 1997). It can be concluded that any simulator-based training or assessment used to demonstrate competence in certifying a certificate required by the Convention and listed in any standard of competence tables of Part A of the Code must be approved by the Issuing Party.

2.2. **Different Types of Training Simulator**

As part of trainees' education and training activities, experience onboard a ship is essential for trainees. Since there is a limited number of qualified ships and the dangerous nature of ship's environment, many simulation scenarios are created to deliver this safe experience to trainees, which mainly depend on a computer to simulate these scenarios. Moreover, the diversity of ship's operation also has created many computer-based simulations scenario, leading to various simulators replicating these operations. Every scenario must be able to accommodate different tasks of seafarers within related scenarios, such as ship bridge simulators, engine room simulators, cargo handling simulators, dynamic positioning (DP) simulators, survival craft and rescue boat operations simulators, global maritime distress and safety system (GMDSS) simulators, and many others (Zghyer & Ostnes, 2019, as cited in Kim et al., 2021). Therefore, one of the world's leading classification societies and advisors in the maritime industry has classified the maritime training simulator into the following classes (DNV, 2021; IMO, 2012):

- **Class A (full-mission)** – Simulator type that encompasses the entire procedure or task to be trained.
• Class B (multi-task) – Simulator type that selectively focuses on the training of several critical skills de-constructed from more extensive tasks.

• Class C (limited task) – Simulator type that selectively focuses on the training of specific critical skills de-constructed from more extensive tasks.

• Class S (special-task) – Simulator type where the performance is defined on a case-by-case basis;

• Class D (distant learning), which is a new addition in 2021 for procedural training through a cloud-based platform.

Furthermore, based on the hardware and technologies, simulators can be categorised into desktop-based simulators, full-mission simulators, Virtual Reality (VR) simulators, and cloud-based simulators (Kim et al., 2021). For instructors to adopt one of the four simulators in delivering the training course, one must correspond to the requirement of the training course and its learning objectives due to the different levels of fidelity provided by each simulator (Hontvedt, 2015, as cited in Kim et al., 2021). Desktop-based simulators only require ordinary desktop computers with pre-loaded simulation software that could replicate some aspects of maritime operations. In contrast, full-mission simulators require dedicated space in MET institutions to mimic a specific environment within maritime operations with replicas of all instruments and displays. Moreover, VR simulators require a wearable head-mounted display (HMD) to enable users to have a real work environment experience virtually. Since they no need big space for maintenance and their high mobility, this simulator is relatively easier to maintain than previous types (Kim et al., 2021).

For MET Institutions, a full-mission simulator is the most preferred type of training simulator for its versatility, high level of fidelity and capability to address most of the regulatory requirements. However, its need for skilled instructors to reach optimal use, the high cost of investment for its hardware setup and maintenance, and also similar to desktop-based and VR simulators, the need for physical presence of trainees and instructors in the same place has proven to be the limitations of this simulator (Branyakov et al., 2017; Kim et al., 2021). On the other hand, a cloud-based simulator relies on internet connectivity and cloud technologies, enabling the instructors and trainees to run the simulation online using a web browser or through
software with their laptops or tablets. It emphasises virtual training activities and reduces the need for physical presence (Kim et al., 2021; Sokolov et al., 2017). It also opens the possibility to conduct training, assessment and certification of skills on an "on-demand" basis of instructors and trainees anytime from anywhere globally (Kongsberg, n.d.; Wärtsilä, n.d.)

**Figure 1.** Desktop-based simulator (Top Left), Full-mission simulator (Top Right), Virtual Reality simulator (Bottom Left) & Cloud-based simulator (Bottom Right)


### 2.2.1. Characteristics of Training Simulators

As mentioned in the previous section, "Fidelity", in more straightforward terms, means how something matches or copies something else (Merriam-Webster, n.d.). In the context of simulators, it refers to the accuracy level of a simulator resembling the actual equipment or situation (Miller, 1974, as cited in Hays, 1980). Since the nature of situations encountered in high-risk professions is complex and dynamic, it is
considered necessary for the simulator to resemble the work setting the trainees are training to transfer skills into professional practice (Dahlstrom et al., 2009, as cited in Sellberg, 2018). From previous studies that have been conducted on the fidelity concept of simulators, Hays (1980) concluded that fidelity has four dimensions, which were later elaborated more by Kim et al. (2021):

- **Physical fidelity** refers to the degree to which the simulator's physical appearance can replicate the actual equipment or system. In the context of a ship's bridge operation, this fidelity pertains to the human-machine interfaces (HMLs) of an actual bridge, where simulators mimic the actual ship's bridge to the details.

- **Functional fidelity** refers to the degree to which the simulator's functional aspects can replicate the functions and experience of the actual operation settings. In the same previous context, the simulators can perform the function of the bridge's equipment and offer the same experience on the bridge, such as the sense of motion (rolling and pitching) and surrounding sound during a voyage.

- **Behavioural fidelity** refers to the degree to which the tasks performed in the simulator setting can replicate the tasks and behaviour in reality. In the same previous context, the simulators can facilitate the situation where trainees can exercise identical sequences of behaviour in performing the task scenario on a bridge.

- **Psychological fidelity** refers to the degree to which the tasks required to be learned by trainees through a simulator are accurately depicted. In the same previous context, simulators can deliver a situation that could engage trainees to solve the problem of a scenario with a similar level of stress and workload in reality.

The degree of fidelities supplemented by scalabilities and accessibilities could be used to differentiate each type of simulator. The external factors encompass the rapid evolution of technologies adopted by a simulator, and its usability in unexpected events contributes to its characteristics. Then all of these characteristics, as shown in Table 1, could be considered before utilising a simulator. Appropriate simulators can
improve the effectiveness of training in achieving the intended outcomes of particular tasks as part of a course. The complexity level of intended outcomes concerning simulation-based training has been classified into the following (IMO, 2012): familiarisation, operational, functional, management task, communication task, emergency, and crisis. Therefore, the role of instructors is crucial in selecting a suitable simulator congruent with the task’s intended outcomes, which will be discussed much further in the next section.
Table 1. Characteristics of different types of simulators using SWOT analysis

<table>
<thead>
<tr>
<th>Type of Simulator</th>
<th>Internal Factors</th>
<th>External Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td><strong>Weaknesses</strong></td>
<td><strong>Opportunities</strong></td>
</tr>
<tr>
<td><strong>Desktop Simulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used for product/equipment familiarization</td>
<td>Lack of fidelity</td>
<td>Potential for new roles such as shore control simulation</td>
</tr>
<tr>
<td>Small learning curve for both instructors and students</td>
<td>Need dedicated infrastructure and space</td>
<td>Use in geographically separated synchronous learning</td>
</tr>
<tr>
<td>Ease of access and setup for students and instructors</td>
<td>Lack of training for team cooperation</td>
<td>Adaptive to future training needs</td>
</tr>
<tr>
<td>Instructor could give formative assessment</td>
<td>Lack of immersivity</td>
<td>Easy to procure and scalable compared to full-mission simulators</td>
</tr>
<tr>
<td>Adjust the learning pace and complexity of the learning during the exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multipurpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Full-mission Simulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High physical and social fidelity</td>
<td>Costly to acquire and maintain</td>
<td>Utilization with the combination of new technologies (Virtual Reality / Augmented Reality)</td>
</tr>
<tr>
<td>Appropriate for all STCW training requirements</td>
<td>Need highly competent instructors</td>
<td>Combination with other means of data collection (eye tracking, heart rate variability, etc.) for assessment</td>
</tr>
<tr>
<td>Beneficial for Non-technical skills development and team training</td>
<td>Require frequent and resource-intensive maintenance</td>
<td></td>
</tr>
<tr>
<td>Possibility to observe the dynamics of a task scenario</td>
<td>Takes time to develop, adjust, and improve exercise content and quality</td>
<td></td>
</tr>
<tr>
<td>Physical interaction with the team</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Virtual-reality (VR) Simulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly immersive</td>
<td>Motion sickness, depth perception issues</td>
<td>Low-cost training per head</td>
</tr>
<tr>
<td>Supports motivation and higher order learning</td>
<td>Steep learning curve</td>
<td>Remote/onboard training</td>
</tr>
<tr>
<td>High mobility</td>
<td>Learning effect is questionable</td>
<td>Fast-paced research and development in VR</td>
</tr>
<tr>
<td>Innovative and attractive training solution</td>
<td>Lack of student-instructor interaction</td>
<td></td>
</tr>
<tr>
<td>Real-time feedback from trainees</td>
<td>Limited team cooperation and interaction</td>
<td></td>
</tr>
<tr>
<td><strong>Cloud-based Simulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ubiquitous learning</td>
<td>Lack of social interaction</td>
<td>Geographically separated synchronous learning</td>
</tr>
<tr>
<td>Self-directed</td>
<td>Lack of formative assessment</td>
<td>Novel mode of training and assessment</td>
</tr>
<tr>
<td>Less capital intensive</td>
<td>Limited transfer of learning</td>
<td>Highly scalable</td>
</tr>
<tr>
<td>Limited maintenance of hardware</td>
<td>Lack of team training opportunities</td>
<td></td>
</tr>
<tr>
<td>No need of physical presence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.2. Training Activities through Simulator

The appropriate way regarding teaching and learning activities through the simulators has been elaborated deeper by IMO in its published IMO Model Course 6.10: Train the simulator trainer and assessor. The course will provide the instructor with technical aspects of simulator teaching by emphasising the simulator pedagogy and psychology of learning in practice (IMO, 2012). However, this model course is only a guideline with the intention to achieve uniformity in the maritime simulator training and assessment in MET Institutions across the world. In practice, simulator training might differ for institutions depending on various factors, such as the cultural background or the interpretation of the model course (Nazir et al., 2018). Since this model course is only a guideline, the institutions should not implement the content of this model course blindly without considering their resources. Practical constraints faced by instructors or differences in budget allocation for each institution need to be considered. Thus, MET institutions must exercise a certain level of adaptation to local circumstances.

According to Tsoukalas et al. (2008, as cited in Kim et al., 2021), pedagogical utilisation of simulators comes through proper selection of simulators and effective assessment techniques, both of which rely heavily on the efficiency of simulator instructors. Therefore, it can be argued that besides the compatibility between simulator fidelity and the course’s intended outcomes, successful simulation-based training is also determined by the efficacy of the transfer of knowledge process, in which the quality of the instructor is the key. A qualified simulation instructor must have training awareness, training skills, managerial skills and aptitudes (IMO, 2012; Nazir et al., 2018). These factors are also supported by another study which proposed the criterion for successful and effective simulation-based training when (Salas & Burke, 2002):

- Instructional features are embedded within the simulation.
- Carefully crafted scenarios are embedded within the simulation.
- The simulation contains opportunities for assessing and diagnosing individual or team performance.
• The learning experience is guided.
• Simulation fidelity is matched to training requirements.
• There is a reciprocal partnership between subject matter experts and learning/training specialists.

In simulator-based training, learning activities are structured to make the most out of the practical exercise, and instructors are known to put effort into scaffolding and reflection to promote learning (Hontvedt & Arnseth, 2013, as cited in Sellberg, 2018). According to Sellberg (2018), there are three phases of training in general that offer different material and temporal conditions for instruction. First, the instructor introduces the assignment to the whole group, called briefing. Secondly, the exercise of tasks by trainees within pre-defined roles and environment, called scenario. Lastly, a debriefing is carried out, described as a post-experience analysis and group reflection on the scenario. This study also has been supported by IMO through one of its published model courses which serves as a guideline. As provided in IMO Model Course 6.10, detailed guidelines for instructors in conducting a simulation exercise have been divided into four main components, encompass:

• Briefing – a structured and systematic introduction to the exercise and the session’s objectives, when the trainees know what to expect during the session. The immediate attention for instructors at this phase would be the assignment of roles to trainees and the facilitating team during sessions which must be carefully considered.

• Planning – which can be carried out in two stages, detailed operational and procedural planning, followed by role-playing before the commencement of the exercise. In the first stage, instructors can do pure observation or provide input regarding exercises, such as weather, tide and current details for navigating simulation. Then continue to the next stage, where the planning meeting would be led by a trainee who performs the lead role in the exercise. The instructor rarely interferes during this stage unless it is vital.

• Simulation Exercise – It is at the instructors’ discretion to provide technical stimuli and cues during the simulation exercise. Hence, for individuals to become effective instructors, they must be able to find a balance between
letting the simulation exercise run without interference and injecting inputs when required. It is advisable to stick to the plan. However, flexibility and openness to any situation that may arise must be implemented so that exercise can be aborted and restarted completely.

- Debriefing – It is the most critical part of a simulation exercise, where trainees can evaluate their performance according to the training objectives. Furthermore, they can reflect on the most appropriate things to do and recommend changes if there are any gaps in their performance.

2.3. Cloud-based Modelling and Simulation

Align to the development of the maritime training simulator, the competencies development of maritime professionals, seafarers particularly, has become more effective and efficient, which could increase the safety-related skills of seafarers. As part of this technological development, maritime cloud-based training simulation creates a new condition for decentralised interaction where its content and functionality mirrors traditional on-site-simulator (Hjellvik & Mallam, 2021). Kim et al. (2021) also stated that a cloud-based training simulator is one of the latest developments in the marine simulator, where previously physical-based training simulators were widely used by MET Institutions worldwide as the only simulator available for instructors to deliver the material.

Furthermore, before moving further into the context of a cloud-based training simulation, it is essential to recall in previous sections that simulation technology is a hybrid technology of using computer science and technology in building and simulating a model of an environment or process and then performing experiences on the models under various conditions (Liu et al., 2012). It is well-known that various advantages (high efficiency, high security, scalability, flexibility and many more) have been inherent in simulation technology and adopted into many domains, including capacity building of human resources such as seafarer training until this day, as elaborated before. Moreover, as the technology develops, simulation technology also evolves as a response to this advancement to the extent where an emerging technology known as cloud computing could be integrated into simulation technology,
resulting in a new type of simulation technology called cloud-based modelling and simulation (CBMS).

According to Erdal (2013, as cited in Zhang et al., 2019), cloud-based simulation (CBS) is a development from previously-known web-based simulation (WBS) technology by integrating it with cloud computing technology for managing various simulation resources and building different simulation environments. In which way, cloud-based simulation provides a new way to utilise computing resources in modelling and simulation services, including infrastructure, platform and software based on the user's demand through a connected resource cloud pool and cloud simulation platform (Zhang et al., 2019; IGI Global, n.d.). Referring to the definition, one can understand that internet connectivity is a mandatory requirement to run a cloud-based simulation. Onggo et al. (2014) argue that the effort to perform modelling and simulation through the internet or web (web-based simulation) started decades ago by tracing back to a paper published by Fishwick in 1996. Fishwick (1996, as cited in Padilla et al., 2014) has identified several benefits of having simulations that run through the web, including:

1. A vast amount of storage provided by a networked infrastructure compared to a personal computer's storage capabilities, in other words, "do not require local storage".
2. Reusing the existing information stored in the storage that can be accessed by users on a global scale.
3. Client-server relations, where this simulation relies on one entity to provide the services while the clients use the services.
4. Browser accessible where the users do not need to install additional programs, as the programs are delivered through a web browser.
5. Multi-user capability, which allows multiple users to interact with each other.
6. Reduced simulation cost, where a simulation usually requires a costly computer or software or both.

Given all of the similarities between WBS and CBS, cloud-based simulation technology is developed to address the issues of web-based simulation in its long-
term application. First, the performance of many WBS that just focused on reimplementing the existing standalone simulation software caused an often-occurred mismatch between the main characteristics of the web and the approach taken by the domain of WBS, which failed to take full advantage of the features of the web including common standards, interoperability, ease of navigation and use, and others (Kuljis & Paul, 2003, as cited in Onggo et al., 2014). This argument is also supported by the literature review done by Byrne et al. (2010), which showed some disadvantages of web-based simulation encompassing loss in speed, graphical user interface limitation, security vulnerability, application stability, licensing restriction and difficulty in simplifying simulation. Secondly, the emphasise on WBS technology as a technological tool rather than a socio-technical one, as observed by Onggo et al. (2014). They argue that the cloud-based simulation could serve as a socio-technical tool, which is proven by the simulation practitioner’s significant increase in communication tool usage during performing cloud-based activities. Through their study, a significant number of simulation practitioners work as a team located in separate geographic locations, let themselves be exposed to cloud-enabled applications and utilise communication technologies to support their work through mobile gadgets at work.

2.3.1. Cloud Computing

Nowadays, we already feel the benefit of cloud computing through various services, even on smartphones, such as Netflix, as a movie streaming service. It can be accessed anywhere and is easy to use. As the vital aspect of cloud-based simulation technology, the idea of cloud computing has existed for decades, yet its implementation could only be perceived these days since various configurations are needed to implement cloud computing in this ever-changing computing technology (Mansouri et al., 2020; Padilla et al., 2014). According to Foster et al. (2008), “Cloud computing is a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualised, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on-demand to external customers over the Internet”. It will enable people to compute on centralised facilities operated by third-party computing and storage utilities rather than
a local computer. They also suggested that cloud computing is developed to address emerging problems regarding computing capabilities, broad network access, maintainability and multiplatform support, to which cloud technology is seen as a solution since it serves as a large pool of computing and storage resources and can be accessed via standard protocols of an abstracted interface (Foster et al., 2008).

From various articles, cloud computing is generally offered in three different types of services, encompassing IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service), and SaaS (Software-as-a-Service) (Foster et al., 2008; Onggo & Taylor, 2014; Buyya et al., 2009). These services can be deployed in four models of cloud computing: public cloud (the public can use infrastructure), private cloud (infrastructure can only be used by an individual organisation), community cloud (infrastructure can be used by a community of users with shared missions) and hybrid cloud (the combination of the other three deployment models). And lastly, all of these types and models exhibit similar five essential characteristics that must be possessed by cloud computing: on-demand self-service (automatic deployment of computing abilities), broad network access using multiple platforms (such as mobile devices, laptops and desktop computers), resource pooling, rapid elasticity (computing capabilities can be scaled up and down to match the fluctuation in demand) and measured service (subscription-based services in a pay-as-you-go model). (Onggo et al., 2014; Buyya et al., 2009).

2.3.2. Implementation of Cloud-based simulation for MET

It has been known that most educational institutions in scientific or engineering disciplines use computer simulations in their laboratory sessions to carry out learning activities. Students can design and run simulations of specific scenarios by modifying their parameters in simulation tools installed on the computers (Cano-Parra et al., 2013). Allowing the learners to carry out experiments which cannot be performed in reality due to expensive costs, unreachable, inexistent and such makes simulators beneficial for educational institutions, including MET, in training seafarers and other maritime professionals to the extent that simulator-based training became mandatory and established in international regulations as explained in previous sections. However, longer response times in running a simulation model have become a well-
known problem for the academic community. Sufficient computational resources by additional infrastructure are needed to reduce response time, which causes high-cost demand and burdens the institution, which is an inevitable impact of this approach (Cano-Parra et al., 2013). Whereas, cost-related issues have also become one of the important limitations to be considered by MET institutions in utilising conventional simulator-based training. Therefore, the emergence of cloud-based simulation could be a feasible solution to solve these limitations, as mentioned before.

From the literature review conducted by Sanders (2019), three approaches have been used generally in implementing cloud-based simulation: establishment of virtual machines in the cloud, containerising existing simulations in the cloud and composing simulations from services deployed in the cloud. Furthermore, the utilisation of simulation for education/research purposes, including in the MET context, falls within the third approach in implementing cloud-based simulation, which in its implementation efforts by using different methods realised in several projects. CloudSME Simulation Platform targets commercial independent software vendors and consultant companies in the scope of developing and offering various simulation software solutions. This platform was developed by Taylor et al. (2018) and could also be utilised for academic/research-oriented scenarios. In their published study, this platform utilises three layers of services: Simulations Applications Layer (similar to SaaS), Cloud Platform Layer (similar to PaaS) and Cloud Resources Layer (similar to IaaS). The other project is a SaaS service called Cloud-based Distributed Network Simulation Environment (CloudDNSE), proposed by Cano-Parra et al. (2013) that enables running simulations with response time constraints by using infinite resources from the cloud and reduces the cost for educational institutions’ computational demands.

Meanwhile, introducing cloud-based training simulators for MET could create new opportunities and challenges for trainees, instructors and administrators in interacting and engaging with the simulators and training content. The benefits of cloud-based training simulators are promoting decentralised learning, which could remove, reduce or reorganise the traditional supportive structures (interactions and collaborations between trainee-instructor and trainee-trainee peers) found in conventional on-site, in-person classrooms and simulation training (Hjellvik & Mallam,
This decentralised learning could present challenges for instructors in correcting and assessing trainees, whereas the interaction and guidance from instructors are crucial factors for trainees toward desired outcomes, as argued by Sellberg (2018). Therefore, modification of the well-established pedagogical structure in conventional simulation-based training is needed to ensure that trainees have achieved the intended learning outcomes at the end of the cloud-based training simulations (Kim et al., 2021). Through this modification, trainees' self-efficacy could also be encouraged as the effect of self-regulatory learning experiences and exploration into the new possibility of collaborative training scenarios by cloud-based simulators.

2.3.3. Development of Cloud-based Training Simulator in MET

Since the COVID-19 pandemic emerged, physical restrictions have been imposed in every country and have caused a massive impact on many aspects of human life. In the maritime industry, many seafarers are stranded on ships beyond their original contract and cannot go home, which also applies to those stuck at home and unable to provide for their families because they cannot join ships (IMO, n.d.). The MET field is not an exception which causes learning activities must be stopped. MET, which primarily emphasises the practical aspect of its learning outcome, is having difficulty addressing this issue. Eventually, the distance learning concept was introduced and applied in many MET institutions. Furthermore, cloud-based simulation training rose as one of the solutions to address those limitations of physical-based simulators and to support the implementation of distance learning in practical training. Through years of development, many maritime training simulator providers exist today, dominated by two major suppliers in distribution, Kongsberg Digital and Wärtsilä. They built cloud-based simulators to enable the delivery of training remotely, and until now, they are still developing their technology to make cloud-based simulators better in addressing their weaknesses and limitations.

Kongsberg Digital developed K-SIM Connect as its cloud-based digital platform, providing exclusive subscription-based services to all members (Kongsberg, 2020). Currently, three training simulation environments are available for its member: K-Sim Engine, K-Sim Navigation, and K-Sim Cargo. Moreover, these three groups of
Simulators were the first that achieved certification from DNV according to the new DNV’s class D standard set (Kongsberg, 2021). The other major provider, Wärtsilä, also developed its cloud-based simulator within the family of Wärtsilä Voyage and won the 2021 SMART4SEA Training Award for ensuring the continuity of seafarer training even during COVID-19 lockdowns (Wärtsilä, 2021). In the same essence as Kongsberg’s cloud-based training simulation, Wärtsilä Cloud Simulation uses a Software as a Service (SaaS) which allows the users to have remote access to application software and navigate through the exercises and scenarios (Wärtsilä, n.d.). Wärtsilä also collaborated with Ocean Technologies Group as the owner of Ocean Learning Platform, which is the leading service provider in maritime knowledge and technology solutions. Through this collaboration, Wärtsilä’s cloud simulation services will be available within the platform.

However, the implementation of cloud-based simulators is still limited for some MET institutions in various countries, including Indonesia, which is ironically known as one of the main suppliers for STCW certified seafarers in the world for several years consecutively, according to the Seafarer Workforce Report published by BIMCO & ICS (2021). As this study is being finished, no publications or discussions are related to the concept of cloud-based simulation training for MET in Indonesia, not to mention implementation. Even for the available simulators, the designed courses for simulation-based training do not make full use of simulators, according to the study done by Flor (2011). He argued that maritime lecturers and instructors should undertake advanced studies in formal education, master’s degree or doctoral degree to enable them to design simulator-based educational models and utilise simulators to the maximum of their limited lifespan. Cloud-based simulators could open many opportunities for developing multifaceted MET in Indonesia, including precaution measures if a similar situation to the COVID-19 pandemic emerges again. The scenario of course delivery through Online Distance Learning could be used in the MET sector, which is supported by cloud-based simulators in delivering practical content to achieve Indonesia’s potential in the maritime industry.

2.4. Summary
As one of the largest suppliers of seafarers, Indonesia is assumed to be underdeveloped in terms of variety in available training simulators. Physical-based simulators play a bigger role in simulation-based training for all MET institutions, and the whereabouts of the cloud-based simulators are still unknown to some instructors, let alone the trainees. Even to the degree that there are not many published articles within national journals discussing cloud-based simulators or at least the introduction of the cloud-based simulator concept to MET in Indonesia. Furthermore, existing studies relating to cloud-based training simulators are more focused on cloud computing as the key technologies, concepts and applications of cloud-based simulators in simulating the environment for research and study purpose. The study on utilising cloud-based simulators for training purposes in the MET sector is rarely discussed. The factors that need to be considered before adopting Cloud-based simulators in a MET institution should be discussed much further, which in this study will revolve around government-owned MET in Indonesia as the population. Based on those factors, the appropriateness, advantages and disadvantages of implementing cloud-based training simulation in a MET institution will be discussed in this study.
Chapter 3: Research Methodology

According to Kothari (2004), a research methodology is a way to systematically conduct research by identifying and examining the various steps along with their foundation logic, which is necessary for solving research problems. Through this chapter, the researcher will discuss the research methodology used to conduct this study. Furthermore, this chapter will elaborate on the framework design of this research, various methods used to collect the data, data analysis techniques on the findings, ethical issues and limitations. At the end of this research, by adhering to this research methodology, it is expected that the objectives of this research could be achieved by answering three research questions as provided below for recollection:

- What are the main factors that affect the selection of simulators in a MET Institution?
- Are the existing training simulators appropriate and capable of accommodating the training and assessment activities in Indonesia’s MET Institutions?
- Are cloud-based simulators needed to be adopted by MET Institutions in Indonesia?

3.1. Research Design

This research will explore the topic using a combination of two basic approaches in methodology, the qualitative and the quantitative approaches. This pluralism in methodology is necessary to overcome the cognitive limitations and biases inherent in human mental processing and responding (Sechrest & Sidani, 1995). These approaches will complement each other in completing this research, which is divided into three stages, as indicated in figure 2. The first stage is designed as a qualitative approach to answer the first research question regarding the relevant factors which could affect the selection of a training simulator in MET institutions.
In this stage, a combination of methods: semi-structured interviews and document review as the primary data sources, complemented by the literature review in chapter 2 as the secondary data source, will complement each other and generate a hierarchy structure of multilevel factors or criteria which inherent differently to each type of training simulator. This structure intends to provide an overall view of the complex relationships inherent to the situation and assist the researcher in comparing elements of the same magnitude (Saaty & Vargas, 2012). Simultaneously, this stage is also the completion of the first phase in applying the Analytic Hierarchy Process (AHP) method, which will be further elaborated on in the next paragraph. Furthermore, the alternatives of simulators are proposed at this stage, complementing the hierarchy
structure discussed before as the alternatives. Further explanation of this analysis will be presented in later sections and chapter 4 of this research.

Move forward to the second stage, which is designed in a quantitative approach to answer the second research question regarding the appropriateness and capabilities of existing training simulators in many of Indonesia’s MET institutions in accommodating the simulation-based training and assessment for seafarers as trainees in those institutions. In this stage, the respondents' inputs received from the training instructors and trainees through distributed questionnaires are required to objectively measure the actual condition of Indonesia’s MET institutions in the context of training simulators. Since the criteria and alternatives generated in the first stage are correlated with each other within a complex multilevel hierarchy structure, then implementing Multi-Criteria Decision Making (MCDM) models is seen as the most suitable model for evaluating these criteria and making decisions for the best alternatives options (Aziz et al., 2016).

By imposing the respondents as the decision maker, the strength of each criterion and sub-criteria will be weighed in quantifiable value for their importance in performing simulation-based training under their preferences, which could impact the selection of an optimum training simulator. The values of these criteria will be analysed using the previously mentioned AHP method, generally known as one of the MCDM methods in deriving ratio scales from discrete and continuous paired comparisons (Saaty & Vargas, 2012). Moreover, these values will determine the rank of importance from each criterion and sub-criteria, which is also the last phase of the two phases (hierarchy design and evaluation) in the AHP method (Lee, 2016). At the end of this stage, the results will be presented in two rank sequences of criteria by adhering to the respondents' backgrounds. It will show more objective results by providing the difference in preferences between training instructors and trainees.

Lastly, the third research question will be answered in this stage by utilising the same AHP method used in the previous stage, which is also the completion of the method in determining the best option of alternatives, as mentioned in the first stage. The performance value of each alternative is measured for each criterion, adhering to analysis results in the first stage. The alternatives and their characteristics defined in the first stage are used as measurement preferences. This approach is taken to
reduce respondents’ uncertainty and biased result, probably caused by their lack of knowledge and experience with some simulators. Furthermore, the results obtained from the calculations of the combined results from the second and third stages are expected to objectively reflect the priority of the four alternatives to training simulators, where the highest priority represents the best option and vice versa. Additionally, this result will be discussed further to determine the necessity of cloud-based training simulators in Indonesia’s MET institutions. The methodology of this research has been conceptualised in the framework, as shown in Figure 2.

3.2. Data Collection Methods

The data used in this research will be collected by mixed-method between qualitative data and quantitative data collection methods. This study uses three data collection methods for its primary data: semi-structured interview, documents review and self-administered questionnaire.

3.2.1. Semi-structured Interview

The researcher used a semi-structured interview as part of the qualitative data collection methods used in this research. The participants for these interviews are decided based on their involvement and experience with cloud-based training simulators used in MET. Furthermore, these participants come from two different backgrounds: (1) academics with expertise in simulation-based training, especially cloud-based simulation training and (2) respective officials in maritime training simulators provider companies (industry) who are closely related to the development of simulators. These people have been interviewed through video conference programs, specifically Zoom Meetings and Microsoft Teams.

3.2.2. Documents Review

The researcher will look into the documentation of cloud-based training simulators as part of the qualitative data collection methods collected from two cloud-based training simulator manufacturers, specifically Kongsberg and Wärtsilä. The other documents related to simulation-based training within MET, such as Indonesia’s
policies that regulates the application of training simulators for MET institutions, are also included in this review.

3.2.3. Questionnaire

The researcher used a close-ended questionnaire as the quantitative data collection method used in this research. The questionnaire is designed based on the answer to the first research question, obtained from a collaborative analysis of the literature review in chapter 2, related documents, and interviews with experts. The accumulated result from this questionnaire will be used to answer the second research question, which also serves as the foundation of discussion in answering the third research question. Meanwhile, this questionnaire's respondents will initially be selected using the stratified sampling method, which was collected from twelve (12) government-owned MET Institutions in Indonesia. At least there will be six simulator instructors and six trainees divided equally between each institution's deck and engine departments. This questionnaire is designed on OneClick Survey online software and distributed through email.

3.3. Data Analysis

3.3.1. Qualitative Data Analysis

The qualitative approach has been used in many research fields to gain a better and deeper understanding of a phenomenon through various unique viewpoints of those who directly experience the phenomenon (Castleberry & Nolen, 2018). The qualitative data collected from interviews and document review as the primary source, complemented by the literature review in chapter 2, will be analysed using thematic code analysis with the aid of Atlas.ti 22 software in the process, which is seen as the most suitable method to answer the first research question. Thematic analysis is a method of identifying, analysing and reporting patterns (themes) within data while allowing flexibility and interpretation during the process (Castleberry & Nolan, 2018). Through this, a wide variety of topics and concepts can be addressed, including the relationships between them and compared with other data from different projects (Alhojailan, 2012). From various topics/themes contained in the data, two main
themes, which encompass possible alternatives to training simulators and key factors (criteria) in selecting the best training simulator, become the framework and scope of the analysis. Nevertheless, this scope will not limit the possibility of new ideas or concepts found in the data. The results of this analysis will be used as the elements in building the hierarchy structure, as depicted in figure 3.

**Figure 3. Multilevel Hierarchy Structure**

![Multilevel Hierarchy Structure](image)


### 3.3.2. Quantitative Data Analysis

The quantitative data of this research are collected and analysed as part of the last phase under the AHP method, the evaluation phase, which involves the second and third stages of this research methodology. Developed by Saaty in 1971-1975, this method creates a simple hierarchy/ network structure in the decision-making problem by integrating relevant factors simultaneously. These can then be measured using a fundamental scale, which reflects the relative strength of the
decision maker’s preferences and feelings (Saaty, 1987; Soberi & Ahmad, 2016). Generally, the hierarchy structure of AHP has three levels consisting of a goal placed at the top level, criteria placed at the middle level and may have multiple levels depending on the problem’s complexity, and at the bottom level, alternatives are placed (Lee, 2016). In this last phase, the weight of criteria and alternatives are measured based on the pair-wise comparison concept on their respective importance or contribution, using the fundamental scale for the comparison as shown in table 2 (Lee, 2016; Soberi & Ahmad, 2016).

<table>
<thead>
<tr>
<th>Intensity of Importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two activities contribute equally to the objective</td>
</tr>
<tr>
<td>2</td>
<td>Weak <em>(Intermediate values)</em></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance of one over another</td>
<td>Experience and judgement slightly favour one activity over another</td>
</tr>
<tr>
<td>4</td>
<td>Moderate plus <em>(Intermediate values)</em></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Strong importance</td>
<td>Experience and judgement strongly favour one activity over another</td>
</tr>
<tr>
<td>6</td>
<td>Strong plus <em>(Intermediate values)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very strong importance</td>
<td>An activity is favoured very strongly over another</td>
</tr>
<tr>
<td>---</td>
<td>------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Very, very strong</td>
<td>(Intermediate values)</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
<td>The evidence favouring one activity over another is at the highest possible order of affirmation</td>
</tr>
<tr>
<td></td>
<td>1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9</td>
<td>Reciprocal values which assigned to the opposite of the activities that valued with above numbers</td>
</tr>
</tbody>
</table>


As discussed in many papers (Aziz et al., 2016; Ge et al., 2008; Saaty, 1987; Shapira & Goldenberg, 2005; Yasseri, 2012), the basic steps in conducting AHP involve: (1) Hierarchy Construction, (2) Pairwise Comparisons, (3) Relative-Weight Calculation, (4) Aggregation of Relative Weights, and (5) Consistency Ratio, which could be elaborated in the followings:

- **Step 1: Establish the hierarchical structure**
  This step is started by decomposing the complex system of the problem into a hierarchical structure, as shown in figure 3, starting from the goal or objective of the problem at the highest level, followed by “sets of attributes”, which could be called criteria (and sub-criteria at one level lower if needed in the problem system) in the middle level and alternatives at the lowest level of the structure.
• Step 2: Employ the pair-wise comparison

The pair-wise comparison matrices are employed separately for each group of elements (criteria, sub-criteria, alternatives) to investigate the relative weight of each element by comparing them in pairs with respect to the element immediately above them, and the result for each group is recorded in the comparison matrix separately. The respondents, as decision-makers, have to choose which criterion is more important in each question and assess the intensity of its importance (e.g. equally important, strong, very important, or other). Generally, each choice is delivered to decision-makers in a format shown in figure 4, which then could be translated into a specific preference value. For example, “Criterion 1 is more strongly important than Criterion 2” means decision-makers choose scale 5 in the left section of the scale or “Criterion 1 is less moderately important than Criterion 2” means decision-makers choose scale 3 in the right section of the scale.

Figure 4. Format for pair-wise comparison

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very Strong</th>
<th>Strong</th>
<th>Moderate</th>
<th>Equally</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td>Important</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Then those values are assigned to a comparison matrix, in which row elements (left section) represent the earlier criteria, and the column elements (top section) represent the latter criteria, adhering to the general linguistic phrase used in delivering the compared choices as previously discussed. See the example in Figure 5 for a detailed illustration of how to assign the value to the comparison matrix.

• Step 3: Relative weight calculation

After the value assignment, the relative weights of elements are obtained by solving the eigenvector of each comparison matrix and then normalising the result as local relative weights.
Manually, the decision makers have to sum all the values in each column

\[
\begin{bmatrix}
C_{11} & C_{12} & C_{13} \\
C_{21} & C_{22} & C_{23} \\
C_{31} & C_{32} & C_{33}
\end{bmatrix}
\]

as depicted in the following equation.

\[
C_{ij} = \sum_{i=1}^{n} C_{ij}
\]

Then divide each element of the column by its sum value to generate a normalised matrix

\[
\begin{bmatrix}
X_{11} & X_{12} & X_{13} \\
X_{21} & X_{22} & X_{23} \\
X_{31} & X_{32} & X_{33}
\end{bmatrix}
\]

as depicted in the following equation.
\[ X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} \]

Lastly, divide the sum of the normalised column of matrix for each row by the number of criteria used (n) to generate a weighted vector of elements \[ \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix} \], as depicted in the following equation.

\[ W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n} \]

- **Step 4: Aggregation of relative weights**

Once each group’s local relative weights are produced, the alternatives’ overall score can be obtained. This score shows the preference for one alternative over another. In case of sub-criteria exist in the structure, relative weights of element (sub-criteria) are only applied locally with respect to the element (criteria) above them, which do not represent the weights of elements in correspondence with the entire hierarchy. Therefore, aggregation is needed to show the global relative weights by multiplying the local relative weights of each group of sub-criteria by the relative weights of the respective criteria above them (Shapira & Goldenberg, 2005). After the calculation, the sum value for relative weights of all sub-criteria in the hierarchy is one (1). The overall score of alternatives could be determined by multiplying the weighted matrix of alternatives with respect to each sub-criteria by the global relative weights of that sub-criteria and summing the results. These results represent the entire contributing elements in the hierarchy, which enables the comparison between alternatives and determines the most weighted alternative to the less weighted alternative.

- **Step 5: Measure the consistency ratio (CR)**

Consistency Ratio (CR) measurement controls the consistency of pair-wise comparisons. Since the subjective judgement and intuition of decision-makers
are used in the AHP method to select the best alternative, absolute consistency should not be expected. Hence, the extent of inconsistency within a pair-wise comparison should be controlled to the maximum desirable level, which according to Saaty (1987), CR must be less than or equal to zero point one (0.10) to be acceptable. Finding the consistency measure is the first step, in which the consistency vector is generated by the multiplication of the group’s comparison matrix with its weighted vector, as depicted in the following equation.

\[
\begin{bmatrix}
C_{11} & C_{12} & C_{13} \\
C_{21} & C_{22} & C_{23} \\
C_{31} & C_{32} & C_{33}
\end{bmatrix}
\times
\begin{bmatrix}
W_{11} \\
W_{21} \\
W_{31}
\end{bmatrix}
\begin{bmatrix}
C_{11}W_{11} + C_{12}W_{21} + C_{13}W_{31} \\
C_{21}W_{11} + C_{22}W_{21} + C_{23}W_{31} \\
C_{31}W_{11} + C_{32}W_{21} + C_{33}W_{31}
\end{bmatrix}
\]

It is continued by dividing the weighted sum value by element weight, as depicted in the following equation.

\[
Cv_{11} = \frac{1}{W_{11}} [C_{11}W_{11} + C_{12}W_{21} + C_{13}W_{31}]
\]
\[
Cv_{21} = \frac{1}{W_{21}} [C_{21}W_{11} + C_{22}W_{21} + C_{23}W_{31}]
\]
\[
Cv_{31} = \frac{1}{W_{31}} [C_{31}W_{11} + C_{32}W_{21} + C_{33}W_{31}]
\]

Then eigenvalue \( \lambda_{\text{max}} \) is obtained by averaging the value of consistency vector, which is needed to calculate the Consistency Index (CI), as depicted below.

\[
\lambda_{\text{max}} = \frac{1}{n} \sum_{i=1}^{n} Cv_{ij}
\]
\[
CI = \frac{\lambda_{\text{max}} - n}{n - 1}
\]

After that, the CR could be obtained by diving CI with the Random Consistency Index (RI) provided by Saaty (1987), as shown in Table 3.

<table>
<thead>
<tr>
<th>n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0.58</td>
<td>0.90</td>
<td>1.12</td>
<td>1.24</td>
<td>1.32</td>
<td>1.41</td>
<td>1.45</td>
<td>1.49</td>
</tr>
</tbody>
</table>

The most weighted alternative in generated in step 4 represent the final result of the whole AHP method in assisting the decision-making process, while the step 5 determines the consistency of the process. If the consistency ratio surpasses the maximum level, then it is advised for the decision maker to revise their judgements to achieve the desirable result. Additionally, the calculation process in this process will be done mostly with the aid of SuperDecision software and Microsoft Excel, which will be elaborated more on in the analysis chapter.

3.4. Ethical Issues

Since there is human participation in this study, the researcher followed the rules and guidelines on ethical considerations established by WMU Research Ethics Committee. The researcher already acquired approval from the committee before conducting any collection methods elaborated in the next section. Adhering to the committee’s approval, the privacy of participants’ data in this study is protected, and their consent is acquired before participating. Finally, the data and materials obtained from participants will be deleted after the graduation date.

3.5. Summary

As have been explained in this chapter, that the qualitative and quantitative approaches will be used to conduct this study. The framework shown before, which covers the stages of this study, how the data will be collected and analysed, also the correlation between stages, will become the guidance of this study. The findings, analysis and discussions of collected data will be presented in the following chapters, which will be separated into two chapters. Chapter 4 will elaborate the results on qualitative data, while chapter 5 will elaborate the results on quantitative data, which are required to answer the research questions of this study.
Chapter 4: Findings, Analysis, & Discussion for Qualitative Data

In this chapter, the researcher will provide the analysis result of the first stage, in which qualitative data from interviews and documents review will be analysed using thematic analysis as discussed before. Additionally, the transcription of interviews and relevant documents on some providers’ cloud-based training simulators will be codified under two pre-determined broad themes, consisting of (1) Criteria in Selection of Training Simulator and (2) Possible Alternatives of Training Simulator.

Table 4. Elaboration on broad theme

<table>
<thead>
<tr>
<th>Code 1</th>
<th>Code 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>Criteria of selection</td>
</tr>
<tr>
<td>Definition</td>
<td>Attributes of simulators that will become the deciding factors for users in choosing a training simulator</td>
</tr>
<tr>
<td>Description</td>
<td>Essential characteristics of simulators which are different between one type of simulator over another</td>
</tr>
</tbody>
</table>

The researcher concludes these themes based on the literature review discussed in chapter 2 and becomes the scope of this analysis. Additionally, these themes serve the purpose of gathering and categorising the elements of the hierarchy structure needed in the AHP method, which will be used in the second and third stages of this
research. The themes are elaborated (Table 4) in a template referring to Boyatzis (1998, as cited in Fereday & Muir-Cochrane, 2006), including: (1) the code label or name, (2) the definition of what the theme concerns, and (3) a description of how to know when the theme occurs. The experts who participated in the interview will be referred to as Expert 1, Expert 2, Expert 3 and Expert 4. These experts come from different backgrounds, involving academics and officials from training simulator provider companies who are credible to provide the answers to the interview questions.

4.1. Criteria in Selection of Training Simulator

Continuing the discussion in the previous section on broad themes of this research, the researcher also determines three prior sub-themes which fall under theme 1, which will be directly involved in the hierarchy structure of the AHP method as the “criteria”. Based on the analysis, the researcher found that these three criteria, consisting of (1) technical, (2) educational function and (3) institutional capability of a MET institution, should be considered by MET institutions as the most users of training simulators in selecting their simulator. By using the same reference in the previous section, further elaboration on sub-themes is provided in Table 5.
Table 5. Elaboration on sub-themes

<table>
<thead>
<tr>
<th>Code 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
</tr>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>
Table 6. Criteria and Sub-criteria of simulators generated from qualitative data analysis

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>SUB-CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 TECHNICAL</td>
<td>SC1 FIDELITY  the level of realism portrayed in a simulated scenario or accuracy level of a simulator resembling the actual equipment or situation (physical fidelity, psychological fidelity, behavioural fidelity, etc.)</td>
</tr>
<tr>
<td></td>
<td>SC2 USER FRIENDLY The well-designed simulators so they could be easy to learn, use, and understand by the user (operation system, hardware, etc.)</td>
</tr>
<tr>
<td></td>
<td>SC3 POSSIBILITY OF REMOTE TRAINING the ability of simulators to deliver simulation-based training anywhere for trainees without their physical presence needed in a training centre</td>
</tr>
<tr>
<td></td>
<td>SC4 POSSIBILITY OF COLLABORATIVE LEARNING the potential of simulators to train multiple people in the same scenario in collaborative environment</td>
</tr>
<tr>
<td></td>
<td>SC5 PEDAGOGICAL APPROPRIATE the ability of simulators in enabling the pedagogic approach in simulation-based training (briefing, planning, simulation exercise, debriefing, instructor’s feedback etc) to achieve intended learning outcomes</td>
</tr>
<tr>
<td>C2 EDUCATIONAL FUNCTION</td>
<td>SC6 AVAILABILITY OF VARIOUS TRAINING SCENARIOS Ability of simulators to simulate different scenarios and tasks with various complexity, which engage with technical (navigation, engine operation, etc.) and non-technical (decision-making, teamwork, etc.) skills training</td>
</tr>
<tr>
<td></td>
<td>SC7 FLEXIBILITY the degree of freedom in accessing the simulators for instructors and trainees: 1. come to training centre or connect to simulators through internet 2. simulation exercise could proceed with/without instructors (instructor-led / student-led)</td>
</tr>
<tr>
<td></td>
<td>SC8 TRAINING EFFICIENCY the ability of simulators to support the skill acquisition process in short time</td>
</tr>
<tr>
<td>C3 INSTITUTIONAL</td>
<td>SC9 REGULATION COMPLIANCE refers to the compliance of simulators according to international regulations (STCW 1978) and national regulations (PK.16/BPSDMP-2017)</td>
</tr>
<tr>
<td></td>
<td>SC10 COST the cost incurred for procurement and maintenance of simulators by institution</td>
</tr>
<tr>
<td></td>
<td>SC11 INSTRUCTOR’S CAPABILITY the qualified and sufficient instructors along with simulators should be available in an institution</td>
</tr>
</tbody>
</table>
4.1.1.  Criteria 1: Technical

4.1.1.1. Sub-criteria 1: Fidelity

The first attribute that is found under technical features is fidelity. The fidelity of a training simulator is emphasised heavily through the discussion in the literature review. This assumption is taken due to numerous articles which suggest that fidelity is one of the most important attributes of a simulator. However, it does not indicate a better result of training caused by higher fidelity of the simulator, as stated in IMO Model Course 6.10: Train the Simulator Trainer and Assessor, page 6.

*Simulation fidelity or behavioural realism is defined as the degree to which a simulation is a close representation of the real equipment, system, process and environment ………. Moreover, it is not necessary if high fidelity does improve the training experience or improves learning* 

It is also indicated from the interview with expert 4 regarding the company’s product on cloud-based training simulation, as quoted below:

*…… So we have gone about creating a cloud-native infrastructure where we are actually rebuilding and refitting our simulator technology to be a complete cloud-native …… we are relying on our legacy, which if you already know our simulators, we try to reuse as much of the technology and the workflows in the simulators as possible ……* – Expert 4

This statement indicated that all the strengths of simulator technology developed for many decades must be available in their new cloud-based simulator, including the fidelity of the simulator. Furthermore, it reflected the importance of fidelity as one of the decision factors.

4.1.1.2. Sub-criteria 2: User-friendly

User-friendliness is the second found attribute under the technical feature that a training simulator possesses because most maritime training simulators are generated through computer processing. Consequently, the complexity of the user interfaces in computer operation to initiate the simulation program and in operating the program itself needed to be highlighted. A user-friendly training simulator (easy to
learn, use and understand) is beneficial for users, both training instructors and trainees, since it could affect their performance and lead to the efficiency of TLAs. The interview with expert 3 regarding the feedback received on their all simulator products indicates that user-friendly is essential, as quoted below:

“…… our goal is to make it as user-friendly as possible ….. that is why we also collaborate together with many of our customers by giving us feedback on, for example, the place of button, or others ….” – Expert 3

Additionally, for the instructor/lecturer, designing a new training scenario to meet the trainees' needs is challenging, as stated by expert 1, on the experience of engaging with the trainees by using a cloud-based simulator for exercising training scenario:

“…… so if you are going to make your own content, it will be more hassle to deal with, and you need a dedicated computer programmed with the simulator instructor tool ….” – Expert 1

Therefore, the researcher concluded that a “user-friendly” interface and operation contributes to the selection of training simulator by users. Moreover, it could assist them in maximising the utilisation of the simulator by reducing the difficulties and working duration needed by training instructors in preparing a simulation scenario.

4.1.1.3. Sub-criteria 3: Possibility of Remote Training

The third attribute is the possibility of remote training, which is the main advantage of cloud-based simulators compared to other training simulators. As discussed in the literature review, an increasing trend is happening to the blended learning method in educational institutions, including MET, for both theory and practical material by combining online distance learning with conventional in-site learning. This argument is supported by the statement from experts 2 and 4, as stated:

“…… the kind of initiative or reasoning as to why we develop this cloud-based simulator so that you can connect anytime, anywhere, most of the time ….” – Expert 2
Their statements indicate that the ability to perform simulation training without being physically present in a training centre has gradually become important in meeting users’ current needs at the current moment.

As stated by expert 1 above, in his experience engaging with a cloud-based simulator, the simulator’s ability to perform training simulation from a distance could assist in maximising the skill acquisition and utilisation by the students or trainees in this context. Further explanation regarding the “student-led” concept stated above and as shown in table 6 will be put in the next section.

4.1.1.4. Sub-criteria 4: Possibility of Collaborative Learning

Lastly, the researcher sees the possibility of collaborative learning as another factor contributing to the selection of training simulators for their technical feature since experts highly emphasise it during interviews about their taking on how simulators should be.

Based on these inputs from all experts, the ability of a simulator to enable learning and training activities of multiple trainees in a collaborative environment is critical. Their inputs also indicate the practice of collaborative learning with a different
method by combining a different type of training simulator, for instance, a cloud-based simulator, either to assist the training scenario through integration or to supplement the training activities, such as for familiarisation. The other possible indications are the role of instructors in designing the scenario, the scenario’s diversity and the scenario’s efficiency, which probably contribute as decision factors as shown in table 6 and will be elaborated on further in the next section.

4.1.2. Criteria 2: Educational Function

4.1.2.1. Sub-Criteria 5: Pedagogical Appropriate

The first attribute found under educational function is pedagogical appropriate. The ability of simulators to enable the pedagogic approach during simulation-based training is essential to support the TLAs through a training simulator.

"...... And that is why we want to have close communication with all our users and customers, the organisation’s instructors, on how they use it and what they want to use it for. So we focus the effort of creating the tools they need to achieve their objectives, which is the building the competency with their crew, and students......" – Expert 3

The statement from expert 3 indicated the importance of achieving the learning objective, which is perceived by the researcher heavily correlated to the facilitation of a pedagogical approach during simulation training. Moreover, training simulators can fulfil their role as one of the educational tools in MET. As discussed in the literature review, proper pedagogy structure during TLAs, including simulation-based training, must be implemented to ensure that trainees have achieved the intended learning outcomes at the end of simulation training. Especially at the current moment, as technology advances and new types of training simulators emerge, the role of pedagogy structure as a guideline is getting more important to accommodate the interaction between instructors and trainees in different environments. This argument is supported by expert 2 in the statement as follows:

"...... It does not matter which simulator provider you use, except that simulator has to be useful. It must have a good assessment system and all that. You have to embrace a new way of learning, but of course, you have to conduct the learning with the standard conventional way of learning as you progress ......" – Expert 2
Experts 2 and 4 encourage the training materials to be delivered to the trainees pedagogically appropriate, adjusting to the objectives and type of simulators being used. They also stressed the role of the instructor, which will be explained in the next section.

4.1.2.2. Sub-criteria 6: Availability of Various Training Scenarios

The second found attribute that reflects the educational function of a simulator is the availability of various training scenarios for a type of training simulator. The disparity in the ability of each type of training simulator to simulate different scenarios with varying complexity must also be considered by decision-makers when selecting a training simulator. Consequently, the complexity of a training scenario that a particular training simulator can facilitate to a certain degree contributes to the development of the trainee’s skills. As discussed in the literature review, the nature of people’s skills involves hard skills (technical skills) and soft skills (non-technical skills), which are equally crucial for maritime professionals. Employing the trainees in a less complex training scenario will engage them to expand their skills differently compared to the higher complexity, especially for soft skills, which dwell on human interaction. This issue has been brought up by the researcher based on the literature review supported by the argument from experts, as stated:

“……. But if you are going to make the content yourself for the exercise, there will be more work, and you have to know the K-Sim Connect instructor tool, but then you are much more in control of the work you want to teach the students” – Expert 1

“……. If you have the ability to invest in a bit more on another simulator ……. then you can also integrate that into your training. And you can continue to build the various scenarios or the various setups.” – Expert 4

The statement from experts suggested the importance of this ability of the simulator to simulate scenarios to varying degrees in supporting the TLAs and preparing the trainees who are equipped with the necessary skills needed in their life as maritime professionals. Therefore, provider companies provide a beneficial feature
within their cloud-based simulator, as cited from documents related to their cloud-based simulators:

“By using your own classroom simulators, you can deliver your exercises using your existing ship models, sailing areas and simulator configuration as you already have available, or create new exercises if you prefer” – Kongsberg Digital

“The K-Sim eLearning solution is easy to use and enables you to upload your own exercises from the instructor system at your school to the K-Sim Connect platform, efficiently manage them and make them available for your students” – Kongsberg Digital

“As an instructor, you can also upload and apply your own exercises, supporting the specific model and software version. In order to run your own exercises, you will need to use a K-Sim Instructor System in addition to the eLearning module” – Kongsberg Digital

“Easy content management: Build courses, assign them to students, and accurately track the results — all seamlessly” – Wärtsilä Voyage

“Instructors can run the course from day one using their existing databases, models and exercise areas” – Wärtsilä Voyage

As shown above, besides the prepared training scenarios by providers, instructors are allowed to design their own scenarios for training exercises and assessment of trainees. However, even with this mechanism and encouraged by the provider companies, a cloud-based simulator cannot fully replace the role of the conventional in-site simulators, as expressed by expert 1:

“...... that the cloud simulator will replace everything, but that will not happen in my opinion in years. At the moment, it supplements, and you can combine it with the desktop training .......” – Expert 1

The researcher assumed that the limitation in the complexity of the scenario that a cloud-based simulator could generate compared to a conventional in-site simulator, such as a full-mission simulator, is the reason behind this opinion. Despite that, the users must consider the availability of training scenarios for each type of training simulator in the selection process.

4.1.2.3. Sub-criteria 7: Flexibility

The third attribute is the flexibility of a training simulator, which means the degree of freedom in accessing the simulators for instructors and trainees as users. From the analysis, there are two approaches relating to the simulator’s flexibility, which consist: (1) simulators that are located and operated in a fixed position, such
as a training centre or simulators that can be operated through internet connectivity, and (2) simulators that need the presence of instructor (instructor-led) or simulators that do not need the presence of instructor (student-led). The first approach is closely related to the capability of simulators in exercising remote training, which depends on the available feature of the simulator, as discussed in the previous section. This feature affects the degree of accessibility to a training simulator, which is undoubtedly beneficial for users, including MET institutions, shipping companies and seafarers as trainees. A physical-based simulator's usage can be limited by its capacity, school hours, and distance for a shipping company, which its usage requires dedicated space and regular maintenance. The followings are the collection of opinions and suggestions from experts and some citations from related documents, which indicate the significance of having a remote training feature:

“……. if you have this kind of multi-room, where you can just have a computer desktop with screens or laptops, and then you log into whatever cloud-based you use…….physical simulators take about a lot of spaces while cloud-based simulator is not necessarily taking up the space and maintenance because that is done in the cloud…….” – Expert 1

“……. sometimes it is costly to undergo training where shipping companies have to send their crew from one country to the other for the training……. that is why we want to invest in that technology to kind of connect people and make learning simplified, in a way and accessible to all…….” – Expert 2

“Preferably, we offer the simulation service. And if you want to do familiarisation or instrument training, it is most practical and convenient to do it in a classroom where maybe the students bring their tablets or bring their own laptops, and they sit together, and they simulate and explore in that environment!” – Expert 4

“Flexibility – simulation designed to give the training provider more flexibility in deciding time, place, path or pace of training, supported in a wide range of devices” – Wärtsilä Voyage

“With K-Sim Connect’s remote desktop solution, it’s totally up to you to manage and give your students access to online simulation training; you don’t need to book any simulator time at an external support centre” – Kongsberg Digital

“Flexible configuration – Use the number of workplaces you need, when you need them” – Wärtsilä Voyage

“Access to simulators at school can be limited by capacity and school hours, but it is commonly understood that volume training is key to increasing competence levels” – Kongsberg Digital
From these inputs, the researcher also wants to emphasise the other benefit of remote training, which is encouraging the new training delivery method resulting in another approach of simulator’s flexibility. The new delivery method enables trainees to exercise the scenario independently anytime and anywhere without being bound to the presence and guidance of an instructor, known as a “student-led” exercise. Additionally, the session is also conducted with the instructor either in a classroom, where instructors and trainees use their own devices or remotely by internet connectivity, which is supported by external communication software, such as zoom, skype or others, to ensure interactive training and assessment sessions, known as “instructor-led”. This advantage is enhanced by provider companies creating their single e-learning platform or integrating with another e-learning platform which can support the blended learning implementation in the MET sector, as expressed in the followings:

“… the main advantage is including student-led and instructor-led in cloud-based simulation. If it is student-led, then the student can do the training whenever they would like because it is already kind of pre-programme to run the exercise ….” – Expert 1

“… by taking full advantage of both cloud-based simulation that is student-led, which means they do it alone, while instructor-led, typically conducted in a classroom type session ….” – Expert 4

“Wärtsilä Simulation Cloud Services – Instructor-led interactive simulation virtual classrooms and Student-led training and assessment” – Wärtsilä Voyage

“The instructor may choose to teach the remote class from actual classroom which gives better control and the ability to assist students more quickly if needed” – Kongsberg Digital

*The remote desktop solution enables the students with the flexibility to join training sessions remotely on their own devices* – Kongsberg Digital

*The eLearning module is recommended for volume training and can either be used in a classroom situation or at home* – Kongsberg Digital

4.1.2.4. Sub-criteria 8: Training Efficiency

Lastly, training efficiency is the attribute sustaining a simulator to perform its educational function. The ability of a simulator to support the skill acquisition process
in the shortest time possible is indeed different between one simulator over another. Many factors affect the efficiency of the skill acquisition process in a simulator, such as a simulator’s fidelity degree, the instructor’s role, and many other factors. However, the main factor contributing to training efficiency is the objective of training itself. For instance, it will be more efficient to use a lower fidelity cloud-based simulator in a training session in which the training’s objective is to familiarise the enormous volume of trainees compared to a higher fidelity full-mission simulator. Conversely, if the objective is to conduct the training and assessment of soft skills in a collaborative environment, then an integrated high-fidelity full-mission simulator would be the best option to increase the training efficiency compared to a cloud-based simulator. It does not necessarily mean that a full-mission simulator cannot be used for familiarisation sessions for many people or that a cloud-based simulator is used to train the soft skill collaboratively. It can still be conducted only at a different level of efficiency.

The provider companies are competing with each other to make their simulators more efficient in delivering the simulation, either improving the capabilities of their existing simulator or creating a new type of simulator. However, each type of simulator has its limitations which could hinder the planned scenario of a training session resulting in the inefficiency of the session, such as the problems with internet connectivity which cloud-based simulators depend on, or the regular maintenance of the full-mission simulator. Therefore, the instructors need to find a creative way to evade these possibilities and decrease the inefficiency of the process, such as combining the full-mission simulator with a cloud-based simulator so trainees can prepare and practice by themselves before engaging with the full-mission one, as proposed earlier.

“......but there are a lot of hurdles and challenges with this new technology if implemented. At first, I thought the students will be really engaged, but you know, when students are used to TikTok or any social media, then they easy to get bored with waiting for e-coach messages......” – Expert 1

“......Through cloud-based training, it can complement and enhance the amount of learning from conventional in-site simulation training......first and foremost, you must have a dedicated internet network because, in order to run the training simulation, you cannot use a shared network whereby other people are also using the internet......” – Expert 2
These opinions, added by all previous citations from simulator provider companies, have reflected all real challenges and how they try to solve them, indicating the importance of training efficiency as a decision factor.

4.1.3. Criteria 3: Institutional

4.1.3.1. Sub-criteria 9: Regulation Compliance

The third criterion is more related to the external aspects of the simulator, encompassing (1) regulation compliance, (2) cost and (3) instructor’s capability. The first attribute generated from the analysis is the compliance of simulators to any legal requirements, either the international regulations, primarily Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW 1978) or national regulations, in respect to Indonesia’s regulations regulated by Peraturan Kepala Badan Pengembangan Sumber Daya Manusia Perhubungan Nomor: PK.16/BPSDMP-2017 tentang Pedoman Standarisasi Penyelenggaraan Simulator untuk Pendidikan dan Pelatihan Kepelautan. As previously explained in the literature review, these regulations, especially STCW 1978, regulate a simulator’s performance standards at the international level. Hence it can be used for training and assessing seafarers appropriately. While at the national level, the national regulation is made by adhering to STCW 1978, which could be modified to adapt to the state’s regulatory structure or condition without changing the standard, such as PK.16/BPSDMP-2017 is only applied to Indonesia as a Flag State. The users must ensure the compliance of the simulator used to conduct any mandatory simulation-based training by adhering to those standards.
“As expressed above, the involvement of Classification Societies by creating the new standards for cloud-based simulators and certifying them indicates the importance of standard regulation being applied to training simulators. The certification of Kongsberg Digital from DNV and Wärtsilä Voyage from Class NK for their cloud-based simulator could maintain the quality of the simulator’s performance and gain users’ trust to adopt the cloud-based simulators.”

4.1.3.2. Sub-criteria 10: Cost

The following attribute found under this criteria is the cost, which has often been indicated implicitly and explicitly in the previous opinions, arguments, or citations. The cost incurred for procurement and maintenance of simulators will also be prioritised by users when selecting the simulator. For users with limited financial ability, such as a small school, installing and maintaining a physical simulator will generally incur a cost they cannot afford.

“…… I think, especially for small schools, they don’t have to invest and think about maintenance for the cloud-based simulators, that could be a huge benefits deposit…… So Cloud simulators have a kind of small fee, a monthly fee. …… That’s what you have to pay for the subscription. And then you pay per use, per hour, per student normally, and you don’t need to think about anything more” – Expert 1

“…… if you buy a traditional in-site simulator, there’s an upfront cost, which can be quite expensive. And for many schools, particularly smaller schools, it’s a very high price. But then, with cloud-based simulators, they don’t have to make the upfront investment, but they can simply subscribe to what they need. And that way, they will only pay for what they use……” – Expert 4


“As if there is no regulation that dictates the lead for cloud-based simulators, people will not use it…… but of course, now we see that Class Societies like DNV has certified the use of cloud-based simulators, so I believe that the way forward will be based on cloud-based simulators……” – Expert 2

“The purpose of the standard is to ensure that the simulations provided by the simulator include an appropriate level of physical and behavioural realism in accordance with recognised training and assessment objectives” – DNV

As expressed above, the involvement of Classification Societies by creating the new standards for cloud-based simulators and certifying them indicates the importance of standard regulation being applied to training simulators. The certification of Kongsberg Digital from DNV and Wärtsilä Voyage from Class NK for their cloud-based simulator could maintain the quality of the simulator’s performance and gain users’ trust to adopt the cloud-based simulators.
Therefore, developing cloud-based simulators indicated that providers are trying to make simulators accessible for everyone, not only those with the financial backbone to support expensive simulators. Moreover, it indicated that cost is a priority for providers and users, serving as a critical decision factor.

4.1.3.3. Sub-criteria 11: Instructor’s Capability

The last found attribute of the institutional criterion is the instructor’s capability, which also has been indicated in many previous discussions. The role of an instructor as one of the elements in the learning and training process is undoubtedly necessary. Therefore, a qualified instructor is needed, especially for a MET institution which requires a sufficient and qualified instructor to be available.

“……and so in our lab, we see that we need research, a lot of testing. Since this (cloud-based simulator) is quite new for the students and instructors. And I am eager to learn and use it more …….” – Expert 1

“…… That is why it’s important for instructors (as part of roles) to inculcate the level of knowledge to motivate the student to go in and try. You must have this push and pull thing where we say, for example, if the students connect on the simulator and train on the simulator before the assessment, if they clock in a certain number of hours, then they might get a reduction or minimum grade or points to your studies. It will help in motivating the student because if there is no initiative or incentive to connect and familiarise themselves with the interface (of cloud-based simulator), if not they won’t do it ……” – Expert 2

“…… So I think it’s important that you as an instructor, think about how you can provide the most convenient and efficient training for your students, by maybe considering self-study……” – Expert 4

“……But that depends on actually on the schools and instructors, because they are the ones who know what is required actually to create the teaching environments that they need……” – Expert 4

As pointed out by experts, the ability to design a training scenario creatively which combines and maximises the use of available simulators or develops the skill to communicate with the trainees by giving and receiving feedback or to have rewards and punishment for trainees for specific results or another effort to motivate the trainees and engage them in the session need to be possessed by an instructor. The
eagerness to improve the skill and capabilities is also included in the instructor’s roles to provide the best for trainees. Therefore, instructors’ capability in performing their roles must be considered before adopting a simulator.

4.2. Possible Alternatives of Training Simulator

For this section, the researcher will discuss the analysis result regarding the existing training simulators developed by provider companies and could be employed as alternatives for the users in the MET sector to conduct simulation-based training. Documents collected from Kongsberg Digital and Wärtsilä Voyage show a wide range of simulator types in their products, which are available in different configurations. These simulators are offered to the users by adjusting to their needs in a fully scalable range from a PC-based desktop system to a fully equipped environment (full-mission simulator), from physically in-site simulators to remotely cloud simulators (cloud-based simulators), which cover all vessel types, engines and operations (Kongsberg Digital, n.d.; Wärtsilä Voyage, n.d.).

“Scalable: at whatever scale you need – Individual users, remote, virtual or physical classrooms, part-task, full mission, multi-mission, and connected systems in varying geographical locations” – Wärtsilä Voyage

“Our K-Sim simulators range from full-scale bridge simulators with realistic features to cloud-based training to enable engaging exercises anytime and anywhere” – Kongsberg Digital

About the criteria and sub-criteria explained in the previous section, each type of simulator must have its strength and weakness in one or several factors, which users must consider. Despite that, users and providers must have their opinion on the best option from the available training simulators, which might be based on their technical knowledge or long-time experience with the simulator. This knowledge and experience could provide a suggestion on possible alternatives for the next stage of analysis.

“…..But of course, I prefer the full mission. And the students also, but I’m used to working mostly on the desktop simulator…..” – Expert 1
Supported by these opinions from experts, the researcher proposes four alternatives to training simulators, categorised based on the medium of the simulations being facilitated. This proposition has also been corresponding to the alternatives suggested in the literature review, which consist of:

- **Desktop-based simulators**
  Simulators that can replicate certain parts of real equipment with a selected number of scenarios or operations in 2D screens as facilitated by pre-loaded simulation software in desktop computers

- **Full-mission simulators**
  Simulators that are capable of virtually mimicking the real environment with a good level of fidelity by utilising replicas of all essential physical instruments and displays of the actual workplace

- **Virtual Reality (VR) simulators**
  Simulators that provide the most immersive experience for trainees by replicating the real-world environment virtually using Head-Mounted Displays (HMDs) featuring the possibility to interact with virtual objects

- **Cloud-based simulators**
  Simulators that enable trainees to run simulations with or without instructors on mobile devices (e.g. laptops, PCs, tablets, etc.) everywhere without being present in a training centre, where the simulation is processed by cloud computing through internet connectivity
4.3. Summary

In summary, there are eleven (11) sub-criteria under three (3) criteria, complemented with four (4) alternatives generated from the thematic analysis of the qualitative data. Even though the collected data revolved around using cloud-based simulators, the decision factors are still implicitly indicated within the data. These factors have also answered the first research question, which is also needed for the following stages. It is important to be understood that these factors are related by adding value to other factors, as explained in this section. The findings, analysis and discussion of the quantitative data will be presented in the following chapter, which contains the final result of the AHP method and answers the other research questions.
Chapter 5: Findings, Analysis & Discussion for Quantitative Data

As this chapter goes on, the researcher will analyse the results of quantitative data to answer the second and third research questions, consisting: (1) “are the existing training simulators appropriate and capable of accommodating the training and assessment activities in Indonesia’s MET institutions?” and (2) “are the cloud-based simulators need to be adopted by MET institutions in Indonesia?”. As explained in chapter 3, the data will be analysed using the Analytic Hierarchy Process (AHP) framework to determine the weight of each element (criterion, sub-criteria and alternatives), which are generated in the previous section. Ultimately, the best alternative will emerge and define the necessity of cloud-based simulators for Indonesia’s MET institutions. This chapter will be presented in two sections: (1) the characteristics of respondents who participated in the questionnaire and (2) the calculated weight of the elements by adhering to the AHP steps in chapter 3.

5.1. Characteristics of Respondents

This analysis is based on the 112 Indonesian respondents divided based on age, last formal education, professional background, and other characteristics. Concerning that, the professional backgrounds of respondents become the determining factor in how the analysis will be discussed further. There are two primary groups: human resources of state-owned MET institutions and seafarers as trainees in those institutions. The respondents who have a background as (1) Deck Department Training Instructor, (2) Engine Department Training Instructor and (3) Head of Department/ Unit/ Institutions are put in the first group. Meanwhile, the respondents who have a seafarer background, including (4) Deck Department Trainee, (5) Engine Department Trainee, (6) Deck Cadet and (7) Engine Cadet, are put in the second one. The questionnaire is completed by these two groups in almost similar proportion, with 54.46% of respondents belonging to the first group and
45.54% of the second group, as table 7 shows in detail. Furthermore, the respondents with a profession as training instructor/lecturer for the deck department become the contributor with the highest proportion.

**Table 7. Distribution of respondents based on professional background**

<table>
<thead>
<tr>
<th>LAST POSITION / TRAINING PHASE</th>
<th>TOTAL</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human Resource of METIs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck Department Training Instructor / Lecturer (Instruktur / Dosen Nautika)</td>
<td>41</td>
<td>36.61%</td>
</tr>
<tr>
<td>Engine Department Training Instructor / Lecturer (Instruktur / Dosen Teknika)</td>
<td>61</td>
<td>54.46%</td>
</tr>
<tr>
<td>Head of Department / Unit / Institution (Kepala Jurusan / Unit / Institusi)</td>
<td>6</td>
<td>5.36%</td>
</tr>
<tr>
<td><strong>Seafarer Trainee</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck Department Trainee (Peserta Diklat Peningkatan / Penyegaran Nautika)</td>
<td>29</td>
<td>25.89%</td>
</tr>
<tr>
<td>Engine Department Trainee (Peserta Diklat Peningkatan / Penyegaran Teknika)</td>
<td>7</td>
<td>6.25%</td>
</tr>
<tr>
<td>Deck Cadet (Taruna Jurusan Nautika)</td>
<td>9</td>
<td>8.04%</td>
</tr>
<tr>
<td>Engine Cadet (Taruna Jurusan Teknika)</td>
<td>6</td>
<td>5.36%</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>112</strong></td>
<td></td>
</tr>
</tbody>
</table>

While most respondents engage in MET activities organised by 12 state-owned MET institutions in Indonesia, around 6.25% of respondents originated from private institutions, such as vocational schools and maritime academies. A detailed distribution of respondents based on MET institutions is shown in table 8, which exhibits that the portion of respondents from Poltekpel Sulawesi Utara contributed to 34.82% or one-third of total respondents. Subsequently, this dominance can affect the final result of the analysis, which could be biased to the locally perspective of MET activities in Poltekpel Sulawesi Utara. It could generalise the result overall METIs, especially with the ones from Poltekpel Banten, which only reached 0.89% of total respondents.

As for the distribution based on respondents’ age shown in table 9, around 39% of the respondents come from 26 – 30 years of age, known as digital natives.
Technology has been part of their daily lives and will continue to grow due to its rapid advancement and evolution. Subsequently, the input from this group could affect the results to a different degree than other age groups since training simulators are closely related and evolve as the evolution of technologies. However, they could also be recognised for their experience in professional life, which probably have less experience compared to the older age groups. Their experience could also be the determinant factor and affect their judgement in the questionnaire. Additionally, the youngest respondents who are less than 20 years old fulfilled 5% of the total respondents.

**Table 8. Distribution of respondents based on METIs**

<table>
<thead>
<tr>
<th>LATEST MET INSTITUTION</th>
<th>HUMAN RESOURCE of METIs</th>
<th>SEAFARER TRAINEE</th>
<th>TOTAL</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sekolah Tinggi Ilmu Pelayaran (STIP) Jakarta</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4.46%</td>
</tr>
<tr>
<td>Politeknik Ilmu Pelayaran (PIP) Semarang</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>6.25%</td>
</tr>
<tr>
<td>Politeknik Ilmu Pelayaran (PIP) Makassar</td>
<td>7</td>
<td>5</td>
<td>12</td>
<td>10.71%</td>
</tr>
<tr>
<td>Balai Besar Pendidikan Penyegaran dan Peningkatan Ilmu Pelayaran (BP3IP) Jakarta</td>
<td>3</td>
<td>14</td>
<td>17</td>
<td>15.18%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Malahayati Aceh</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.79%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Sumatera Barat</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4.46%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Banten</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.89%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Surabaya</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.79%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Barombong</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>4.46%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Sulawesi Utara</td>
<td>19</td>
<td>20</td>
<td>39</td>
<td>34.82%</td>
</tr>
<tr>
<td>Politeknik Pelayaran (Poltekpel) Sorong</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>7.14%</td>
</tr>
<tr>
<td>Balai Pendidikan dan Pelatihan Transportasi Laut (BP2TL) Jakarta</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1.79%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>6.25%</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>61</strong></td>
<td><strong>51</strong></td>
<td><strong>112</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PERCENTAGE</strong></td>
<td><strong>54.46%</strong></td>
<td><strong>45.54%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The formal education of respondents also plays a role in the process of answering the questionnaire. As in formal education, people come to learn how to adapt to social dynamics by cultivating their intellectual prowess and deductive reasoning skills (Manuel, 2017). Subsequently, by those skills, people are expected to develop more skills needed for their personal, social and professional future; by that, the quality of their life could be increased (Rodrigues et al., 2021). Including MET, respondents with a higher degree in formal education could be expected to have

<table>
<thead>
<tr>
<th>AGE GROUPS</th>
<th>TOTAL</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 20 years old</td>
<td>6</td>
<td>5%</td>
</tr>
<tr>
<td>21 - 25 years old</td>
<td>14</td>
<td>13%</td>
</tr>
<tr>
<td>26 - 30 years old</td>
<td>44</td>
<td>39%</td>
</tr>
<tr>
<td>31 - 35 years old</td>
<td>12</td>
<td>11%</td>
</tr>
<tr>
<td>36 - 40 years old</td>
<td>14</td>
<td>13%</td>
</tr>
<tr>
<td>41 - 45 years old</td>
<td>11</td>
<td>10%</td>
</tr>
<tr>
<td>46 - 50 years old</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>51 - 55 years old</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>56 - 60 years old</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>≥ 61 years old</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>112</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Distribution of respondents based on age
refined judgements on the development of MET and its attributes. The training simulators which develop as the technology evolves could be seen as a beneficial factor in developing seafaring skills rather than a challenge for some people with lower education.

Furthermore, the respondents with bachelor's degrees contributed the most to this survey, with 45% of respondents. Followed by senior high school graduates in 29%, master's degrees in 21% and others, which are shown in table 10. Around 3% of respondents who are put as "other" in the table have a diploma III degree which is classified as higher education in Indonesia.

Table 10. Distribution of respondents based on last formal education

<table>
<thead>
<tr>
<th>LAST FORMAL EDUCATION</th>
<th>TOTAL</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary school or equivalent (SD dan sederajat)</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Junior High School or equivalent (SMP dan sederajat)</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Senior High School or equivalent (SMA dan sederajat)</td>
<td>33</td>
<td>29%</td>
</tr>
<tr>
<td>Bachelor Degree or equivalent (S1 dan sederajat)</td>
<td>50</td>
<td>45%</td>
</tr>
<tr>
<td>Master Degree (S2)</td>
<td>23</td>
<td>21%</td>
</tr>
<tr>
<td>Doctoral Degree (S3)</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>112</strong></td>
<td></td>
</tr>
</tbody>
</table>
As the questionnaire goes, the respondents will be directed to two different sets of questions based on their professional backgrounds:

- **Human Resource of METIs**

  In total, 61 respondents are categorised in this group with different lengths of experience and knowledge about training simulators. The respondents with 1-5 years of experience are the ones who participated the most in the survey, which reached around 77% of total respondents. The more detailed distribution of respondents based on their experience is illustrated in figure 6.

**Figure 6. Distribution of first group respondents based on their experience**

The respondents of this group are also measured on their knowledge and understanding of all types of training simulators proposed in the questions through self-assessment. Most of the respondents chose to agree to the
statement that they are informed about the available training simulators as shown in Figure 7.

**Figure 7. Self-assessment of first group respondents on the knowledge of available training simulators**

- **Seafarer Trainee**

  For this group, 51 respondents have been categorised with different levels of competencies. A considerable portion of participating respondents in the second group are deck officers, with Deck Officer Class III certificate holders being the most among them, as shown in figure 8. The Deck Officer Class III certificate is issued according to Indonesia’s regulation as being equivalent to the Officer in charge of a Navigational Watch on ships of 500 gross tonnages or more as regulated in Regulation II/1 and Code Section A-II/1 of STCW 1978, as mandated. The corresponding regulation in STCW 1978 with the other certificates listed in figure 8 can be seen in Appendix 1.
The last factor is a measurement based on the types of training simulators that respondents have been familiar with or engaged with during their professional life. Based on the chart shown in figure 9, it was found that only a tiny portion of the respondents from both groups have been involved with cloud-based simulators, especially virtual-reality simulators. On the contrary, full-mission simulators and desktop-based are the ones that respondents have been engaged with frequently. This result has proven the researcher’s assumption at the beginning of this study.
5.2.  **Recommended Training Simulator**

As explained in chapter 3, the AHP method is the method that will be used to assist the decision-making process in this study. The steps in conducting the AHP method are also explained in that chapter. Additionally, in this study, the researcher has used the *SuperDecision* software to assist in the calculation process. Therefore, the final result from those processes will be presented as follows:

5.2.1. **Pair-wise Comparison Analysis**

The hierarchical structure is needed to create this pair-wise comparison. At the first step in the AHP method, the hierarchical structure is established using the elements generated from the previous chapter. Accordingly, all those elements are put in the structure, as shown in figure 10. In this figure, the objective of structure is positioned at the top of structure, which is the “Recommended Training Simulator.” Below the top structure are level 1 elements comprising the main criteria from the previous chapter. They are (C1) Technical, (C2) Educational Function, and (C3) Institutional. After those, there is level 2, which consists of the elements under the scope of each criterion. For (C1) Technical, there are (SC1) Fidelity, (SC2) User Friendly, (SC3) Possibility of Remote Training and (SC4) Possibility of Collaborative Learning. For (C2) Educational Function, there are (SC5) Pedagogical Appropriate, (SC6) Availability of Various Training Scenarios, (SC7) Flexibility and (SC8) Training Efficiency. For the last criteria (C3) Institutional, there are (SC9) Regulation Compliance, (SC10) Cost and (SC11) Instructor’s Capability. At the bottom level, there are alternatives for the objective, consisting of (ALT1) Desktop-based Simulator, (ALT2) Full-mission Simulator, (ALT3) Virtual Reality (VR) Simulator and (ALT4) Cloud-based Simulator. For more detailed explanations about these elements, readers are advised to read chapter 4.
Figure 10. Hierarchical structure for Recommended Training Simulator

- **C1** Technical
  - SC1 Fidelity
  - SC2 User Friendly
  - SC3 Possibility of Remote Training
  - SC4 Possibility of Collaborative Learning
- **C2** Educational Function
  - SC5 Pedagogical Appropriate
  - SC6 Availability of Various Training Scenarios
  - SC7 Flexibility
  - SC8 Training Efficiency
- **C3** Institutional
  - SC9 Regulation Compliance
  - SC10 Cost
  - SC11 Instructor's Capability
Since this questionnaire involves multiple respondents leading to multiple values for the same comparison, those values must be consolidated into one set of values through geometric mean. This method is typically used to consolidate the multiple values, as it preserves the axioms of the AHP (Aczél & Saaty, 1983, as cited in Scala et al., 2010). Through geometric mean, the multiple values of each paired comparison from every respondent are calculated into a single value, as shown in table 11. While the values of criteria and sub-criteria matrix are obtained from the

| Table 15. Values for each paired comparison (criteria and sub-criteria) |
|-------------------------|-------------------|
| **Comparison**          | **Geometric Mean** |
| **Recommended Training**| **Simulator**     |
| C1, C2                  | 0.68324           |
| C1, C3                  | 0.81172           |
| C2, C3                  | 1.84674           |
| Criteria 1              |
| SC1, SC2                | 0.55395           |
| SC1, SC3                | 0.61873           |
| SC1, SC4                | 1.05140           |
| SC2, SC3                | 1.65156           |
| SC2, SC4                | 2.08632           |
| SC3, SC4                | 1.42735           |
| Criteria 2              |
| SC5, SC6                | 1.353501          |
| SC5, SC7                | 0.52386           |
| SC5, SC8                | 1.13501           |
| SC6, SC7                | 0.59622           |
| SC6, SC8                | 0.80331           |
| SC7, SC8                | 1.26291           |
| Criteria 3              |
| SC9, SC10               | 1.87646           |
| SC9, SC11               | 0.47747           |
| SC10, SC11              | 0.32248           |
questionnaire, the value of alternatives is assigned based on the accumulated knowledge and experience gained by the researcher during study at World Maritime University and professional work. All values, including the value of paired alternatives in respect to each sub-criteria in table 12, will be assigned to the comparison matrix, as shown in figure 5.

Table 19. Values for paired comparison (alternatives) respective to each sub-criteria

<table>
<thead>
<tr>
<th>SUB-CRITERIA</th>
<th>ALT1, ALT2</th>
<th>ALT1, ALT3</th>
<th>ALT1, ALT4</th>
<th>ALT2, ALT3</th>
<th>ALT2, ALT4</th>
<th>ALT3, ALT4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1_Fidelity</td>
<td>0,25</td>
<td>0,333333333</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>SC2_User Friendly</td>
<td>3</td>
<td>2</td>
<td>0,5</td>
<td>1</td>
<td>0,333333333</td>
<td>0,333333333</td>
</tr>
<tr>
<td>SC3_Possibility of Remote Training</td>
<td>1</td>
<td>0,2</td>
<td>0,111111111</td>
<td>0,2</td>
<td>0,111111111</td>
<td>0,166666667</td>
</tr>
<tr>
<td>SC4_Possibility of Collaborative Learning</td>
<td>0,333333333</td>
<td>2</td>
<td>0,5</td>
<td>3</td>
<td>2</td>
<td>0,333333333</td>
</tr>
<tr>
<td>SC5_Pedagogical Appropriate</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SC6_Availability of Various Training Scenarios</td>
<td>0,5</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0,5</td>
</tr>
<tr>
<td>SC7_Flexibility</td>
<td>1</td>
<td>1</td>
<td>0,333333333</td>
<td>0,5</td>
<td>0,25</td>
<td>0,333333333</td>
</tr>
<tr>
<td>SC8_Training Efficiency</td>
<td>0,333333333</td>
<td>0,5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SC9_Regulation Compliance</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SC10_Cost</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0,333333333</td>
<td>0,333333333</td>
</tr>
<tr>
<td>SC11_Instructor's Capability</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0,5</td>
</tr>
</tbody>
</table>

The values shown in tables 11 and 12 indicate the importance of factors. If the value for a pair is =1, it means that both factors are equally important. However, if the value for a pair is <1, it means that the latter factor is more important than the other. Otherwise, if the value for a pair is >1, the earlier factor is more important. The values in table 11 indicate that C2 (1st row), C3 (2nd row) and C2 (3rd row) are the important factors of the objective, which is the recommended training simulator. Under the scope of each criterion, the more important factors in each row are sorted as follows: (1) Criteria 1: SC2, SC3, SC1, SC2, SC2 and SC3, (2) Criteria 2: SC5, SC7, SC5, SC7, SC8, and SC7, and (3) Criteria 3: SC9, SC11, and SC11. The higher the
frequency of a factor chosen within its scope, the higher the indication that it is the most important among other factors. The (C2) Educational function is indicated as the most important factor for recommended training simulator, as well as the (SC2) User Friendly for Criteria 1: Technical, (SC7) Flexibility for Criteria 2: Educational Function and (SC11) Instructor’s Capability for Criteria 3: Institutional. It also applies to the values of alternatives with respect to each sub-criteria (table 12) which are indicated as follows:

1. (ALT2) Full-mission simulator is chosen in respect to (SC1) Fidelity
2. (ALT4) Cloud-based simulator is chosen in respect to (SC2) User Friendly
3. (ALT4) Cloud-based simulator is chosen in respect to (SC3) Possibility of Remote Training
4. (ALT2) Full-mission simulator is chosen in respect to (SC4) Possibility of Collaborative Learning
5. (ALT2) Full-mission simulator is chosen in respect to (SC5) Pedagogical Appropriate
6. (ALT2) Full-mission simulator is chosen in respect to (SC6) Availability of Various Training Scenarios
7. (ALT4) Cloud-based simulator is chosen in respect to (SC7) Flexibility
8. (ALT2) Full-mission simulator is chosen in respect to (SC8) Training Efficiency
9. (ALT1/ALT2/ALT3/ALT4) All training simulators are chosen in respect to (SC9) Regulation Compliance
10. (ALT4) Cloud-based simulator is chosen in respect to (SC10) Cost
11. (ALT1/ALT2) Desktop-based simulator and Full-mission simulator are chosen in respect to (SC11) Instructor’s Capability

It must be emphasised that this list is only indications based on the frequency of the selected factor due to its value. The relative weight for all elements is still needed to validate these indications and proceed with the calculation of aggregation, which will be provided in the next section.
5.2.2. Relative Weight Analysis

As mentioned in the previous section, the relative weights of elements still need to be defined to proceed with the calculation. This section will elaborate more on the findings of elements’ relative weights. Based on tables 13 and 14, the indications made in the previous section are proven true. The relative weights of elements shown in these tables reflected the weight of factors in their respective scope. Consequently, the factors with the highest weight are pointed out as the most important. At the top structure, the highest relative weight for the recommended training simulator is the educational function (C2) of a simulator with a value of 0.44303, which means it is the most important factor, followed by the institutional factor (C3) with a value of 0.28402 and technical factor (C1) with a value of 0.27295. Being the most important factor means the ability of a training simulator to deliver the training material to the trainees is measured above the technical aspects of the simulator itself and the institutional aspect that support the operation of the simulator.

It applies the same to the lower levels, including sub-criteria and alternatives. For sub-criteria under (C1) Technical, it was found that (SC2) User Friendly is the most important factor for technical features of a training simulator whose relative weight value is 0.37323. It indicates that as simulator users, the respondents mostly prefer a training simulator that can be used easily. The (SC3) Possibility of Remote Training took the second place with its relative weight value is 0.26122, followed by (SC1) Fidelity with its relative weight value is 0.18389, and (SC4) Possibility of Collaborative Learning with its relative weight value is 0.18166. This order indicates that the technical feature of a training simulator, by which trainees can perform simulation-based training remotely (SC3), turns out to be more preferred than the simulator's (SC1) fidelity and (SC4) capability to perform simulation-based activity for multiple people simultaneously.
Next set of sub-criteria under (C2) Educational Function, it was found that (SC7) Flexibility of a training simulator is the most important factor in its educational function, with a relative weight value is 0,347. It means the function of simulating a training scenario flexibly, by which simulator can be operated with (instructor-led) and without (student-led) an instructor, either in a training centre or remotely, as explained in the previous chapter, is the most preferred function that a training simulator should possess. After this function, there are (SC8) Training Efficiency and (SC5) Pedagogical Appropriate in almost equivalent relative weight values, 0,23482 and 0,23061. It indicates that the simulator’s function to enable the (SC5) pedagogic approach (briefing, planning, debriefing, etc.) in the simulation-based activity is
similarly important to its function that (SC8) enables the skill acquisition process in a short time. The researcher perceives this condition happened because both functions have a similar goal to achieve the learning objectives effectively and could be completed even if either of those factors is not found in a training simulator. At last, is the (SC6) function to simulate different training scenarios with its relative weight value is 0.18756.

In the last set of sub-criteria under (C3) Institutional, it was found that (SC11) Instructor’s capability is the most important factor that supports the operation of the simulator, with its relative weight value is 0.55106. It indicates that the respondents still recognise the capability of a training instructor in operating the training simulator and delivering the training material to achieve the learning objectives at the end of the session as the most important aspect that supports simulation-based activities. Followed by the (SC9) compliance of training simulator to regulation with its relative weight value is 0.28473, and the (SC10) cost must be incurred for procurement and maintenance of the simulator. Even though measured at the last position, the (SC10) cost factor and other resources are still significant deciding factors in selecting and implementing a training simulator that every MET institution should consider. The researcher assumed that this happened because only a tiny portion of participating respondents are the head of the training unit/ institution/ other departments that have been engaged in the decision-making process within the institution, particularly related to the training simulators, which might be the issue discussed in future research.

At the lowest level, the relative weight of alternatives is measured in respect to each sub-criteria, as mentioned earlier. As shown in table 14, two alternatives mostly dominate the other alternatives for each sub-criteria: the (ALT2) Full-mission simulator and (ALT4) Cloud-based simulator. Based on the researcher’s judgement, the higher the (SC1) fidelity degree, the higher the chance for trainees to have a real-life experience onboard, which a full-mission simulator can provide. A (ALT2) full-mission simulator has the advantage for this sub-criteria since it is equipped with the actual equipment like when onboarding the ship, which can be used and interacted with during simulation—followed by the (ALT3) virtual reality (VR) simulator, which can simulate the ship’s operation and equipment in a virtual environment. The
researcher perceives these two simulators are the best in offering a high-fidelity simulation with their technical advantages.

Table 21. Relative weights of alternatives with respect to each sub-criteria

<table>
<thead>
<tr>
<th>SUB-CRITERIA</th>
<th>ALT1 DESKTOP-BASED SIMULATOR</th>
<th>ALT2 FULL-MISSION SIMULATOR</th>
<th>ALT3 VIRTUAL-REALITY SIMULATOR</th>
<th>ALT4 CLOUD-BASED SIMULATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1_Fidelity</td>
<td>0.12479</td>
<td>0.49184</td>
<td>0.30557</td>
<td>0.0778</td>
</tr>
<tr>
<td>SC2_User Friendly</td>
<td>0.28795</td>
<td>0.1258</td>
<td>0.13767</td>
<td>0.44858</td>
</tr>
<tr>
<td>SC3_Possibility of Remote Training</td>
<td>0.05368</td>
<td>0.05368</td>
<td>0.20445</td>
<td>0.6882</td>
</tr>
<tr>
<td>SC4_Possibility of Collaborative Learning</td>
<td>0.16382</td>
<td>0.44755</td>
<td>0.10592</td>
<td>0.2829</td>
</tr>
<tr>
<td>SC5_Pedagogical Appropriate</td>
<td>0.3203</td>
<td>0.39189</td>
<td>0.14391</td>
<td>0.14391</td>
</tr>
<tr>
<td>SC6_Availability of Various Training Scenarios</td>
<td>0.18838</td>
<td>0.46234</td>
<td>0.1444</td>
<td>0.20488</td>
</tr>
<tr>
<td>SC7_Flexibility</td>
<td>0.16193</td>
<td>0.12737</td>
<td>0.19341</td>
<td>0.51728</td>
</tr>
<tr>
<td>SC8_Training Efficiency</td>
<td>0.14088</td>
<td>0.45541</td>
<td>0.26283</td>
<td>0.14088</td>
</tr>
<tr>
<td>SC9_Regulation Compliance</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>SC10_Cost</td>
<td>0.31682</td>
<td>0.15047</td>
<td>0.12037</td>
<td>0.41234</td>
</tr>
<tr>
<td>SC11_Instructor's Capability</td>
<td>0.35091</td>
<td>0.35091</td>
<td>0.10911</td>
<td>0.18906</td>
</tr>
</tbody>
</table>

A full-mission simulator also is recommended for its capability to (SC4) train multiple trainees simultaneously with its (SC6) vast diversity of available training scenarios, which is enabled by the technology used in its technical specification that has been developed for decades and has been the priority products for most provider companies. As explained in chapter 2, the (SC5) pedagogical approach must be emphasised in a simulation-based activity according to IMO Model Course 6.10, which serves as a guideline for the standard performance of a training simulator. The researcher perceives this function cannot be applied optimally in a (ALT3) VR simulator and (ALT4) cloud-based simulator due to its limited interaction between trainee and instructor, which is the backbone of the pedagogical approach. Furthermore, (ALT2) full-mission simulator is the most recommended for its (SC8) training efficiency. The researcher perceives this simulator has a high degree of fidelity (SC1), not limited to physical fidelity but also functional fidelity, behavioural
fidelity and psychological fidelity, as explained in chapter 2. Therefore, it could increase the skill acquisition process of trainees (SC8), in which trainees can experience an actual ship’s operation in every dimension of fidelity.

Meanwhile, a cloud-based simulator is the most recommended training simulator for its (SC2) user-friendly interface, (SC3) possibility of remote training, (SC7) flexibility and (SC10) incurred cost. All simulator provider companies are trying to optimally design their simulators to be (SC2) user-friendly for their users. However, since the (ALT4) cloud-based simulators are specifically designed with the advantage of being (SC7) flexible so they can be used with and without an instructor, provider companies emphasise a user-friendly interface for this simulator, which might be better than the others. The other alternatives need an instructor or simulator technician, which might require specific training/courses to prepare the simulator and its training session. Consequently, it will hinder the simulation activities, particularly in student-led sessions where students operate the simulator independently. Regarding the (SC7) flexibility of the simulator, this function also heavily correlated to the capability to perform simulation activities (SC3) remotely without physical presence needed at the training centre or something. Therefore, the advantages possessed by (ALT4) cloud-based simulators justify the relative weight values gained by cloud-based simulators for these sub-criteria.

The other factor is the (SC10) cost for procurement and maintenance of simulators, in which (ALT4) cloud-based simulators become the recommendation. As mentioned by the interview experts in the previous chapter, this simulator operates in a cloud environment. It means the maintenance, as well as the specific hardware needed to use this simulator, are no longer something to worry about by the users. It will indeed reduce the cost incurred by users. Additionally, (ALT4) cloud-based simulators operate as pay-per-use, where the institution as users need to pay for how many trainees have used the simulator. This cost advantage makes (ALT4) cloud-based simulators more beneficial compared to other alternative as a recommendation. Other than those sub-criteria, it was found that all alternatives are equally recommended in respect to their (SC9) compliance to the existing regulations, international regulations such as STCW 1978, DNV certification on training simulators and many others, also from national regulations in Indonesia. The (ALT1) desktop-
based simulator and (ALT2) full-mission simulator also have equal relative weights in respect to (SC11) instructor’s capability. This condition happened because of the familiarity of training instructors and trainees in many of Indonesia’s MET institutions limited to desktop-based and full-mission simulators, as observed by researcher. They have relied on those simulators for many years, especially in state-owned institutions, which might cause a challenge in operating the other alternatives, except the (ALT4) cloud-based simulator. As shown in table 14, its (ALT4) relative weight is slightly above the (ALT3) VR simulators. Based on the previous chapter, the researcher found that the operation of (ALT4) cloud-based simulators is not entirely different from conventional simulators, which is probably less challenging than (ALT3) virtual-reality simulators and also justify the relative weights given to the alternatives.

5.2.3. Consistency Ratio Analysis

The result for consistency ratio, as referring to step 5 in chapter 3, will be provided in this section. By recollecting the details in that step, the consistency ratio (CR) is intended to control the consistency of pair-wise comparison, so the ratio will not exceed zero point ten (0,10). The consistency ratio for each comparison matrix of criteria and sub-criteria are listed in table 15, as shown below.
Table 22. Inconsistency ratio of criteria and sub-criteria comparison

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Comparison</th>
<th>Consistency Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Training Simulator</td>
<td>C1, C2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1, C3</td>
<td>0,02747</td>
</tr>
<tr>
<td></td>
<td>C2, C3</td>
<td></td>
</tr>
<tr>
<td>Criteria 1</td>
<td>SC1, SC2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC1, SC3</td>
<td>0,00435</td>
</tr>
<tr>
<td></td>
<td>SC1, SC4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC2, SC3</td>
<td></td>
</tr>
<tr>
<td>Criteria 2</td>
<td>SC5, SC6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC5, SC7</td>
<td>0,01115</td>
</tr>
<tr>
<td></td>
<td>SC5, SC8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC6, SC7</td>
<td></td>
</tr>
<tr>
<td>Criteria 3</td>
<td>SC9, SC10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC9, SC11</td>
<td>0,00600</td>
</tr>
<tr>
<td></td>
<td>SC10, SC11</td>
<td></td>
</tr>
</tbody>
</table>

From the table, it can be seen that the highest ratio is 0,02747, produced by the comparison matrix between the criteria. As for other comparison matrices, no consistency ratio exceeds 0,10, which means all relative weight values in the table are valid for the calculation in the final step.
While for the consistency ratio of alternatives’ comparison in respect to each sub-criteria, there is no found the matrix with consistency exceeds 0,10 as well. The highest ratio is produced by the comparison matrix of (SC10) cost with the ratio of 0,08062. On the other hand, the lowest ratio is 0, produced by comparison of (SC9) regulation of compliance, which means all the alternatives have the same relative weights to be recommended. This condition happened because of the availability of appropriate regulations that could mandate all alternatives for MET activities, as observed by the researcher.
5.2.4. Total Weight Alternatives Analysis

In this last section, the total weight of alternatives after the aggregation step, referring to step 4 in section 3.3.2, will be elaborated. These results will show the most recommended training simulator among all alternatives, providing insight into this study’s second and third research questions. As explained in chapter 3, that aggregation is needed to show the global weights of each sub-criteria which is just weighted locally in respect to the element immediately above them, as shown in table 13. The global weights of sub-criteria shown in figure 11, which illustrate the overall weights of each sub-criteria without being limited to its respective criteria, will show the position of each sub-criteria based on its importance.

Figure 20. Global weights of sub-criteria

![Global weights of sub-criteria](image)

As shown in the figure, the (SC11) instructor’s capability demonstrates itself as the most important sub-criteria among all sub-criteria by its global weight value of 0.15651. It indicates that training simulator users within Indonesia’s MET sector prioritised the capability of instructors in operating and utilising the simulator to its limit in delivering the training material. The importance of this factor is almost equivalent to the (SC7) flexibility of a simulator by the weight value of 0.15373. The researcher assumed this condition is caused by the flexible access offered in conducting
simulation-based training, where trainees do not need to be present and could be done at users' own pace. The users must deem this freedom as a huge advantage, and it should be applicable in a training simulator. While in the following position is (SC8) training efficiency in delivering the material, which is also almost equivalent to (SC5) pedagogical appropriate and (SC2) user-friendly feature or a simulator. Conversely, the (SC10) cost is positioned at last, which indicates that respondents' perception of (SC10) cost is the last factor that should be considered in adopting a training simulator. However, even IMO, as an international shipping body, emphasises that cost and other resources should be considered when selecting an appropriate training simulator, which shows the importance of cost and other resources in adopting a training simulator.

Figure 28. Total weighted alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Weight</th>
</tr>
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<tbody>
<tr>
<td>DESKTOP-BASED SIMULATOR</td>
<td>0.225368632</td>
</tr>
<tr>
<td>FULL-MISSION SIMULATOR</td>
<td>0.291077617</td>
</tr>
<tr>
<td>VIRTUAL-REALITY SIMULATOR</td>
<td>0.17586758</td>
</tr>
<tr>
<td>CLOUD-BASED SIMULATOR</td>
<td>0.307624307</td>
</tr>
</tbody>
</table>

Finally, the final result of the aggregation demonstrates that (ALT4) a cloud-based simulator, is the most recommended alternative for delivering the training and assessment session for trainees. Being the most recommended alternative, (ALT4) Cloud-based simulators also reflect the users' need in a training simulator. The (ALT2) full-mission simulator is positioned the second place, followed by (ALT1) desktop-based simulator and (ALT3) VR simulators in the last position. Even though (ALT4) cloud-based simulators and (ALT3) virtual-reality simulators are the type of simulators that only a tiny portion of respondents rarely engaged with, (ALT4) cloud-based simulators will be much easier to become familiar with, as observed by the
researcher. It is caused this simulator has almost the same technology as conventional simulators, which can lighten the trainee’s familiarisation. However, it applies differently with (ALT3) virtual-reality simulators because of entirely different technology and operation possessed by (ALT3) virtual-reality simulators, which can complicate the familiarisation. Meanwhile, (ALT1) desktop-based simulator and (ALT2) full-mission simulator are types of simulators that almost all respondents are familiar with, which also can provide the highest multi-dimensional fidelity degree (ALT2). Therefore, there is only a slight difference in global weights of (ALT4) cloud-based simulators and (ALT2) full-mission simulators.

5.3. Summary

This chapter presents the final result of the AHP method that becomes the main framework of this study. After the calculation, it is found that cloud-based simulators become the most recommended training simulators which meet the users’ needs in a training simulator. Meanwhile, the user’s needs are reflected orderly based on the weight of each sub-criteria generated in this chapter, where the instructor’s capability in operating the training simulator and delivering the training material is regarded by users as their most important need. This is followed by the flexibility aspect of a training simulator in the second place, which is more heavily inherent to cloud-based simulators than the other simulators. This result could give insights to answer the rest of research questions, which will be provided in the following chapter.
Chapter 6: Conclusion and Recommendation

6.1. Research Conclusion

The emergence of COVID-19 has affected MET activities during that time, causing classroom teaching and learning activities to be stopped entirely to prevent the spread. Therefore, to sustain the continuity of the learning process, all institutions shifted the learning process into distance learning. It required some time for instructors and trainees to adapt to this new process. However, the biggest challenge is the application of a training simulator for delivering practical training. The conventional simulation-based training, which requires the instructor’s and trainee’s physical presence, cannot be performed. At that time, cloud-based simulators were introduced by provider companies in Indonesia, which, as they claimed, could perform simulation-based training remotely. It also opened up many opportunities for Indonesia’s MET institutions to explore new delivery methods required by the modern world and adapt to its development. However, implementing this simulator within an institution requires careful consideration by decision-makers since the objectives and resources of the institutions are different from each other. Therefore, this study was conducted to assess the necessity of cloud-based simulators in Indonesia.

Furthermore, this chapter will present the conclusion of the findings, which are analysed using a mixed approach of thematic analysis in the first stage and analytical hierarchy process (AHP) in the following two stages. Then these analysis results are used to answer the research questions of this study. From the result, there are 11 factors identified that influence the decision-makers (users) in selecting a training simulator, as asked in the first research question. These factors are classified into three broad criteria: simulator’s technical features, educational function, and institutional supporting capability. Further analysis also showed that the differences in the weight value of each factor which represented its importance scale, are closely related to the objectives and needs of simulator users, as stated by a participating simulator expert. Moreover, the analysis revealed the importance of instructors’ capability and the simulator’s flexibility on the largest scales, meaning the users perceive their immediate needs inherent in that factors.
While the instructor's capability factors depend on a human ability that can be improved, the flexibility of simulators is fixed variables that are different for each simulator. From the interview with experts, it is known that conventional training simulators in all institutions will not be able to compete with cloud-based simulators in accommodating the flexibility needed by users. Consequently, cloud-based simulators have become the leading candidate in the decision-making process. Finally, it was revealed from the analysis result in the last stage showed that cloud-based simulator has the highest weight value, making them the recommended training simulator for users, particularly decision-makers for the institution. This result is contradictory with the actual condition where the majority of respondents are heavily familiarised with desktop-based simulator and full-mission simulator, which indicates the majority of existing simulators at MET institutions and also minimum engagements of respondents to cloud-based simulator. In addition, by possessing different characteristic to cloud-based simulators, the existing simulators are not capable to fully accommodate the respondents' needs. However, it does not mean that the other alternatives are useless and that users rely solely on the cloud-based simulators. It must be noted that the gap between weight value of cloud-based simulators and full-mission simulators is not much different compared to the other two alternatives. This result indicated that the existing simulators are still usable by users, but they must prepare themselves with cloud-based simulators to adapt to technological advancement.

6.2. Limitations and Future Research

- There are some limitations to this research, which are related to the AHP method itself. As concluded by Shapira & Goldenberg (2005) in their paper, limitations in the AHP method include (1) the "rank reversal" phenomenon in the AHP method is likely to happen, in which an alternative determined as the best is not chosen after a particular other alternative is removed from the set of alternatives, (2) the restricted pair-wise comparisons to a 1-to-9 scale and the problematic correspondence between the verbal and the numeric scales impose consistency in the result, and (3) different
perception between one person to another in verbal expressions, as well as their dependence on the type of elements involved in the comparison.

- The questionnaire respondents are not equally distributed in certain aspects as initially planned, particularly the MET institution and professional background. This condition could result in biased judgement from one of the majority group of respondents that could not reflect the result objectively. Additionally, the researcher’s judgement is used in one part of the calculation process to cover the shortcomings of respondents, who are mostly not simulation experts. Therefore, equally distributed respondents are recommended for future research, which could be improved by selecting simulator experts who understand the simulators and their differences as future respondents.

- The correlation between respondents’ demographic and the AHP result could be investigated in future studies.

- Another correlation between the capability of instructors in MET institutions, trainees and the AHP result could be investigated in the future.

6.3. Recommendation

This section provides some recommendations that are addressed to MET institutions in Indonesia. Cloud-based simulators are a new type of simulator that provide many advantages for institutions and trainees. Institutions in Indonesia should consider the cloud-based simulators to be adopted for simulation-based activities. However, it does not mean that their existence will replace the role of conventional physical-based simulators, such as full-mission simulators. As suggested, this simulator could serve as a support training method in addition to the full-mission simulator. Significantly, when the blended learning method is getting known in the education sector. The MET institutions must prepare themselves and learn to adapt to the condition. Additionally, all the training instructors should continuously improve their knowledge and experience to produce highly competent seafarers.
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Appendices

Appendix 1: Comparison of COC Level issued by Indonesia according STCW 1978

<table>
<thead>
<tr>
<th>Competence Level</th>
<th>STCW 1978</th>
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Appendix 2: Interview Questions

INTERVIEW QUESTIONS
The interview questions will revolve around:
- Personal experience in engaging with cloud-based simulators
- Characteristics of cloud-based simulators (advantages, disadvantages, opportunities, limitations, etc.)
- The customer (from provider) / trainee (from academic) ability in engaging with cloud-based simulators
- Comparison between available simulators and preferences
- Future plan related to training simulators

Example of questions:
Academic perspective
1. Why do you want to use a cloud-based simulator?
2. What factors are considered for institutions if they want to adopt cloud-based simulators into their learning methods?
3. What are the challenges or limitations of adopting these cloud-based simulators?
4. Kongsberg provided a training course for instructor before using a physical-based simulator, are there any training or prior knowledge that must be possessed by the instructor or even trainee before using a cloud-based simulator?
5. In your opinion, do you think cloud-based simulators will replace physical-based simulators in the future?
6. Which type of simulator do you prefer in the training process?

Industry/Provider perspective
1. Why do you want to develop a cloud-based simulator?
2. What factors are considered for any users (institutions/individuals) if they want to adopt cloud-based simulators for teaching or self-learning?
3. What are the challenges or limitations of adopting these cloud-based simulators?
4. Kongsberg provided a training course for instructor before using a physical-based simulator, are there any training or prior knowledge needed by the user before using a cloud-based simulator?
5. In your opinion, do you think cloud-based simulators will replace physical-based simulators in the future?
6. Which type of simulator is the most effective for learning?

QUESTIONNAIRE
The format of the questionnaire can be designed only after the conduct of the interviews, as explained within the research proposal at Research Methodology section.