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Enhancing Maritime Higher Education through Technology in a Developing Context

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Abstract. Improving access to higher education and enhancing citizens' skills and knowledge can play a crucial role in South Africa's development. Twenty-five years ago, most of the population in South Africa did not have access to higher education. The situation has changed significantly, although there is room for improvement. This study explored the educators' awareness of the benefits and impediments of blended learning, online distance learning, and virtual exchange or virtual engagement versus face-to-face teaching and learning on campus at maritime higher education and training institutions in South Africa. The study included the educators' readiness to adopt novel forms of knowledge transfer based on emerging technology. The methodological approach is a case study. Interviews and questionnaires were used as data collection tools, and 30 experienced educators from the South African maritime higher education and training institutions were involved. The findings of the study should assist these South African institutions to model and evaluate the feasibility of using technology as an agent for transformative education and as an enabler for the development and accreditation of online distance learning programmes. The results support the use of the best possible blend of cutting-edge digital technology, creative pedagogical approaches, and classical pedagogy. Once successfully implemented and supported by new technologies, online distance learning programmes can serve as a model for maritime higher education and training institutions in South Africa and similar developing environments.

Keywords: blended learning; developing environments; maritime higher education and training; online distance learning; smart adoption; virtual engagement

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1. Introduction

Today, seafarers need online distance learning (ODL) education and training because they live and work in a constantly changing, technologically driven, and complex environment. One of the most flexible ways of transferring and acquiring new knowledge is through the Internet. The ODL courses reduce costs and make education affordable, particularly for marginalized groups, such as those in removed rural areas, people with disabilities, the elderly, etc. (Bauk, 2019; Demirel, 2022; Nalupa, 2022). Furthermore, the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention strongly recommends the implementation and adoption of ODL in maritime higher education and training (MHET). The STCW Convention itself calls for proper education as the foundation of successful training and acquisition of competencies. Thus, the STCW Manila Amendments (Section B-II/1) state:

> *The scope of knowledge is implicit in the concept of competence. Assessment of competence should, therefore, encompass more than the immediate technical requirements of the job, the skills and tasks to be performed, and should reflect the broader aspects needed to meet the full expectations of competent performance as a ship's officer. This includes relevant knowledge, theory principles, and cognitive skills which, to varying degrees, underpin all levels of competence. It also encompasses proficiency in what to do, how and when to do it, and why it should be done. Properly applied, this will help to ensure that a candidate can: 1.1 work competently in different ships and across a range of circumstances; 1.2 anticipate, prepare for, and deal with contingencies; and 1.3 adapt to new and changing requirements.* (International Maritime Organization, 2010)

In addition, the newest STCW Code amendments strongly recommend the introduction and adoption of modern training methodologies, including ODL, to uplift seafarers' knowledge, skills, and competencies (Narayanan et al., 2023). The South African national legislation and practices in the sphere of MHET must be modernised in terms of recognition, proper interpretation, and implementation of the STCW Convention requirements, in terms of faster technology-based teaching and learning deployment as a supplement to traditional education. As a first step towards achieving this, the study explored the willingness of a group of lecturers at several selected MHET institutions in South Africa (Masuku, 2020; Masuku, 2021) to adopt technology in teaching on a wider scale. More precisely, it explored whether the lecturers are well-informed about the common advantages and disadvantages of the innovative technology-based ways of knowledge transfer and enrichment. The study also investigates educators' readiness to introduce and adopt blended learning (BL), ODL, and virtual exchange (VE) approaches. Concerning these issues should be a milestone in the process of introducing, adopting, and routinizing technology driven education and training at the MHET institutions in South Africa and other developing countries that function in similar economic, socio-cultural and political circumstances.

Besides the benefits like easier access to learning resources and services, and savings in educators' repetitive work, time, commuting and space, the development of ODL courses at MHET institutions can foster further development of VE that already exists at some institutions in South Africa, e.g., at Durban University of Technology, Maritime Studies Department (Bauk, 2017; Bauk, 2019; Bauk & Fajardo, 2020; Bauk & Gasparini Fernandez, 2021). The VE programs are currently supplementary forms of regular face-to-face or on-campus education but are not yet formal or official modes of attaining new knowledge. The students, i.e., future seafarers, need both the education based on new technologies and the appropriate recognition of in such a way acquired knowledge and skills. Therefore, this research should support the further development of VE and the establishment of recognised maritime ODL programmes in South Africa. Regarding the newest changes in MHET, the research problem addressed can be summarized as developing a model of rational (intelligent, smart) deployment of digital tools in transforming transmission (teacher-centred) into transformative (student-centred) MHET within the South African emerging educational environment. For further clarification of the problem, the problem statement, together with the objectives and research questions, are given in Table 1.

Table 1: Problem statement, objectives and research questions

Problem Statement	Research Objective	Research Question
The MHET sector has many challenges. Digital tools are powerful agents in transitioning F2F to BL, ODL, and VE. Responsibility of the educators is to remain focused on assisting students to achieve technical, intellectual, and social competencies that will fit them to the 21st century maritime sector labor market needs.	• To identify the prerogatives for implementing BL, ODL, and VE into MHET; • To come up with the optimal combinations of well-established pedagogical theories and modern educational digital tools; • To identify opportunities, challenges, and prospective advances of BL, ODL, and VE in MHET; • To identify impediments affecting BL, ODL & VE implementation into higher extent into MHET programs.	1. What are the preconditions for successful implementation of BL, ODL, and VE at the MHET institutions? 2. In which ways can well-established pedagogical theories, approaches, and methods be merged with advanced digital tools in MHET? 3. What are the benefits, challenges and prospective advantages of BL, ODL, and VE in MHET? 4. What are the impediments which affect DL, ODL, and VE implementation at the MHET institutions?

Therefore, the purpose of this study was to increase the quality of MHET in South Africa through innovative approaches in teaching and learning based on technology integration (Masuku, 2020; Masuku, 2021). The constructs, such as advantages as student-centred learning, term work, internationalization, problem-solving orientation, increased digital literacy, improved communication, and critical thinking skills, are among the key aims of this research (Bauk, 2022). Equipping South African maritime students with skills as problem-solving, self-management, working with people worldwide, flexibility, consultative leadership, etc. (Whiting, 2020), are among the main long-term goals of the study.

2. Literature Review

Academics consider the use of digital tools by exploring how digital resources such as computers and the Internet can accelerate learning, democratise access to education, and enable interactivity and collaboration (Timotheou et al., 2022). Digital technology can turn excluded consumers of communication and education into active producers (Shahid & Qureshi, 2022). Some studies showed that information and communication technology (ICT) helps underrepresented groups and makes them more visible (Prasastiningtyas et al., 2024; Rayi, 2023). This supports the actual diversity and inclusion requirements in higher education, including the South African one. The ICT facilitates intergenerational knowledge transfer through VE (Dzimińska & Warwas, 2023) and promotes empowerment, social participation, and advocacy (Björquist & Tryggvason, 2022). Digital technology gives students an opportunity to access educational services and resources at any time and to work through content at their own pace (Turugare & Rudhumbu, 2020). Furthermore, through ICT-enabled problem-based learning, both learners and teachers have an opportunity to develop skills in problem definition and solving, to reflect on their own learning, knowledge and practices, and to develop a deep understanding of the content domain learning (Ghani et al., 2021).

Lecturers need to understand how to use technology to promote student learning and achievement in the interconnected world and ubiquity of technology. They should explore possibilities for how to operate effectively in tandem with technology, with the aim to promote students' growth and new knowledge attainment (Wekerle & Kollar, 2022). The effective integration of technology into learning experiences requires pedagogy based on some of the frameworks and models, including the technological, pedagogical, and content knowledge such as Cultural Historical Activity Theory; Substitution, Augmentation, Modification, and Redefinition (SAMR); Teaching Change Frame; and Change Laboratory theories. The Cultural Historical Activity Theory provides a holistic perspective on the socio-technical environment, where the learners, mentors, technologies, pedagogical values, roles/identities, and rules/cultures act as interdependent elements of a single collective activity system (Wiser et al., 2018). The SAMR has been used as a means for educators to tackle any pedagogical changes when introducing learning technologies to students (Terada, 2020). More precisely, SAMR is a popular framework that discusses the innovative usage of technologies for transforming learning (Nair & Chuan, 2021).

The Teaching Change Frame maps teachers' existing pedagogies and emerging technologies usages as a way of educational change. Therefore, the use of TCF not only locates teaching pedagogies but also provides different pathways to ensure sustainable change in education (Tarling & Ng'ambi, 2016; Turugare &

Rudhumbu, 2020). The Change Laboratory is a participatory work development method based on the theory of expansive learning. It facilitates transformative agency, which is based on the idea that a lecturer's purpose is greater than the delivery of information. This theory explores how transformative agency contributes to collective learning and development (Kajamaa & Hyrkkö, 2022). These theories can help to integrate digital technology with traditional pedagogical approaches. Well-designed integration of pedagogy and technology can support transformative education, where students become agents of knowledge transfer and adaptation.

Furthermore, teaching and learning with technology can be enhanced through VE. It is a cross-cultural and cross-disciplinary pedagogical approach among different higher education institutions. Consiglio (2021) reports that lecture-based learning should be replaced by action-based learning. For instance, through an experimental study in a real environment, a group of history students developed an app that virtually presents the history of the Berlin Wall. This supports the idea that lecturers should redesign the courses and make a move from lecture-based learning towards learning with technology, where students collaborate and develop new solutions through teamwork and digital skills development. The study carried out by Bartsch et al. (2021) explored digital storytelling as an inquiry-based learning and lingua franca model in VE projects that address actual global issues. Ganassin et al. (2021) explored establishing partnerships with a mutual understanding of realities, unique power dynamics among learner groups, and techno-political challenges. Commander et al. (2021) underlined the generalizability of the VE across disciplines and its sustainability for providing wider access to international experiences for all students. Oswel et al. (2021), for example, consider virtual team projects regarding students with disabilities in cross-cultural collaborations, etc.

Albeit there are many sources on teaching and learning with technology, in developing countries, there is very little preliminary research on the adaptation of multimodal pedagogical approaches and digital tools in MHET. The approach that inspired this research was based on a study conducted in Montenegro in Southeast Europe (Bauk, 2017). Consequently, the aim of this study was to enrich the level of knowledge in the domain of digitalization in MHET in South Africa.

3. Methodology

This study was based on critical realism and pragmatism research approaches, using both deductive and inductive reasoning. The researchers' intervention was minimal, i.e. the phenomena are studied as they occur. The units of analysis were individuals, i.e., selected MHET educators in South Africa. The time horizon was single, and cross-sectional. Data collection methods included systematic and critical review of academic and "grey" literature sources, interviews and questionnaires. The study involved the collection of secondary and primary data (Table 2). Secondary data sources included relevant books, articles, dissertations, theses, statistics, bulletins, government publications, conference proceedings, social media, unpublished manuscripts, etc. The nature and value of secondary data were carefully assessed. The criteria for evaluation were the timelines, accuracy, relevance and cost of the data (Sakaran, 2016). Therefore, we used literature resources available in EBSCO, Science Direct, Web of Science, Google Scholar, and IEEE Explore databases through extensive desktop searches.

A case study was applied as a research strategy, while a questionnaire and interview were used as data collection methods. The questionnaire had 14 closed-ended questions, and the interview was composed of 10 open-ended questions. The survey questions were answered with a number from 1 to 5 (Likert scale), while the interview questions were answered in text form. On the quantitative data, we applied basic statistics and factor analysis. We coded qualitative answers manually and analysed them later by using a Python code. The data collection tools, i.e., the questionnaires, were structured after careful consideration and triangulation of several well-established technology adoption theories, such as Theory of Reasoning Action, Technology Acceptance Model, Extended Technology Acceptance Model (TAM2), Uniform Theory of Acceptance and Use of Technology, and Theory of Design Science Research Method. Furthermore, when structuring the questionnaires, we were also guided by the studies of Bauk (2017) and Sabi et al. (2016), which deal with adopting technology driven education in different developing environments.

Table 2: Mixed data collection approach

Target group	Mixed research method	Data collection method	Type of data
Lecturers at selected MHETs in South Africa	Qualitative	Questionnaire (open-ended questions)	Text (words)
	Quantitative	Questionnaire (close-ended questions)	Numbers (Likert scale)

The research was conducted among the educators at the following MHET institutions in South Africa:

1. Durban University of Technology
2. Cape Peninsula University of Technology
3. Nelson Mandela University
4. Umfolozi Maritime Academy

The choice of the MHET institutions was motivated by the fact that these do not have any ODL officially approved programmes. Maritime (ex-)students and seafarers must continuously upgrade their knowledge and skills to be competent in the world maritime labour market. Since they must work as seafarers upgrade their knowledge and refresh their certificates of competencies at the same time, ODL can be an ideal solution for achieving this.

3.1 Quantitative Data Analysis

As a method for quantitative data analysis, besides basic statistics, we used factor analysis. This is a technique for determining the underlying relationships between observed variables (Costello & Osborne, 2005). By combining highly correlated variables into a smaller number of latent (unobserved) variables, or factors, it aimed to simplify data. Coefficients known as factor loadings showed how strongly each observed variable relates to the underlying factor. Strong representation of the latent factor by the observed variable was indicated by high factor loadings (near +1 or -1). The lowest acceptable value of the load factor was 0.50. However, many authors recommend a value of 0.60 prior to factor analysis. Rotation was used to improve the interpretability of the factor structure after initial factor extraction. It modified the factor loadings to make them more comprehensible without altering the solution. There are two primary kinds of rotation: the assumption of uncorrelated factors is made by orthogonal rotation (e.g., Varimax), and factor correlation is made possible by oblique rotation (e.g., Promax). In this study, Varimax is used, along with the Kaiser-Meyer-Olkin (KMO) measurements (Hair et al., 2019). In our study, the KMO was above the cut-off value of 0.5. Factor analysis assisted us in identifying the factors and variables relevant to this study.

3.2 Qualitative Data Analysis

Qualitative data are those that are word-based. Analysing qualitative data is a challenging task. The problem is that there are relatively few well-established and generally accepted guidelines for the analysis of qualitative data, in contrast to the rules and guidelines available for the analysis of quantitative data. For the analysis of qualitative data, numerous general approaches have been developed over time, while the most popular approach is based on Miles and Huberman's (1994) theory. This theory states that the three stages of qualitative data analysis are data reduction, data display, and conclusion drawing. Data reduction is the act of choosing, classifying, and coding the data. Methods of presenting the data are referred to as data display. If the researcher (reader) has access to a collection of quotes, a matrix, a graph, or a chart that illustrates patterns in the data, they might find it easier to understand the data. Analysing qualitative data is a continuous, iterative process as opposed to a sequential, linear one (Sekaran, 2016). Preliminary findings could then influence how the raw data are sorted, coded, and presented. In our study, we edited and analysed the qualitative data by grouping the answers around the key constructs identified through factor analysis. We also used Python code to create word clouds of the most common words in the interviewees' responses.

3.3 Sample

Primary data for analysis was gathered from the specific target group, i.e., professors and lecturers at four selected MHET institutions in South Africa. The sampling was confined to specific people who could provide the desired information. We applied purposive judgement sampling, which is the only viable method for obtaining the data required from very specific individuals who can provide the information we are looking for. In the selection of the respondents, we paid attention to the inclusion and exclusion criteria. Inclusion criteria are the characteristics that prospective respondents or interviewees must have to join the study. On the other side, exclusion criteria are the characteristics that disqualify prospective participants from joining a study.

Inclusion criteria for the study included - 1) employment at Durban University of Technology, Cape Peninsula University of Technology, Nelson Mandela University, and Umfolozi Maritime Academy maritime studies departments as a full, associated, assistant professor, or as a lecturer; 2) PhD degree; 3) at least 5 years of working experience at maritime higher education. *Exclusion criteria for the study* included those who did not comply with the three criteria specified above. Namely, the persons who did not have these qualifications were unable to take part in the study and were initially excluded.

We also paid close attention to the size of the sample. In determining the optimal number of samples, we used Slovin's formula (Glen, 2022). Namely, the sample size was determined using the equation: Sample size = $N/(1+N*e^2)$, where N is the population size and e is the margin error (0.05). Our sample size equalled 10 lecturers and one professor at Durban University of Technology, eight lecturers at Cape Peninsula University of Technology, eight lecturers at Nelson Mandela University, and five lecturers at Umfolozi Maritime Academy. If we assumed that a common margin error was 5% or 0.05, then the calculation based on Slovin's formula led us to the sample size equals to 29.62. Thus, we concluded that the sample of 30 participants is satisfying from the statistical point. Prospective respondents were contacted via e-mail for the purpose of populating the survey. As experienced researchers, we established rapport with and gained the confidence and approval of the respondents before we started with surveying. After 20 days, the targeted respondents at South African MHET institutions sent us their feedback.

4. Analysis and Results

The survey was carried out on a sample of 30 respondents. The sample was made up of approximately 37% women and 63% men. The average experience in higher education was 11 years, and the average age of the respondents was 38 years. Figures 1 and 2 show demographic statistics.

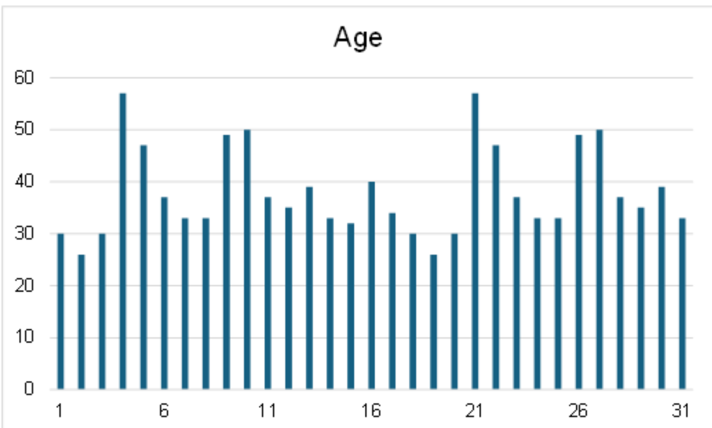

Figure 1: Respondents' age

4.1 Quantitative Data Analysis Results
Within the quantitative part of the study, the respondents were asked to answer fourteen questions (Q1–Q14) by using a Likert scale (1–5), where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree, and 5 is strongly agree. The means of the examined constructs are shown in Table 3. The calculations were done on the 13th Gen Intel (R) Core i5-1335U computer (20 GB, 1.3 Hz) in the licensed IBM SPSS, ver. 29 environment.

Figure 2: Respondents' experience

The analysis showed that the vaguest constructs were Q11, Q12 and Q14. These constructs relate respectively to inclusivity in the context of BL in MHET, teachers' intellectual property rights in relation to teaching materials, and South Africa's capacity to promote the wider adoption of BL in MHET. For other variables, the responses were more-or-less uniform, with the majority being confirmatory. Most responses were strongly agreed and agreed, while neutral answers appeared in a lower number.

Table 3: Analyzed constructs' means

Rank	Question	Mean
1.	*Q10:* BL reduces costs of space, energy, and commuting	4.47
2.	*Q1:* BL brings benefits to MHET	4.43
3.	*Q3:* BL supports lifelong learning	4.43
4.	*Q6:* BL merges formal and informal learning styles	4.43
5.	*Q2:* BL is supported by STCW	4.30
6.	*Q4:* BL enhances digital literacy	4.27
7.	*Q13:* BL requires institutional support	4.20
8.	*Q7:* BL fosters curiosity and creativity	4.07
9.	*Q9:* BL fosters COIL (VE)	3.93
10.	*Q8:* BL makes learning easier	3.87
11.	*Q5:* BL uplifts critical thinking	3.83
12.	*Q11:* BL enhances those who are socially marginalized	3.77
13.	*Q14:* BL can be more widely adopted in South Africa	3.63
14.	*Q12:* BL does not protect intellectual property	3.57

A factor analysis was performed to further examine the interdependencies between the variables. Factor analysis is a technique for determining the underlying relationships between observed variables (Costello & Osborne, 2005; Howard & O'Sullivan, 2024). Combining highly correlated variables into a smaller number of latent (unobserved) variables, factors, or categories, aims to simplify data. Coefficients known as factor loadings show how strongly each observed variable relates to the underlying factor. Strong representation of the latent factor by the observed variable is indicated by high factor loadings (near +1 or -1). The lowest acceptable value of the load factor is 0.50. This analysis has shown that all independent constructs could be grouped into five categories, which were related to inclusion, maritime higher education, generic skills, virtual exchange, and costs. The categorisation and the values of standard factor loadings (λ), average variance extracted (AVE), and composite reliability (CR) are given in Table 4. The identification of hidden variables can be used as a basis for further studies in this area, i.e. new, more extensive questionnaires and structured interviews, e.g., can be developed around some, or all, of these hidden constructs. (the first column in Table 4).

Table 4: Confirmatory factor analysis

Category	Construct	Description	Lambda	AVE	CR
Inclusion	*Q8*	Easier learning	0.836	0.596	0.853
	Q11	Access of socially marginalized	0.833		
	Q13	Institutional technical support	-0.796		
MHET support	*Q5*	Critical thinking	0.598	0.575	0.799
	Q6	Formal and informal learning style	0.837		
	Q2	STCW support	0.809		
	Q1	Boosting BL at MHET	0.609		
Generic skills	*Q3*	Lifelong learning	0.959	0.751	0.856
	Q4	Digital literacy	0.763		
Virtual exchange	*Q7*	Cognitive curiosity	0.843	0.417	0.731
	Q12	IP protection	-0.631		
	Q9	Enhancing BL through COIL/VE	0.581		
Costs	*Q10*	Reducing costs of space, time and energy	0.827	0.684	0.684

The analysed coefficients were of satisfactory values, confirming the validity of the applied factorisation. Negative values of the loading factor of Q13 construct means that this construct had a hindering effect on the smooth inclusion of marginalised students in maritime higher education. The same was true for the Q12 construct, which considers intellectual property concerns regarding the online availability of teaching materials within the BL environment. The construct Q14, or the tentative statement that BL can be widely adopted in South Africa, is excluded because its loading factor was less than 0.5 in the study. This means that it does not have a significant effect on the examined sample. Variations in standardised factor loadings might be due to the presence of latent constructs not included in this study. However, some of these could be uncovered by subsequent qualitative research in the future. The quantitative part of the study was based on questions and answers in a closed form, so the presence of hidden influences was not easy to reveal explicitly. Therefore, in addition to the qualitative study that follows, further research with a larger sample and over a longitudinal time frame may reveal additional, hidden influences on the wider adoption of BL in South Africa's technology-enhanced MHET environment.

4.2 Qualitative Data Analysis Results

Having analysed the quantitative data, a qualitative analysis was carried out. We used Miles and Huberman's approach to analyse the interviewees' responses. In fact, 30 respondents answered 8+2 questions.

```
# Open the file in read mode
text = open("Fourth Industrial Revolution.txt", "r")

# Create an empty dictionary
d = dict()

# Loop through each line of the file
for line in text:
    # Remove the leading spaces and newline character
    line = line.strip()

    # Convert the characters in line to
    # lowercase to avoid case mismatch
    line = line.lower()

    # Split the line into words
    words = line.split(" ")

    # Iterate over each word in line
    for word in words:
        # Check if the word is already in dictionary
        if word in d:
            # Increment count of word by 1
            d[word] = d[word] + 1
        else:
            # Add the word to dictionary with count 1
            d[word] = 1

# Print the contents of dictionary: sorted by value - row by row (key, value starting from max to min)
for word in sorted(d, key=d.get, reverse=True):
    print(word, d[word])
```

Figure 3: Qualitative data analysis in Python

Table 5 shows the interviews, open-ended questions and summaries of responses. Respondents used the digital tools available at the MHET institutions where they work. However, they were aware that there was room for improvement in terms of online tools and simulator facilities. In addition, the respondents did not have access to the XR environment and tools, which would modernize the way they work and further motivate students to learn. In addition to this, we merged all textual answers to two additional questions concerning the fourth and fifth industrial revolution (4IR & 5IR) deployment in MHET into one textual file. We applied Python code to identify different words in the text and to count their number. The Python pseudo-code is shown in Figure 3. Then, we used this dictionary to create a word cloud composed of the most frequent words in the answers (Figure 4).

The respondents stated that the 4IR technologies (digital twins, 3D dynamic holograms, Ml/AI, IIoT, robotics, big data, etc.) are transforming maritime education by creating more dynamic, efficient and personalized learning experiences. These technologies prepare students to work with (semi-) autonomous ships, ML/AI systems, and IIoT-connected devices, equipping them with future-ready skills. Enhanced simulation and remote learning capabilities made education more accessible and flexible, allowing students to continue their studies while on board ships. In addition, 4IR is revolutionizing ship operations, particularly in navigation and logistics, improving safety, efficiency and sustainability in the maritime industry. Furthermore, the educators saw 4IR as a game changer for maritime education and training, offering new opportunities for innovation, sustainability and flexibility in both the learning process and industry practices. The integration of advanced technologies will make maritime education more relevant, accessible and adaptable to the evolving needs of the maritime sector.

Table 5: Summary of open-ended question analysis

No.	Question and summary of all 30 answers
Q1	What of the following management learning systems do you use in teaching? Elaborate (Moodle, Blackboard, Canvas, Brightspace, Other). *Summary of answers:* The answers given are Moodle and Blackboard. These two platforms serve to manage educational content, assignments, assessments and communication with students via announcements and forums.
Q2	Which of these digital platforms do you use for teaching purposes? (MS Teams, YouTube, WhatsApp, Facebook, Zoom, Meet, GoToMeeting, Slack, Flipgrid, Other). Elaborate. *Summary of answers:* The responses were MS Teams, YouTube, WhatsApp, Facebook and Zoom, indicating that lecturers use these platforms to facilitate different aspects of their teaching. Namely, a mix of communication, video conferencing and content sharing platforms is used to enhance teaching, facilitate online learning and engage with students.
Q3	Do you have nautical/mechanical/electric-power simulators at your maritime education and training institution? (Yes, No, I don't know). Elaborate. *Summary of answers:* The answer - "Yes" indicates that the MHET institutions have these types of simulators, providing students with opportunities to practice and develop their skills in a realistic yet safe environment without the risks associated with real-world operations.

No.	Question and summary of all 30 answers
Q4	If your answer on question 3 is Yes, who is producer of the simulator(s)? (Wärtsilä (Transas), Kongsberg, Other). Elaborate. *Summary of answers:* The answers are Wärtsilä (Transas) and Kongsberg, which means that the institutions use simulators produced by these two reputable companies known for providing advanced simulation technology for MHET.
Q5	Do you use simulator in the Cloud at your institution as K-Sim? (Yes, No). Elaborate. *Summary of answers:* The answers – "No", indicate that the institutions do not use the K-Sim simulator, nor a similar cloud-based simulator for its courses or training programmes.
Q6	Do you use any additional maritime simulator training facility/tool? (No, Yes – specify). Elaborate. *Summary of answers:* The answer – "No", indicates that the institutions do not use any additional maritime simulator tools or facilities beyond those already mentioned. This could mean that they rely on traditional training methods or have limited access to simulator-based tools.
Q7	Do you use extended reality (XR) facilities/tools like smart glasses, finger and hand trackers, etc. (No, Yes – specify). Elaborate. *Summary of answers:* The answer – "No", indicates that the institutions do not use any additional maritime simulator tools or facilities beyond those already mentioned, currently available ones. This could mean that they rely on traditional training methods or have limited access to XR facilities/tools. E.g. XR can make maritime education and training more engaging, while a lack of knowledge or resources to implement this advanced technology deprives students of much more interesting and easier learning.
Q8	Would you like to upgrade your training facilities and if yes – in which way? Elaborate. *Summary of answers:* The answer - "Yes", indicates that the respondents are interested in upgrading their facilities. This response suggests that they are looking for more sophisticated and integrated simulation tools to enhance the quality and realism of MHET programs.

The interviewed educators saw the 5IR as an evolution of the 4IR, emphasising the integration of technology with human creativity, ethics and values. They stressed the importance of human-machine collaboration to create an inclusive, sustainable and human-centred future. However, very few lecturers (8 out of 30) had knowledge of the 5IR. This indicates a significant gap in awareness or understanding of this emerging paradigm within the group.

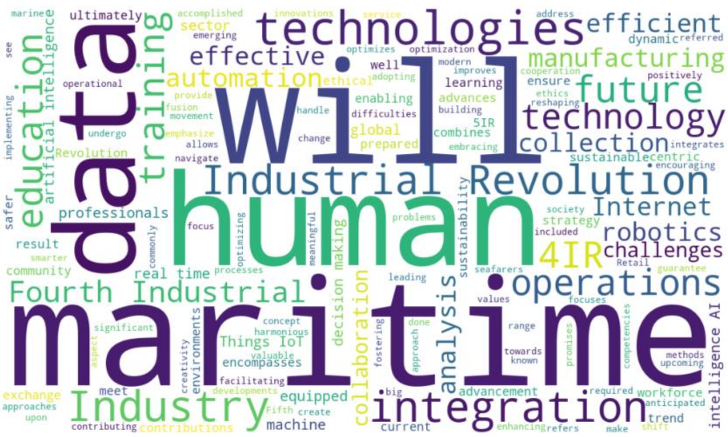

Figure 4: Word cloud generated in Python

The dominant words in the word cloud (Figure 4) were: will (pointing to the future), maritime, data, human, technology, industrial revolution, education, integration, etc. We gave ourselves the freedom to interpret this as *maritime will bring people and data together through industrial revolution in creating efficient and effective maritime education and training*. Of course, the number of possible interpretations of the obtained word cloud was unlimited, and further research is needed to get closer to solving the MHET puzzle in developing environments.

5. Discussion

The respondents, i.e., the experienced educators at the MHETs in South Africa involved in the study, expressed a high degree of agreement (>4) with the tested statements - that BL: reduces costs of space, energy, and commuting; brings benefits to MHET; supports lifelong learning; merges formal and informal learning styles; enriches STCW; enhances digital literacy, and fosters curiosity and creativity. The respondents also dominantly agreed with the statement that BL requires institutional support. To a slightly lesser extent (>3), the respondents expressed agreement with the following tentative statements - that BL fosters VE, makes learning easier, uprises critical thinking and enhances those who are socially marginalized. In addition, with approximately the same level of agreement (>3), the respondents expressed their belief in the widespread use of BL in South Africa and the existing BL's intellectual property protection mechanisms.

After deepening the analysis of the means with factor analysis, clearer insights are gained regarding the importance of the key pillars for the rational implementation of BL in MHET in South Africa. Namely, five key constructs are identified: inclusion, MHET support, generic skills, VE, and costs. This means that the wider use of BL supports the inclusion of students from diverse backgrounds and strengthens MHET, especially when it comes to seafarers' continuing education. It also means that the use of BL can enrich students' generic skills, especially through VE, and that BL reduces time, space and commuting costs.

Regarding the qualitative study, it has been found that educators at the South African MHET institutions predominantly use Moodle and Blackboard as management learning systems, while MS Teams, YouTube, WhatsApp, Facebook, and Zoom are used for online meetings and quick, less official communication with students. When it comes to maritime training, educators use physical Wärtsilä (Transas) or Kongsberg simulators. They do not have the K-Sim Cloud and XR-based training facilities that could better suit BL requirements, although the instructors would like to have them. Greater investment and the provision of institutional and technical support to educators are required to achieve a more intensive and comprehensive integration of BL into MHET in South Africa.

In general, the findings suggest that BL in MHET offers numerous benefits by combining traditional instruction with digital learning. It enhances flexibility and accessibility, allowing students, including those at sea, to access course materials remotely and at their own pace. This approach supports socially marginalized groups by making maritime education more inclusive. BL also improves learning outcomes and engagement through interactive digital content and simulations, fostering critical thinking and cognitive curiosity. Additionally, it is cost-efficient, reducing expenses related to physical infrastructure, travel, and printed materials while optimizing instructor time. Another key advantage is its alignment with international standards like the IMO's STCW requirements, ensuring standardized learning outcomes through digital assessments. Furthermore, BL helps students develop generic and digital skills, promoting lifelong learning and familiarity with maritime technologies. Institutional support, including technical assistance and the integration of VE, enhances global collaboration and knowledge sharing among maritime students. Overall, BL modernizes MHET, making it more accessible, engaging, and industry aligned.

6. Limitations

Although this study was conducted with a rigorous methodological approach, it is not without limitations. Further research should be carried out with a larger sample, and the study should include, in addition to educators, students and maritime stakeholders from higher education policy and the maritime economy. It should be a longitudinal study rather than a closed, cross-sectional one. Longitudinal studies would provide valuable insights by tracking changes over time, allowing researchers to establish cause-and-effect relationships while minimising recall bias. By collecting data repeatedly, such a study could improve accuracy and help identify risk factors. Comparative analyses should be carried out in similar developing regions across the African continent, in Latin America, in some parts of Asia, and in Southeast Europe. These are guidelines for possible future research in this area, which is crucial for the sustainable development of MHET in South Africa and other similar developing environments in terms of social, economic and political dynamics.

7. Conclusion

This study showed that educators at MHET institutions in South Africa are aware of the possibilities and benefits of using digital technologies in education.

Quantitative data analysis showed that the respondents mostly agreed with the statements concerning BL: Q1–Q14 (Table 3). However, a certain level of variation is noticed regarding: (i) inclusivity in the context of BL in MHET, (ii) teachers' intellectual property rights in relation to teaching materials, and (iii) South Africa's capacity to promote the wider adoption of BL in higher education, including MHET. Factor analysis identified five categories around which the measured variables are grouped: (i) inclusion, (ii) institutional support, (iii) generic skills, (iv) virtual exchange, and (v) costs. This indicates that further analysis should be focused on these hidden variables, even though it might be challenging to measure them directly.

Qualitative data analysis showed that educators use management learning, assessment and communication systems like Moodle, Blackboard, and MS Teams. Additionally, they make use of Zoom, Facebook, WhatsApp, YouTube, etc., to support various facets of their instruction. Advanced Wärtsilä and Kongsberg deck and engine simulators are in use at the MHET facilities in South Africa. However, the XR environments and tools are not currently available. Although educators are aware of the advantages of 4IR and 5IR in teaching and learning, they lack access to these cutting-edge technological tools that would improve knowledge transfer. Will (pointing to the future), maritime, data, human, technology, industrial revolution, education, integration, and so on are the most common words in the word cloud based on the respondents' 4IR and 5IR perceptions. This could be read as: *through the industrial revolution, advanced technology will unite people and data to create effective and efficient maritime training and education*.

Although there are many advantages to integrating new technologies into the classroom, educators frequently encounter significant obstacles when trying to do so successfully. Technology adoption may be hampered by infrastructure constraints like antiquated hardware and insufficient internet access. Furthermore, many educators find it difficult to integrate these advanced technology resources into their lesson plans due to inadequate training, which lowers their overall efficacy. These problems are made worse by financial limitations since MHET institutions usually do not have the funds to purchase the required technology or professional development courses. To make sure that technology improves teaching and learning rather than adding to the workload of educators, these issues must be resolved.

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