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Technological Innovations in the Maritime Sector: A Comprehensive Analysis of Intelligence Knowledge and Industry Dynamics for Graduates Adaptation

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المستخلص

تُكمل المهارات الشخصية المُكتسية من قبل الخريجيين، مثل التوعية بالظروف المحيطة، وإتخاذ القرارات، إدارة عبء العمل والتواصل، مُتطلبات الأتفاقية الدولية (STCW) لعام ١٩٧٨، بصيغتها المعدلة. حيث يُساعد أيضاً تطبيق (GMP-BoK) في تصنيف هذه المهارات، بما في ذلك المهارات القيادية، والتي يُمكن تطويرها من خلال النمو المعرفي والسمات المؤثرة (Fjeld et al., 2018).

هناك دراسات قليلة عن الذكاء الاصطناعي (AI) في التعليم البحري، مما أدى إلى وجود فجوة بين صناعات النقل البحري والتعليم (Yang et al. 2019; Mirovi and Milievi et al. 2018).
ومع ذلك، أستنتج Zhang and Lam (2019) أن أبرز العقبات التي تواجه التنمية المتوازنة في قطاع النقل البحري هي قلة الدعم التنفيذي ونقص الخبرة.

تتناول الورقة البحثية أهمية تطوير التعليم والتدريب البحري (MET)، وتقديم حُلول للتعامل مع الفجوة بين التقدم التكنولوجي وإستعداد المعاهد البحرية لتغيير مهارات وقُدرات الخريجيين والعاملين على متن السفن الحديثة. يتم ذلك من خلال إستعراض أساليب مختلفة يُمكن إستخدامها لتطوير التعليم والتدريب البحري، مثل تقنيات الذكاء الاصطناعي (AI) والواقع الافتراضي (VR). وبالإضافة الي ذلك، تم إستخدام تقنية التحليل الإحصائي (SPSS) للحصول على النتائج. كَشفت الدراسة أن الخريجيين الجُدد يعانون من قلق أكبر من الخريجيين الذين لديهم خبرة من أحتمالية إستبعادهم من سوق العمل، حيث يعتقدون أن خبراتهم الحالية تجاه مهارات الذكاء الإصطناعي والتفكير الحاسوبي لن تُسهل توظيفهم في مجالات متنوعة في صناعة النقل البحري. تم تطبيق المنهج الوصفي كمنهجية مُختارة لإستيعاب فهم شامل لإمكانيات الإبتكارات التكنولوجية الحديثة.

Abstract

Interpersonal skills used by mates, such as situational awareness, decision-making, workload management, communication, and leadership, complement the requirements of the International Convention on Standards of Training, Certification, and Watch keeping for Seafarers (STCW) 1978, as amended. The GMP taxonomy helps categorize these skills, including leadership, which can be developed through cognitive growth and emotional attributes (Fjeld et al., 2018).

There have been few studies on Artificial Intelligence (AI) in maritime education, resulting in a gap between the maritime industries and education (Yang et al. 2019; Mirovi and Milievi et al. 2018). However, Zhang and Lam (2019) discovered that the primary impediments to enharmonic development in the marine sector are a lack of executive sponsorship and a lack of expertise.

This paper demonstrates the importance of developing maritime education, bridging the gap between technological progress and the readiness of maritime institutes to change the honor and capabilities of crew and staff on board modern ships, by reviewing the various methods that can be used to change education and training, such as an AI and Virtual Reality techniques (VR). Moreover, it employed the Statistical Package for the Social Sciences (SPSS) technique to acquire the outcomes. Revealed that graduates exhibit greater unease than professionals regarding potential expulsion from the workforce, believing that their acquired expertise and computational thinking skills will not facilitate employment in diverse sectors of the maritime industry. A descriptive approach was employed as the chosen methodology for capturing a comprehensive understanding of the efficiency of the new technology.

Keywords: Virtual Reality / Augmented Reality Techniques, Innovation Intelligence, Autonomous.

1. Introduction

At present, the global shipping industry employs approximately 1.6 million seafarers and is responsible for transporting over 90% of the world's cargo, according to UNCTAD's 2019 report. Despite the significant role of humans in maritime operations, there is a prevalent belief that removing direct human involvement can enhance safety and efficiency in the industry (Wróbel et al. 2017; Hoem et al. 2019; Oksavik et al. 2020). Consequently, ocean-going merchant vessels that are maritime autonomous surface ships, also referred to as MASSs will sail across the ocean either completely autonomously or under the supervision of a remote onshore control center (SCC) (IMO MSC 2018; Strkersen 2021; Ramos et al. 2019).

The level of direct human involvement in maritime operations is decreasing as automation increases, from manual control to remote monitoring (Komianos, 2018). MASSs, or ocean-going merchant ships, can operate autonomously or under remote supervision (IMO MSC, 2018; Kobyliski, 2018; Fan et al., 2020). Maritime Education and Training Institutions (MET) provide practical onboard training as well as theoretical instruction to seafarers, which is critical for their professional education. Apprentices are young people and potential seafarers who provide valuable insights into upcoming changes in the shipping industry and should be actively involved in shaping its future (Glen, 2008). Their viewpoints are critical in the development of international policies concerning marine automation, educational models, and employment.

The present study's purpose is to analyze future maritime institute graduates' perspectives towards autonomous shipping, as well as its consequences for the labor market and its ability to adapt to change. The concerns listed below must be addressed:

- Evaluating the preparedness of METs to address the challenges posed by autonomous shipping.
- Investigating the extent of concerns among cadets regarding potential job displacement in the maritime industry resulting from the rise of autonomous control systems.
- Assessing if graduates are concerned that their talents may become outdated in an increasingly automated marine business.

Furthermore, the study's objective is to gather data on the effectiveness of MET curricula in equipping graduates and seafarers with innovation intelligence knowledge and computational thinking skills for working with emerging technologies. A survey was conducted among recent graduates, seafarers, and industry employees to assess these skills and their perception of the adequacy of their education and training in these areas.

This research paper is structured in the following manner: Initially, the methods and materials, which include the assumptions and demographic information of the participants, are introduced. Subsequently, the results of the survey are presented and discussed.

Literature Reviews

Sharma et al. (2019) conducted expert research to validate the significance of seafarer competency criteria to MASS. Fan et al. (2020) asserted that training and education are variables influencing MASS operational hazards. Janßen et al. (2021) proposed that future remote operators' experience, as well as their training, should be explored. Ultimately, Nautilus Federation (2018) found in its expert-based research that training and reskilling are among the most significant barriers to MASS adoption, however, were considered significantly less important than the dependability of communication linkages or legal difficulties.

The existence of a gap between the current and future industry structure, as well as the methods of training individuals to meet future expectations, has been identified (Pie trzykowski and Hajduk 2019; Hogg and Ghosh 2016). Publishers have expressed opinions on this gap, highlighting the need for educational and professional readiness to keep pace with technological development. These opinions can be summed up as follows:

1. Technological advancements such as the Internet of Things (IoT), big data, AI, cloud computing, VR, simulation, improved connectivity, and e-learning have transformed the

learning process, encompassing emerging technologies, changing ship and port operations, evolving trade patterns, and the need for updated regulations (Kaizer, A. et al. 2021).

2. With the marine industry's increasing globalization, the focus of education and training has shifted from subject matter expertise and competency to developing essential interpersonal skills and attitudes for international work environments. This includes fostering teamwork, leadership, project management, and cultural awareness.
3. The recognition of educational demands and collaborative potential has led to the development of innovative educational techniques aimed at effectively addressing these challenges. e.g., to effectively address these challenges;
   - The ongoing advancements in technology and the increasing importance of developing interpersonal skills and attitudes require a continuous and prolonged learning process, thereby leading MET institutions to expand beyond conventional educational approaches
   - In the new STCW regime, new instructional techniques must blend theory and practice.

2. GMP Project Enhances MET for Innovation

The Nippon Foundation has collaborated with International Association of Maritime Universities (IAMU) members to create the GMP project in response to the rapid changes in the global maritime industry caused by shifting markets, goods, and social norms (IAMU, 2019). The framework of the GMP project is to classify intended learning outcomes into a taxonomy of cognitive, affective, and psychomotor domains to assist educators in designing curriculum, with the objective of defining psychomotor outcomes (Bolmsten, J., Manuel, M.E., Kaizer, A. et al. 2021).

The GMP project aims to provide a foundation for curriculum development, learning activities, and evaluation in 66 maritime institutions. Its objectives, as outlined in the 2019 Body of Knowledge (BoK), are to be specific in the following areas:

a) Meeting the educational requirement for innovation management among aspiring maritime professionals.
b) Meeting the demand for innovation education among new entrants to the labor force.
c) Developing critical thinking, creativity, and innovation skills in order to succeed in the maritime industry.

3. Revitalizing MET for Automation Challenges

Raising awareness of job opportunities necessitates familiarizing future students and employees with emerging technologies such as MASS through curriculum changes and industry partnerships. Consideration should be given to the potential impact of autonomous merchant ships on the maritime job market (Haralambides 2017).

Moreover, broadening the curriculum requires its redesign to incorporate a diverse range of skills, including soft skills, alongside technical subjects. This comprehensive approach aims to enhance the readiness of future students and employees in navigating the changing job market influenced by automation (Baller et al., 2016).

4. Methods

The questionnaire was developed to enable the participation of graduates from diverse backgrounds, such as numerous streams, institutes, and regions, as well as varied degrees of understanding regarding autonomous ships, GMP, and intelligent shipping. The most notable groups were those who were studying to become future navigators or future engineers in the engine department.

In this study, information is provided about the participants who completed the questionnaire in terms of gender, age, country of graduation from the MET, years of sea service, current occupation, and highest educational level received. Out of the 400 participants who returned and properly filled in questionnaires, 357 identified as male and 43 as female, representing 89.25% and 10.75%, respectively. The majority of participants (68.25%) fell into the age range of less than 35 years. The highest number of participants graduated from Egypt (26%), followed by Jordan (17.5%) and Saudi Arabia (12.5%). In terms of years of sea service, 67.25% of participants had less than 5 years of experience, while 32.75% had more than 5 years. The majority of participants identified as O.O.W (42%), followed by Certificate of Competence (CoC) holders (36.5%), while the smallest group was represented by instructors (5.25%). The highest level of education received was a CoC (36.5%), followed by a Bachelor's Degree (26.5%) and basic studies (24.25%). Only a small percentage of participants held a Master's degree (7.25%) or Doctorate (1.75%).

4.1 Questionnaire Panel: The study employed descriptive statistics research methods to collect data and assess the respondent's effectiveness in their current MET curricula. As explained by Payne and Payne (2004), these methods aim to identify patterns in human experiences by breaking down the social world into elements. The questionnaire contains 5 sections targeting different aspects. The five sections were as below:

1. Socio-demographic Data:

This section of the respondents, including age, gender, education, years of experience, occupation, and nationalities, were collected through six questions in this section to better understand the characteristics of the sample.

2. Innovation Intelligence Knowledge and Computational Thinking Skills:

This section is to assess respondents' knowledge of Innovation Intelligence and Computational Thinking Skills, specifically their readiness to handle the most recent technological advancements used in the maritime industry.

3. Practical Applications / Simulator-Based Training and Industry Collaboration:
This section is to assess and measure the respondents' simulator-based training experience with new technological innovations, their perception of the pace of technological change in the industry, and their opportunities to collaborate with industry professionals.

4. STCW on Technological Innovation (MET Curricula):
This section seeks responses on the effectiveness of the IMO and STCW in dealing with the impact of technological innovation on the maritime industry.

5. Emerging the New Technological Innovation and GMPs into MET Curricula:
This section is to assess the value of interpersonal skills, attitudes, leadership, teamwork, project management, and cultural awareness for graduates and seafarers in an international context. The section also seeks to evaluate the role of formal technical education and on-the-job training in the development of diverse skills and knowledge for individuals to become GMPs capable of adapting to new technologies and innovations to remain competitive in the maritime industry.

As shown in Table (1) A questionnaire was given to participants, asking them to indicate their level of agreement with various statements. According to Pimentel (2010), the Likert scale, classified as an interval scale, is used, and the mean value is important for interpreting the responses.

Table (1) Likert Scale Value Interpretation

Level	Scale	Lower Limit	Upper Limit	Interval
Strongly Disagree	1	1.00	1.80	1.00 : 1.80
Disagree	2	1.81	2.60	1.81 : 2.60
Neither agree nor disagree	3	2.61	3.40	2.61 : 3.40
Agree	4	3.41	4.20	3.41 : 4.20
Strongly Agree	5	4.21	5.00	4.21 : 5.00

A Google form with 14 carefully designed questions was distributed in 4 sections in addition to the section on the demographic data to a diverse group of graduates and seafarers to collect data on their perspectives. The research sample was randomly selected and representative. Within two weeks, a response rate of over 400 participants, with 220 responses in the first week, was achieved. To extract meaningful insights, the collected data underwent rigorous statistical analysis using SPSS. The analysis included examining frequency, percentage, and Chi-Square measures within the research sample.

A sample of 15 responses was used for pilot testing conducted for the reliability test (Cronbach's Alpha), In the final stage a total of 400 responses were collected, with half coming from recent graduates with short sea services and half from current seafarers with long sea services, all of them are graduated from different METs institutes.

Table (2) Reliability Analysis (Cronbach's Alpha)

Case Processing Summary			
		N	%
Cases	Valid	15	100.0
	Excluded	0	.0
	Total	15	100.0
a. Listwise deletion based on all studied categories in the procedure.			

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.882	.882	14

As shown in Table (2) the analysis included 14 questions across 5 sections, covering socio-demographic data. A total of 15 responses were used for pilot testing, and no cases were excluded based on the specified criteria. The scale used in the analysis showed high internal consistency, with a Cronbach's alpha coefficient of .882, as a value of .7 or higher is generally considered to be acceptable. This indicates that the items in the scale measure the same construct reliably. Standardizing the items did not significantly improve reliability. These findings validate the scale's internal consistency and support the validity of the study's results.

Table (3) Frequencies Statistics - Section (1)

Socio demographics data	Frequency (N=400)	Percent
Sec.1_Q1_What is your gender identity?		
• Male	357	89.25%
• Female	43	10.75%
Sec.1_Q2_What age range do you fall into?		
• Less than 35 years	273	68.25%
• More than 35 years	127	31.75%
Sec.1_Q3_In which country did you graduate from the maritime education and training institute (MET)?		
• Egypt	104	26.0%
• Jordan	70	17.5%
• Saudi Arabia	50	12.5%
• Syria	40	10.0%
• Lebanon	36	9.0%
• Algeria	34	8.5%
• Oman	26	6.5%
• Bahrain	15	3.75%
• Morocco	10	2.5%
• United Arab Emirates	6	1.5%
• Others	9	2.25
Sec.1_Q4_How many years of sea service do you have?		

• Less than 5 years • More than 5 years	269 131	67.25% 32.75%
Sec.1_Q5_What is your current occupation?		
• Cadets • O.O.W • Master • Chief Engineer • Instructor • Others	97 168 53 48 21 13	24.25% 42.0% 13.25% 12.0% 5.25% 3.25%
Sec.1_Q6_What is the highest educational level you have received after graduation?		
• Basic Studies • Bachelor's Degree • CoC • Master's Degree • Doctorate • Professional • Others	97 106 146 29 7 4 11	24.25% 26.5% 36.5% 7.25% 1.75% 1.0% 2.75%

5. Result

The survey collected opinions on the impact of technological innovation in the maritime industry. As shown in Table (4) In Section 2, a majority (65.55%) disagreed or strongly disagreed with their knowledge and readiness for recent technological advancements, while (16.7%) agreed or strongly agreed. In Section 3, a majority (57.78%) disagreed or strongly disagreed with simulator-based training, perception of technological change, and collaboration opportunities, while (33.26%) agreed or strongly agreed.

In Section 4, (54.75%) disagreed or strongly disagreed with the effectiveness of IMO and STCW, while (32.2%) agreed or strongly agreed. In Section 5, a significant majority (63.63%) expressed agreement on the importance of interpersonal skills, leadership, teamwork, and cultural awareness, as well as the significance of formal technical education and on-the-job training for adapting to new technologies and remaining competitive. However, (19.43%) strongly disagreed or disagreed with these views.

Table (4) Distribution of the studied sample according to Items (n = 400)

Q	Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	SD.
		No.	%	No.	%	No.	%	No.	%	No.	%		
1	Section 2	185	46.3	110	27.5	65	16.3	29	7.3	11	2.8	1.93	1.08
2		124	31.0	105	26.3	78	19.5	63	15.8	30	7.5	2.43	1.28
1	Section 3	110	27.5	135	33.8	85	21.3	55	13.8	15	3.8	2.33	1.13
2		92	23.0	124	31.0	78	19.5	64	16.0	42	10.5	2.60	1.29
3		102	25.5	134	33.5	73	18.3	44	11.0	47	11.8	2.50	1.30
4		117	29.3	110	27.5	78	19.5	54	13.5	41	10.3	2.48	1.31
1	Section 4	150	37.5	120	30.0	50	12.5	45	11.3	35	8.8	2.24	1.30
2		75	18.8	105	26.3	85	21.3	80	20.0	55	13.8	2.84	1.32
3		101	25.3	126	31.5	67	16.8	51	12.8	55	13.8	2.58	1.35
4		83	20.8	115	28.8	73	18.3	63	15.8	66	16.5	2.79	1.38
1	Section 5	54	13.5	62	15.5	43	10.8	141	35.3	100	25.0	3.43	1.37
2		28	7.0	33	8.3	85	21.3	137	34.3	117	29.3	3.71	1.18
3		28	7.0	33	8.3	70	17.5	147	36.8	122	30.5	3.76	1.18
4		33	8.3	39	9.8	75	18.8	152	38.0	101	25.3	3.62	1.20

SD: **Standard deviation**

As shown in Table (5), In Section 2, respondents' understanding of Innovation Intelligence and Computational Thinking Skills showed room for improvement, with an average score of 2.18 out of 5.0. The variability in scores was highlighted by a standard deviation of 0.81, indicating differences in individual performance. Similarly, Section 3 revealed opportunities for enhancement in simulator-based training and industry collaboration, with an average score of 2.48 out of 4.25 and a moderate standard deviation of 0.63. Promoting these areas can better prepare respondents for technological advancements in the maritime industry.

Moving on to Section 4, respondents demonstrated a partial understanding of the impact of technological innovation in relation to the IMO and STCW, with an average score of 2.61 out of

4.50. The standard deviation of 0.68 indicated variability in individual scores, necessitating further examination of the effectiveness of these organizations in addressing technological challenges.

Finally, in Section 5, respondents showcased a good level of interpersonal skills, leadership, teamwork, and cultural awareness, with an average score of 3.63 out of 4.75. The low standard deviation of 0.61 suggested consistent performance in these areas, highlighting the value of formal technical education and on-the-job training for developing versatile maritime professionals capable of adapting to new technologies and innovations.

Table (5) Descriptive analysis of the studied sample according to score (n = 400)

	Total Score	Average Score	% Score
Section 2	**(2 – 10)**		
Min. – Max.	2.0 – 10.0	1.0 – 5.0	0.0 – 100.0
Mean ± SD.	4.35 ± 1.62	2.18 ± 0.81	29.41 ± 20.23
Median	4.0	2.0	25.0
Section 3	**(4 – 20)**		
Min. – Max.	5.0 – 17.0	1.25 – 4.25	6.25 – 81.25
Mean ± SD.	9.91 ± 2.53	2.48 ± 0.63	36.91 ± 15.83
Median	10.0	2.50	37.50
Section 4	**(4 – 20)**		
Min. – Max.	4.0 – 18.0	1.0 – 4.50	0.0 – 87.50
Mean ± SD.	10.44 ± 2.71	2.61 ± 0.68	40.27 ± 16.96
Median	10.0	2.50	37.50
Section 5	**(4 – 20)**		
Min. – Max.	8.0 – 19.0	2.0 – 4.75	25.0 – 93.75
Mean ± SD.	14.51 ± 2.43	3.63 ± 0.61	65.69 ± 15.21
Median	15.0	3.75	68.75

SD: **Standard deviation**

Based on the chi-square test results shown in Table (6) and p-values ranged (0.333:0.710) greater than 0.05, there is no statistically significant association between occupation and all the questions in Section 4 on the effectiveness of the IMO and STCW in dealing with the impact of technological innovation on the maritime industry which are the respondents' perspectives on crucial aspects of technological innovation in the maritime industry.

The data strongly indicate that the occupation of the individuals surveyed does not exert a statistically significant influence on their beliefs regarding the recognition of technological innovation in the STCW convention, the potential efficacy of a new IMO model course in enhancing graduates' knowledge and skills, the customization of curricula and conventions to accommodate autonomous ships, and the alignment of technical expertise with evolving transportation needs.

Table (6) Relation between occupation and Section 4 (n = 400)

Q	Section 4	Q5 What is your current occupation?												χ^2	p
		Cadet (n = 97)		O.O.W (n = 168)		Master (n = 53)		Chief Engineer (n = 48)		Instructor (n = 21)		Others (n = 13)			
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
1															
	Disagree	68	70.1	115	68.5	37	69.8	29	60.4	12	57.1	9	69.2		
	Neutral	10	10.3	17	10.1	10	18.9	6	12.5	5	23.8	2	15.4	9.689	$^{MC}p=$ 0.447
	Agree	19	19.6	36	21.4	6	11.3	13	27.1	4	19.0	2	15.4		
2															
	Disagree	42	43.3	74	44.0	29	54.7	19	39.6	10	47.6	6	46.2		
	Neutral	22	22.7	38	22.6	9	17.0	12	25.0	4	19.0	0	0.0	7.454	0.682
	Agree	33	34.0	56	33.3	15	28.3	17	35.4	7	33.3	7	53.8		
3															
	Disagree	57	58.8	97	57.7	30	56.6	29	60.4	10	47.6	4	30.8		
	Neutral	15	15.5	27	16.1	9	17.0	6	12.5	5	23.8	5	38.5	7.167	0.710
	Agree	25	25.8	44	26.2	14	26.4	13	27.1	6	28.6	4	30.8		
4															
	Disagree	49	50.5	84	50.0	28	52.8	16	33.3	11	52.4	10	76.9		
	Neutral	14	14.4	34	20.2	10	18.9	11	22.9	3	14.3	1	7.7	11.326	0.333
	Agree	34	35.1	50	29.8	15	28.3	21	43.8	7	33.3	2	15.4		

$\chi2$: **Chi square test** MC: **Monte Carlo**

p: p value for comparison between the studied categories

*: Statistically significant at $p \leq 0.05$

6. Conclusion

The analysis of the research findings explored a significant gap between maritime intelligence innovation and the knowledge and skills possessed by graduates and mates in the industry. The findings suggested the need for improvement in areas such as Innovation Intelligence and Computational Thinking Skills, simulator-based training, industry collaboration, and understanding the impact of technological innovation. These findings highlight a discrepancy between the advancements and demands of the maritime industry and the preparedness of graduates and mates to effectively navigate and utilize emerging technologies.

Addressing this gap is crucial to ensure that maritime professionals are equipped with the necessary knowledge and skills to meet the challenges and opportunities presented by maritime intelligence innovation, Respondents also have conflicting views on the potential impact of an IMO model course on these critical factors.

The feedback provided was considered, and revisions were made to enhance the rigor and validity of the research paper, including the incorporation of open-ended questions in the questionnaire. However, should be noted that further research and investigation may be necessary to gain a comprehensive understanding of the intricate dynamics of technological innovation in the maritime industry, as well as the implications for the development of knowledge and computational skills related to innovation intelligence among the workforce.

Survey participants are appreciated for their valuable contributions, and response limitations are acknowledged. This study improves the understanding of maritime professionals' perceptions of innovation intelligence, computational skills, and training effectiveness. The insights obtained guide policymakers, educators, and industry stakeholders in enhancing workforce readiness amidst technological advancements. Further research is needed to explore the evolving landscape of technological innovation and its impact on innovation intelligence and computational skills in the maritime industry.

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