# The Role of New Technologies and Digital Transformation in Enhancing Maritime Education and Training

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**المستخلص:**

الغرض من هذا البحث تقييم فوائد تعزيز التعليم والتدريب البحري من خلال دمج التقنيات الجديدة والرقمية، حيث تم تطوير وتنفيذ استبيان شامل وتوزيعه على الخبراء في مجال التعليم والتدريب البحري، وتم اختيار العوامل الحاسمة والمؤثرة باستخدام تقنية التسلسل الهرمي التحليلي من بين الخصائص المشتركة التي تم تحديدها بدقة، بينما أظهرت النتائج أن العوامل والمحاور الرئيسية الثلاثة لتقييم فعالية دمج التقنيات الرقمية الجديدة في مؤسسات التعليم والتدريب البحري تأتي بأولاً البنية التحتية التكنولوجية (TI)، ثانيا جاهزية المؤسسية (RI)، التأثير التربوي (PI).

الكلمات المفتاحية:التقنيات الجديدة - التحول الرقمي - تعزيز - التعليم البحري - التدريب البحري.

**Abstract**

**Purpose**: This paper evaluates the benefits of enhancing maritime education and training through the integration of new technologies and digitalization.

**Design/Methodology/Approach**: A comprehensive questionnaire was developed and distributed to experts in maritime education and training; the critical factors were selected using the AHP technique from among the identified common characteristics.

**Findings**: The results showed that the three main decisions for evaluating the effectiveness of integrating new digital technologies into maritime education and training institutions come first (TI), second (IR), and last (PI).

**Key-words:** New Technologies - Digital Transformation- Enhancing- Maritime Education- Maritime Training.

## 1- INTRODUCTION

Amid the rapid development of technology and digitization, educational institutions are facing increasing pressures to update their curricula and teaching methods to keep pace with the digital age, The maritime education sector, being both technical and vital, is no exception to these pressures, However, maritime institutions encounter multiple challenges in effectively integrating these technologies and digitization, such as high costs, resistance to change, lack of technical skills, and inadequate infrastructure. (Honnetveit, 2015)

Maritime education has seen significant developments thanks to modern technologies, fundamentally transforming training methods and the preparation of maritime personnel. Advanced technologies such as maritime simulators, Virtual Reality (VR), and Augmented Reality (AR) have become essential tools in maritime education, allowing students to acquire practical skills in safe and interactive environments where they can experience realistic scenarios without actual risks (Gordon, 2015).

Additionally, smart systems and big data analytics play a crucial role in enhancing the efficiency of navigation and maintenance operations, thereby improving the mariners' ability to make informed decisions based on real-time data. The widespread use of technology in remote learning has also become prevalent, enabling students worldwide to access best practices and maritime knowledge without the need to be physically present at training centers. Consequently, maritime education within the context of modern technology contributes to preparing more efficient and safer maritime personnel capable of addressing contemporary challenges in the maritime industry (Rajab, 2018).

Maritime education has seen considerable improvements thanks to modern technologies, which have significantly changed the way maritime personnel are trained and prepared to face the challenges of working at sea. The increasing reliance on advanced technologies such as maritime simulators, VR, and AR has provided trainees with the opportunity to gain experience in virtual environments that mimic real-world conditions, thereby reducing risks and enhancing practical readiness. Maritime simulators offer comprehensive training experience, enabling seafarers to manage a wide range of situations, from routine operations to complex emergencies, enhancing their ability to make quick and accurate decisions (Youssef, 2000).

VR and AR technologies add an interactive dimension to training, allowing trainees to learn through immersive experiences that deepen their understanding of various scenarios and challenges they may encounter at sea. Additionally, big data analytics and smart systems contribute to providing customized training that aligns with each trainee's needs, enhancing the efficiency and effectiveness of the training process. Remote learning has also become more common thanks to e-learning platforms, enabling trainees to access advanced educational programs without the need to be physically present at specific training centers (Gordon, 2021).

By utilizing these new technologies, maritime training becomes more comprehensive and efficient, enhancing seafarers' readiness to tackle modern challenges in the maritime industry, ensuring their safety and operational effectiveness at sea (Al-Amoudi,2013).

However, despite the potential benefits of integrating new technologies and digitization in maritime education and training, maritime educational institutions often face difficulties in effectively implementing these innovations. These challenges may result in not achieving the desired improvements in efficiency and performance, thereby hindering the development of necessary skills in the maritime sector.

**2- Research Hypotheses**

- There is an influential relationship between enhancing maritime education and training and the integration of new technologies and digital transformation.

- There is a correlation between the integration of new technologies and digital transformation in maritime education and training and the increase in students' efficiency and performance.
- There is a correlation between the integration of new technologies and digital transformation in maritime education and training and the increase in students' satisfaction with their educational experience.

**3- Study Objectives:**

- Monitoring how to enhance maritime education and training through the integration of new technologies and digital transformation,
- Monitoring the improvement of students' efficiency and performance through the integration of new technologies and digital transformation in maritime education and training.
- Measuring the extent of students' satisfaction with their educational experience through the integration of new technologies and digital transformation in maritime education and training.

**4- Literature Review**

**A- Theoretical Background**

The issue of the human factor has been a significant topic of discussion in maritime transport. One of the main subjects related to the human factor in the maritime field is the competencies acquired by the ship's crew through education and training. Inadequate competencies resulting from deficiencies in education and training have clear correlations with human errors. These human errors have been cited as the primary causes of maritime accidents. In fact, 45% of the safety recommendations related to human factors in maritime accident reports were related to training, skills, and experience. Therefore, the quality of Maritime Education and Training (MET) activities directly affects the efficiency and safety of maritime transport operations (Silberg, 2017).

It is worth noting that the maritime industry is a complex socio-technical environment operating under highly variable operational, regulatory, economic, political, social, and international conditions. Maritime transport still relies on people and their expertise. Future projections indicate that the global commercial fleet, along with the need for qualified seafarers, will continue to grow. However, technological advancements and digitization have also transformed maritime transport from a labor-intensive industry into a more technical field. Some of these notable developments in maritime transport include the emergence of automation and autonomous ships, the use of advanced navigation systems, energy efficiency and emission reduction systems, hybrid and electric propulsion systems, remote monitoring and condition-based maintenance practices, and enhanced safety measures. Technologies such as improved weather forecasting, collision avoidance systems, and advanced fire suppression systems contribute to enhancing safety at sea. Most of these developments involve integrating digital tools and processes into current maritime workflows and transportation systems to improve efficiency, safety, and sustainability, this situation has also increased the need for highly trained and skilled individuals rather than unskilled labor for maritime-related roles (Jensen, 2018).

Traditionally, MET has been associated with vocational education methods for skill acquisition. This type of education emphasizes the practical capabilities of daily activities. This also means that maritime students must undergo shipboard training to gain knowledge, experience, and skills. However, onboard training is generally limited to routine and daily operations, and learning outcomes vary significantly from one ship to another. Consequently, simulation-based training and education have gained a solid footing for acquiring technical and advanced skills in MET, Initially, the primary goal of simulation training was to facilitate the development of navigation skills and aid in emergency preparedness. Today, with technological advancements, cost-effectiveness, and increased accuracy, simulators have become more readily available for a large part of the MET curriculum. This teaching method is now used alongside traditional teaching methods and has become standard in MET. Nevertheless, the use of other teaching methods or the integration of visual materials, animations, videos, and other advanced teaching tools remains very limited. One potential reason for this may be the traditional nature and strict regulations governing MET (Wahl, 2018).

The literature on MET typically refers to the education and training of seafarers, specifically focusing on the ship's crew, which includes captains, navigation officers, engineers, chief engineers, communications officers, and sailors. MET is often provided in two separate divisions (deck or engine) depending on the educational institution. Regardless, the education and competencies of the mentioned seafarers are regulated internationally according to the Standards of Training, Certification, and Watchkeeping (STCW) established by the International Maritime Organization (IMO). Training plays a crucial role in the IMO's efforts to support the implementation of international maritime standards. The STCW Code sets minimum requirements for the training of all ship crews, addressing the challenge of validating educational programs and their variability between countries by providing a unified minimum standard of competence. Revisions and amendments to the STCW Code were made in 2010, known as the "Manila Amendments". This revised version focuses on training technical and non-technical skills, as well as introducing modern teaching methods (Malalm, 2019).

Additionally, the IMO has numerous training programs, called IMO model courses, developed with contributions from various IMO members to assist in implementing STCW regulations across educational institutions. The use of simulators is well-documented and endorsed in these guidelines. Consequently, MET providers have focused on expensive, full-mission simulators to obtain high-fidelity environments, thus offering a sophisticated and established learning environment. However, exploring more personalized immersive, mobile, and accessible training opportunities such as multimedia uses, web-based and computer-based training, game-based training, and the applications of (VR) or (AR) is limited. The STCW 2010 Manila Amendments contain guidelines for e-learning processes, but they are very limited and not specific compared to the guidance and promotion provided in simulation-based training. However, as seen before the Manila Amendments, the learning environment in MET has changed again in recent years (Ortega, 2018).

Access to different technologies has become more accessible, and e-learning solutions have become part of modern society, from mobile phones to AR and VR, Game-based platforms are used not only in education but for all kinds of purposes, from marketing to business. Additionally, the maritime industry has also undergone a digital transformation. Most operational processes are now digital, and the advanced use of technology is more prevalent in the industry than ever before. This paradigm shift towards a more digital future has only accelerated when educational activities were challenged by the COVID-19 pandemic. Restrictions on face-to-face training and quarantine measures disrupted traditional maritime education. Travel restrictions and crew changes prevented students from boarding ships, and restrictions on physical training activities prevented the use of simulators in educational facilities. Suddenly, remote, or online learning became the norm. All these factors combined have made e-learning a widespread topic in many industries, and MET is one of them. This increased digitization presents an opportunity for MET to integrate various teaching technologies into training programs (Silberg, 2018).

E-learning is generally used as a complementary means to traditional learning, it is "learning supported by electronic digital tools and media, " The initial uses of the term focused on web-based tools and activities. Nowadays, it is used alongside digital learning, which consists of the use of Information and Communication Technology (ICT) in open learning and distance education. This definition includes the use of the internet, multimedia, and other immersive technologies to enhance the quality of learning. There are several forms of e-learning, and the term's use and definition can change depending on the research field. However, its popularity and applicability have significantly increased (Jensen, 2018).

Technologically enhanced learning appears to be the way forward for many industries as it offers vital advantages in motivation, engagement, time, and skill acquisition. There are clear reasons to integrate advanced learning tools into the maritime industry to move MET toward the future. E-learning can serve as a bridge between classrooms and real-life experiences. The increasing use of these learning tools in the maritime industry will open new opportunities and support the current paradigm shift we are experiencing. However, it is also crucial to determine the extent to which these tools can be integrated into MET. Therefore, this research focuses on e-learning efforts and the adoption of learning tools in maritime education. Given the growing volume of research and applications of modern learning tools, we believe a bibliometric analysis will be helpful to gain insight into the current and future state of MET (Wahl, 2018).

**B- New Technologies in Maritime Education and Training**

1.Virtual Reality (VR) is a technology that allows users to immerse themselves in simulated environments representing specific virtual worlds, it can be utilized across various fields including education and training, here are its uses in maritime education and training:-

- **Maritime Training**: VR can be used to provide realistic training experiences for students in various aspects of navigation and maritime skills such as navigation, rescue operations, and maritime maintenance.

- **Interactive Learning**: With VR's ability to interact with users within the simulated environment, learning experiences can be enhanced through students' direct interaction with educational materials.
- **Safe Environment Provision**: VR can offer a safe learning environment for college students to explore dangers and situations they will come upon within the maritime environment without actual publicity to real chance.

Compared to traditional strategies, VR can provide more practical and interactive gaining knowledge of stories, helping to decorate college students' understanding and abilities within the subject of maritime education and training (Khamees, 2015).

2. Augmented Reality (AR) is a generation that combines virtual and actual elements to create a more advantageous environment based on fact, AR will have applications in maritime training and education similar to those found in Virtual Reality, together with: -
   - **Enhanced Interaction**: AR can provide interactive studies with simulated maritime elements, permitting college students to interact greater extensively with the maritime environment and benefit deeper understanding.
   - **Hands-on Training**: Using augmented academic packages, students can simulate maritime renovation operations, protection methods, and rescue operations realistically without the want for a real device.
   - **Navigation and Exploration**: Students can use augmented packages to explore the maritime environment and examine the abilities important for navigation, path making plans, and obstacle avoidance (Khamees, 2015).
3. Big Data Analytics is a present-day approach used to extract treasured patterns and insights from massive datasets, it has exciting programs in maritime schooling and training:
   - **Performance and Safety Enhancement**: By studying large information related to supply normal overall performance and maritime device, traits and functionality risks can be recognized, allowing proactive measures to decorate safety and average performance.
   - **Maritime Operations Improvement**: Big statistics analytics may be applied to enhance safety, restore operations, and maritime experience making plans, thereby increasing resource usage overall performance and lowering costs,
   - **Personalized Educational Experiences**: Using student information and analysis, educational and education testimonies may be customized to meet each scholar's man or woman wishes, enhancing studying effectiveness (Khamees, 2015).
   - **Maritime Behavior Analysis**: Ship and navigation records may be used to research maritime behavior styles and expect capacity dangers, aiding in making strategic choices to decorate safety and protection (Khamees, 2015).
4. Artificial Intelligence (AI) is an innovative technology that can revolutionize maritime education and training in several ways:-
   - **Personalized Learning**: AI can analyze scholars' conduct and academic wishes, building customized mastering models to provide a customized and effective learning level in.

- **Curriculum Development**: AI can examine overall performance data and extract developments to develop advanced curricula and deliver adaptive and appropriate academic substances.
- **Assessment Enhancement**: AI can offer smart evaluation tools that efficiently compare scholar performance and provide instantaneous remarks to useful resource improvement.
- **Simulation of Maritime Environments**: AI can be used to create realistic simulation models of maritime environments, facilitating training, and getting to know without the need for real dangers (Diop, 2018).

5. The use of robotics and automation in maritime education and training can provide numerous benefits:

- **Student Training in Maintenance and Repair**: Robots can simulate protection and restore operations on ships and maritime systems, correctly assisting university students collect realistic skills.
- **Safety Improvement**: Robots can fulfill hazardous responsibilities within the maritime environment, reducing the dangers related to gaining knowledge of and education aboard ships.
- **Simulation of Maritime Conditions**: Robots can be advanced to simulate quite a few maritime conditions, supporting students in understanding the challenges they may come across whilst strolling aboard ships (Diop, 2018).

**C- Expected Benefits of Integrating Modern Digital Technologies in Maritime Education**

1. Enhancing Efficiency and Professional Readiness: Integrating new digital technology in maritime education can make contributions to providing an extra interactive and attractive gaining knowledge of environment for students, growing their stage of interest and interplay with the observe materials. Moreover, technology can be used to deliver multimedia educational content tailored to each student's needs effectively, enhancing the learning experience and aiding academic success.

The use of modern technologies in maritime education can also provide a practical and safe framework for training students on maritime work and navigation skills, thus equipping a new generation of well-prepared sailors and navigators to tackle future challenges in the shipping and maritime industry. Therefore, integrating new digital technologies in maritime education can achieve several advantages, including: -

- Using modern technologies such as virtual maritime simulators can reduce training costs and the time required to train students on maritime skills, for example, a study conducted by the International Maritime Organization showed that the use of maritime simulators can reduce the training time by up to 50%.
- Utilizing technologies like virtual reality to deliver realistic educational experiences encourages student participation and enhances their understanding of maritime concepts, in a study conducted by Stanford University, researchers found that using virtual reality in education can increase interaction and engagement levels by up to 80% (Rajab, 2018).

2. Increasing Interaction and Participation: Increasing interaction and participation are among the key expected benefits of integrating new digital technologies in maritime education, which include: -

- Using VR and AR technologies provides immersive educational experiences simulating real maritime environments. These technologies enable students to interact with virtual training environments that embody real-life scenarios at sea without any risk. For example, students can practice maritime maneuvers or emergency procedures in a safe environment before dealing with them in reality. According to a study conducted by PwC, the use of virtual reality in education showed an 85% increase in student interaction compared to traditional methods.
- Providing e-learning platforms offering interactive video lessons, quizzes, and forums encourages active student participation in the learning process. These platforms allow students the opportunity to review lessons, participate in group activities, and take tests that stimulate interaction. According to a study from the University of Michigan, students using interactive online educational platforms showed a 60% increase in participation rates compared to traditional education (Rajab, 2018).
- Using educational games and simulations to teach students navigation and handling of maritime equipment provides a fun and stimulating learning environment where students learn through play and interaction. According to Ed Tech Foundation, educational games increase student engagement by 70% because they make learning more enjoyable and motivating.
- Utilizing VR and AR technologies offers immersive educational experiences that replicate real maritime settings. These tools allow students to engage with virtual training environments representing authentic maritime scenarios, all without any actual risk, for instance, students can practice maritime maneuvers or emergency protocols within a safe virtual space before applying them in real-life situations. Research conducted by PwC indicates an 85% increase in student engagement when using virtual reality compared to traditional methods (Al Banna, 2019).
- Offering e-learning platforms featuring interactive video lessons, quizzes, and discussion forums encourages active student involvement in the learning journey. These platforms provide students with opportunities to revisit lessons, engage in collaborative activities, and complete assessments that promote interaction. According to a study conducted at the University of Michigan, students utilizing interactive online educational platforms demonstrated a 60% increase in participation rates compared to traditional educational approaches.
- Implementing educational games and simulations for teaching navigation skills and equipment handling in maritime contexts creates an enjoyable and stimulating learning atmosphere where students learn through interactive experiences. According to the EdTech Foundation, educational games enhance student engagement by 70% as they transform learning into a more enjoyable and motivating endeavor (Rajab, 2018).

**D- Challenges in Integrating New Technologies in Education:**

**1.Costs and Funding: These include the following:**

- Infrastructure and Equipment Costs: Marine simulators are essential tools in modern maritime education and require significant investments. Additionally, technological devices such as computers, tablets, and high-speed internet networks that support online learning and interactive applications are also needed.
- Software and Update Costs: Simulation software requires periodic updates to maintain its effectiveness and accuracy in simulating real marine conditions. Furthermore, e-learning platforms need licenses and regular testing to ensure they keep up with technological and educational advancements.
- Training for Educational Staff: Implementing modern technologies necessitates intensive training for teachers and educational staff on how to effectively use these tools. Continuous training courses are also needed to keep up with technological updates and changes (Ali, 2018).
- **Partnerships with the Private Sector**: Partnerships with technology companies and the private sector can provide financial and technical support to educational institutions, Joint funding programs and grants can help alleviate financial burdens.
- **Research and Development**: Institutions need to allocate resources for research and development to ensure the improvement and advancement of the technologies used. Collaboration with research and academic institutions can contribute to cost reduction and efficiency (Ali, 2018).

**2.Administrative and Cultural Challenges: which can be summarized in the following points:**

- Resistance from Employees: The introduction of new technologies often faces resistance from employees who prefer traditional methods of teaching. Additionally, there may be cultural rejection, as some institutional cultures are resistant to change, hindering the adoption of recent technology.
- Lack of Awareness and Understanding: Many educational and administrative staff may lack the necessary knowledge about the benefits and importance of new technologies, making them less receptive. There is also a shortage of qualified personnel capable of effectively implementing and managing new technologies (Ali, 2018).
- Change Leadership: Institutions need effective leadership capable of skillfully managing the change process, including providing ongoing support and guidance.

**3.Infrastructure and Access to Technology Challenges: which can be summarized in the following points:**

- **Lack of Equipment and Devices**: Some educational institutions may suffer from a shortage of essential technological devices such as computers, tablets, and marine simulators (Ali, 2018).
- **Internet Connectivity**: The availability of reliable high-speed internet is crucial for implementing digital education, which can be a challenge in remote or less developed areas.
- **High Costs**: Upgrading the existing infrastructure to align with modern technologies requires significant investments, posing a financial burden on educational institutions.

- **Maintenance and Updates**: Technological infrastructure requires regular maintenance and continuous updates to ensure its effectiveness, increasing long-term costs (Al - Gam,2005).
- **Digital Divide**: The digital divide can lead to unequal opportunities among students in accessing modern educational technologies, especially in less privileged areas.
- **Variable Technological Support**: There may be inconsistencies in the level of technological support available to students and teachers, affecting the quality of education.
- **Classroom Preparation**: Classrooms need to be equipped with the necessary technological tools, such as smart boards and interactive devices.
- **Necessary Infrastructure Setup**: This requires institutions to be equipped with advanced networks and stable electricity to support modern technological devices (Ali, 2018).

**4. Security and Privacy Challenges: which can be summarized in the following points:**

- **Sensitive Data**: Maritime education requires the collection and storage of sensitive personal data of students and teachers, making the protection of this data a top priority.
- **Legislation and Compliance**: Educational institutions must comply with data protection laws and regulations, such as the General Data Protection Regulation (GDPR).
- **Cyber Attacks**: There is an increasing number of cyber-attacks on educational institutions, including ransom ware and breaches, putting data and systems at risk.
- **Viruses and Malware**: Devices and networks can be affected by viruses and malware, which can disrupt operations and lead to data loss (Ali, 2018).
- **Access Control:** Strong access control systems are necessary to ensure that only authorized individuals can access sensitive information.
- **Multi-Factor Authentication**: Implementing multi-factor authentication procedures to enhance the security of system and data access (Shehata,2019).
- **Security Awareness:** A lack of awareness about the importance of cyber security among students and teachers can increase the risk of security breaches.
- **Secure Infrastructure**: Technological infrastructure must be secured against attacks, including networks, servers, and storage devices.
- **Security Updates**: Regularly applying security updates is essential to protect systems from discovered vulnerabilities (Ali, 2018).

## 5- RESEARCH METHODOLOGY

Based on a literature review and discussions with experts, the descriptive-analytical method was adopted as the most suitable scientific approach for collecting field data on this phenomenon using a field questionnaire. A comprehensive questionnaire was developed and distributed to a group of students, totaling fifty, who were selected through purposive sampling to understand their characteristics, attitudes, thoughts, and uses regarding the study topic.

The retrieved questionnaires were examined, and the most common criteria were identified and agreed upon. Subsequently, the critical factors were selected using the Analytic Hierarchy Process (AHP) technique from those common attributes. AHP is an analytical method used for decision-making in multi-dimensional and complex scenarios. In this context, it is employed to select

critical factors or key factors to be focused on in the study or research. This allows researchers to prioritize various factors based on the opinions of experts or study participants. This is done by evaluating the relative importance of each factor compared to others and determining which factors have higher priority. Using AHP, researchers identify the main critical factors that will significantly impact the quality of maritime learning and should be emphasized in the current study.

To illustrate the process of selecting factors, criteria, and alternatives in the research using AHP, Figure (1) shows the hierarchical diagram of the Analytic Hierarchy Process, this diagram consists of the following levels: -

- **Main Objective**: Enhancing maritime education and training through the integration of new technologies and digital transformation.
- Criteria: The most common and agreed-upon criteria.
- Critical Factors: The factors identified using AHP significantly impact the achievement of the main objective.

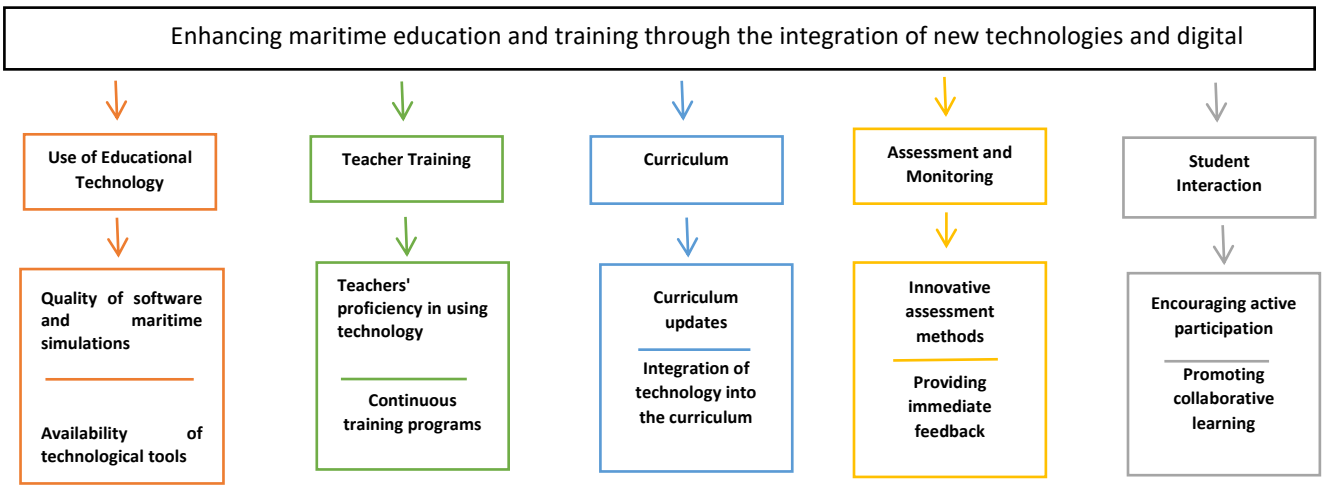



**Figure (1): Hierarchical Diagram of the Analytic Hierarchy Process (AHP)**

The AHP was chosen as an analytical tool used in various fields such as business management, engineering, social sciences, medicine, and others. This method was originally developed by the American scholar Thomas L, Saaty in the 1970s. AHP relies on the technique of pairwise comparison, where the question "Which is more important: factor (A) or factor (B)?" is posed to determine priorities among different factors. AHP is distinguished by its ability to handle complexity and provide systematic solutions to multi-dimensional and intricate decision problems. Analysts use AHP to set priorities and provide a comprehensive assessment of the factors influencing decisions, whether these factors are related to setting strategic goals, project planning, or making daily operational decisions. AHP applies the idea of pairwise comparison along with a hierarchical structure or network analysis to choose the optimal option from a list of possible choices. The main objective of the AHP method is to select an alternative from a list of options that best meets a specific set of criteria, or to calculate the weight of the criteria in any application

by utilizing the decision maker's or expert's experience or knowledge in a pairwise comparison matrix of attributes.

The AHP methodology uses a natural, pair-wise mode to compare criteria or alternatives in relation to a criterion. The three parts of the AHP approach are: (1) identifying obstacles and designing a hierarchy prioritizing model) (2) (creating a questionnaire and gathering data, and (3)figuring out normalized weights for each category of barriers and each individual barrier.

**6- DATA ANALYSIS**

"In this section, it will be demonstrated how the AHP can be utilized to assess the effectiveness of integrating new digital technologies in maritime education and training institutions. Application of AHP to Evaluate the Integration of New Digital Technologies. Three primary criteria for assessing the effectiveness of integrating new digital technologies in maritime education and training institutions will be considered, which are: (1) Pedagogical Impact (PI); (2) Technological Infrastructure (TI); and (3) Institutional Readiness (IR) .

A recognized pairwise comparison matrix of the effectiveness of integrating new digital technologies in maritime education and training institutions, provided by one of the specialists involved in the investigation, is depicted in Table 1, Pedagogical impact is assigned the highest weight, followed by technological infrastructure, and institutional readiness.

**Table (1): Pairwise Comparison Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions,**

| Challenges | PI | TI | IR | CW | GM | W | WSV |
|---|---|---|---|---|---|---|---|
| PI | 1 | 1 | 0, 5 | 1, 83 | 1, 83 | 9, 56% | **1, 83** |
| TI | 3, 45 | 0, 56 | 1 | 2, 71 | 2, 71 | 22, 9% | **2, 71** |
| IR | 3, 21 | 0, 89 | 0, 5 | 2, 46 | 2, 46 | 36, 8% | **2, 46** |
| SUM | 7, 66 | 2, 45 | 2 | - | 7 | 1 | |

**CW = Σ PI + TI + IR / 3**

Then, ƛ max, Consistency Index (CI) and Consistency Ratio (CR) are determined by summing the results of multiplying the pair wise comparison's overall value by each of the system's weights.

ƛ MAX = Σ (WSC n / CW n)

ƛ Max= = $\lambda$ max= (1, 831+2, 713, 45+2, 463, 21+27, 66)/3=2, 318

CI = ƛ MAX / total of criteria – 1 CI= 2, 318/ 3-1 = -0, 22733 CR = CI / -0, 22733

For validation CR = 0, 078546 (CR < 0, 1 valid)

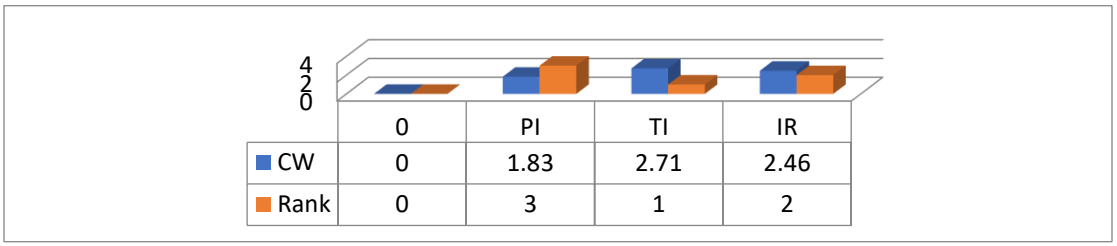
The pair wise determination is declared valid with this CR value when the CR value is less than 0, 1, Table 1 values are acceptable and consistent because CR is less than 0, 1,

The pair wise compression matrix's consistency is verified before the decision matrix is obtained as follows:

**Table (2): Decision Matrix for Main three Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions**

| Criterion | CW | Rank |
|---|---|---|
| PI | 1, 83 | **3** |
| TI | 2, 71 | **1** |
| IR | 2, 46 | **2** |

According to Table 2, it can be observed that the three main decisions for evaluating the effectiveness of integrating new digital technologies into maritime education and training institutions come first (TI), second (IR), and last (PI),




**Fig, 2, Decision Matrix for Main three Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions, According to Table 2**

**1. Results of the first hypothesis test:** There is an influential relationship between enhancing maritime education and training, integrating new technologies, and digital transformation,

**Table (3): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions**

| Dependent Variable | Independent Variable | Correlation Coefficient (R) | Coefficient of Determination ($R^2$) | Significance Level |
|---|---|---|---|---|
| Integrating new technologies and digital transformation | Enhancing maritime education and training | 0, 559 | 0, 313 | 0, 00 )(Statistically significant |

It is evident from Table 3, which shows the influential relationship between enhancing maritime education and training, integrating new technologies, and digital transformation using the statistical test (Simple Regression Analysis), that: There is a significant relationship between enhancing maritime education and training and integrating new technologies and digital transformation, with a strong correlation coefficient of 0, 559 at a significance level of 0, 00, which is statistically significant. The effect size is 0, 313, indicating that 31% of the variations in maritime education and training are explained by the integration of new technologies and digital transformation. This means that the newer technologies and digital transformation are integrated, the more they enhance maritime education and training. From the above, the hypothesis that there

is an influential relationship between enhancing maritime education and training and integrating new technologies and digital transformation is confirmed.

**2. Results of the second hypothesis test:** There is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance.

**Table (4): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions**

| **Integrating new technologies and digital transformation in maritime education and training** | **Increasing students' efficiency and performance** |
|---|---|
| Pearson Correlation Coefficient | Significance Level |
| 0, 939 | (0, 00) |

It is evident from Table 4, using the Pearson correlation coefficient that: There is a strong positive correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance, with a Pearson coefficient of 0, 939 at a significance level of 0, 00, which is statistically significant. This means that the more capable the integration of new technologies and digital transformation in maritime education and training, the more it affects the increase in students' efficiency and performance, whether positively, negatively, or both. From the above, the hypothesis that there is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance is confirmed.

Results of the third hypothesis test: "There is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' satisfaction with their educational experience".

**3. Results of the third hypothesis test: "**

**Table (5): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions**

| Increasing students' satisfaction with their educational experience | Integrating new technologies and digital transformation in maritime education and training |
|---|---|
| Pearson Correlation Coefficient | Significance Level |
| 0, 918 | (0, 00) |

It is evident from Table 5, using the Pearson correlation coefficient that:

There is a strong positive correlation between integrating new technologies and digital. transformation in maritime education and training and increasing students' satisfaction with their educational experience, with a Pearson coefficient of 0, 918 at a significance level of 0, 00, which is statistically significant. This means that the more capable the integration of new technologies

and digital transformation in maritime education and training, the more it affects the increase in students' satisfaction with their educational experience, whether positively, negatively, or both.
From the above, the hypothesis that there is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' satisfaction with their educational experience is confirmed.

## 7- CONCLUSION AND DISCUSSION

In conclusion, it can be confidently stated that integrating new and digital technologies into maritime educational institutions is a crucial step towards enhancing the quality of education and training in this field. By leveraging modern technology, institutions can provide an advanced and comprehensive learning environment that helps equip students with the necessary skills to tackle the challenges of the modern era.
Additionally, this integration contributes to enhancing student interaction and effective participation in the learning process, ultimately leading to distinguished and qualified professionals for the global maritime job market. However, institutions must continue to monitor the implementation of these technologies and regularly evaluate their effectiveness to ensure the ongoing improvement of maritime education and training in the future.

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