Digital Transformation of South African Maritime Higher Education and Training (MHET)

by

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DECLARATION

I Margaret Balungile Masuku, hereby declare:

I confirm that I have acknowledged all content in this dissertation that is not my own original work, and that none of it includes information for which I have previously earned a degree.

The views expressed in this dissertation are my own and do not necessarily reflect the views of the university.

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ABSTRACT

Global learning patterns are changing as a result of the digital revolution (DT) in higher education and training, and South Africa's marine industry is no exception. By improving the education, knowledge, and skills of its people, South Africa, a developing country, has the potential to become a developed one. A significant section of South Africa's population did not have access to higher education 25 years ago. There is still room for expansion even though there have been notable advancements since then.

This paper explores the digital transformation of South African maritime higher education and training (MHET), focusing on the integration of digital technologies and their implications for curricula, teaching methodologies, and industry collaboration. The maritime sector is facing increasing demands for skilled professionals, with digitalisation playing a pivotal role in the development of competency-based training, simulations, and e-learning platforms. The paper highlights key challenges and opportunities, such as limited infrastructure, digital literacy gaps, and the need for industry-academia partnerships to ensure relevant and future-proof education. Through a comprehensive review of current digital tools, strategies, and initiatives, this study aims to provide a roadmap for advancing South Africa's maritime education system.

This paper explores lecturers' understanding of the benefits and challenges related to blended learning (BL), online distance learning (ODL), and virtual exchange or engagement (VE) compared to traditional face-to-face (F2F) teaching and learning at maritime higher education and training (MHET) institutions in South Africa.

It also examines policy recommendations and the potential of emerging technologies, such as virtual reality and artificial intelligence, in shaping a digitally competent workforce. Ultimately, the paper advocates for a balanced approach that integrates traditional maritime knowledge with cutting-edge digital practices to enhance the overall quality and accessibility of maritime education in South Africa.

The results of this study should assist South African MHET institutions in developing and evaluating the viability of certifying online distance learning (ODL) programs that combine state-of-the-art digital technology, creative teaching approaches, and traditional pedagogy. These ODL programs could be used as a template by MHET institutions in other developing environments if they are implemented successfully.

Keywords: Maritime higher education and training, digital transformation, online distance learning, blended learning, virtual engagement, smart adoption, developing environments.

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LIST OF ABBREVIATIONS /ACRONYMS

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
AIS	Automatic Identification System
AR	Augmented Reality
CHAT	Cultural Historical Activity Theory
BL	Blended Learning
CL	Change Laboratories
COIL	Collaborative Online International Learning
CPUT	Cape Peninsula University of Technology
DSRM	Design Science Research Methodology
DT	Digital Technologies
DUT	Durban University of Technology
ECDIS	Electronic Chart Display and Information System
ECT	Expectation-Confirmation Theory
ECT	Expectation-Confirmation Theory
F2F	Face-to-Face
GMDSS	Global Maritime Distress and Safety System
ICT	Information and Communication Technologies
IBS	Integrated Bridge System
IDT	Innovation Diffusion Theory
IMO	Intenational Maritime Organization
IS	Information Systems
IT	Information Technology
LMS	Learning Management Systems
MASSs	Maritime autonomous sea surface systems
MHET	Maritime Higher Education and Training
MHETI	Maritime Higher Education and Training Institution
MLRM	Multiple Linear Regression Model
MPCU	Model of Personal Computer Utilization
MR	Mixed Reality
NGO	Non - Government Organisation
NMU	Nelson Mandela University
NQF	National Qualifications Framework
NSMW	National Single Maritime Windows
NSMW	National Single Maritime Windows
NTPro	Navi-Trainer Professional
OECD	Organization for Economic Cooperation and Development
ODL	Online Distance Learning
OT	Operational Technology
PCS	Port Community Systems
PCS	Port Community Systems
PEU	Perceived Ease of Use
PU	Perceived Usefulness

SAIMI	South African International Maritime Institute
SAMR	Substitution, Augmentation, Modification, and Redefinition
SAMTRA	South African Maritime Training Academy
STCW	Standard of Training Certification of Watchkeeping
TAM	Technology Acceptance Model
TAM2	Technology Acceptance Model
TCF	Teaching Change Frame
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UMA	Umfolozi Maritime Academy
VE	Virtual exchange
VR	Virtual Reality
XR	Extended Reality

CHAPTER 1 - OVERVIEW AND CONTEXT OF THE RESEARCH

1.1 INTRODUCTION

This chapter provides an overview of the research, outlining its purpose, relevance, and objectives. It highlights key issues to be explored and offers background information on the evolving landscape of higher education, particularly in online distance learning (ODL). The chapter also discusses the role of technological advancements and innovative teaching methods, as well as the challenges faced by South Africa's higher education system in adapting to digital transformation.

The maritime industry remains a critical driver of global trade and culture, with shipping recognised as the "backbone" of the global economy. According to UNCTAD (2024), international seaborne trade reached approximately 12.3 billion tonnes in 2023, facilitated by a global fleet of around 109,000 vessels of at least 100 gross tons, and supported by over one million seafarers of diverse nationalities. The expertise and proficiency of these maritime professionals are vital to ensuring the safety, resilience, and efficiency of global shipping operations (UNCTAD, 2024).

Maritime Higher Education and Training (MHET) is a cornerstone of the industry, ensuring standardised skills and competencies for seafarers while adapting to the demands of modern maritime operations. Beyond basic certification, continuous professional development is emphasised to equip seafarers for evolving challenges in 21st-century operations (ICS 2020).

Advances in technology, including automation and digitalisation, are reshaping workforce training and skill acquisition. These changes necessitate reskilling, yet educational institutions and regulatory bodies often struggle to respond effectively due to limited empirical data on the impact of new technologies and required competencies within MHET (Sharma 2023).

It should be noted that technology enhanced learning offers significant chances to enhance maritime education and training, especially in order to fulfil the requirements of the Standards of Training, Certification, and Watchkeeping (STCW). Seemingly, collaboration, innovation, and regulatory compliance are key factors in maximising the benefits of digital technologies in MHET, while collaborative online projects and virtual teamwork tasks empower students to create innovative solutions and proposals for maritime challenges (Lim and Yoon 2020).

The efficiency of global supply chains and the secure operation of maritime transportation are being disrupted by the persistent worldwide problems brought on by economic, financial, climate, pandemic, and military crises. Addressing these issues requires a shift in thinking, where big data, digitalisation, and exponential technologies play a pivotal role. The digital revolution is being welcomed by ports, international marine organizations, maritime universities, and other logistics partners.

This is because digitalisation and emerging technologies are critical for achieving standardisation, improving shipping efficiency, and supporting economic recovery. However, it is also acknowledged that this transition must balance economic growth, safety, environmental sustainability, and cybersecurity (Narleva and Gancheva 2023). Additionally, the advancements in technology are creating new opportunities for exploration within the maritime education and training sector. The growing adoption of automation and digitalisation is reshaping the operational roles of seafarers aboard merchant vessels, as well as the competence requirements for various functions.

The regulations governing competence accreditation will need to be reviewed in order to prepare the future seafaring workforce. Additionally, players in the maritime industry will need to evaluate the potential and difficulties that digital technologies provide. Information and communication technology (ICT)-enabled innovative learning solutions have the ability to make learning accessible and distributed. However, the abilities of instructors and students in the maritime field will be crucial to the effective acceptance and integration of new technologies.

1.2 TEACHING WITH TECHNOLOGY IN GENERAL

The shift toward digitalisation has transformed education and workforce training, emphasising shorter, targeted learning, and innovation hubs. Maritime institutions and universities are playing a key role in preparing students to develop and apply cutting-edge technologies. This shift requires new skill sets not only for learners but also for educators (Sivkov 2022).

The rapid adoption of digitalisation, AI, and robotics has significantly changed skill requirements, demanding a combination of strong digital, cognitive, and socioemotional skills. Skill shortages, particularly among the unemployed and low-skilled groups, are limiting productivity in Europe's most competitive industries (Narleva andand Gancheva 2023). Academia faces challenges in aligning curricula with Industry 4.0, highlighting the need for updated educational ecosystems, industrial partnerships, and programs to develop soft skills and technological competencies (Zeidan and Bishnoi 2020; Lutzkanova *et al*. 2022).

Emerging technologies like AI, robotics, and machine learning are creating demand for specialists, but formal training programs struggle to keep up with the pace of change, resulting in significant digital skill gaps. Industry 4.0 requires qualified professionals to manage high-tech systems and analyse data effectively (Hernandez-de-Menendez *et al.* 2020).

Governments, businesses, and educational institutions must collaborate to provide diverse opportunities for developing digital skills, adopting a holistic approach to nurture talent and support technological advancement (Stefanova and Kanev 2022).

Academics consider the use of digital tools by exploring how digital resources such as computers and the Internet can accelerate learning, improve and democratise access to education, and enable interactivity and collaboration over years (Selwyn 2007). Technology is an important tool used to enhance teaching and learning activities, thus ensuring accessible education for all. This gives students an opportunity to access educational services and resources at any time and to work through content at their own pace (Turugare and Rudhumbu 2020). Studies show that ICT gives “voice to the voiceless” (Guidi 2003).

This refers to the actual diversity and inclusion requirements in higher education, particularly when it comes to South African. Digital technology holds promise in its ability to transform marginalized communication consumers into engaged creators (Shaw 2012). Additionally, ICTs have fostered advocacy, social involvement, and empowerment (Makrakis 2012) and enabled the transmission of information across generations (Chikonzo 2006).

Additionally, according to Makrakis and Kostoulas-Makrakis (2012), an ICT-enabled problem-based learning (PBL) process enables teachers and students to gain a thorough grasp of the content domain learning, enhance their problem-definition and problem-solving abilities, and reflect on their own knowledge, learning, and practices.

1.3 TEACHING WITH TECHNOLOGY IN MARITIME

There is more to the digitalization of maritime universities than just software and hardware. It primarily involves the design, implementation, and management of an innovative educational environment, using specific tools and resources. The aim of any transformation, including digitalisation, is to optimise the educational process in terms of time, costs, profitability, and contributions. These contributions should be explored across three key areas: learners, universities, and society. Digitalization in marine education should prioritize the following resources:

Creating Hubs for Maritime Innovation: Maritime universities should collaborate with industrial partners to create innovation hubs. These hubs unite students, professionals, companies, NGOs, governments, and other stakeholders, fostering opportunities for joint development and collaboration. This strategy encourages open innovation and the development of ecosystems that facilitate information exchange and professional mobility. In addition to enhancing port infrastructure and logistics, these hubs can aid in the development of innovative technical solutions (Dimitrakieva et al. 2022).

- **Using New Technologies and Simulators:** Simulators are essential for maritime education to develop seafarer competencies. Emerging multimedia technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) offer new opportunities for simulation. These technologies improve operations on land and at sea by offering training that is more accessible, immersive, and less expensive than traditional methods (Mallam et al. 2019).
- **Sustainable Cooperation between Maritime Universities and the Industry**: Collaboration between universities and the maritime industry is essential for regional economic development, human capital creation, and knowledge transfer. This collaboration, which could include staff exchanges, research projects, alliances, consortia, and direct communication between academics and business executives, improves sustainability in maritime education.
- Overcoming challenges like funding access, differing views, and organizational differences is crucial for a successful partnership (Michel-Schneider 2021). Public institutions also play a key role in supporting academic research, skills development, and attracting new talent to the maritime sector.
- **Enhancing Human Resource Skills and Abilities**: Human resources are critical in any transformation, especially in digitalisation. Training and

developing staff for the implementation of digitalisation initiatives is essential for optimising processes and increasing efficiency. By automating processes, universities can enhance their operations with the same number of employees, thus improving the quality and number of trainees. Continuous upskilling of all participants, including trainers, is necessary to support this transformation and improve overall educational outcomes (Narleva and Gancheva 2023).

Furthermore, teaching and learning with technology can be enhanced through Virtual Exchange (VE). Virtual Exchange is a cross-cultural and cross-disciplinary pedagogical approach among different higher education institutions. Jahnke (2020), claims that lecture-based learning should be replaced by an action-based theme.

Lecturers should rethink their courses, moving from lecture-based to technology-based learning, where students collaborate to develop new solutions. An example of this is a group of history students who created an app to virtually showcase the history of the Berlin Wall.

Bartsch *et al*. (2021) characterise digital storytelling as an inquiry-driven learning approach and a "lingua franca" model within virtual exchange projects that tackle real-world global challenges. Similar to this, Ganassin et al. (2021) looked at the process of establishing partnerships with particular power dynamics among learner groups, techno-political challenges, and a shared understanding of realities. The generalisability of VE across fields and its sustainability in granting all students more access to international experiences is highlighted by Commande et al. (2021). For example, Oswel *et al.* (2021) consider virtual team projects with accessibility in mind for students with disabilities in cross-cultural collaborations.
Despite there being a plethora of literature on teaching and learning with technology, very little preliminary research on the use of digital technologies and multimodal educational techniques in MHET has been conducted in poor nations.

The approach that inspired our methodological approach is based on studies conducted in sub-Saharan Africa (Sabia *et al.* 2016) and in Montenegro in Southeast Europe (Bauk 2017). Consequently, the aim of this study is to enrich the level of knowledge in the domain of digitalisation in higher education in South Africa, with focus on the MHETs. The next chapter will discuss the details of the study.

CHAPTER 2 - STUDY OVERVIEW

2.1 RESEARCH PROBLEM AND OBJECTIVES

Modern seafarers require ODL education and training due to the ever-evolving, technology-driven, and complex nature of their work and environment. The internet provides one of the most adaptable methods for gaining and sharing new knowledge (Masuku, 2021). ODL initiatives lower educational costs and increase accessibility, particularly for underserved populations like the elderly, people with impairments, and those living in remote rural regions (Bauk, 2019; Nalupa, 2022; Demirel, 2022). The integration of Online Distance Learning (ODL) in Maritime Higher Education and Training (MHET) is encouraged by the STCW Convention. However, South Africa's MHET legislation needs to be updated to properly recognize and implement these standards, facilitating the faster integration of technology-based learning alongside traditional approaches (Masuku, 2021).

As a first step towards achieving this goal, the study examines a group of lecturers from various selected MHET institutions in South Africa. Specifically, it investigates if these instructors are knowledgeable of the typical advantages and disadvantages of cutting-edge technology-based approaches to enrichment and information transfer.

The study also assesses the educators' readiness to implement and adopt Blended Learning (BL), Online Distance Learning (ODL), and Virtual Engagement (VE) approaches. In South Africa and other developing nations with comparable political, sociocultural, and economic circumstances, answering these concerns marks an important turning point in the introduction, adoption, and institutionalization of BL, ODL, and VE in MHET institutions.

The expansion of Collaborative Online International Learning (COIL) or Virtual Engagement/Exchange (VE) could be further facilitated by the creation of ODL courses at MHET colleges, which are already in place at some MHET institutions in South Africa, particularly at the Durban University of Technology's Maritime Studies Department (Bauk 2017; Bauk 2019; Bauk and Fajardo 2020; Bauk and Gasparini Fernandez 2021). These programs currently supplement traditional face-to-face (F2F) on-campus education but have not yet been established as formal or official methods for acquiring new knowledge.

Students who will be mariners in the future need education that integrates new technologies and appropriately recognizes their acquired knowledge and abilities. Therefore, the purpose of this study is to help establish accredited ODL study programs in South Africa.

Regarding the newest changes in MHET, the afore described problem can be summarised 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.*

Thus, the **objectives** of the study are to determine:

[RO1] To identify the prerogatives for implementing BL, ODL, and VE into MHET;

[RO2] To come up with optimal combinations of well-established pedagogical theories and modern educational digital tools;

[RO3] To identify opportunities, challenges, and prospective advances of BL, ODL, and VE in MHET;

[RO4] To identify impediments affecting BL, ODL and VE implementation at higher extent into MHET programmes.

All of the above applies to the selected and considered South African MHET institutions: Durban University of Technology (DUT), Cape Peninsula University of Technology (CPUT), Nelson Mandela University (NMU), and Umfolozi Maritime Academy (UMA).

In an attempt to further clarify the issue in hand, the following **research questions** are formulated:

1. What are the preconditions for successful implementation of contemporary digital aids at South Africa MHET institutions by means of BL, ODL, and VE programmes?
2. How can well-established pedagogical theories, approaches and methods be merged with advanced digital tools to realise the MHET curricula through applicable practical examples / case studies from pedagogical practice?
3. What are the benefits and challenges of VE in MHET in general and in a South African context?
4. What are the impediments, which affect ODL official programmes accreditation at the selected South African MHET institutions?

These research questions specify what we intend to establish through this study. They translate the problems underlying the successful implementation BL, ODL, and VE across South African MHET institutions, into a specific need for data and information collection, coding, analysing, and adequate presentation. For further clarification of the problem, the problem statement, together with the objectives and research questions, are oultined in Table 2.1.

Table 2. 1 Problem statement, objectives and research questions

Problem Statement		
	Research Objective	**Research Question**
The MHET sector has many challenges. Digital tools are a powerful agent 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 competences 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;	1, What are the preconditions for successful implementation of BL, ODL, and VE at the MHET institutions?
	To come up with the optimal combinations of well-established pedagogical theories and modern educational digital tools;	2, In which ways well-established pedagogical theories, approaches, and methods can be merged with advanced digital tools in MHET?
	• To identify opportunities, challenges, and prospective advances of BL, ODL, and VE in MHET;	3, What are the benefits, challenges and prospective advantages of BL, ODL, and VE in MHET?
	• To identify impediments affecting BL, ODL and VE implementation into higher extent into MHET programs.	4, What are the impediments, which affect DL, ODL, and VE implementation at the MHET institutions?

Source: Researcher.

2.2 SIGNIFICANCE OF THE STUDY

This study is vital for modernising education through innovative teaching methods like e-learning and virtual simulations. It addresses industry demands by aligning with global standards and equipping graduates with skills for the Fourth Industrial Revolution (4IR). The research informs policies and strategies for modernisation, empowers the workforce to remain globally competitive, and promotes inclusivity by overcoming barriers to education.

Additionally, it contributes to academic knowledge, fosters sustainability, and enhances South Africa’s competitiveness in the maritime sector.

2.3 RESEARCH METHODOLOGY OVERVIEW

A sequential explanatory mixed-method research (MMR) design is used in this investigation. This method allows the qualitative phase to build upon and expand upon the quantitative phase's findings by doing the later phase after the quantitative phase.

The research design, methodology, data collection, and theoretical grounding were all aligned within a solid theoretical framework. Teaching with technology in higher education is often underpinned by specialised theoretical models (Bond *et al*. 2020), which serve as catalysts for transformative change in maritime education. These frameworks guide advancements in pedagogy and technology, particularly in the context of digital transformation (Omarsaib 2022).

A mixed-method approach, specifically an explanatory sequential design, was chosen as the most suitable methodology for addressing the research problem, critical questions, and objectives. Mixed-method research is especially effective in combining multiple approaches to enhance the relevance and depth of a study (Ngulube 2019).

By incorporating both quantitative and qualitative methods, this design provides a critical lens for examining the research questions and problems, making it well-suited to this study's context.

To explore the digital transformation of South African MHET, the researcher uses mixed method approache. The quantitative phase involved collecting numerical or measurable data, while the qualitative phase focused on gathering textual or verbal insights (Bertram and Christiansen 2020).

Specifically, a survey questionnaire was administered to maritime lecturers in South Africa as part of the quantitative phase. This survey method was appropriate for achieving the study's objectives, including reflection, exploration, integration, and resolution of issues related to digital transformation in maritime higher education and training. Furthermore, the mixed-method approach, utilising survey and semi-structured interviews, provided a practical and effective way for the researcher to gather insights from maritime lecturers in South Africa as they navigate the transition to a digital environment within higher education institutions.

Furthermore, survey results are essential for identifying important issues pertaining to the viewpoints and experiences of academic lecturers in the context of marine higher education in South Africa. These observations offer helpful guidance for dealing with the sector's prospects and problems.

2.4 LIMITATIONS OF THE STUDY

Research studies often face constraints related to time and financial resources, as well as challenges in securing sufficient respondents. Regarding the limitations of this study, it primarily employed descriptive and exploratory approaches. Given the fact that there are only four Maritime Universities in South Africa the research was centred on a case study with a relatively small sample size, consisting of a few individuals working in the maritime institutions in South Africa who served as the primary data sources.

A cross-sectional study was carried out as a one-time event. Future studies in this field ought to take into consideration adopting longitudinal studies with larger and more diverse samples, including participants from various organisational levels across different maritime businesses and administrative bodies in South Africa and beyond.

Rather than relying solely on descriptive and exploratory methods, future studies could utilise causal approaches, combining quantitative and qualitative techniques to test hypotheses and establish causal relationships between variables related to the adoption of new technologies.

Despite these limitations, this study made a concerted effort to collect, contextualise, analyse, and present findings in a manner that is both relevant and useful for researchers, maritime institutions and maritime professionals. It serves as a valuable foundation for future research in this field.

2.5 RESEARCH OUTPUTS (PUBLISHED PAPERS)

This research study led to the publication of multiple scholarly works, including journal articles, a book chapter, and conference papers. These publications are provided as annexures and listed in the bibliography. A comprehensive list of outputs from this project follows:

2.5.1 Book Chapter:

1. Masuku, M.B. (2021). Enhancing Maritime Education Through Online Distance Learning in Developing Environments: Case Study of South Africa. In: Bauk, S., Ilčev, S.D. (eds) The 1st International Conference on Maritime Education and Development. Springer, Cham. https://doi.org/10.1007/978-3-030-64088-0_13.

2.5.2 Journal Papers:

2. **Masuku M.B.**, Bauk S., Enhancing Maritime Higher Eucation through Technology in a Developing Context, International Journal of Learning, Teaching and Educational Research, Vol. 24, No. 3, March 2025: 75-93. https://doi.org/10.26803/ijlter.24.3.4

3. Bauk S., Masuku M.B. 2022 On adopting e-learning in maritime higher education in South Africa, *High Technology Letters*, 28(5): 98-113. Link

4. Bauk S., **Masuku M.B.** 2022. Concerning international virtual exchange at the MHE institution in South Africa. *High Technology Letters*, 28(6): 462-478. Link

5. Bauk S., **Masuku M.B.** and Khumalo N. 2022 Enhancing virtual simulator training at MHET institutions. *High Technology Letters*, 28(7): 733-743. Link

2.5.3 Conference Paper:

6. **Masuku M.B.** and Bauk S. 2024. Enhancing maritime education and training through virtual collaborative learning environment. In: *Proceedings of the 16th International Conference on Information Technologies for e-Education (ITeO),* Banja Luka, Republic of Srpska, 27-28 September 2024, 19−26. Link

2.6 PRESENTATION OF CHAPTERS

This study is divided into seven chapters, organized in the following manner.

Chapter 1: Research Overview and Context

An outline of MHET's digital transformation and the study's history are given in this chapter.

Chapter 2: Overview of the Study

The study's emphasis is described in this chapter along with the primary research questions, justification, and a breakdown of the problem, goals, importance, and scope of the study. It highlights how technology may improve maritime education while addressing the difficulties in implementing digital technologies. Along with outlining the study's anticipated contributions, the chapter also offers a research path.

Chapter 3: Literature Review

A thorough analysis of pertinent literature is provided in this chapter. It highlights the advantages and disadvantages of the models and ideas of blended learning (BL), open and distance learning (ODL), and virtual education (VE) that are now in use in MHET institutions across several nations.

A critical review of existing research on digital transformation, maritime education, and relevant pedagogical models follows. The chapter also discusses global trends, case studies, and best practices related to the adoption of digital learning in higher education.

Chapter 4: Theoretical Framework

The theoretical frameworks used in the study are presented in this chapter. It examines several models used in technology-based instruction, including the Unified Theory of Acceptance and Use of Technology (UTAUT), the Technology Acceptance Model (TAM) and the Revised Technology Acceptance (RTA) and Extended Technology Acceptance Model (TAM2). These frameworks are examined in the context of digital adoption in maritime education and training, particularly for blended and online learning.

Chapter 5: Research Methodology

The research design, data collection procedures, and analysis strategies employed in the study are described in Chapter 5. It describes the qualitative and quantitative methods used to evaluate MHET's digital transformation. The research was conducted using a mixed-methods technique.

Chapter 6: Results and Discussion

In this chapter, the findings from data collection are presented, analysed, and interpreted. Key themes, challenges, and opportunities related to digital transformation in MHET institutions are discussed.

Chapter 7: Findings, Recommendations, and Conclusion

This chapter presents the conclusions drawn from the analysis of the data. A summary of the major findings, including insights into challenges related to digital adoption, faculty readiness, and infrastructure, is provided. Strategic recommendations for policymakers, educators, and industry stakeholders are also included. The chapter reflects on the overall contributions of the study, its limitations, and suggestions for future research. It reaffirms the importance of digital transformation in MHET and proposes paths for ongoing improvement, concluding with a summary of the findings.

2.7 SUMMARY

An outline of the study's context and research problem was provided in the introductory chapter. It introduced the problem statement and described the goals of the investigation, emphasizing their importance. Along with the anticipated research results and the thesis format, the chapter also included a summary of the study's constraints and scope. The literature review is covered in detail in the next chapter.

CHAPTER 3 - LITERATURE REVIEW

3.1. INTRODUCTION

This research aims to enhance the quality of MHET in South Africa by integrating innovative technology into teaching and learning (Masuku 2021). It includes the promotion of student-cented learning, internationalisation, problem-solving, digital literacy, communication, and critical thinking skills. It also focuses on equipping students with essential skills such as decision making, self-management, and flexibility (Bauk 2022).

Digital tools can democratise access to education and enable interactive learning, offering benefits like increased accessibility, and the empowerment of marginalised groups. The integration of ICT promotes social participation and intergenerational knowledge transfer, fostering an environment conducive to lifelong learning and professional development (Makrakis 2012).

The universities must adapt to the evolving educational landscape by improving organisational systems, embracing multimodal learning, and providing specialised courses that meet industry demands. They should aim to balance teaching, research, and community support, despite decreasing governmental support (Turugare and Rudhumbu 2020).

For effective technology integration, lecturers need to understand how to use digital technology to enhance learning and adapt their teaching strategies accordingly. Therefore, frameworks like Cultural Historical Activity Theory (CHAT); Substitution, Augmentation, Modification, and Redefinition (SAMR); Teaching Change Frame (TCF); and Change Laboratories (CL) can provide structured approaches for integrating technology into education (Nair and Chuan 2021).

These theories are introduced here within the context of Bloom’s taxonomy, which outlines cognitive progression through the learning process and its objectives (Chen *et al*. 2021).

3.1.1. Bloom’s taxonomy

Learning with digital technologies is an experience that leads to lasting behaviour change, resulting in propositional (knowing that) and procedural (knowing how) knowledge. Bloom's taxonomy describes the cognitive domain, which includes knowledge, comprehension, application, analysis, evaluation, and synthesis. It advances from simple recollection to higher-order thinking.

Objectivism sees knowledge as independent and transmittable, while constructivism sees it as constructed through experience and interaction. The rapid expansion of human knowledge necessitates careful curriculum content selection based on societal needs.

Bloom's taxonomy provides a framework for understanding and categorising learning objectives and outcomes, guiding the development of digital learning resources and assessment strategies.

Digital platforms and resources facilitate the storage and retrieval of maritime knowledge, allowing students to recall facts, procedures, and concepts (Mukherjee *et al.,* 2019), whereas interactive multimedia materials and virtual simulations help

students to comprehend complex maritime concepts and principles, fostering deeper understanding (Lee *et al.* 2020).

As noted by Chen (2021), online case studies and scenario-based exercises offer students the chance to apply theoretical knowledge to real-world maritime contexts (Chen et al. 2021). Moreover, digital tools allow students to analyse maritime data, trends, and scenarios, fostering critical thinking and problem-solving abilities (Jiang et al. 2018). Additionally, online assessments and peer feedback systems enable students to assess both their own learning progress and that of their peers, encouraging self-assessment and reflection (Shin and Kim 2017).

Anderson and Dron (2011) discussed the evolution of distance education pedagogy from cognitive behaviourist to constructivist and connectivism, noting each theory’s strengths and weaknesses. They concluded that these theories are complementary, suitable for different subjects, and guide the use of digital technologies. Meaningful learning with digital technologies is active, intentional, authentic, cooperative, and constructive. Lastly, activity theory helps to design constructivist learning environments using digital tools, focusing on interactions to achieve learning outcomes.

The above-mentioned theories are well-established and have a wealth of theoretical and practical context, but it is important to remember that we live in the digital age and that we must look for fresh, cutting-edge approaches to teaching and learning in the maritime industry as well as in general. As a result, virtual exchange (VE) as a cutting-edge pedagogical strategy should be considered as well.

Jahnke (2020) argues that action-based learning should replace lecture-based methods. He supports this argument with an example where a group of history students developed an app that virtually showcased the history of the (former) Berlin Wall. This example demonstrates how educators can redesign courses to shift from lecture-based learning to technology-enhanced learning, where students work together and create innovative solutions through collaboration.

Bartsch et al. (2021) highlight digital storytelling as an inquiry-driven learning approach and a "lingua franca" model for VE projects that address current global challenges. Ganassin et al. (2021) examined the importance of establishing partnerships with a shared understanding of realities, power dynamics within learner groups, and techno-political challenges. Commander et al. (2021) emphasize the wide applicability of VE across various disciplines and its potential for offering broader international experiences to all students. Oswel, Palmer, and Koris (2021) explore virtual team projects for students with disabilities in cross-cultural collaborations.

In the South African context, the adoption of multimodal e-learning is growing but faces challenges due to disparities caused by poverty and historical disadvantages. Effective implementation of digital education can transform both the educational sector and broader society, making learning more accessible for diverse learners (Masuku 2021).

The approach proposed in this study was inspired by studies carried out in the developing environments like sub-Saharan Africa (Sabia *et al.* 2016) and Montenegro (Bauk 2017). The goal of this study is to enhance the understanding of digitalisation in higher education in South Africa, specifically within the MHET sector.

3.1.2. Cultural-Historical Activity Theory (CHAT)

One theoretical paradigm is the Cultural-Historical Activity Theory (CHAT) which explores how human activities are socially and culturally mediated. The CHAT focuses on understanding the systemic and developmental aspects of human practices and learning processes. It can be understood as a socially embedded approach to teaching that aims to transform thinking or enhance learners' cognitive abilities. Furthermore, it also serves as an analytical tool to evaluate classroom challenges and ensure meaningful technological integration. The targeted learning goals and objectives must be in line with emerging technologies.

Furthermore, learners, mentors, technology, pedagogical ideals, role identities, and cultural norms all work together as interrelated parts of a single activity system in the socio-technical environment, as provided by CHAT (Wiser et al. 2018). CHAT is especially well-suited for comprehending how sailors learn in the fast-paced, technologically advanced setting of a ship. The goal of the recent increase in ship automation and digitization is to improve marine efficiency and safety. However, because seafarers are overburdened by the intricacy of automated systems and new technology, they continue to fail to identify and react quickly to growing threats, which leads to maritime mishaps and accidents.

The significant shifts in shipboard work environments, along with the need for seafarers to interact with advanced tools, demand a new perspective on cognitive and learning processes, as well as on situated actions aboard ships.

A theoretical framework that offers a comprehensive, socio-technical viewpoint on the interrelated components of a collective shipboard learning system is provided by activity theory. Contradictions may arise from misalignments between these components or between the onboard system and other relevant activity systems. Producing capable sailors who can safely run today's increasingly digitalized vessels requires resolving these inconsistencies (Saratkumar et al., 2023).

During classroom participation, students can participate in a simulated navigation exercise. where they must plan and execute a voyage using digital navigation tools. The simulation includes real-time feedback and scenarios such as weather changes or equipment failures, for example, when the instructor trains seafarers on advanced navigational skills using an electronic chart display and information system (ECDIS) (see Table 3.1). Throughout the training, ECDIS is integrated meaningfully, as a technological tool, with the learning objectives at each level of Bloom's taxonomy.

The CHAT provides a framework to understand the interactions among learners, tools, and the community, ensuring that technological integration supports the cognitive development goals effectively. The CHAT theory can be described as a socially situated pedagogy used to create shifts in thinking or to uplift learner’s cognitive level. It can be also described as an analytical lens to assess challenges in the classroom when the objective is to make technological integration meaningful. Stated differently, learning goals and objectives must be in line with the tools, including developing technology.

Table 3. 1 Bloom's taxonomy and CHAT at an ECDIS lesson.

Bloom's taxonomy	Activity	Outcome
Remembering	Introduction to ECDIS interface and functions through lectures and manuals.	Students can recall ECDIS functions and interface components.
Understanding	Group discussions and QandA sessions on ECDIS functionalities and their importance in navigation	Students understand how ECDIS functions support safe navigation.
Application	Hands-on practice with ECDIS simulators, plotting courses, and setting waypoints.	Students can operate ECDIS to plot courses and set waypoints
Analysis	Scenario-based exercises where learners analyse different navigational scenarios using ECDIS	Students can analyse navigational data and scenarios using ECDIS.
Creating	Group projects where learners design navigation plans for complex voyages using ECDIS.	Students can create comprehensive navigation plans using ECDIS.
Evaluation	Critical review and discussion of the created navigation plans, identifying potential improvements	Students can evaluate and refine their navigation plans using feedback

Source: Researcher.

3.1.3. Substitution Augmentation Modification Redefinition (SAMR)

A framework for integrating technology into teaching and learning is offered by the Substitution Augmentation Modification Redefinition (SAMR) model. The SAMR model has been utilized by educators to address pedagogical shifts when introducing learning technologies to students. Specifically, the SAMR framework is widely recognized for exploring the innovative use of technology to transform learning experiences (Nair and Chuan 2021).

Additionally, this model promotes digital transformation in pedagogy by offering an organized method for assessing and improving the use of technology in the classroom. With or without functional enhancements, technology functions as a direct tool substitute at the most fundamental levels.

Studies show that substitution primarily focuses on enhancing traditional teaching methods. Digital tools could replace paper-based resources, providing students with more accessible and engaging learning materials. Augmentation, which includes functional improvements, allows for more interactive and dynamic content, such as multimedia presentations and digital assessments, thereby increasing student engagement and understanding (Hamilton *et al*. 2016).

The higher levels, of modification and redefinition, signify a transformative impact on pedagogy. Modification involves significant task redesign. Research by Romrell *et al*. (2014) highlights how technology can fundamentally change classroom activities, enabling collaborative projects and real-time feedback mechanisms. Redefinition makes it possible to create activities that were previously unthinkable.

This level of integration supports innovative teaching strategies, such as flipped classrooms and virtual field trips, which can lead to deeper learning and critical thinking skills.Numerous studies have shown the positive effects of SAMR-based digital integration on student outcomes.

According to a Hilton (2016) study, students' motivation, engagement, and achievement can be increased by the smart use of technology at the modification and redefinition stages. Moreover, integrating technology effectively can support differentiated instruction, catering to diverse learning needs and promoting inclusivity (Blundell *et al*. 2020).

Although the SAMR paradigm offers a useful foundation for digital transformation, its implementation is not without challenges. Teachers often require professional development and ongoing support to integrate technology effectively (Hughes 2005).

To fully exploit the promise of digital transformation in pedagogy, it is also necessary to solve technological challenges, lack of resources, and reluctance to change (Kirkland and Sutch 2009).

The SAMR model and Bloom's taxonomy both provide hierarchical frameworks for enhancing teaching and learning processes, with SAMR focused on integrating technology and Bloom's taxonomy on cognitive skills such as remembering, understanding, applying, evaluating, .and creating. SAMR relies on technology to enhance learning, while Bloom's taxonomy does not depend on an online environment. The SAMR aligns with Bloom's stages, facilitating a cognitive progression like Bloom's hierarchical structure (Muktiarni 2021).

Bloom's taxonomy is criticized, meanwhile, for lacking flexibility and adaptability in blended and online learning settings (Johnston et al. 2021). It represents cognitive processes as distinct phases and is conventionally linear and hierarchical, making it appropriate for in-person training.

This ranked approach can imply that some stages are more important or difficult than others, which may not align with modern, flexible pedagogical approaches.

Figure 3.1 illustrates the relationship between SAMR and Bloom's taxonomy model. The first level of the SAMR model is substitution, aligning with the remembering and understanding stages of Bloom's taxonomy. The augmentation level and applying stage are comparable in their teaching and learning methods. Next is the modification level in the SAMR model, which corresponds to the analysing stage in Bloom's taxonomy. Finally, the redefinition level of SAMR relates to the evaluating and creating stages of Bloom's taxonomy (Omarsaib 2022).

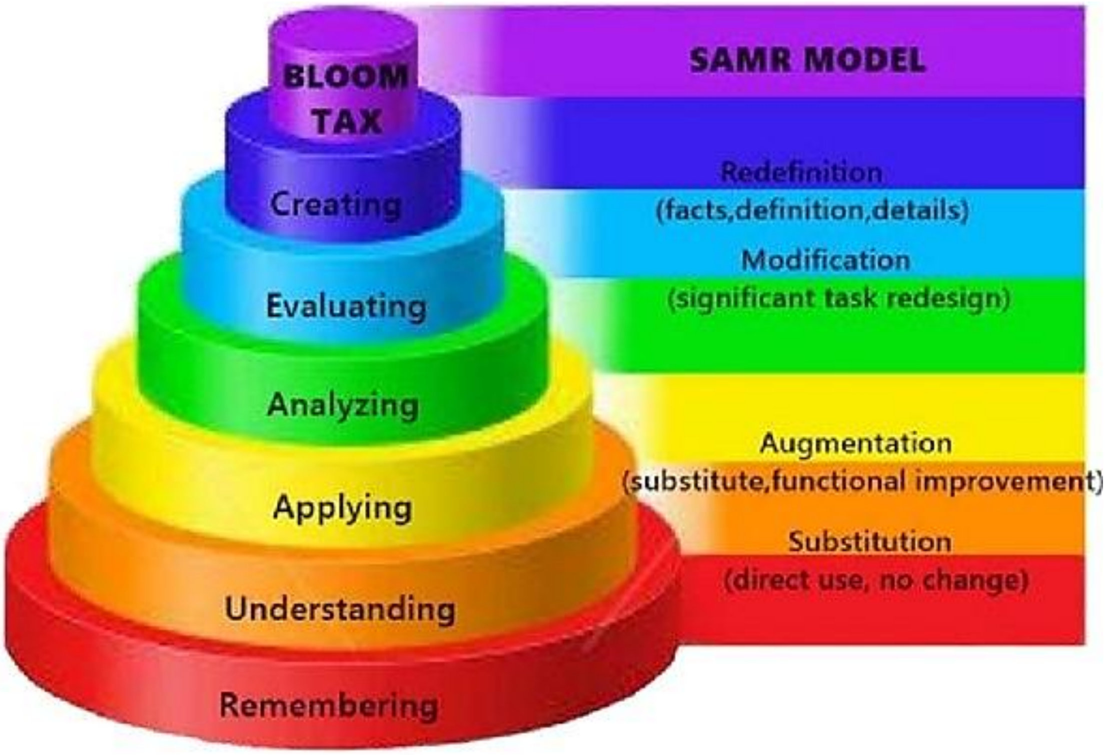


Figure 3.1: The SAMR and Bloom's taxonomy

Source: Nair and Chuan 2021.

The third level of redefinition in the SAMR paradigm integrates all three knowledge a reas: content, pedagogy, and technology, to redefine the job.Students have to asses s their results and show them to others (Chuan and Nair 2021).

Notably, the SAMR model provides an organized framework for incorporating technol ogy into the classroom, improving conventional teaching techniques, and changing e ducational experiences.

By moving through the stages of substitution, augmentation, modification, and redefi nition, educators can effectively employ technology to improve student results and pr omote a more engaging and inclusive learning environment.

3.1.4. Teaching Change Frame (TCF)

A teaching strategy called the Teaching Change Frame (TCF) was created to facilitate organisational and educational change by fostering reflective practices and collaborative learning.

The TCF creates a change process pathway to bring about the desired change by

mapping teachers' current pedagogies and rising technology uses. Thus, in addition to identifying teaching methodologies, TCF offers other avenues for ensuring long-lasting educational transformation (Tarling and Ng’ambi 2016; Turugare and Rudhumbu 2020).

The TCF is grounded in the principles of reflective practice and collaborative learning. It emphasises the role of educators as facilitators who guide learners through a process of critical reflection, dialogue, and problem-solving (Brookfield 2017). The TCF aims to create a learning environment where participants can question existing practices, identify areas for improvement, and co-construct new knowledge and skills (Mezirow 2000). This approach is especially applicable in domains like maritime education, where the dynamic nature of the industry necessitates continuous adaptation and innovation. Maritime education is characterised by its emphasis on practical skills, safety, and adherence to international standards. The TCF provides a structured approach to integrating these elements into the curriculum through reflective and collaborative processes.

The TCF encourages students to engage in reflective practice, where they critically analyse their experiences and identify areas for improvement. In maritime education, this approach can be used to enhance practical skills by encouraging students to reflect on their hands-on training and simulations. A study by Selleberg et al. (2023) demonstrated how TCF facilitated reflective discussions among maritime students, leading to improved problem-solving skills and greater confidence in practical applications.

Safety is a paramount concern in maritime education. The TCF promotes a culture of safety by encouraging students and instructors to collaboratively identify potential hazards and develop strategies to mitigate them. Through reflective discussions and case studies, students learn to anticipate and respond to safety challenges. According to a case study by Lappalainen et al. (2014), TCF assisted maritime students in adopting a proactive safety management strategy that decreased mishaps and near-misses. The maritime industry operates under strict international standards and regulations. The TCF provides a framework for integrating these standards into the curriculum through collaborative learning and reflective practices. By engaging in discussions about regulatory requirements and best practices, Students have a deeper comprehension of their importance and learn how to apply them in real-world scenarios. Kontio and Lützhöft (2020) found that TCF helped maritime educators effectively integrate International Maritime Organization (IMO) standards into their teaching, resulting in better-prepared graduates.

The TCF offers a valuable pedagogical approach for addressing the unique challenges of maritime education. By fostering reflective practice, collaborative learning, and a culture of safety, TCF can significantly enhance the quality and effectiveness of maritime training programs. The empirical evidence supports the efficacy of TCF in developing practical skills, promoting safety, and integrating international standards, thereby preparing students to fulfil the requirements of the maritime sector.

3.1.5. Change Laboratory (CL)

The principle of expanded learning serves as the foundation for the Change Laboratory (CL), a participatory work development approach. It promotes transformative agency, which is predicated on the notion that a lecturer's mission extends beyond merely imparting knowledge. This theory investigates the role that transformational agency plays in group learning and growth (Kajamaa and Hyrkkö 2022).

The CL is grounded in the principles of CHAT, which emphasises the systemic and mediated nature of human activity (Engeström 1987). The CL interventions typically involve a series of workshops where participants collaboratively analyse their work activities, identify contradictions, and develop new models of practice. The process is iterative and dialectical, fostering expansive learning — a type of learning that transcends existing knowledge boundaries and leads to the transformation of activity systems (Engeström and Sannino 2010).

Maritime education faces unique challenges, including the need for rigorous safety standards, technological advancements, and evolving regulatory requirements.

Traditional pedagogical methods often fall short in addressing these multifaceted demands. The CL provides a structured yet flexible approach to foster innovation and adaptation in maritime training programs. Maritime education must continuously adapt to stringent safety and regulatory standards. The CL interventions help educators and practitioners collaboratively identify gaps in training programmes and develop more effective safety protocols. For instance, a study by Harrington, (2024). demonstrated how CL workshops in maritime academies led to the development of enhanced simulation-based training modules that better address real-world scenarios and regulatory changes.

The maritime industry is increasingly reliant on advanced technologies such as automation and digital navigation systems. The CL enables educators to integrate these technologies into the curriculum effectively. By engaging in collective analysis and problem-solving, educators can redesign training modules to include hands-on experiences with new technologies, thus preparing undergraduates for the evolving demands of the maritime sector (Ahonen et al., 2014). Maritime operations are inherently collaborative, requiring effective communication and teamwork. The CL promotes a culture of collaborative learning where students and instructors work as a team to find solutions to challenging issues.

This approach mirrors the real-world environment of maritime operations, enhancing students' readiness for professional practice. A case study by Abeysiriwardhane, (2017) highlighted how CL interventions in maritime schools led to the development of team-based learning strategies that improved student engagement and learning outcomes.

It is worth noting that CL theory offers a strong foundation for addressing the multifaceted challenges of maritime education. By fostering collective reflection, problem-solving, and expansive learning, CL interventions can lead to significant improvements in safety protocols, technological integration, and collaborative learning practices. The empirical evidence supports the efficacy of CL in improving marine training programs' caliber and applicability while equipping students to handle the changing needs of the sector (see Table 3.2).

Table 3.2 illustrates how the activities within the frameworks of CL and TCF can be mapped onto the Bloom's taxonomy model, enhancing the learning process in maritime education. Each level of the Bloom's taxonomy model is addressed through specific activities that promote understanding, application, analysis, evaluation, and creation of knowledge in a structured manner.

Table 3. 2 The CL and TCF mapped onto Bloom's taxonomy.

Bloom's taxonomy level	CL activity	TCF activity	CL maritime example	TCF maritime example
Remember	Recall and document current practices	Reflect on previous lessons	List safety procedures	Recount navigation steps
Understand	Discuss principles and regulations	Collaborative discussions on key concepts	Explain safety protocols	Discuss navigation principles
Apply	Role-playing or simulations	Practical exercises	Practice emergency procedures	Navigate using simulators
Analyse	Analyse contradictions and identify improvements	Reflective practice sessions	Conduct a SWOT analysis of safety procedures	Review and identify errors in navigation exercises
Evaluate	Evaluate effectiveness through feedback	Group evaluations and peer assessments	Assess safety drill outcomes	Peer feedback on navigation strategies
Create	Co-design new models and innovative solutions	Projects to develop new approaches	Develop a comprehensive safety management plan	Design an innovative navigation training module

Source: Researcher.

3.2. DIGITAL TRANSFORMATION

The crucial process of using digital technology to develop new corporate cultures, customer experiences, and business procedures—or alter current ones—in order to adjust to changing market conditions is known as digital transformation (DT).

The DT in education involves the integration of digital technologies into teaching and learning processes, fundamentally changing how education is delivered and experienced. This transformation is driven by advancements in technology, changes in pedagogical theories, and the increasing demand for flexible, personalized learning experiences.

In addition, McCarthy et al. (2023) develop an article which discusses the concept of DT, often misunderstood as solely technological changes within large organizations. Tabrizi (2019) clarifies that DT is not primarily about technology but about supporting broader organizational change. Kane (2019) emphasises the importance of understanding the drivers of DT in education, such as the increasing need for remote learning platforms. Gobble (2018) defines digital transformation as the combined effects of digital innovations that change organizational structures and practices. Dehning et al. (2003), Jeansson andand Bredmar (2019) and Hess (2016), all describe DT as reshaping business models causing fundamental changes through digital technologies.

Online learning gained popularity more quickly as a result of the COVID-19 epidemic exposing inequities in access to technology, with 47% of students lacking internet access at home (Giannini 2020). This shift particularly affected students with disabilities (Di Pietro et al. 2020).

In 2019, the OECD, or Organization for Economic Cooperation and Development, addresses educational equity, noting that innovation has not consistently improved outcomes due to inequities in resource distribution. As a consequence, McCarthy *et al*. (2023) recommend studying factors such as infrastructure, school culture, and teacher competence, aligning with theories that consider the school system's complexity (Szekely and Manson 2018).

Methods of instruction and learning have been profoundly changed by the digital transition. Selwyn (2012) asserts that digital technologies present fresh chances for student participation, teamwork, and individualized instruction.
For instance, educational apps and learning management systems (LMS) offer platfo rms for dynamic and flexible learning.
In order to accommodate various learning preferences and styles, these tools allow t eachers to provide knowledge in a variety of formats, including games, simulations, a nd films (Johnson et al. 2016).

Additionally, DT makes it easier to use cutting-edge teaching strategies like flipped classrooms and blended learning. Online and in-person training are combined in blended learning, allowing for flexible learning environments. Flipped classrooms reverse the traditional teaching model, with students accessing instructional content online and engaging in interactive activities during class time. Research by Bergmann and Sams (2012) indicates that these approaches enhance student engagement, motivation and achievement. The DT in education has disadvantages despite its benefits. One important problem is the "digital divide," or the gap between people who have access to digital technologies and those who do not. This gap can exacerbate educational gaps, especially for students from disadvantaged families (Warschauer 2004). Ensuring equal access to technology and the internet is necessary to address this problem.

The requirement for instructors to get support and professional development presents another difficulty. Teachers must acquire new competencies and skills in order to integrate digital technologies effectively. For educators to effectively use technology and adjust to the evolving educational landscape, professional development programs and continuous assistance are crucial (Ertmer and Ottenbreit-Leftwich 2010).

New technologies such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI) extended reality (XR), and blockchain technology are anticipated to influence DT in education in the future. By analyzing student data and offering customized feedback and recommendations, artificial intelligence has promise for personalizing educational experiences (Luckin et al. 2016).

The VR, AR and XR can create immersive learning environments, enhancing experiential learning and engagement. Blockchain technology offers possibilities for secure and transparent administration, management, credentialing and assessment systems.

Moreover, the COVID-19 epidemic hastened the integration of digital tools in the classroom. The importance of DT was brought to light by the move to remote and hybrid learning methods and the need for resilient and adaptable educational systems. As institutions continue to navigate the post-pandemic landscape, DT will remain a critical focus for enhancing teaching and learning experiences.

3.3. DIGITAL TRANSFORMATION IN THE MARITIME SECTOR

Digital transformation in the maritime industry refers to the integration of digital technologies and innovative solutions to enhance efficiency, safety, and sustainability across various aspects of maritime operations. Technology breakthroughs are causing a major digital change in the nautical sector, altering market dynamics, and regulatory requirements (Tongzon and Luo, 2020). This transformation is revolutionising traditional maritime practices, leading to improvements in vessels, port operations, trade management, logistics, and global supply chains (Yang *et al.* 2019).

The maritime sector faces specific challenges, including a lack of awareness, inadequate strategies, and insufficient initiatives for successful DT. There's also a significant gap in comprehensive research on DT in this sector (Gausdal et al. 2018; Kapidani *et al.* 2020).

The main goal of digitalisation is to automate information processing, commercial activities, and processes. Digitalisation has had a major impact on the high-tech and public transportation sectors, while the maritime industry has so far been less affected.

In their study of the literature on the digitalization of maritime transportation, Sanchez-Gonzalez et al. (2019) identified eight major application domains: 3D printing, cloud computing, AI, Big Data, virtual/augmented reality, IoT, autonomous vehicles and robotics, and digital security.

Their study highlighted gaps in research, particularly in areas like AI integration and the use of robotics, emphasising the need for further exploration in these fields. In addition, there's noticeable growth in navigation systems digitalisation, such as e-navigation (PWC Norway 2017).

3.3.1. Smart ships and ports

The DT and emergence of cyber-physical systems were made possible by inventive solutions in maritime information and operational technology (OT). Information technology (IT) manages data and administrative tasks, whereas operations technology (OT) encompasses a wide variety of programmable controllers that enable the convergence of physical and cyber systems.

The integrated bridge system (IBS) and the ECDIS marked the beginning of significant digitisation in the shipping industry. Port community systems (PCS) and national single maritime windows (NSMW) were implemented in some seaports.

The real-time monitoring of ship performance, fuel usage, and cargo conditions is made possible by the use of IoT devices, sensors, and networking solutions (Wang et al. 2021). According to Parola et al. (2020), the incorporation of IoT in maritime operations improves fuel efficiency and predictive maintenance, which both increase total operational efficiency.

Key drivers include cost reduction, regulatory pressures, data processing needs, and business effectiveness. Specific to maritime transport are the needs to reduce information exchange costs, meet environmental regulations, and improve efficiency (Causdal 2018).

Digital technologies such as automated container terminals, blockchain-based platforms, and predictive analytics optimise port operations, reduce congestion, and improve efficiency (Notteboom and Yang 2020). Blockchain technology, enhances transparency and security in port logistics, streamlining documentation processes and reducing fraud (Ntshangase 2024).

Maritime blockchain integrates smart payment systems like 300Cubits, Ship-Chain, and Prime Shipping Foundation, utilising cryptocurrencies. Despite this potential, significant barriers hinder the widespread adoption of blockchain and smart contracts in validating shipments and payments in the maritime industry. Cybersecurity threats, exemplified by incidents like the Net-Petya ransomware attack on Maersk in 2017, pose substantial risks, with estimated losses reaching $300 million in bitcoins (Bauk and Ntshangase 2023).

In addition, blockchain is a technology crucial for maritime clusters, offering benefits like container tracking, logistics adjustments, risk management, and insurance. It records transactions in blocks forming a chain, creating a transparent ledger visible to all involved. Errors require new blocks, maintaining integrity. Multiple transactions result in multiple blocks, allowing all participants to track progress. This transparency is advantageous for logistics, accounting, and risk management (Kapidani *et al*. 2021).

Digital platforms and data analytics tools provide end-to-end visibility and transparency in supply chain operations, enhancing coordination and decision-making (Monios e*t al.* 2019). Advanced analytics enable stakeholders to anticipate disruptions and make informed decisions, thereby improving supply chain resilience (Heilig *et al.* 2017).

Innovations such as autonomous vessels, remote monitoring systems, and predictive maintenance algorithms contribute to improving safety standards and reducing maritime accidents (Acciaro *et al*. 2019). Autonomous shipping, supported by advanced navigation systems and AI, holds the potential to minimise human error and enhance safety at sea (Rødseth et al.2023). It is possible to develop maritime autonomous sea surface systems (MASSs) to be lighter, more fuel-efficient, less costly to run, and more wind-resistant and streamlined. However, the trend toward further development of MASSs is accompanied with a number of obstacles. Among these obstacles are:

- Human factors related to faults in programming and coding, errors in remote control, and ignorance of MASS response in certain crucial circumstances.
- Interaction with (un)manned vessels under situations of high traffic, including not being able to identify small objects.
- Interaction with physical environment at unfavourable weather conditions like strong wind and precipitation, heavy ice, and intense tidal effect system failures like operation systems or communication link dysfunctions or breakdowns.
- Cyberattacks manifested as a breakdown or failure of communication links with shore-based control centers, jamming or spoofing of global navigation satellite

system or automatic identification system (AIS) signals and data, or corrupting IT/OT structure onboard.

- Equipment failure, including sensor malfunction, power outage, loss of propulsion or rudder function, and malfunctioning IT system.
- Combinations of the above-mentioned risks.

Practitioners struggle with cyber threats and cyber-attacks, including the lack of mitigation measures when these attacks succeed. Cyber threats evolve fast, therefore, interim practices like encryption, firewalls, anti-virus programs, monitoring systems, regular audits, and backups should be in place. Cyber intentional (security) and non-intentional (safety) incidents can cause harms that go beyond ship and marine infrastructure, affecting marine ecosystems and human lives. Lastly, most insurance policies do not mention cyber-risks, while some explicitly exclude these from coverage. As a result, the process of developing autonomous vehicles will be difficult and take time.

3.3.2. Digitalisation benefits

Successful DT requires addressing both individual needs and the unpredictable external environment, making stakeholder collaboration vital. The education on the benefits and challenges of DT is crucial to overcome resistance from stakeholders and promote adoption of technologies like blockchain and autonomous shipping (Tijan *et al*. 2021).

Digitalisation streamlines processes, reduces manual tasks, and optimises resource utilization, leading to cost savings and operational efficiencies (Nguyen *et al.* 2020). For instance, digital twins in maritime operations allow for virtual modelling of vessels and ports, enabling efficient resource management and scenario planning (Lu *et al*. 2021).

By providing better services, cutting lead times, and promptly responding to market developments, businesses that embrace digital transformation obtain a competitive advantage (Lu et al. 2021). Early adopters of digital technologies can leverage data-driven insights to enhance customer satisfaction and achieve market differentiation (Sánchez-González *et al*. 2019).

Digital technologies enable better environmental monitoring, fuel efficiency optimisation, and emissions reduction, supporting the maritime industry's sustainability goals (Wan *et al.,* 2021). Green, or zero-emission shipping initiatives, facilitated by digital solutions, help in meeting international environmental regulations and reducing the carbon footprint of maritime operations (Zhang *et al*. 2022).

3.3.3. Digitalisation concerns

Adoption of digital technologies requires investment in infrastructure, cybersecurity measures, and employee training, which may pose challenges for some stakeholders (Yang *et al*. 2019). The initial cost of implementing digital solutions can be a significant barrier, especially for smaller maritime companies (Lim *et al*. 2020).

These barriers include high implementation costs, poor internet quality, aging decision-makers, overly technology-focused cultures, lack of investment, low modern technology levels, and risk aversion (Tijan *et al*. 2021).

Ensuring adherence to changing rules and guidelines related to data privacy, cybersecurity, and environmental protection is a critical consideration for DT initiatives (Tongzon and Luo, 2020). Therefore, maritime regulations are continually evolving, necessitating ongoing adaptation and compliance efforts (Pardali *et al*. 2021). In addition, DT often necessitates cultural shifts, organisational restructuring, and change management strategies to overcome resistance and foster innovation (Monios *et al.* 2019). Effective change management is crucial for ensuring employee buy-in and successful implementation of digital initiatives (Westergren and Holmström 2017).

3.3.4. Collaboration needs

Driving innovation, exchanging best practices, and tackling shared obstacles in digital transformation all depend on cooperation between industry stakeholders, technology suppliers, and regulatory agencies (Acciaro et al. 2019). Public-private partnerships can facilitate the development and adoption of digital solutions across the maritime sector (Perera and Sollid 2021).

To seize new opportunities and maintain its competitive edge in the digital era, the marine sector should use cutting-edge technologies including artificial intelligence (AI), machine learning (ML), and digital twins (Wang et al. 2021). Sustaining competitiveness and promoting long-term growth require constant investment in innovation and research and development (R&D) (Fritz and Schulze 2019).

Investing in digital literacy, skills training, and talent acquisition is crucial for building a workforce capable of leveraging digital technologies and driving future innovation in the maritime sector (Lu *et al*. 2021). Developing a digitally skilled workforce will enable maritime companies to maximise the benefits of digital transformation (Sousa and Rocha 2019).

3.4. MARITIME HIGHER EDUCATION AND TRAINING (MHET) IN DIGITAL AGE

Maritime industry and business are undergoing significant DT, impacting various aspects, including education and training. Digital technologies are reshaping teaching methodologies, curriculum design, and skill development in maritime higher education and training (MHET).

Multimodal platforms and virtual classrooms are increasingly being adopted in maritime education institutions (Smith *et al.* 2019). Simulation technologies offer realistic training environments for maritime students, enhancing their practical skills (Hegland *et al*. 2020). The V/A/X reality applications are revolutionising maritime training by providing immersive learning experiences (Jensen *et al*. 2021).

According to Alzahrani (2020), 3D visual representations can boost sense of touch reading skills by combining numeracy plans, helping students to quickly and effectively understand complex academic topics, especially in physics and chemistry. The V/A/X reality is beneficial in labs for presenting intangible concepts, increasing student engagement and comprehension. Lu *et al*. (2021) notes that AR aids visual analysis, helping students understand and solve real-world problems. Enzai *et al*. (2021) highlight that AR allows learners to interact with virtual objects, improving comprehension. Nesenbergs *et al*. (2020) found that AR is more effective for vocabulary acquisition than memorisation, as it reduces interruptions and transforms 2D images into engaging 3D objects (Elfeky and Elbvaly 2021). Figure 3.2 illustrates the basis of an AR system.

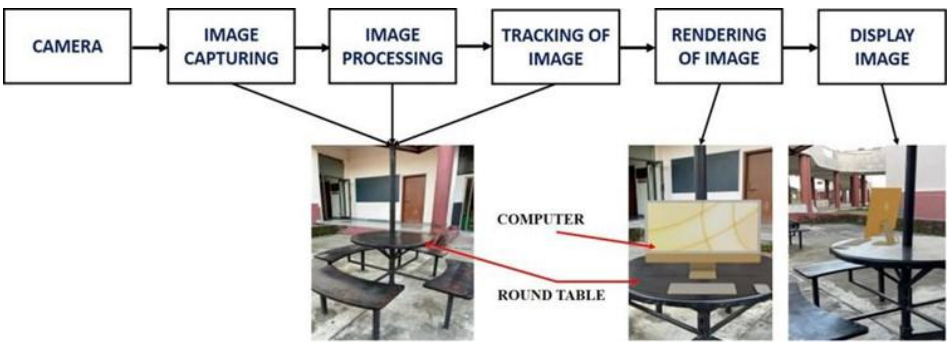


Figure 3. 1: Flow-diagram of an AR system

Source: Schmalstieg and Hollerer 2016.

The AR system uses a camera to scan the environment; process captured images and track the position of the virtual object or information. This can be done using markers or spatial mapping. Once finalised, the object is rendered at the selected position, displaying a 3D object.

Figure 3.3 shows a person using AR technology on a smartphone, highlighting that AR content can be accessed in various locations once a user engages with it. Using technology, AR blends the real world with a virtual one. AR creates a virtual environment through optics that enhances or annotates the real world, giving the user the impression that they are one.

A computer with real-time simulation capabilities that synchronises and uses a visual output display to map the simulation to the real world is usually included in the hardware for AR.

What is the process of optical communication? The foundation of optical communication is the use of light signals to transfer data through optical fibres. These signals, which are usually in the form of laser light pulses, have a high bandwidth and speed for carrying information over long distances (Lenovo 2024).

Figure 3. 2: Augmented reality display

Source: Lu *et al*. 2021.

Figure 3.4 depicts students' interaction while participating in a course who increasingly interact, thanks smart technology, with systemic circulation concepts.

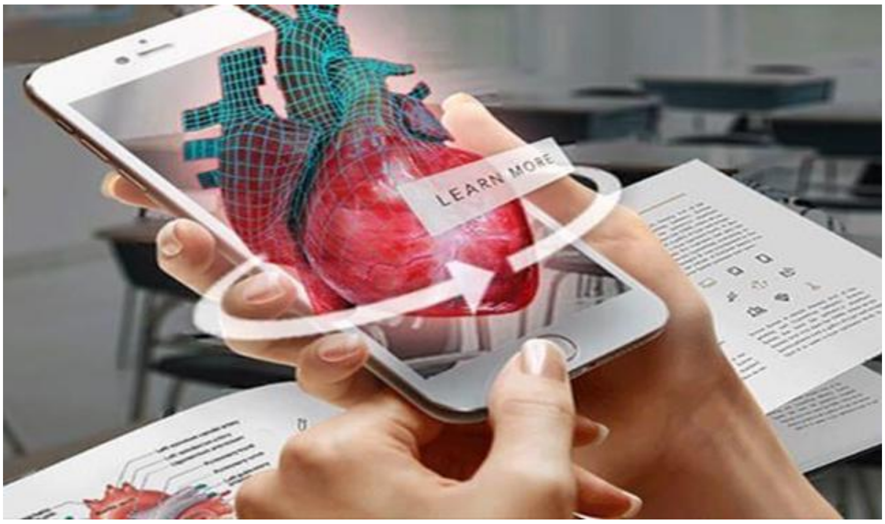


Figure 3. 3: An example of smart AR based learning

Source: Enzani *et al.* 2021.

Incorporating XR technology into maritime higher education and training is essential for a comprehensive digital transformation. The XR, comprising VR, AR, and MR, provides immersive learning experiences, bridging theory and practice in maritime contexts. The VR simulations offer realistic scenarios for ship navigation, cargo handling, and emergency response, enhancing operational understanding.

The AR superimposes digital data over actual marine habitats aiding on-the-job training and maintenance tasks. These immersive experiences engage learners and cultivate critical skills in a safe environment. The XR also enables remote collaboration, connecting maritime students and professionals globally. Integrating XR into education prepares future maritime professionals, fostering innovation and efficiency in the industry (Lee *et al*. 2020).

A fully functional system for navigation, ship handling, maneuvering, bridge resource management, piloting, and integrated operations training, Morild Interaktiv unveiled t he first virtual reality ship and bridge simulator in the world in 2013 (AFMA 2013).

Figure 3. 4: Ship bridge simulator

Source: Australian Maritime and Fisheries Academy.

Morild Ship and Bridge is a VR-based mission simulator system (Figure 3.4) that allows an unlimited number of users to train together in the same scenario. It scales well to large and complex scenarios, with virtual interaction with bridge equipment. The system offers new possibilities for vessel types and propulsion system configurations, ensuring a natural and intuitive user experience.

According to a study by Lee *et al*. (2020), immersive VR simulations were implemented in maritime education to train students in ship engine room operations. The results demonstrated significant improvements in students' knowledge retention and operational competency compared to traditional training methods.

The shipping industry requires adherence to high international standards, and qualified personnel are crucial for success. Continuous improvement and the adoption of new technologies in MHET are essential (Erdogan and Demirel 2017).

Furthermore, the shipping industry is becoming more technical, necessitating highly skilled maritime professionals. Traditional training focused on practical skills, but since the 1990s, there's been a shift towards training officers capable of using advanced technology (Demirel 2020). Modern MHET trends combine vocational training with academic components, facilitating the migration of seafarer skills to other maritime industry areas and enhancing the reputation of seafaring careers (Manuel 2017). Significant technological changes have transformed business methods in technology-dependent sectors. The IT and OT advancements have enabled full automation of ship management and continuous online data transfer.

Automation of knowledge, advanced robotics, autonomous vehicles, the IoT and mobile internet are crucial for modern maritime industry. These require continuous development of the MHET system (Demirel 2020). Predicted breakthroughs include sensors, IoT, AI, data science, VR and AR, blockchain, and neural feedback. Maritime officers need more IT/OT skills to operate digitalised ships equipped with robot-controlled cargo systems and IoT for data transfer (Islam *et al*. 2020). The industry's role in MHET is currently limited. The IMO advocates for greater involvement of shipping companies in MHET planning to align industry needs with education and training programs (Demirel 2020). Moreover, digital learning platforms enable remote access to educational resources, benefiting students in remote locations or those unable to attend traditional classes (Jones and Wang 2018). The interactive digital tools foster active learning and student engagement, leading to better retention and understanding of maritime concepts (Nicol and Macfarlane-Dick 2006). In addition, digital simulations and virtual training environments reduce the need for expensive physical equipment and resources, making maritime education more cost-effective (Islam *et al*. 2020).

3.4.1. Regulations

Maritime higher education and training (MHET) is a crucial component of the maritime industry, as highlighted by the IMO Secretary-General Koji Sekimizu in 2015 (IMO, 2014b). The MHET ensures standardised competence and skills for seafarers across various career paths in the maritime domain. Additionally, it must change to reflect the changing nature of operations, requiring seafarers to have 21st-century skill sets and manage ships securely. Continuous professional development for seafarers is essential, extending beyond achieving a Certificate of Competency (CoC) to ongoing competence reinforcement throughout their careers (Sharma 2023). The MHET play a fundamental role in shaping seafarers both globally, and in South Africa. In addition to producing competent marine workers, a variety of MHET systems are used to guarantee adherence to the International Convention on the STCW. While MHET faces challenges, many of these issues are not unique to South Africa but are shared among maritime nations. In South Africa, the training and development of seafarers adheres to STCW standards and aligns with the National Qualifications Framework (NQF). However, maritime education extends beyond vocational training for seafarers, with various MHETs offering academic courses. Manuel (2017) notes that, while training emphasises practical skills, academic education focuses on nurturing analytical and critical thinking abilities in students.

Informal apprenticeship and unstructured learning methods were used in the marine industry until the 1978 adoption of the STCW for Seafarers convention to convey maritime competencies for its workforce. The adapted STCW advocates for the integration of on-the-job hands-on experience training with the traditional classroom teaching, and has resulted in school-based vocational education being a standard for maritime education and training. For example, simulator training and practical experience is typically offered at sea on a real-world hands-on experiential basis (STCW 2011).

The maritime industry is experiencing DT impacting various facets including education and training. The STCW sets the global standards for seafarer training and certification, guiding the integration of DT into maritime education.

Online platforms provide access to the STCW-compliant courses and materials, facilitating remote learning for maritime students (Kojima *et al.* 2019). Digital simulators offer realistic environments for learning STCW-required abilities including navigation, firefighting, and cargo management (Chawla et al. 2021).

The STCW Convention strongly recommends the introduction and application of e-learning in maritime higher education. Currently, the South African national MHET legislation needs to be updated to recognise, correctly interpret and implement the requirements of the STCW Convention and to more rapidly adopt technology-based teaching and learning to complement and/or replace its traditional pedagogical approaches (Bauk and Masuku 2022).

Because they live and operate in a complicated, technologically driven environment that is always evolving, today's sailors require e-learning. The Internet is one of the most adaptable means of communication and information acquisition. Online courses lower prices and make education more accessible, particularly for underserved populations including the elderly, the disabled, and those living in rural regions (Bauk and Masuku 2022).

The proposed framework (see Figure 3.6) illustrates the intricate nature of MHET, emphasising the various factors involved in its development and management. Clear definition of these factors is essential to achieve desired MHET outcomes, aligning with national educational policies and international STCW requirements. Effective coordination among stakeholders is vital for efficient learning and program synchronization while meeting the needs of all parties involved. Despite its complexity, this synchronisation is crucial for successful MHET implementation.

Digital learning solutions must align with the STCW standards to ensure that graduates meet the competency requirements for safe and efficient maritime operations (IMO 2017). Online assessment tools and digital portfolios facilitate the evaluation of seafarer competencies and issuance of the STCW-compliant certificates (Nguyen *et al.* 2020). Digital learning platforms enable flexible access to the STCW training materials, catering to the needs of remote learners and working professionals (Gurney *et al.* 2018).

Digital simulations and online courses reduce the need for physical infrastructure and travel expenses associated with traditional training methods (Geng *et al.* 2021). For digital learning projects in maritime education to be implemented successfully, access to reliable Internet connectivity and suitable technology are essential (Hakim and Zafar 2019). Adapting digital learning environments to comply with evolving STCW requirements poses challenges related to standardization and accreditation (Li *et al.* 2022).

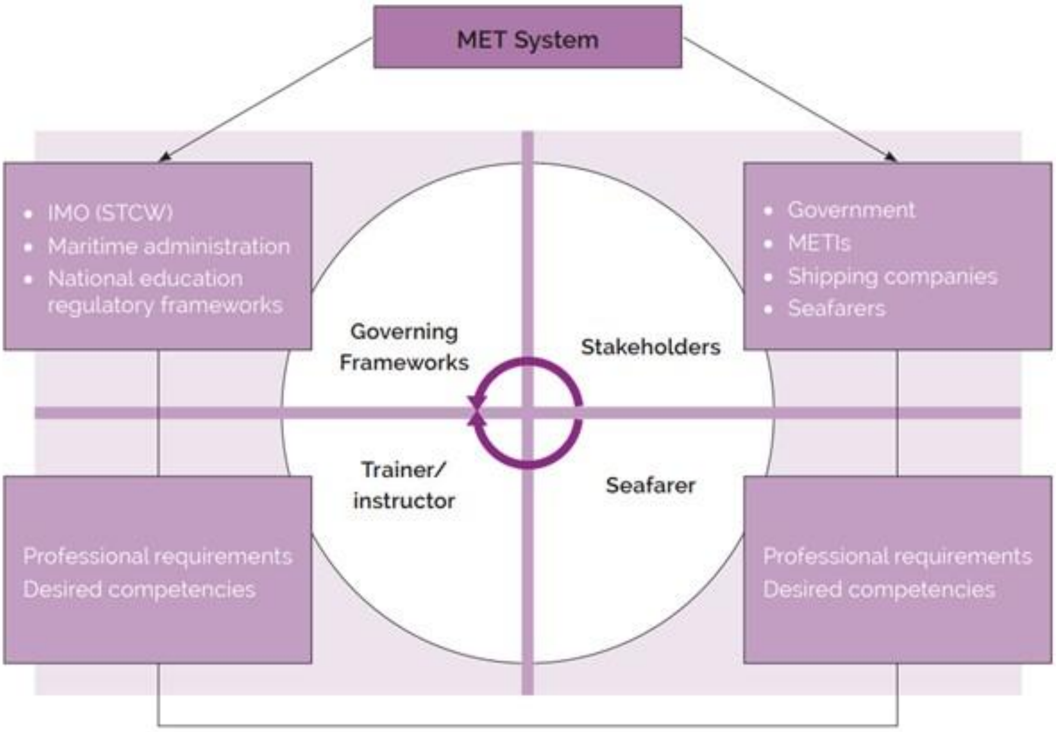


Figure 3. 5: The MHET system framework

Source: Nhleko 2023.

3.4.2. Enhancements

The Internet has significantly altered people's lifestyles and working environments worldwide, alongside transforming methods of generating and sharing knowledge. Through a variety of channels that combine in-person and virtual encounters, technological improvements have made learning and teaching easier. Collaborative online international learning (COIL) is one such channel. The Durban University of

Technology (DUT) joined the State University of New York's (SUNY) international network of partners in 2014, making it the first African university to do so. DUT is now working on several COIL projects that integrate several fields, including software testing techniques, chemistry and information technologies, medicine and journalism, and maritime navigation information systems (Bauk and Fajardo 2020).

This involvement has enhanced curriculum development, education quality, and graduate attributes, and provided systemic benefits for staff and students, while fostering innovative and cost-effective strategies (Pillay and Samuels 2016).

Collaborative online learning environments enable real-time interaction between instructors and students, enhancing engagement and knowledge transfer (Rodrigues *et al.* 2020). Furthermore, collaborative online projects and group assignments facilitate teamwork and communication skills development, which are essential for effective maritime operations (Gallagher and Cook 2016). Additionally, through the use of transformational pedagogy and mindfulness meditation, COIL programs promote creative ways to research, teaching, and learning. According to Anderson et al. (2010), the goal of these virtual engagements is to internationalize students' educational experiences and get them ready for a competitive global labor market. Working in multicultural, interdisciplinary environments enhances mindfulness in teaching, teamwork, research, and service provision. Additionally, the COIL environment's learning processes and outcomes benefit from the SAMR model, which emphasises integrating technology to transform and enhance education.

Bingham (2019) asserts that cooperative online learning programs with industry participants give students practical experience and real-world insights, improving their employability (Bingham et al. 2019). To improve the efficacy of STCW training programs, maritime education institutions ought to adopt new pedagogical strategies and technologies (Palos and Marques 2021). It is worth noting that collaboration between maritime education providers, industry associations, and regulatory bodies is essential for ensuring the relevance and applicability of digital learning solutions in meeting STCW requirements (Choo et al. 2021).

It should be noted that DT offers significant opportunities for improving maritime education and training, particularly in meeting STCW requirements. Seemingly, collaboration, innovation, and regulatory compliance are key factors in maximizing the benefits of digital technologies in MHET and collaborative online projects and virtual teamwork tasks empower students to create innovative solutions and proposals for maritime challenges (Lim and Yoon 2020).

Introduction of basic digital tools and resources, such as e-learning platforms and digital libraries, are essential to supplement traditional teaching methods (Hassan and Ooi 2019). Systematic integration of digital technologies into curriculum design and instructional practices, following Bloom's taxonomy enhances learning outcomes (Wang *et al.* 2021). Adoption of advanced digital solutions, including VR, AR, XR and AI, create immersive and personalised learning experiences (Samarakoon *et al.* 2022). On the other hand, training and support for faculty members are important to ensure effective utilisation of digital tools, as well as alignment with Bloom's taxonomy principles (Kumar *et al*. 2020).

Adequate infrastructure and technical support are required to sustain digital learning initiatives and ensure equitable access for all students (Cheng *et al.* 2018). Supplementary study is required to explore innovative applications of digital technologies in maritime education, leveraging Bloom's taxonomy to design effective learning experiences (Zhang *et al*. 2022).

Digital learning resources should be carefully integrated into maritime curricula to ensure coherence and alignment with learning objectives (Gutierrez *et al*. 2021). Maritime higher education institutions should prioritise ongoing evaluation and enhancement of digital learning environments to satisfy the changing demands of stakeholders in the maritime sector as well as students (Tan and Li 2021).

3.4.3. Training facilities

Exploring new perspectives of maritime education and training involving simulator training in the Cloud and immersive technologies such as V/A/X reality opens up exciting opportunities for enhancing learning experiences and preparing maritime professionals for real-world challenges. The V/A/X reality have the potential to transform education by creating immersive learning experiences. The V/A/X reality enables students to interact with simulated objects and environments, while it provides real-time feedback and allows interaction with virtual items in the real world. These technologies can enhance student retention and improve learning efficiency (*Aroba* 2024). Simulators are tools used in high-stakes industries such as aviation, healthcare, nuclear, maritime, and rail to train personnel and ensure peak performance in high-pressure scenarios. Advances in technology have enhanced the effectiveness of these simulators, offering a safe space for trainees to hone their skills without the risk of financial loss or environmental harm.

Simulation technology also facilitates learning navigational skills, ship reactions, and behaviours in a risk-free environment, allowing detailed feedback and discussions. Instructors can tailor training content and monitor and assess the effectiveness of simulations. (Sharma 2021). The Navi-Trainer Professional 4000 nautical simulator (NTPro), created by Transas Marine (Figure 3.7), is an example of a maritime simulator. It was first introduced in the late 1990s to teach seafarers how to navigate and manoeuvre ships optimally. Furthermore, the Navi-Trainer Professional 5000 (NTPRO 5000) is the *latest generation* simulator released by Transas/Wärtsilä, and it has replaced the older Navi-Trainer Professional 4000 as the industry standard in maritime training institutions. It has a main control console, a simulacrum of a ship's command bridge, radar, ECDIS, AIS, GPS, NAVTEX (NAVigational TelEX), GMDSS (Global Maritime Distress and Safety System), an alarm system, and other auxiliary navigation devices. It enables two-way communication between the main control panel, Radar and ECDIS, as well as additional navigation and alarm devices (Bauk and Masuku 2022).

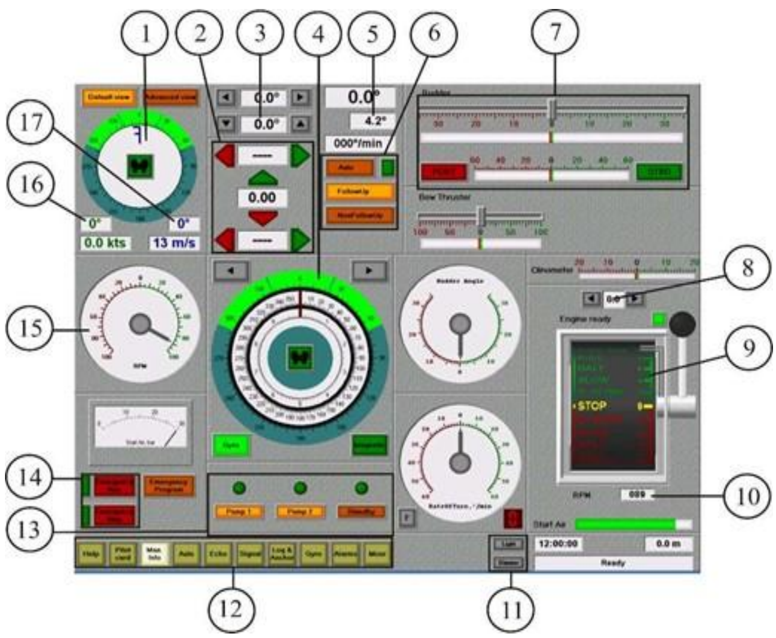


Figure 3. 6: The NTPro nautical simulator control panel elements

Source: Bauk *et al*. 2022.

Table 3.2 illustrates how the activities within the frameworks of CL and TCF can be mapped onto the Bloom's taxonomy model, enhancing the learning process in maritime education. Each level of the Bloom's taxonomy model is addressed through specific activities that promote understanding, application, analysis, evaluation, and creation of knowledge in a structured manner.

3.4.4. Training in the Cloud

Simulator training in the Cloud offers several advantages, including scalability, accessibility, and cost-effectiveness (Wu *et al.* 2021). Cloud-based simulators, such as K-Sim, developed by Kongsberg, enable maritime students to access training scenarios remotely from any location with Internet connectivity (Jensen *et al.* 2020). The Cloud infrastructure allows real-time collaboration and interaction among students and instructors, facilitating teamwork and knowledge sharing (Rani and Sharma (2021). Examples of simulators used in the maritime industry include ship bridge simulators, cargo handling simulators, dynamic positioning simulators, survival craft simulators, rescue boat operation simulators, GMDSS simulators, and vessel traffic service simulators.

The simulators used by MHET universities around the world vary depending on the resources, training goal, and provider. There are four types of ship bridge simulators: limited task, special task, multi-task, and complete mission. Full-mission simulators are specialized spaces in MHET facilities that accurately replicate a ship's bridge with all the necessary instruments and displays, whereas desktop-based simulators are low-fidelity. But maintaining and acquiring them requires a lot of resources (Sharma et al. 2021).

Figure 3. 7: Examples of simulators used in maritime education and training

Source: DNV 2021.

Desktop-based simulators, full-mission simulators, virtual reality simulators, and cloud-based simulators are all shown in Figure 3.7. Desktop-based simulators are used to simulate several aspects of nautical operations loaded with simulation software. These are regarded as low-fidelity simulators, with limited ability to replicate specific operational scenarios (Wahl and Kongsvik 2018). Conversely, full-mission simulators entail specific areas within MHET facilities that replicate a ship's bridge in a realistic manner, complete with duplicates of all necessary equipment and displays.

These simulators are presently the preferred type for meeting the bulk of regulatory requirements and workplace learning needs because of their high fidelity, even if they are expensive to buy, maintain, and upgrade (Sharma et al. 2021).

3.4.5. Extended reality

As noted earlier, XR, VR, AR, and MR have emerged as revolutionary technologies across multiple sectors, including education and training. In particular, the integration of XR with cloud computing for simulator training offers significant potential for enhancing training efficacy, accessibility, and scalability. The XR technologies have been increasingly utilised to create immersive and interactive training environments. The VR creates a completely simulated environment, while AR superimposes digital information onto the real world, and MR combines elements of both the physical and digital worlds. These technologies offer unique advantages for training by providing realistic simulations without the risks or costs associated with real-world training.

For example, the VR simulators provide a realistic work environment using wearable head-mounted displays (HMDs). Developed in the 1960s, they gained popularity in the maritime industry in the 2010s. These simulators allow multiple users to train and collaborate on different ships worldwide. They require moderate investment and are easy to maintain. Cloud-based simulations offer remote delivery of training activities, reducing physical presence and allowing instructors and trainees to run simulations on their devices. However, communication in MHET facilities is not equivalent to face-to-face conversation, and the fidelity experienced varies depending on the technology (Sharma 2021).

The VR technology provides immersive, interactive environments for maritime training, allowing students to simulate navigation, ship operations, and emergency procedures (Ismail *et al*. 2021). The VR simulations offer realistic experiences that enhance situational awareness, decision-making skills, and crisis management abilities (Mukherjee and Ghosal 2018).

Applications such as ship bridge simulators and engine room simulations enable students to practice tasks in a safe and controlled environment, reducing the risk of accidents and injuries (Ogrizovic 2024).

The AR and XR technologies overlay digital information onto the physical environment, providing contextually relevant guidance and support for maritime tasks (Wang *et al*. 2021). The AR applications in maritime education include maintenance and repair procedures, where digital overlays provide step-by-step instructions and visual aids (Holloway 2024).

To provide a combination of virtual and physical interactions for improved learning outcomes, the XR solutions combine VR and AR capabilities to produce mixed reality experiences (Li et al. 2021). Students can acquire practical skills in a secure setting by using immersive technologies, which provide realistic simulations of maritime conditions (Wang et al. 2021). Notably, V/A/XR encounters hold students' interest and promote involvement, which enhances their memory and comprehension of marine ideas (Said & Elaraby 2020).

On the other hand, implementation of V/A/XR solutions requires investment in hardware, software, and technical infrastructure, which may pose challenges for some educational institutions (Venkatsan *et al*. 202021). Furthermore, effective integration of immersive technologies into maritime curricula requires careful planning and alignment with learning objectives, as well as training for faculty members (Kim *et al.* 2021).

Clearly, additional research is necessary to explore the potential of simulator training in the Cloud and the use of immersive technologies to address specific training needs and improve learning outcomes in maritime education (Holloway, 2024). Collaboration between maritime educational institutions, technology providers, and industry stakeholders can help drive the development and implementation of innovative V/A/XR solutions tailored to the maritime sector's needs (Jiang et al., 2020).

Lastly, ongoing evaluation and feedback mechanisms are essential for refining V/A/XR applications and ensuring their effectiveness in preparing maritime professionals for real-world challenges (Chen *et al.* 2021). Simulator training in the Cloud and immersive technologies such as V/A/XR hold great promise for revolutionising maritime education and training, offering realistic, engaging, and effective learning experiences for future maritime professionals. By embracing these technologies and addressing associated challenges, maritime education institutions can stay at the forefront of innovation and prepare graduates to thrive in the dynamic and evolving maritime industry.

3.5. THE SOUTH AFRICAN CONTEXT

The development of MHET in a South African environment involves examining its historical context, status, challenges, and prospects. These will be considered in the following sub-sections of the study.

3.5.1. Legacy

South Africa's maritime education and training has developed considerably over time influenced by the country's colonial history, apartheid-era policies, and post-apartheid transformations (Bennett and Sowman 2017). During the apartheid era, maritime education was largely inaccessible to non-white South Africans, resulting in disparities in training opportunities and representation within the maritime industry (Geldenhuys and King 2015).

Since the democratic transition in 1994, efforts have been made to tackle historical inequalities and broaden access to maritime education and training for all South Africans (Geldenhuys and King, 2015). South Africa has the potential to shift from a developing to a developed nation by improving its citizens' education, knowledge, and skills to meet the demands of the modern workforce (Whiting, 2020).

Today, access has improved significantly, although there is still room for further development. To thrive in a technology-driven, complex society, individuals require sound lifelong education and skills, which can be obtained through both official and familiar learning channels. The internet, serving as a vast virtual library, can facilitate lifelong learning, providing people with access to fundamental knowledge and education. Technology-based learning is an effective method to harness the Internet for the attainment of knowledge and educational purposes.

3.5.2. Current situation

With the founding of organizations like the South African Maritime Training Academy (SAMTRA) and the South African International Maritime Institute (SAIMI), South Africa has made notable progress in growing its MHET sector. The country offers a range of maritime-related courses and programmes at universities, colleges, and vocational training centres, covering areas such as maritime law, navigation, engineering, and logistics. In addition, efforts have been made to align maritime education and training programs with international standards, such as those established by the IMO and the STCW Convention (SAMSA, 2020).

The South African legislation concerning higher maritime education requires modernisation to align with the STCW requirements. This upgrading is expected to support the integration of e-learning as either a complement to or replacement for traditional seafarers' education. It is crucial to recognise that the STCW emphasises the significance of proper education as a cornerstone for effective training and competence acquisition. The STCW Manila Amendments highlight the importance of knowledge, theory, principles, and cognitive skills, which are essential for competent performance in various maritime situations (IMO 2010). Moreover, the recent amendments to the STCW Code encourage the use of modern training methods, such as e-learning, to improve the knowledge and skills of seafarers (Bauk and Masuku, 2022). It is important to highlight that maritime education and training institutions are expected to play a key role in South Africa's efforts to develop its maritime economy and tap into the potential of the ocean economy (SAMSA, 2018). Ongoing investment in infrastructure, faculty development, and industry partnerships is crucial for enhancing the quality and relevance of MHET programs (SAMSA, 2018).

In addition, collaboration between government, industry stakeholders, and educational institutions is key to addressing skills gaps, promoting transformation, and ensuring the sustainability of the maritime sector (SAMSA 2020). Despite the progress that has been made, South Africa continues to face challenges in addressing skills shortages in the maritime sector, particularly in critical areas such as shipbuilding, maritime law, and marine engineering (SAMSA 2018). Limited infrastructure and resources in certain regions pose challenges for delivering quality MHET programs, particularly in rural and coastal areas (Bennett and Sowman 2017). Nevertheless, interventions to promote transformation and diversity in the maritime sector, including increased participation of women and historically disadvantaged groups, remain ongoing (Geldenhuys and King 2015).

In 2019, South Africa, along with more than 80 other countries, faced the risk of being removed from the STCW Convention's Whitelist due to issues with quality management systems and regulations. However, by 2022, South Africa successfully retained its Whitelist status, demonstrating compliance with STCW standards. Despite being recognized as a member of the IMO Whitelist, South Africa continues to face challenges in aligning its MHET requirements with the STCW regulations (Nhleko, 2023). Ruggunan et al. (2014) pointed out that significant challenges arise from the misalignment between South Africa's National Qualifications Framework (NQF) and the STCW in the maritime sector. This lack of alignment places conflicting demands on Maritime Higher Education and Training Institutions (MHETIs) and other stakeholders, who must simultaneously meet the accreditation standards of both the national skills framework and the maritime industry.

3.7.4. Prospects

South Africa's colonial past, apartheid-era laws, and post-apartheid changes have all had a significant impact on the country's marine education and training over the years (Bennett and Sowman 2017). Non-white South Africans had limited access to maritime education during the apartheid era, which led to differences in training possibilities and representation in the marine sector (Geldenhuys and King 2015).

Following the democratic transition in 1994, efforts were made to address past inequalities and expand access to maritime education and training for all South Africans (Geldenhuys and King 2015). South Africa has the ability to transition from a developing to a developed country by raising the educational, knowledge, and skill levels of its citizens to meet the demands of the modern workforce (Whiting 2020).

More funds need to be set aside for infrastructure, faculty development, and industry partnerships in order to raise the standard and relevance of maritime education and training programs (SAMSA 2018). The development of MHET in South Africa demonstrates a complicated interplay between past legacies, present problems, and future objectives.

However, South Africa can establish itself as a preeminent maritime nation on the African continent and beyond by tackling skills shortages, encouraging diversity, and fortifying relationships.

3.6. SUMMARY

Digital Transformation in the maritime industry is revolutionising traditional practices, improving efficiency, safety, and sustainability. Despite challenges such as technological barriers and regulatory compliance, the future of DT in maritime operations looks promising, driven by continuous innovation, collaboration, and talent development.

Furthermore, digital transformation (DT) in maritime education and training (MHET), guided by Bloom's taxonomy, presents valuable opportunities to enhance learning outcomes and better prepare students for careers in the maritime industry. A structured development approach is essential to fully unlock the potential of digital learning in maritime education and training.

The DT is reshaping MHET, offering new opportunities for enhanced learning experiences and skill development. Realizing the full potential of digital technology in MHET requires addressing issues like pedagogical integration and the digital divide. The status of MHET is shaped by various factors, including global trends, obstacles, the success of innovations, and sustainability considerations. Consequently, it is essential to ensure the quality, relevance, and effectiveness of MHET programs in preparing the next generation of maritime professionals.

Simulator training in the Cloud and immersive technologies such as V/A/XR hold great promise for revolutionising maritime education and training, offering realistic, engaging, and effective learning experiences.

By embracing new technologies and addressing associated impediments, maritime education institutions can stay at the forefront of innovation and prepare graduates to succeed in the dynamic and ever-changing maritime industry. The evolution of MHET in South Africa reflects a complex combination of historical legacies, current challenges, and future ambitions a complex interplay of historical legacies, contemporary challenges, and future aspirations. Lastly, South Africa has the potential to position itself as the leading maritime nation, in the African continent and outside, by addressing skills shortages, promoting diversity, and strengthening partnerships. The next chapter will discuss the frameworks selected for the study.

CHAPTER 4 - THEORETICAL FRAMEWORK

4.1 INTRODUCTION

New services and applications have been created because of the ICT's quick development. In this knowledge-based culture, the influence of digital technology is so great that successful organizations have experienced a digital transformation (Islam et al. 2020).

While various discussions, interpretations, and conceptualisations of the Fourth Industrial Revolution (4IR) exist across different disciplines or sectors, it is generally linked to technology. However, 4IR within the education sector is aligned with the World Economic Forum's perspective and is defined as the integration of human and technological intelligent systems that merge the physical, digital, and biological realms. This fusion has profound implications across different educational disciplines and presents significant challenges in the ways we learn, teach, and work (Oke and Fernandes 2020).

The application of technology in reshaping teaching and learning in higher education is shaped by numerous models and frameworks developed in the twenty-first century. However, it is crucial to align technology with pedagogical practices when teaching in a digital environment (Abdou 2020).

Several adoption theories and technological acceptance models, as well as several extensions and revisions, have been developed during the past few decades as a result of intensive research. To verify their applicability and increase their predictive accuracy, these well-established theories and models have been widely used to evaluate a wide range of ICT products and services, including technologies, systems, settings, tools, applications, services, and devices. The acceptance, integration, and embrace of new technology are generally referred to as technology adoption (Granic 2022).

The theoretical framework provides a structured approach to guide the research process coherently as the research problem is identified (Hennink *et al*. 2020). It supports a systematic research process by aiding in the exploration and clarification of the research problem. This is accomplished through the research design and methodology, data collection, and the theory that explains the data, all of which are grounded within the theoretical framework. Teaching with technology in higher education has been associated with specialised theoretical frameworks (Bond *et al*. 2020). These frameworks can act as catalysts for driving meaningful change in maritime education and training, offering direction in the pedagogical and technological advancements related to digital transformation (Omarsaib 2022).

The initial phase of adopting technology, referred to as technology acceptance, is shaped by multiple factors and reflects an individual's perspective on technology. The decision to fully embrace a technological innovation as the best approach is known as adoption. This process requires that the adopter, whether an individual or an organization, perceives the concept, behavior, or product as new or innovative. Additionally, numerous theories and models have been employed to analyse and predict how individuals respond to technology adoption.

Davis et al. (1992) applied the Motivational Theory (MT) to explore the adoption and usage of information technology. MT, rooted in psychological aspects of technology acceptance, suggests that both intrinsic and extrinsic factors influence an individual's behavior, acceptance, and use of technology. Intrinsic motivation includes perceived enjoyment, while extrinsic motivators encompass perceived usefulness (PU), perceived ease of use (PEOU), and subjective norms. To understand why employees might adopt e-learning technology in professional settings, MT has been utilized to examine external motivators such as performance expectancy, social influence, and facilitating conditions, as well as internal motivators like effort expectancy, anxiety, and attitude toward e-learning (Venkatesh *et al.*, 2012).

Technology acceptance is often regarded as the opposite of rejection, signifying an individual's affirmative choice to adopt an innovation (Simon, 2001). Decision-makers must identify the factors that influence user behavior and adoption decisions to address these effectively during the development process (Mathieson, 1991).

The questions of why and how users adopt new technologies are crucial to both practitioners and researchers. Addressing these questions aids in the creation of effective strategies to predict, design, and evaluate user responses to emerging technologies (Dillon & Morris, 1996). In this regard, technology acceptance models and various theories have been extensively applied to understand user behavior and intentions in areas such as consumer satisfaction, purchasing behavior, and technology adoption.

Beyond MT, several studies have developed models and frameworks to investigate the factors influencing technology adoption, including the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), its extended version (TAM2), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Design

Science Research Methodology (DSRM) (Hevner et al., 2004). While some studies adopt these models as they are, others modify or integrate them to improve research outcomes (Alshammari & Rosli, 2020).

4.2 THE THEORY OF REASONED ACTION (TRA)

The TRA is among the pioneering frameworks for analysing technology acceptance and has significantly influenced subsequent models such as TAM, TAM2, UTAUT, and DSRM. This theory examines individual technology acceptance behaviors through a social psychology lens, proposing that behavior is determined by behavioral intention (Ajzen & Fishbein, 1975). Behavioral intention, in turn, is shaped by two primary factors: subjective norms and attitudes toward the behavior. TRA assumes that individuals are rational decision-makers who continuously evaluate their behavior based on their attitudes toward it. According to Lai (2017), attitude refers to the positive or negative feelings an individual experiences when performing a particular behavior. Subjective norm, another key component of TRA, reflects an individual's perception of social pressure from significant others who influence whether they should or should not engage in a specific behavior (Ajzen & Fishbein, 1975).

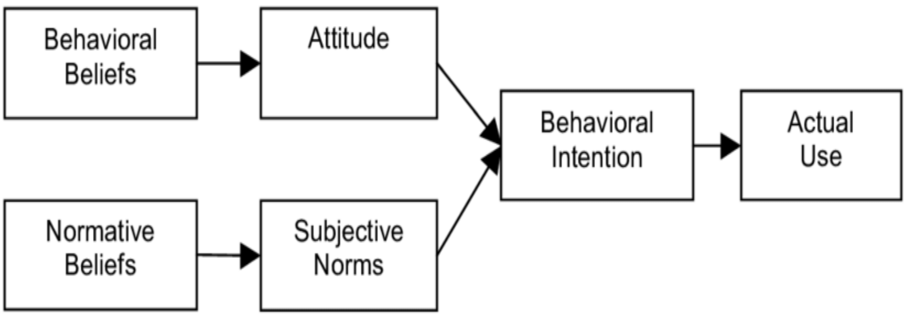


Figure 4. 1: Theory of Reasoned Action model

Source: Ajzen and Fishbein 1975.

Recent studies have employed various models to explore the factors affecting user behaviour and technology acceptance. For instance, Cai and Zheng (2017) utilised the TRA to elucidate the use of digital libraries, concluding that this theory effectively explains users' adoption of these resources. Similarly, Sheldon (2016) applied the TRA to investigate what drives students and professors to connect as friends on social media, specifically Facebook. The results aligned with the theory, demonstrating that intention was the primary predictor of mutual friend requests. Among faculty members, personal attitude played the most significant role, whereas subjective norms were the strongest influence for students seeking to add professors as friends on Facebook.

Regarding the Technology Acceptance Model (TAM), numerous recent studies have explored technology adoption. Teeroovengadum et al. (2017) examined the factors influencing educators' adoption of ICT, concluding that perceived usefulness (PU) and perceived ease of use (PEOU) played crucial roles in this process. Similarly, Kaushik and Verma (2020) investigated the factors driving the adoption of the Internet of Things (IoT), identifying PU, PEOU, trust, attitude, behavioral control, and subjective norms as key determinants.

The extended version of TAM, known as TAM2, has been widely applied to analyze the factors affecting online teaching acceptance and learning management system (LMS) usage (Tiwari, 2020). Furthermore, the Unified Theory of Acceptance and Use of Technology (UTAUT) has gained popularity among researchers studying technology adoption. Venkatesh et al. (2003) used UTAUT to evaluate users' intentions toward Internet banking, finding that PU, PEOU, social influence (SI), and facilitating conditions (FC) were all significant predictors of adoption. Likewise, Abbad (2021) conducted a study on mobile learning adoption in university settings, identifying key influencing factors.

Overall, these studies underscore the significance of utilizing various models and theories to gain a comprehensive understanding of the critical factors driving users' adoption of different technologies.

4.3 TECHNOLOGY ACCEPTANCE MODEL (TAM)

A fundamental model for understanding the factors that influence technology acceptance or rejection, particularly in the field of educational technology, is the Technology Acceptance Model (TAM). Developed from the Theory of Reasoned Action (TRA), TAM was first introduced by Davis (1986, 1989). The TRA, formulated by Fishbein and Ajzen (1975), aims to predict and explain behaviors and attitudes based on the assumption that individuals generally act in a rational manner. According to this theory, an individual's behavioral intention is primarily determined by their attitude toward the behavior and the perceived social influence from significant others, referred to as subjective norms.

A person's attitude indicates how they feel about a particular behavior, whereas their behavioral intention represents their likelihood of engaging in that behavior and subjective norms represent the perception of what significant others believe the individual should or should not do (Davis 1986).

Davis modified the TRA by emphasizing attitudes as the primary predictors of behavior, rather than solely focusing on behavioral intentions, to create a reliable model for predicting actual technology usage. According to Davis, three key factors shape user motivation: attitude toward using the technology, perceived usefulness (PU), and perceived ease of use (PEOU). Consequently, TAM identifies PU and PEOU as crucial determinants that influence users' attitudes and their intention to adopt technology.

According to Davis's (1986) PhD dissertation, a user's attitude toward the system (attitude toward using) has a big impact on whether they will accept or reject it (real use). PU and PEOU are the two primary beliefs that influence this attitude, with PEOU having a direct impact on PU. According to Davis (1986), perceived usefulness refers to the extent to which a user believes that using a system will enhance job performance, while perceived ease of use indicates the extent to which a user perceives the system as easy to operate. Both of these perceptions are influenced by the system's design characteristics. Numerous studies have confirmed that TAM’s core variables—perceived usefulness and perceived ease of use—are strong predictors of technology acceptance in educational contexts. Research has introduced additional components to the basic TAM model. For example, Yu and Huang (2020) expanded TAM to assess the acceptance of WeChat for language learning, incorporating factors such as perceived enjoyment, conforming behavior, and self-esteem. Similarly, Lin and Yeh (2019) included perceived fun as a motivating factor when examining the adoption of virtual reality (VR) motion control technology for mental rotation learning. In another study, Aburagaga et al. (2020) used an expanded TAM model to evaluate faculty needs for integrating social networks into learning environments, considering factors like access devices, infrastructure, privacy, and institutional support.

According to Abdullah and Ward (2016) and Granić and Marangunić (2019), the TAM is widely acknowledged as a strong and reliable method for forecasting and explaining consumers' behavior regarding the adoption of educational technology. Numerous studies across various fields, such as electronic learning (Anthony et al. 2020), mobile learning (Lai 2020), personal learning environments (PLEs) (Rejón-Guardia *et al.* 2020), virtual reality environments (Fussell and Truong 2021), massive open online courses (MOOCs) (Al-Adwan 2020), and learning management systems (Dampson 2021), have validated its predictive power. These studies have examined both open-source LMS Moodle (Vanduhe et al. 2020) and commercial LMS Blackboard (Ibrahim et al. 2017). Additionally, the applicability of TAM to other educational technologies has been explored, including social media platforms (Al-Rahmi et al. 2021; Yu 2020), simulators, virtual reality (Lin and Yeh 2019), augmented reality (Jang et al. 2021), and teaching assistant robots.

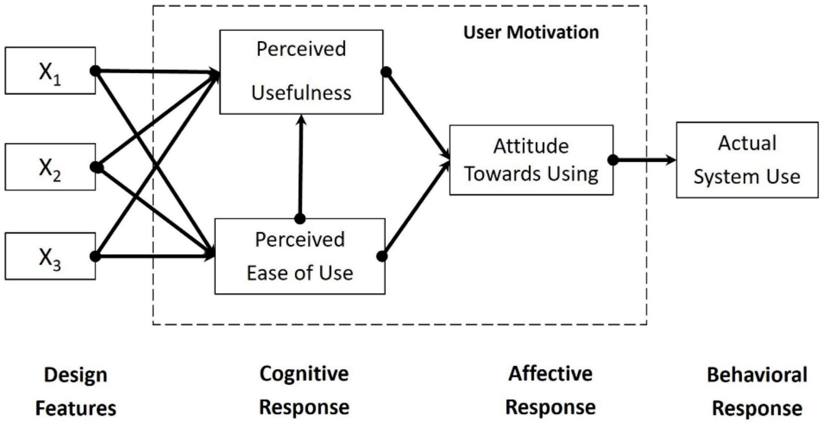


Figure 4.2: Technology Acceptance Model (TAM)

Source: Sadeck 2022.

The core elements of the original Technology Acceptance Model (TAM)—Perceived Usefulness (PU), Perceived Ease of Use (PEOU), attitude, and behavioral intention to use—were introduced by Davis (1986, 1989), as depicted in Figure 4.2. PU and PEOU are two key variables that shape users' attitudes toward technology, which, in turn, influences their perceptions and ultimately determines the acceptance of the technology (Ma and Liu 2004). Susant and Ashuti (2019) note that various factors impact a user's decision to adopt new technology, with a primary focus on perceived ease of use and perceived benefits. Usability reflects how much a user believes the technology can enhance their performance, while ease of use relates to the belief that the technology is simple and requires minimal effort.

Ethics in research refers to the expected norms and standards of behavior that guide the research process. Both researchers, who conduct the study, and participants, who provide data, are expected to act ethically. The researcher’s responsibility to maintain integrity, thoughtfully consider findings, and prioritize the interests of others is essential. Ethical practices must be followed throughout every stage of research, including data collection, analysis, reporting, and dissemination. Academic ethics and good practices guide the treatment of participants and the protection of sensitive information.

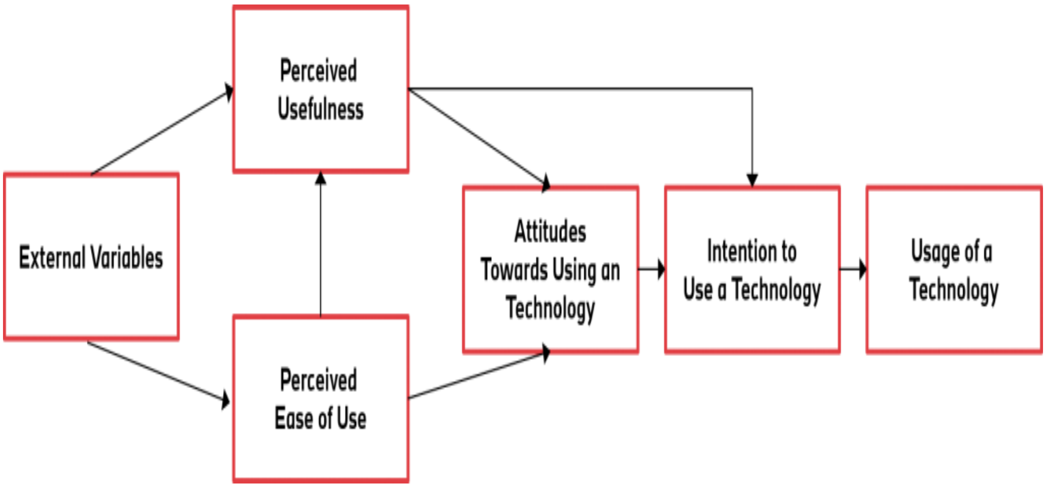


Figure 4. 3: Revised Technology Acceptance Model

Source: Davis *et al.* 1989.

This concept emphasises the importance of having a clear purpose for using technology and ensuring the system is easy to use, aligning with the user's needs. If the system is user-friendly, the likelihood of the technology being adopted increases (Susant and Astuti 2019). The revised TAM framework illustrates the relationship between factors influencing technology acceptance, as shown in Figure 4.3. Users' reactions and perceptions of IT significantly impacts their attitudes towards adopting it. A key influence is how users perceive the usefulness and ease of use of IT, which in turn drives their behaviour and actions in technology adoption. The TAM model, grounded in psychological theories, explains computer users' behaviour based on beliefs, attitudes, intentions, and the relationship between these factors. It aims to identify the primary factors influencing user acceptance of technology. It describes how specific factors might influence consumers' acceptance of IT, emphasizing two crucial elements that influence user behavior: perceived utility and ease of use (Susant and Astuti 2019). TAM has also been applied to support digital transformation in maritime education, focusing on how well new technologies are accepted by both educators and students in this field. The model suggests that the primary factors influencing technology adoption are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). As defined by Davis et al. (1989), perceived usefulness refers to the degree to which an individual believes that using a particular system will enhance their performance at work, while perceived ease of use relates to the extent to which a person feels that using the system will require little effort.

The application of TAM in maritime education has gained significant attention in recent years, particularly in studies aiming to understand the factors influencing the adoption of e-learning platforms, simulators, and other digital tools. Research by Tseng *et al.*

(2019) demonstrated that both PU and PEOU significantly influence the intention to use e-learning systems in maritime education. They discovered that maritime students who view e-learning platforms as both useful and easy to use are more likely to incorporate these tools into their learning activities. Additionally, TAM has been used to assess the effectiveness of maritime simulators in training. A study by Al-Rahmi et al. (2021) and Yu (2020) explored the acceptance of maritime simulators among students revealing that PU is a critical factor influencing students' attitudes toward these simulators. The study also highlighted that enhancing the usability of simulators could lead to greater acceptance and better learning outcomes.

4.4 THE EXTENDED TECHNOLOGY ACCEPTANCE MODEL (TAM2)

The Extended Technology Acceptance Model (TAM2) was developed by Venkatesh and Davis in 2000. It builds upon the core elements of the original TAM, specifically Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). TAM2 introduces the influence of social factors, including subjective norms and image, as well as cognitive elements such as output quality, job relevance, and result demonstrability (Figure 4.4). Both TAM and TAM2 have been extensively utilized to examine technology acceptance behaviors in various organizational contexts.

The TAM2 proposes that individuals form judgments about a system's usefulness based on how well it supports important work goals, using these evaluations to shape their perceptions of performance-related factors like PU. (Alshammari and Rosli, 2020).

Based on theories of cognitive matching, TAM2 suggests that users assess job relevance through a compatibility test (Venkatesh and Davis 2000), viewing job relevance as a personal assessment of how applicable a system is to their work. This relevance positively impacts PU. Users tend to choose the system offering the highest perceived output quality, which TAM2 links to a perceived profitability test. A third PU determinant, results demonstrability, describes the tangible impact of using a technology (Moore and Benbasat 1991). Together, these factors outline TAM2's approach to understanding the extended impacts of systems attributes.

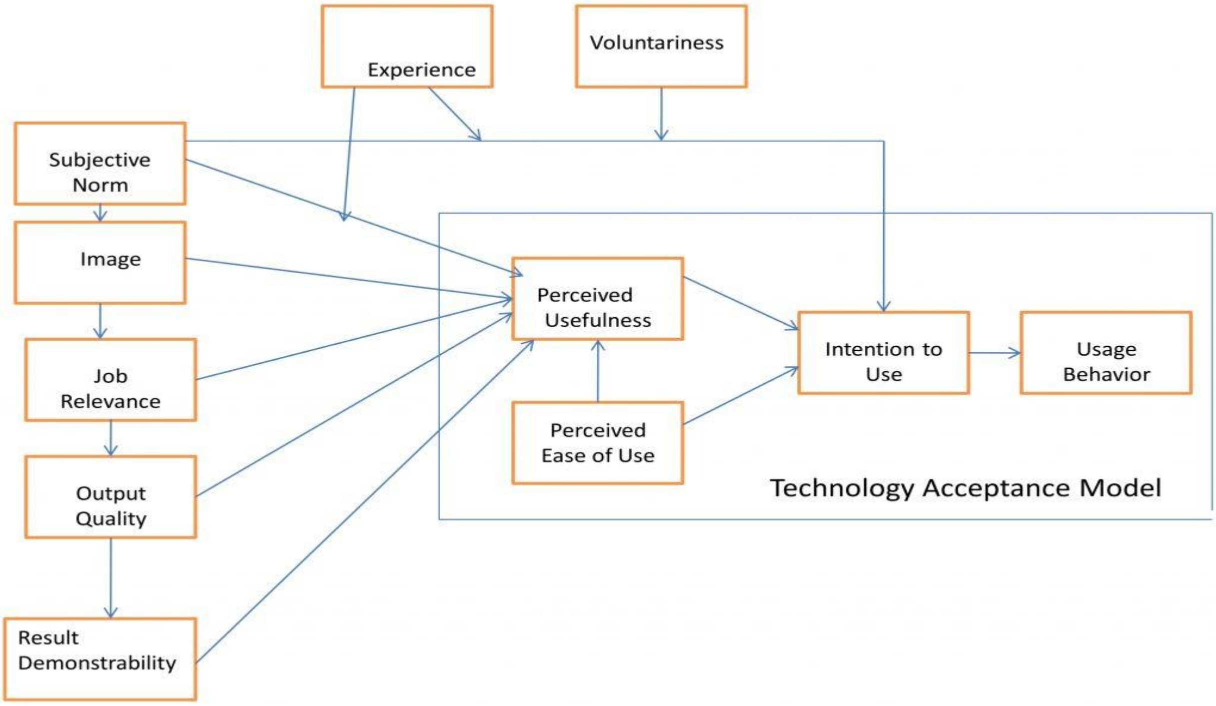


Figure 4. 4: Extended Technology Acceptance Model

Source: Sullivan 2016.

4.5 UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY (UTAUT)

The **Unified Theory of Acceptance and Use of Technology (UTAUT)** is a robust theoretical framework that integrates multiple models to explain user intentions and subsequent technology adoption. Developed by Venkatesh et al. (2003), the UTAUT combines and updates several existing theories related to technology acceptance. The theory synthesizes elements from eight well-known user acceptance models, including the **Theory of Reasoned Action (TRA)** (Fishbein and Ajzen, 1975), **Technology Acceptance Model (TAM)**, **Motivational Model (MM)**, **Theory of Planned Behavior (TPB)**, **Augmented TAM (A-TAM)** (Davis, 1986, 1989; Davis, Bagozzi, and Warshaw, 1989), **Model of Personal Computer Utilization (MPCU)** (Thompson, Higgins, and Howell, 1991), **Innovation Diffusion Theory (IDT)**, and **Social Cognitive Theory (SCT)** (Bandura, 1986).

Three main constructs that have a direct impact on behavioral intention are performance expectancy, effort expectancy, and social factors, according to the UTAUT. It also identifies supportive factors and behavioral intention as predictors of actual technology use. The core components of the **Unified Theory of Acceptance and Use of Technology (UTAUT)** have been applied in various contexts, such as the use of e-learning systems in developing countries (Abbad, 2021), the integration of

ICT by preservice teachers (Birch and Irvine, 2009), and the adoption of e-learning by students in postgraduate programs (Mahande and Malago, 2019).

Researchers often extend the UTAUT model by adding additional factors. For example, Tiwari (2020) modified the UTAUT to include perceived cost in order to study university students' attitudes toward online course adoption during the COVID-19 pandemic. Similarly, Chao (2019) expanded the UTAUT to incorporate constructs like mobile self-efficacy, perceived enjoyment, contentment, and trust to explore university students' behavioral intentions toward mobile learning. Almaiah, Alamri, and Al-Rahmi (2019) also used an expanded version of the UTAUT to examine how factors such as perceived information quality, compatibility, trust, awareness, resource availability, self-efficacy, and perceived security influence students' acceptance of mobile learning applications in higher education.

As previously noted, **TAM** and **UTAUT** are the most prominent theoretical frameworks used in educational contexts. While a detailed comparison is outside the scope of this chapter, a few important points should be highlighted. Practically, the effectiveness of a model can often be improved by using the fewest constructs necessary, a concept known as **model parsimony**. The simplicity of TAM has proven to be an effective and valid way of explaining technology acceptance. However, for a deeper understanding of technology adoption, some degree of parsimony may need to be sacrificed (Samaradiwakara and Gunawardena, 2014). On the other hand, while the UTAUT offers comprehensive insights into technology use and behavioral intentions, it has faced criticism for incorporating too many independent constructs, which may complicate the prediction of intentions and behaviors (Bagozzi, 2007).

The adoption of instructional technology has been the subject of in-depth research on both TAM and UTAUT. These models' predictive potential has been increased by adding more features in order to cover all important facets of technology adoption in educational settings. Furthermore, research has shown that both models have been successfully integrated with other pertinent techniques from different domains, even if they are adaptable to diverse technologies and educational situations on an individual basis (Giani 2022).

The UTUAT looks at how technology is accepted based on social influence, performance expectancy, effort expectancy, and facilitating conditions. According to the UTAUT theoretical model, actual technology use is driven by behavioral intention, as illustrated in **Figure 4.5**, four key factors—**performance expectancy**, **effort expectancy**, **social influence**, and **facilitating conditions**—influence the likelihood of adopting technology. These factors are affected by variables such as **age**, **gender**, **experience**, and whether the use is **voluntary** (Venkatesh et al., 2003). The integration of **UTAUT** with other models has mainly focused on users' ongoing intentions to use mobile banking and payment systems, or employees' adoption of e-government, with relatively limited application in educational contexts. In educational settings, theories and models that focus on **post-adoption** behaviors have generally been more prevalent.

Some notable contributions include:

- The **TAM**, a widely used model in technology acceptance research, was combined with **UTAUT** to examine the factors influencing preservice teachers' intentions to use Learning Management Systems (LMS) in developing countries (Buabeng-Andoh and Baah, 2020).
- The **Expectation-Confirmation Theory (ECT)**, a prominent cognitive theory in customer satisfaction, explores post-purchase or post-adoption satisfaction in relation to expectations, perceived performance, and belief disconfirmation. In a recent study, this theory was combined with **UTAUT** to investigate students' perceptions of mobile learning adoption in higher education (Alowayr and Al-Azawei, 2021).

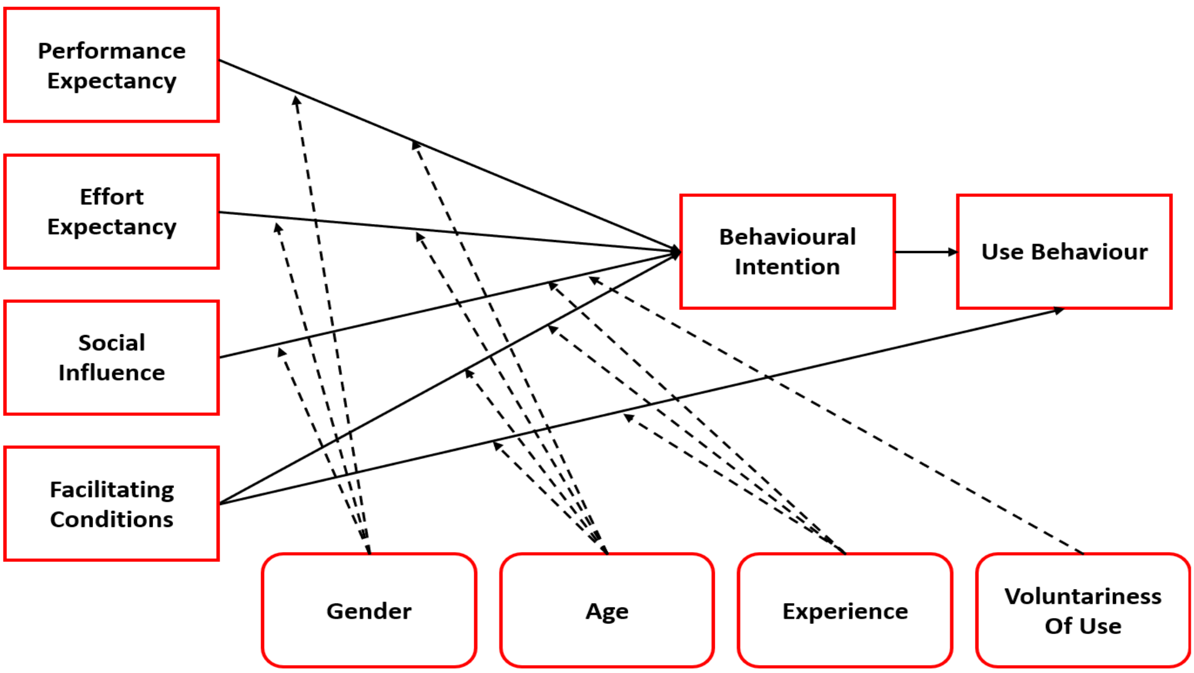


Figure 4. 5: Unified Theory of Acceptance and Use of Technology

Source: Venkatesh 2003.

Given the complexity and diversity of the Fourth Industrial Revolution (4IR), the three constructs of the **TAM** may not always be sufficient to fully capture perceptions of 4IR in the education sector, especially regarding its role in enhancing teaching and learning. As a result, a single theory, such as the **Theory of Planned Behavior (TPB)** or **TAM**, may have limited effectiveness in predicting the adoption and use of 4IR technologies in education, particularly when evaluating their impact and acceptance (Oke and Fernandes, 2020).

In contrast, while the **UTAUT** offers a valuable framework for understanding technology adoption in maritime education, it is crucial to acknowledge both the challenges and opportunities that come with digital transformation in this field. One of the primary challenges is initial resistance to change, often stemming from a lack of familiarity with new technologies. However, there are significant opportunities as well, including enhanced learning experiences, improved accessibility to education, and the ability to simulate complex maritime scenarios that would otherwise be impossible or prohibitively expensive to replicate in real life.

4.6 THEORY OF DESIGN SCIENCE RESEARCH METHODOLOGY (DSRM)

The **Design Science Research Methodology (DSRM)** is a problem-solving approach that originates from engineering and the artificial sciences (Simon, 1996). It seeks to advance human knowledge by developing creative artifacts and design knowledge (DK) to address practical challenges (Hevner et al., 2004). Over the last two decades, DSRM has gained attention for its ability to stimulate organizational innovation and support social sustainability (Watson et al., 2010; von Brocke et al., 2013). Through the creation of new artifacts—such as constructs, models, techniques, and instantiations (ideal examples or representations)—DSRM aims to enhance human and organizational capabilities (Hevner et al., 2004; Gregor and Hevner, 2013).

The goal of DSRM is to generate design knowledge, which involves understanding how to structure or organize systems to achieve specific objectives. In the context of **Information Systems (IS)**, this includes designing database systems, modeling business processes, aligning IS with business strategies, supporting decision-making through data analytics, and using IT for sustainability (Becker et al., 2015; Seidel et al., 2013). The impact of DSRM in IS has been profound, with notable economic and societal benefits (Gregor and Hevner, 2013). DSRM also serves as a key research framework in fields such as engineering, architecture, business, economics, education, and other IT-related domains, driving innovation across multiple sectors.

The framework of DSRM, as depicted in **Figure 4.6**, involves understanding, conducting, and evaluating research to solve real-world problems. The "environment" of the research includes people, organizations, and technologies, with goals, tasks, and perceived needs being assessed within the context of organizational strategies and structures. These needs help define the "research problem," ensuring that the research remains relevant (Hevner et al., 2004).

The knowledge base for DSRM includes foundations (theoretical background) and methodologies (guidelines for evaluation). Existing research provides the foundational theories, models, and methods used in the "build" phase, while methodologies guide the "evaluate" phase, ensuring rigour in the study.

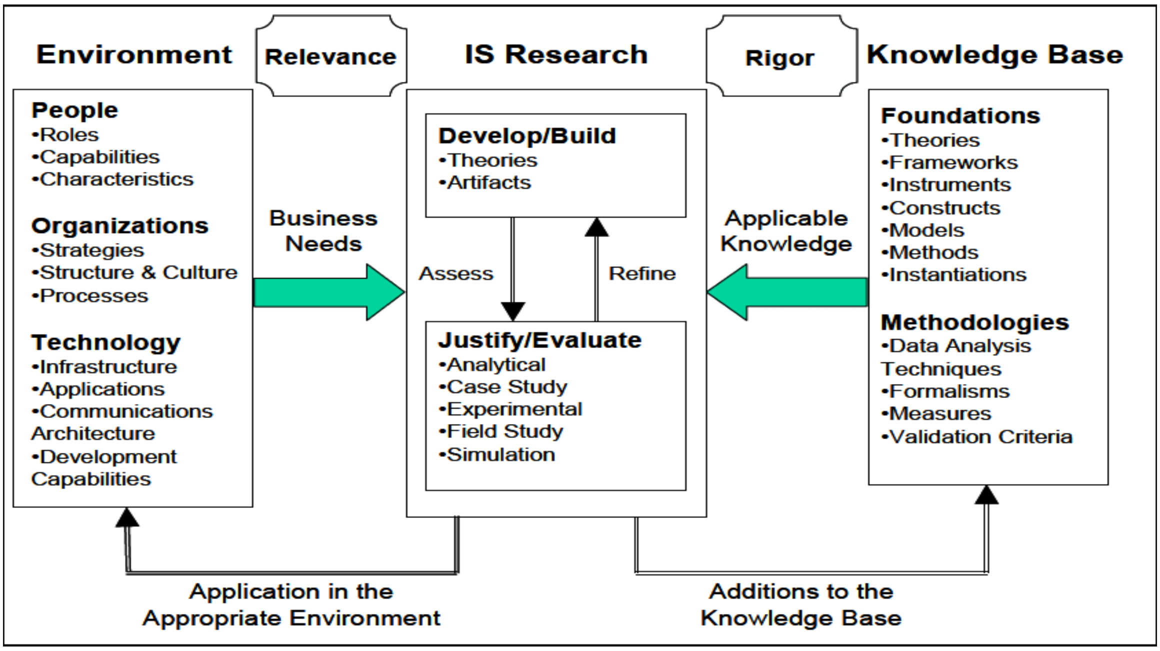


Figure 4. 6: Design Science Research Framework

Source: Hevner *et al.* 2004.

The DSRM addresses practical problems by first identifying specific needs through the analysis of the business environment. It then evaluates existing design knowledge, such as theories, frameworks, and artefacts to determine if a solution is already available. If not, DSRM aims to create an innovative solution, often by adapting and extending existing knowledge. The design process in **Design Science Research Methodology (DSRM)** involves iterative "build" and "evaluate" activities. These activities are carried out using a variety of research methods, such as interviews, surveys, literature reviews, and focus groups (vom Brocke et al., 2020).

Furthermore, DSRM is a practical research paradigm that focuses on creating innovative artefacts to solve real-world problems. This contrasts with behavioural science research, which focuses on understanding and theorising about technology use and its impact. There is ongoing debate among scholars about the philosophical underpinnings of DSRM. Some argue that the researcher's perspective evolves iteratively throughout the research process (Vaishnavi *et al.* 2004), while others, like

Carlsson (2005), suggest that the researcher's understanding of the world changes, not their philosophical viewpoint. There is no consensus on a single research philosophy driving DSRM, and various methods and philosophical approaches, such as critical realism and pragmatism, have been proposed. However, it is agreed that DSRM requires two main criteria: relevance (contribution to foundational knowledge), and rigour (methodological soundness) (Kotze *et al.* 2015). The DSRM outputs can be categorised into three types of knowledge contributions: conceptual (e.g. models, frameworks), descriptive (e.g. theories, observations), and prescriptive (e.g. methods, design processes). Several DSRM frameworks and processes have been developed over time, often involving identifying the problem, designing the solution, and evaluating the artefact. Common DSRM guidelines include creating viable artefacts such as constructs, models, methods, or instantiations.

In academic research, particularly for doctoral dissertations, students often struggle with understanding and applying research philosophies. A survey at the University of Pretoria found that 76% of students found the research design section of their dissertations, especially relating to philosophical foundations, the most challenging. This highlights a broader challenge in postgraduate research supervision. However, DSRM is becoming an increasingly popular approach for doctoral research in IS, particularly in South Africa, with ongoing studies investigating its application in completed doctoral theses (Kotze *et al.* 2015).

4.7 REVIEW AND INTEGRATION

The review of various models on technology adoption, as shown in **Table 4.1**, indicates that each model has its own strengths and weaknesses, with no model being entirely free from limitations. While some models use different terminology—such as **performance expectancy** in **UTAUT** and **effort expectancy** in **TAM**—the core constructs of many models overlap. Despite this, no single model is without its limitations.

The **Theory of Reasoned Action (TRA)**, developed by Ajzen and Fishbein (1975), laid the foundation for later models like **TAM**, **TAM2**, and **UTAUT**. TRA explains technology adoption from a social psychology perspective, suggesting that an individual's **behavioral intention (BI)** is influenced by subjective norms and attitudes toward the behavior. However, TRA has its drawbacks, including its failure to account for situational factors that may affect behavior, attitude, and BI.

Table 4. 1 A review of TRA, TAM, TAM2, UTAUTand.DSRM

Theory Model	***Developed by***	***Strength***	***Limitations***
Theory of Reasoned Action (TRA)	Ajzen and Fishbein (1975)	• Was a base and fundamental of most theories. • Explaining the user behaviour from the view of social psychology	• General in nature. • Ignoring the situational factors that may influence user's behaviour intention as it claims that behaviour intention is influenced only by the attitudes and subjective norms. • Extending it usually does not increase the explanatory power of the model. • A clear risk of confounding between subjective norms and attitude constructs as attitudes can often be reformed as norms.

Theory Model	*Developed by*	*Strength*	*Limitations*
Technology Acceptance Theory (TAM)	Davis (1989)	• Overcomes the limitations of TRA. • Includes the users' belief factors in the model: Perceived ease of use and perceived usefulness. • Can be extended to study any external factors with the choice of different application, culture and work-settings. • Extending it could improve the explanatory power of the model. • A valid and robust model which was tested widely in different situations, context and applications to explain the acceptance and usage of systems.	• Using the original TAM without extending it, is considered as general theory and might not provide a clear explaining about how users accept technology. • The belief factors PU and PEU can also be influenced by many external factors that may influence the usage of technology.
Extended TAM	Vekantesh and David (2000)	• Extension of the original TAM to overcome its limitations. • Takes into consideration both social influence and cognitive instrumental processes. • Integrates eight of most popular past theories.	• The belief factors PEU and PU can be also influenced by other various factors such as facilitating condition, self-efficacy, computer anxiety etc. • Inflexible Model to be adapted in different contexts such as non-western culture, which results in lower explanatory power in behaviour intention variance (only explained in the variance of behaviour intention when it was applied in different contexts)

Theory Model	***Developed by***	***Strength***	***Limitations***
Unified Theory of Acceptance and Use of Technology (UTAUT)	Venkatesh *et al* (2003)	• Provides a higher explanation power in behaviour intention. (could explain 70% of variance explained). • Considers the power role of moderating variables	• The consensus in the nature of the relationships between its factors does not always exist, especially when applied in different contexts. • UTAUT is not perfect for some applications (such as commerce), often needing modification. • Results in reduced simplicity due to the intricate connections between constructs, which are further influenced by varying moderation effects.
Design Science Research Methodology (DSRM)	Simon (1996)	• Ensures solutions address real-world maritime challenges. • Emphasises continuous refinement, crucial for adapting to evolving technologies and regulations • Involves maritime professionals and educators in the design process to ensure practical applicability • It directly tackles specific technological problems • DSRM fosters teamwork among experts from various fields, ensuring holistic innovations.	• Coordinating input from diverse stakeholders (regulators, educational institutions, industry players) can be difficult • Developing simulations and VR tools can be expensive and time-consuming. • The fast pace of technological advancement in the maritime industry requires continuous adaptation of educational tools • Aligning multiple stakeholders in large projects can be challenging and time intensive. • Measuring success in emerging fields can be difficult, especially when metrics are not well-established.

Source: Alshammari and Rosli 2020.

To address these limitations, TAM was introduced by Davis (1989) by incorporating belief constructs, specifically PEU and PU, as well as their impact on attitude, actual use (AU) of technology, and BI. TAM has become a popular model for studies on technology adoption due to its reliability and effectiveness in explaining system usage and acceptance across diverse settings.

Recent research has expanded TAM to explore additional constructs for a more comprehensive understanding of technology acceptance and to boost its explanatory power. Venkatesh and Davis (2000) introduced a new model called the **Adaptive Technology Acceptance Model (ATM)** to overcome the limitations of **TAM** and enhance its explanatory power. Additionally, DSRM provides a powerful framework for technological transformation, focusing on artifact creation, iteration, and evaluation. Its interdisciplinary and practical approach drives innovation across industries. Despite challenges like resource demands and stakeholder coordination, DSRM's benefits — such as adaptability, continuous improvement, and fostering collaboration — make it an invaluable tool in the rapidly evolving technological landscape.

4.8 MARITIME APPLICATIONS

In order to address particular issues in maritime education, the research have expanded TAM by combining it with other pedagogical theories. For example, Venkatesh and Bala (2008) suggested TAM3, an extension of TAM that takes into account elements like conducive circumstances and social impact. To determine how these extra characteristics affect maritime instructors' use of technology, this extension has been used in maritime contexts (Park and Del Pobil 2013).

Technology adoption in maritime education has also been explored through the **UTAUT**, which builds on the **TAM**. The **UTAUT** provides a more comprehensive framework by incorporating factors such as social influence, performance expectancy, effort expectancy, and facilitating conditions (Venkatesh et al., 2003). According to studies that apply **UTAUT** in maritime education (Cheng et al., 2020), these additional elements offer deeper insights into the barriers and drivers of technology adoption.

While TAM has provided valuable insights into technology adoption in maritime education, there are challenges in its application. One significant challenge is the diversity in technological proficiency among maritime students and educators, which can affect the generalizability of TAM's findings (Alam and Noor 2022). Furthermore, the rapidly changing nature of maritime technology requires continuous updates to the theoretical frameworks used to assess technology acceptance. However, opportunities exist to enhance the application of TAM in maritime education. Future research could focus on developing more context-specific extensions of TAM that address the unique needs of maritime education and training. Additionally, integrating TAM with other frameworks such as UTAUT or Diffusion of Innovations (DOI) could provide a more robust understanding of technology adoption in this sector.

Moreover, DSRM can be applied in maritime education to develop practical tools, curricula, and systems that improve training and address real-world challenges. It also helps design simulation tools that mirror real-world maritime scenarios, enhancing practical skills like navigation and safety procedures. Simulations are iteratively refined based on feedback, such as ship navigation simulation system designed to improve

decision-making skills in maritime students (Salim *et al.* 2018). The DSRM also supports the creation of curricula that integrate new technologies, such as e-learning, gamification, and Virtual Reality (VR), to enhance the learning experience (Mohammad *et al.* 2020). Furthermore, safety is paramount in maritime education, and DSRM can design VR-based safety training tools that simulate emergency scenarios for better decision-making in critical situations (Li *et al.* 2017). As maritime technologies evolve, DSRM helps develop training systems that incorporate real-time data from actual vessels, preparing students for modern operational challenges (Mohammad *et al.* 2020). With the increasing digitalisation of the maritime industry, DSRM is crucial for addressing cybersecurity risks posed by new technologies like autonomous ships and IoT devices and helps develop tools to investigate maritime incidents like accidents, piracy, and safety violations (Amro 2023).

Lastly, DSRM provides a robust framework for advancing maritime education by developing practical, solution-focused tools that enhance training, improve safety, and prepare students for the industry's evolving challenges. Despite challenges like cost and technological change, DSRM offers significant potential for improving maritime education outcomes.

4.9 SUMMARY

Ng’ambi et al. (2016) observed that teaching practices in South Africa have remained largely unchanged despite the introduction of smart devices and social media, despite the promising potential of technology to transform teaching and learning, particularly in higher education.

The education sector has largely focused on digitisation rather than fully embracing digitalisation, and many technological innovations are not regulated by academic institutions. While Rashid and Asghar (2016) highlighted the role of digital technologies in boosting student engagement and self-directed learning, they found no significant improvement in student performance. Although technology has altered the teaching and learning landscape in recent years, questions remain about its actual impact on teaching quality and student outcomes.

Evidence from five examples of interactive learning indicates that interactive e-learning methods can enhance educational experiences. For instance, Chang (2016) emphasised that e-learning is most effective when it combines face-to-face interaction with online components in a collaborative, flexible format. However, the rapid pace of current digital innovations outstrips previous technological revolutions, posing challenges for many industries in adapting, and in particular - education. Additionally, the inconsistent application of digital technologies in teaching, raises doubts about the potential for organisational learning within the education sector. Moreover, Design Science Research Methodology (DSRM) provides a powerful framework for improving maritime education by developing practical solutions to real-world challenges. Its iterative, solution-driven process can enhance training tools, curricula, and systems, ultimately better preparing maritime professionals. Despite challenges in applying DSRM in this context, its potential to create more effective learning experiences and safer operational practices makes it a valuable approach for advancing maritime education. The next chapter will focus on the methodology used in this study.

CHAPTER 5 - RESEARCH METHODOLOGY

5.1 INTRODUCTION

Research is a structured process aimed at gathering scientific evidence about a phenomenon within a specific field (Pandey and Pandey 2021: 5-15). This phenomenon is defined as the research problem within the study. The research process follows an objective approach, involving a comprehensive analysis of the phenomenon through suitable methodological frameworks. Phaladi (2021: 102) agrees, emphasising that research entails the organised collection of evidence using relevant methods. Similarly, Welman *et al.* (2005: 2) assert that research is a scientific procedure that seeks to address a phenomenon in a particular field, employing scientific methods and tools to analyse it. The goal is to establish a scientific approach that investigates, uncovers, resolves, and offers solutions to the research problem. Leedy et al. (2021: 2) describe research as a "systematic process of collecting, analysing, and interpreting information to solve clearly defined problems and develop a deeper understanding of a phenomenon."Research is generally divided into two main categories: research methodology and research methods (Al-Ababneh 2020: 76-77). Research methodology encompasses the broader approach associated with theoretical frameworks and paradigms (Crotty 1998: 1-4).

These paradigms or theories form the foundational philosophy that informs the research problem. Davis and Fisher (2018: 21-25) identify several research paradigms, including pragmatism, interpretivism, and positivism. Research methods, on the other hand, refer to the systematic procedures followed when exploring the phenomenon through data collection and analysis (Morgan 2017: 2). Tools for data collection and analysis, such as surveys, interviews, and software, provide clear insights into the phenomenon under investigation through findings, presentations, analysis, and interpretation. Thus, research is guided by paradigms that ensure the scientific inquiry process is grounded, and it is a disciplined approach for uncovering knowledge about a specific phenomenon.

According to Guba and Lincoln (1994: 105–117), paradigm is a belief system that influences the researcher's perspective and approach when investigating a specific phenomenon. When selecting the most appropriate paradigm for a study, the researcher reviews the literature to understand the human constructs presented in the philosophical foundations of research. This leads to a process of intrinsic reasoning in the researcher's mind after reflecting on these philosophical foundations and paradigms (Denzin 1970; Denzin and Lincoln 2000). The researcher evaluates which paradigm is most suitable for exploring the phenomenon in the study, and this selection influences the methodical approach taken in the research process. Therefore, the chosen paradigm becomes central to the methodology and methods used in the research. phenomenon. Sarantakos (2013: 28-30) asserts that a philosophical paradigm governs the research methods and techniques a researcher adopts when exploring a phenomenon. Additionally, Ngulube (2015: 125-143) elaborates that the paradigm helps the researcher determine which methods and tools are most effective for understanding the phenomenon.

5.2 METHODOLOGICAL APPROACH

The research methodology chapter outlines the systematic approach used to investigate the digital transformation of maritime higher education and training in South Africa. This chapter provides a detailed explanation of the research design, target population, sampling strategies, data collection methods, data analysis procedures, and ethical considerations. To enhance the validity and reliability of the findings, the study must be conducted in a rigorous, transparent, and replicable manner.

The digital transformation of education, particularly within specialised fields such as maritime higher education, requires a nuanced understanding of both technological acceptance and pedagogical integration. Given the complexity of these factors, a mixed-methods approach was deemed most appropriate. This approach allows for the collection of both quantitative and qualitative data, providing a comprehensive understanding of the lecturers' perspectives on the integration of digital tools in their teaching practices.

The study aims to investigate the dynamics of digital transformation from various perspectives by integrating the TAM as a theoretical framework with a variety of methodologies. This provides a strong basis for determining the main advantages, difficulties, and opportunities related to blended and online distance learning in the maritime education industry. The research design and the justification for employing a mixed-methods strategy are described at the beginning of this chapter. The target audience is then covered, including the institutions that were chosen to participate and the sampling techniques that were employed to find participants.

The chapter then goes on to discuss the tools and methods used for data gathering, such as the protocols for surveys and interviews, as well as the data analysis methods used to compile and analyse the results.

The chapter concludes with a discussion of the ethical considerations that guided the conduct of the research, ensuring that the study adhered to the highest standards of research integrity and participant protection. The research problem addressed in this study was to develop a model of rational (intelligent, smart) deployment of digital tools to transform transmission (teacher-centred) into transformative (student-centred) MHET within the South African emerging educational environment. The aim was to ascertain, explore and establish the pedagogical skills, digital skills, and online teaching of maritime students in a digital environment and to identify opportunities, challenges, and prospective advances of VE in MHET.

Additionally, research questions specify what we intended to find out through the study. They translate the problem of BL, ODL, and VE's successful implementation across South African MHET institutions, into a specific need for data and information collection, coding, analysing, and adequately presenting. Accordingly, Table 5.1 summarises the research problem, objectives and research questions.

Table 5. 1 Problem statement, objectives and research questions

Problem Statement		
	Research Objective	**Research Question**
The MHET sector has many challenges. Digital tools are a powerful agent 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 competences that will fit them to the 21st	• To identify the prerogatives for implementing BL, ODL, and VE into MHET;	1, What are the preconditions for successful implementation of BL, ODL, and VE at the MHET institutions?
	To come up with the optimal combinations of well-established pedagogical theories and modern educational digital tools;	2, In which ways well-established pedagogical theories, approaches, and methods can be merged with advanced digital tools in MHET?
	• To identify opportunities, challenges, and	3, What are the benefits, challenges and prospective

century maritime sector labor market needs.\	prospective advances of BL, ODL, and VE in MHET;	advantages of BL, ODL, and VE in MHET?
	• To identify impediments affecting BL, ODL and VE implementation into higher extent into MHET programs.	4, What are the impediments, which affect DL, ODL, and VE implementation at the MHET institutions?

Source: Researcher.

5.3 RESEARCH DESIGN

Research approaches can involve quantitative, qualitative, or mixed methods, with the choice depending on the study's nature, purpose, goals, and objectives. According to Creswell (2014: 247), a research approach is a systematic procedure that encompasses overarching assumptions and specific techniques, which include data collection, analysis, and interpretation. Another way to think of research approaches is as the combination of data gathering techniques, research design, and philosophical presumptions (Omarsaib 2022).

This study's research strategy is based on a mixed-methods design, which integrates both quantitative and qualitative research approaches. This method was selected to provide a comprehensive understanding of the digital transformation processes in South African maritime higher education and training.

By utilizing both techniques, the study sought to capitalize on each approach's advantages and provide a more comprehensive and nuanced analysis of the research problem. According to Sekaran and Bougie (2016), a study gains rigor and credibility when it is supported by a solid theoretical foundation and a sound methodological design.

This study is based on critical realism and pragmatism research approaches, using both deductive and inductive reasoning. The researcher’s intervention was minimal. Phenomena will be studied as they occur. The units of analysis were individuals, i.e. selected MHET educators in South Africa. The time horizon was cross-sectional, i.e. carried out at a specific point in time. 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. The details are outlined in Table 5.2.

Secondary sources of data included relevant books, articles, dissertations, theses, statistics, bulletins, government publications, conference proceedings, social media and unpublished manuscripts. The nature and the value of secondary data was carefully evaluated before it was used. Criteria for evaluating noted timelines, accuracy, relevance, and cost of the data (Sekaran 2016).

The examples, statements, and questions for case studies and the questionnaire were based on the researcher’s knowledge and experience, along with the results of a detailed study of the secondary literature resources available at EBSCO, Science Direct, Web of Science, Google Scholar, and IEEE Explore databases, through extensive desktop search. In collecting primary data, mixed, sequential method were applied as illustrated in Table 5.2.

Table 5. 2 Mixed research method in collecting primary data.

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

Source: Researcher

5.4 METHODOLOGY

A case study was applied as a research strategy, while questionnaires and interviews were used as data collection methods. The questionary had 14 closed-ended questions, while the interview was composed of 10 open-ended questions. The survey questions were answered by means of a number, ranking 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. Qualitative answers, were coded and analysed manually and by through the application of a Python code.

The data collection tools, i.e. the questionnaire and the structured interview, were structured after careful consideration and triangulation of several well-established technology adoption theories, such as: the TRA, the TAM, TAM2, the (UTAUT, and the DSRM.

Furthermore, when structuring the questionnaire and the interview, we were also guided by past studies, namely, Sabia *et al.* 2016 and Bauk 2017, which both dealt with the adoption of technology driven education in different developing environments.

Teachers at the following MHET institutions in South Africa participated in the study:

1. DUT, or Durban University of Technology
2. Technology University of the Cape Peninsula (CPUT)
3. NMU, Nelson Mandela University
4. Umfolozi Academy of Maritime Arts (UMA).

Since none of these institutions currently offer an officially approved ODL curriculum, the MHET institutions were chosen. To remain competitive in the global marine labor market, sailors and maritime (ex-)students must constantly improve their knowledge and abilities. ODL provides the perfect option because they are mariners who must constantly update their knowledge and renew their certifications of competence.

5.5 MIXED APPROACH

The mixed-methods research approach is often considered the most effective as it integrates both quantitative and qualitative methodologies (Creswell & Clark, 2006; Greene, 2007). This approach can be applied to both survey and case study research. Researchers typically combine multiple methods to enhance the validity of their studies.

For example, surveys may collect quantitative data for correlation analysis to explore relationships between variables. Meanwhile, interviews or focus group data can provide deeper insights into the participants' perspectives on the issue being studied. A case study exploring an organisation’s processes could illustrate this methodology, where processes are observed, modified, measured, compared, and statistically analysed. The case study (qualitative) sets the context, while surveys, quasi-experimental designs, or correlation studies (quantitative) help to identify causal relationships or correlations between variables. Researchers might further enrich their findings by conducting interviews or focus groups to understand how individuals in the organisation experience specific processes. The sequence in which qualitative and quantitative methods are applied depends on the research questions (Creswell and Clark 2006).

5.6 RATIONALE FOR MIXED APPROACH

A comprehensive view of the study issues is provided by the mixed-methods technique, which blends quantitative and qualitative data. While qualitative approaches enable a thorough examination of lecturers' experiences and perspectives through interviews, quantitative methods are used to evaluate and analyze trends, patterns, and relationships in data gathered from surveys.

This combination is particularly valuable in educational research, where complex human behaviours and institutional dynamics are better understood through both numerical data and narrative insights. The integration of these methods aligns with the study's objectives to explore not only the extent of digital transformation but also the contextual factors influencing its adoption and implementation. The study offers a more thorough knowledge of the digital change in maritime education by integrating quantitative and qualitative data, capturing both quantifiable results and educators' real-world experiences. Triangulation of data sources lowers the possibility of bias associated with single-method studies and increases the findings' reliability and dependability.

The approach allows for the exploration of unexpected findings that may emerge during the qualitative phase, offering flexibility to adapt and refine the research focus as needed.

The mixed-methods approach has many advantages, but it also has drawbacks, such as the need for meticulous preparation to guarantee correct data integration and the additional time and resources needed for data collection and analysis. Notwithstanding these difficulties, the method offers a strong foundation for comprehending the study's quantitative and qualitative aspects and is well-suited to handle the intricacies of digital revolution in marine education and training.

5.7 QUANTITATIVE APPROACH

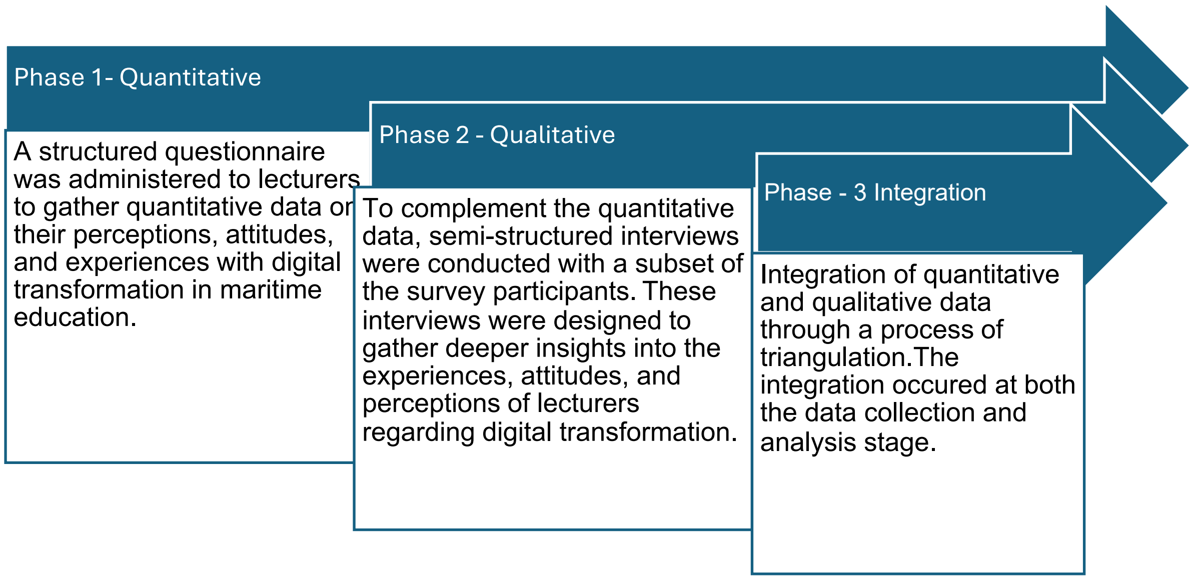
The quantitative component of the study employed a descriptive and inferential statistical approach to analyse the data collected through structured surveys administered to lecturers at the four key maritime institutions The survey instrument was developed using the TAM as a reference, with an emphasis on important characteristics such behavioral intention to use digital technologies, perceived usefulness, and perceived ease of use. This method made it possible to find trends and connections among these variables, which improved our knowledge of the elements influencing maritime instructors' adoption of technology.

5.8 QUALITATIVE APPROACH

The qualitative component included semi-structured interviews with a selected group of survey participants. These interviews aimed to gain deeper insights into lecturers' experiences, attitudes, and perceptions of digital transformation.

Through thematic analysis, qualitative data provided rich, contextualised understanding of the challenges, opportunities, and personal experiences that quantitative methods alone may not haveccaptured. This approach was particularly useful for exploring the nuanced and often complex nature of digital transformation, including resistance to change, institutional barriers, and individual adaptation strategies.

Table 5. 3 Quantitative and qualitative research methods



Source: Researcher.

5.9 INTEGRATION

Through a triangulation process, the mixed-methods approach made it easier to integrate quantitative and qualitative data. Triangulation improves the conclusions' validity and reliability by cross-checking data gathered from various sources and techniques. A thorough investigation of the study issues was made possible by the integration, which took place during both the data gathering and analysis phases. Deeper understanding of the causes of the noted patterns and trends was provided by the qualitative findings, which also assisted in contextualizing and explaining the quantitative data.

5.10 DATA COLLECTION

A one-time or one-shot survey was employed in the initial phase of primary data collecting. Self-administered questionnaires, the survey tool, with closed-ended questions were used. Collected data was coded, keyed in, edited, analysed and adequately presented. A quantitative approach was applied. The survey included the following constructs:

- lectures' attitudes towards BL, ODL, and VE (willingness to deploy these approaches);
- actual use of BL, ODL, and VE at the selected MHET institutions;
- lecturers' knowledge on classical pedagogical methods and possibilities of their matching with different digital education tools;
- objective capacities for BL, ODL and VE implementation and adoption;
- prospective benefits of implementing BL, ODL and VE for students;
- rising MHET accessibility and affordability; and
- concerns related to mainstream implementation of BL, ODL and VE at the MHETs.

Questionnaire structure was adjusted for the Multiple Linear Regression Model (MLRM) approach, which included dependent and independent variables. Close-ended questions were conceived around the relevant constructs (see Figure 5.4). The responders, i.e., the experienced educators at the selected MHET institutions used a Likert (1-5) scale to answer the questions. The collected data was edited, coded, stored, and statistically analysed in MS Excel Module and SPSS.

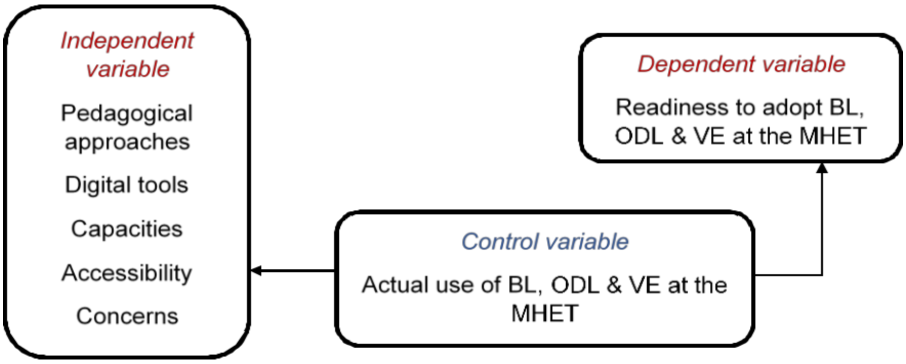


Figure 5. 1: The MLRM framework for the study

Source: Researcher.

For the second phase, 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 was the only viable method for obtaining the data required from very specific individuals, who could provide the information we were looking for. When selecting respondents, careful consideration was given to the inclusion and exclusion criteria. Inclusion criteria refer to the characteristics required for prospective participants to be eligible for the study, while exclusion criteria outline the characteristics that disqualify individuals from participation. The inclusion criteria for this study included employment at Durban University of Technology (DUT), Cape Peninsula University of Technology (CPUT), and Nelson Mandela University (NMU)or Umfolozi Maritime Academy (UMA) maritime studies departments as either a full, associated or assistant professor, or as a lecturer; 2) in possession of a PhD degree; 3) at least five years of working experience in maritime higher education.

Exclusion criteria for the study: included those who did not comply with the three criteria specified above. Thus, they could not participate in the study, and hence were excluded. We also paid close attention to the size of the sample.

Sample: In determining an optimal number of samples, we used Slovin’s formula (Glen 2022). Hence, the sample size was determined by means of the following equation:

Sample size = $N/(1+N*e^2)$, where N is the population size and e represent the margin error (in this case 0.05).

Our sample size amounted to ten lecturers and one professor at Durban University of Technology (DUT), eight lecturers at Cape Peninsula University of Technology (CPUT), eight lecturers at Nelson Mandela University (NMU), and five lecturers at

Umfolozi Maritime Academy (UMA). Assuming that the common margin error was 5% or 0.05, then the calculation based on Slovin's formula led us to the sample size of 29.62. Thus, it was concluded that the sample of 30 participants was appropriate from the statistical point-of-view. Prospective respondents were contacted via e-mail for both survey and structured interviews. As experienced researchers, we established rapport with and gained the confidence and approval of the respondents before we started with surveying and interviewing processes. After 20 days, the interviewees sent us their feedback.

5.11 TARGET POPULATION

Lecturers from four important South African universities that provide maritime education and training were among the study's target population: Durban University of Technology (DUT), Cape Peninsula University of Technology (CPUT), Nelson Mandela University (NMU), and Umfolozi Maritime Academy. These institutions were selected due to their significant role in maritime education and their varying levels of digital transformation implementation.

The recruitment process was mediated by gatekeepers, who were the Head of the Departments at the target institutions/departments. A letter was emailed requesting contact details of potential respondents and permission to reach out for the study.

5.12 SAMPLING TECHNIQUE

Sampling is a critical aspect of research procedures, providing a foundation for the quality of inferences drawn by the researcher after analysing findings. Combining quantitative and qualitative approaches can make sampling strategies complex. However, Taguchi (2018: 27-30) asserted that despite the challenges, mixed-method designs, such as concurrent and sequential approaches, enables researchers to gain a comprehensive understanding of the phenomenon under study.

Therefore, the sampling strategy and the mixed-method design must align seamlessly within the research process. Moreover, the sampling method used should reflect the mixed-method design chosen for the study.

The sampling design emanates from the type of mixed-method approach and guides the researcher in navigating the study's objectives. Thus, researchers must explicitly define the sampling size, framework, and characteristics (Vasileiou *et al.* 2018: 2-4).

In quantitative research, sampling strategies involve the intentional selection of specific units from a population for analysis. This process allows researchers to generalise findings to the larger population, achieving what is known as external validity. According to Findley et al. (2021: 368-369), external validity refers to the ability to generalize the findings of a study by systematically collecting, analyzing, and interpreting data to apply the results to a broader population. Probability sampling is a key method for ensuring external validity.

Mishra and Alok (2022) explain that probability sampling is a technique where every member of the population has an equal chance of being selected for the sample. This approach enhances the reliability of the results by ensuring the sample accurately represents the population. They highlight several probability sampling techniques, such as cluster, stratified, simple, and systematic sampling. In contrast, non-probability sampling methods are typically used in qualitative research to explore a phenomenon (Mishra and Alok 2022). With non-probability sampling, the researcher cannot ensure that every part of the population is represented in the sample. Instead of relying on random selection, this approach depends on the researcher's judgment (Elfil and Negida, 2017: 1-3).

Common non-probability sampling techniques include purposive, quota, convenience, and snowball sampling (Berndt 2020: 224-226). When selecting a non-probability sampling method, researchers must consider the study goals, methodology, population size, and population knowledge (Shorten and Moorley, 2014: 32-33). Purposive sampling is a non-probability method where the researcher intentionally selects participants with direct experience relevant to the phenomenon under study.

(Creswell and Clark 2007: 415). This approach allows the researcher to explore information-rich cases related to the phenomenon, engaging participants to understand their perspectives through their lived experiences. Other non-probability sampling methods include convenience sampling, which targets an easily accessible sub-population; homogeneous sampling, which focuses on a small sub-population for in-depth study; and snowball sampling, where participants help recruit additional subjects during the sampling process (Berndt 2020: 224-226). Participants who have firsthand knowledge and experience with the use of digital technology in teaching and learning within their respective institutions will be chosen for this study using a purposive sample technique.

5.13 QUANTITATIVE DATA COLLECTION

Respondents answer a systematic set of pre-formulated questions in a questionnaire, usually selecting from pre-established categories. This method is commonly used to collect quantitative data and can be distributed electronically, in person, or by mail. Compared to interviews and observations, questionnaires are generally more cost-effective and less time-intensive. However, they often face a higher likelihood of non-responses (Ntshangase 2024).

.A structured questionnaire was distributed to lecturers for this study in order to gather quantitative data on their attitudes, opinions, and experiences with the digital transformation of maritime education. The TAM served as a guiding framework for the survey's design, with a focus on perceived utility, perceived ease of use, and intention to adopt digital technologies. The topics covered in the poll included acceptance of technology, readiness for digital transformation, perceived difficulties, and the impact of digital tools on the effectiveness of instruction. The questionnaire consisted of closed-ended questions that participants were required to answer on a 5-point Likert scale.

The questions and statements were designed to encourage respondents to consider the pros and cons of different digital technologies dimensions before selecting a number on the scale. A rating of one represented the lowest level of agreement, while five indicated the highest. A copy of the questionnaire can be found in Annexure C of the dissertation.

To gather quantitative data the questionnaires were sent with closed-ended statements to respondents at four selected maritime institutions via emails. Each respondent received the questionnaire as a link created on google drive, along with a request for their participation. Out of 30 distributed questionnaires, 18 were completed within the four-weeks response period. To encourage timely responses, reminders were sent through emails and phone calls.

Once collected the data was analysed. The results will be presented in the following chapter.

5.14 QUALITATIVE DATA COLLECTION

Semi-structured interviews with a subset of survey respondents were used to supplement the quantitative data, providing richer contextual understanding and allowing for a deeper exploration of themes that emerged from the survey data. The interviews were designed to provide in-depth insights into the lecturers' experiences, challenges, and recommendations regarding digital transformation.

One popular technique for gathering data in research is conducting interviews on a specific subject. Typically, an interview is a purposeful interaction between two or more individuals (Ntshangase 2024). Interviews can be structured or unstructured, conducted individually or in groups, and carried out face-to-face, over the phone, or via mail. In structured interviews, the required information is predetermined, allowing for preparation in advance. A structured interview generally includes the following components:

- The interviewer introduces oneself, explains the objective of the interview, ensures confidentiality, and gets permission to record the talk.
- These cover the study's objectives and begin with "warm-up" questions that are easy and non-threatening to answer.
- These are follow-ups to clarify ambiguous or incomplete responses or to gather more detailed information (Sekaran and Bougie 2016).

For this study, structured interviews were employed. The study was first presented to the respondent by measn of a consent letter, which was a prerequisite for obtaining ethical clearance. The consent letter was shared with participants before the interview questions were sent. The computer-assisted interviews were then conducted by emailing the interview questions as a Word document attachment to respondents from the four selected maritime institutions. All participants finally responded albeit at a slow pace. The researcher sent follow ups messages via email, phone calls and WhatsApp to remind and encourage the participants to respond.

The interview design included general questions at the start, followed by more specific ones addressing participants' knowledge of digital transformation and its applications in the maritime institutions.

As the interviews were computer-assisted and conducted via email, probing questions were not used. Instead, the questions were carefully crafted to be concise and clear, minimizing the possibility of misunderstandings. The interview comprised twelve open-ended questions, allowing respondents to provide detailed answers in their own words aiming to avoid overwhelming participants by limiting the number of questions, ensuring they remained focused and provided thoughtful responses.

There were no restrictions on the length of participants' responses, allowing them to address each topic freely based on their knowledge and experience. Feedback from all respondents indicated that the questions were answered thoroughly and meaningfully. Their responses confirmed their expertise in their field and their strong interest in digital transformation and its potential applications in the maritime institutions.

The findings from these interviews will be presented in the next chapter, focusing on qualitative data analysis. The interview questions are included in Annexure M of this dissertation.

5.15 DATA ANALYSIS PRESENTATION

Research is a systematic and organised process designed to explore, examine, and gain a deeper understanding of a specific phenomenon. In this context, if the methodology is viewed as a roadmap guiding the research journey, data analysis serves as the stage where the researcher confirms whether the correct path has been followed. This confirmation is based on the results obtained through the application of appropriate scientific methods that align with the study's objectives. Essentially, data analysis is the process of reviewing the results to ensure that the researcher has adhered to the roadmap and conducted the data collection process effectively. (Omarsaib 2022).

Data analysis begins by simplifying large volumes of data. During this reduction process, three primary strategies are employed: deductive, inductive, and abductive reasoning (Maree 2016). These strategies not only reflect the variety of data sources used but also highlight the philosophical underpinnings of the analysis methods. The process also includes checking the raw data for consistency and accuracy before moving into a more detailed examination (Bryman 2016). At this stage, issues such as missing data or incorrect coding are identified. The researcher then verifies the data before proceeding with further analysis Scharp and Sanders (2019: 117–121) emphasize that verification is essential, as it enables the researcher to make meaningful interpretations and derive insights from the data. This process helps identify patterns and thematic connections. From this analysis, the researcher can draw inferences, organize the data into tables, establish correlations, and interpret the findings. According to Babbie (2008: 122), data analysis aims to understand the relationships between various elements through inference and interpretation. This is achieved using both quantitative and qualitative data analysis techniques, with the ultimate objective of presenting the data in a clear and meaningful way.

The first phase of this study involved analysing the quantitative data collected through a questionnaire sent to 30 academic lecturers at South African maritime institutions. The raw data was extracted from the QuestionPro survey software in SPSS format and transferred to an Excel spreadsheet. Using SPSS, the researcher began by cleaning and refining the data.

A statistician further simplified the data by coding and analysing it in SPSS, producing frequency tables with labels, values, and percentages. The results were presented in graphs, cross-tabulations, correlations, and regression tables. In the quantitative data analysis, the associations between dependent and independent variables were investigated using descriptive and inferential statistics. Multiple regressions and Pearson Product Moment correlations were also used to investigate these connections.

The interview questions for the study's second qualitative phase were developed using the quantitative results. As part of a "fully mixed sequential equal status design," the sequential explanatory mixed-method design guided the research process, and both qualitative and quantitative approaches were seen as equally significant. Consequently, the quantitative data was examined initially. SPSS was used to process the questionnaire's closed-ended items, which used a five-point Likert scale.

Descriptive and inferential statistics were used to assess and analyse the raw data, further analysing the independent and dependent variables to provide regression tables and correlations. Planning for the second phase, which included semi-structured interviews, was informed by the results of the quantitative phase.

The mixed approach analysis combined both the empirical evidence from the quantitative phase and the themes identified in the qualitative phase. The researcher integrated components from the theoretical frameworks, literature, and data from both methods to present the findings and discussions.

5.16 QUANTITATIVE DATA ANALYSIS

The quantitative data was analysed using factor analysis in addition to standard statistics. The underlying correlations between observable variables can be determined using this method (Costello and Osborne 2005).

By combining highly correlated variables into a smaller number of latent (unobserved) variables, or factors, it 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. However, many authors recommend a value of 0.60 prior to factor analysis.

Rotation is used to improve the interpretability of the factor structure after initial factor extraction. It modifies 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 assists us in identifying the factors and variables relevant for our study.

5.17 QUALITATIVE DATA ANALYSIS

Qualitative data are word-based and analysing them can be a complex task. Unlike the established rules and guidelines available for analysing quantitative data, there are fewer widely recognized criteria for qualitative data analysis. Over time, several generic approaches have been developed for analysing qualitative data, with the methodology of Miles and Huberman (1994) being one of the most widely used. According to this approach, qualitative data analysis involves three stages: data reduction, data display, and conclusion drawing. Data reduction is the first stage in qualitative data analysis, involving the process of selecting, categorizing, and coding the data. Data display refers to the methods used to organize and present the data for further interpretation.

The researcher (reader) may find it easier to comprehend the data if they haveacces s to a matrix, a graph, a chart, or a collection of quotes that highlight trends in the dat a. Analysing qualitative data is a continuous, iterative process as opposed to a sequential, linear one. 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. The next section explores the ethical considerations that were fundamental to this research.

5.18 ETHICAL CONSIDERATIONS

A rule of conduct or expected societal norms of behavior during research is referred to as ethics in research. Both the researcher, who conducts the study, and the respondents, who supply the data, must act ethically. The first step in adhering to ethical standards is for the researcher to act with integrity, consider the findings, and act in the interests of others rather than their own. Every stage of the research process, including data collection, analysis, reporting, and information distribution, must be conducted ethically. Academic ethics and good practices up to this point have directed the treatment of the subjects and the protection of sensitive material.

Ethical considerations play a crucial role in maintaining the integrity of scientific research. Researchers must follow protocols such as obtaining informed consent and receiving gatekeeper approval to engage with participants. Ensuring respect for participants is equally important, which includes maintaining confidentiality throughout the study (Omarsaib 2022). Parameshwara (2019: 38–42) emphasises the importance of trust in planning data collection, highlighting ethical principles such as beneficence, autonomy, justice, veracity, and privacy, which help build positive relationships between researchers, participants, and institutions. Similarly, Creswell (2014: 92) stresses the significance of personal privacy, credibility, and the use of disclosure agreements in all research stages, whether quantitative, qualitative, or mixed methods.

Ethical considerations in social sciences have been extensively studied. Zhang and Liu (2018: 505–508) categorise these issues into two main groups. The first relates to ethical and professional codes of conduct, which form the basis for this study's principles. The second group consists of a checklist of ethical factors to be addressed before, during, and after the research process. The following guidelines were applied in this study:

- Research should aim to contribute to the broader field of knowledge rather than serve personal interests or recognition.
- An appropriate research design must be chosen to ensure rigorous and thorough scientific inquiry.
- The confidentiality of participants and their data must always be protected.
- Researchers should respect and safeguard participants' data and information, ensuring their privacy is maintained.
- The purpose of the study must be clearly communicated to all participants.
- The researcher must avoid misrepresenting the study's nature or influencing participants' views after data collection.
- Participants should not be coerced into participating, as this compromises the study's integrity.
- Participants' decisions to decline participation must be respected if they communicate this intention.
- Informed consent must be obtained from participants to ensure their legitimate involvement.
- The researcher must ensure data accuracy during both quantitative methods and qualitative methods

- Participants must be informed beforehand and encouraged to provide honest responses once they consent to participate (Omarsaib 2022).

Sekaran and Bougie (2010) stressed that while it is essential for participants to provide honest responses, the researcher must ensure that participants are not subjected to any physical, mental, or environmental harm throughout the study.

In this study, the researcher adhered to these ethical guidelines and protocols. Ethics clearance was first obtained from the Durban University of Technology (see Annexure E), where the study was registered. Permission to conduct the research was then requested from the research ethics offices of the four South African maritime institutions via email. CPUT and NMU requested that we also apply for their ethical clearance (Annexure F and G). While identifying the correct channels for obtaining permission was relatively straightforward, the response rate from some research offices was low, despite follow-up emails and phone calls. Delays were further caused by the variation in research procedures across the maritime institutions, such as differing documentation requirements and the infrequent quarterly meetings of ethics committees. Ultimately, permission was granted by all four maritime institutions through email correspondence.

Once permission was granted by the maritime institutions, the researcher contacted the head of departments via email to inform them about the study. Copies of the ethical clearance letter and the gatekeeper permission letters (see Annexures D, H, I and J) were shared with the departmental heads. This gesture was met with positive responses, either directly from the heads or through their secretaries, who provided the researcher with the contact information of academic lecturers.

The researcher then reached out to the academic lecturers by email, including the relevant ethics documentation. Most participants willingly signed the informed consent forms, while others were reluctant to sign (see Annexure C). Nevertheless, confidentiality and privacy were strictly maintained throughout the study. No personal information or specifics about the maritime institutions were disclosed. The purpose of the study was clearly communicated in the accompanying information letter (see Annexure C). As per the ethics checklist, participation in both the survey and the semi-structured interviews was completely voluntary. The information letter for the reassured participants that their anonymity would be preserved. Responses were automatically recorded using the QuestionPro survey software, and only the researcher and supervisors had access to the data.

The participants were treated with respect, dignity, fairness, and politeness throughout the process. The researcher adhered to ethical principles at every stage of the interaction, ensuring that no harm was caused to participants. While the ethical protocols followed may not cover every moral consideration in research, the researcher made sure key ethical principles, including voluntary informed consent, confidentiality, data security, and participant protection, were consistently upheld before, during, and after data collection.

Efforts were made to fully comply with ethical standards, ensuring that informed consent forms, disclosures, and the security of participants were never compromised. Participants were also informed of the potential benefits of the research.

5.19 LIMITATIONS

The study's findings may not be applicable to other maritime education contexts because it only included instructors from four South African maritime schools. Additionally, bias may be introduced by depending solely on self-reported data; however, this is lessened by the mixed-methods approach, which triangulates data sources.

5.20 EXPECTED OUTCOMES

The study is to comprehend the prospects and constraints of digital change, define important prerogatives for blended and online distance learning, and offer practical suggestions for improving virtual engagement in maritime higher education and training in South Africa

5.21 SUMMARY

This chapter explained the research methodology by discussing the underlying philosophies, research approaches, mixed methods research designs, and the data collection methods and procedures. These elements of the methodology were aligned with the current study. The study's objective aspect examined the digital transformation used by academic lecturers at maritime institutions in South Africa, while the subjective perspective explored. This chapter focused on the various research approaches applicable to scientific inquiry. The researcher examined different scientific methods to determine the most suitable one for this study. Instead of dismissing any approach, the researcher combined both quantitative and qualitative methods using a mixed-methods approach.

Liu (2022) suggested that paradigmatic duality is not simply about combining different scientific methods, but rather about establishing compatibility through the methodological process. The researcher adopted this perspective, taking a scientific approach to implement both methods in the study through the mixed-methods research approach and design, as outlined in this chapter. Furthermore, integrating both quantitative and qualitative approaches enhance their strengths as complementary partners, helping to offset any shortcomings in the study.

The chapter also covered various mixed method research designs and the rationale for choosing the explanatory sequential design for this research.

The researcher further detailed the data collection instruments and procedures used, including the questionnaire utilising a Likert scale, semi-structured interviews, and sampling methods. The chapter also addressed the reliability, validity, and ethical considerations associated with the study. It concluded with a brief evaluation of the methodology used. The next chapter will focus on the findings of the study, analysing the results and validating the methodology by showing how the findings support the research process.

CHAPTER 6 - DATA ANALYSIS

6.1 INTRODUCTION

Research is a systematic and organised process designed to explore, examine, and gain a deeper understanding of a specific phenomenon. In this context, if the methodology is viewed as a roadmap guiding the research journey, data analysis serves as the stage where the researcher confirms whether the correct path has been followed. This confirmation is based on the results obtained through the application of appropriate scientific methods that align with the study's objectives. Essentially, data analysis is the process of reviewing the results to ensure that the researcher has adhered to the roadmap and conducted the data collection process effectively. (Omarsaib 2022).

Data analysis begins by simplifying large volumes of data. During this reduction process, three primary strategies are employed: deductive, inductive, and abductive reasoning (Maree 2016). These strategies not only reflect the variety of data sources used but also highlight the philosophical underpinnings of the analysis methods. The process also includes checking the raw data for consistency and accuracy before moving into a more detailed examination (Bryman 2016). At this stage, issues such as missing data or incorrect coding are identified. The researcher then verifies the data before proceeding with further analysis. Scharp and Sanders (2019: 117–121) note that this verification is vital as it allows the researcher to make meaningful interpretations and draw insights from the data. This leads to the identification of patterns and thematic connections. From this analysis, the researcher can make inferences, organise the data into tables, establish correlations, and interpret the findings. According to Babbie (2008: 122), the purpose of data analysis is to understand the relationships between various elements through processes of inference and interpretation. This is accomplished using both quantitative and qualitative data analysis techniques, with the ultimate goal of presenting the data in a meaningful and understandable way.

6.2 QUANTITATIVE DATA ANALYSIS

The initial phase of this study involved analysing the quantitative data collected by means of a questionnaire sent to 30 academic lecturers at South African maritime institutions. The raw data was extracted from the Question Pro survey software in SPSS format and transferred to an Excel spreadsheet. Using SPSS, the researcher began by cleaning and refining the data. A statistician further simplified the data by coding and analysing it in SPSS, producing frequency tables with labels, values, and percentages.

Regression tables, correlations, cross-tabulations, and graphs were used to display the findings. In the quantitative data analysis, the associations between dependent and independent variables were investigated using descriptive and inferential statistics. Multiple regressions and Pearson Product Moment correlations were also used to investigate these connections.

The interview questions for the study's second qualitative phase were developed using the findings from the quantitative investigation. According to a "fully mixed sequential equal status design," the sequential explanatory mixed-method design guided the research process, and both qualitative and quantitative approaches were seen as equally significant. Consequently, the quantitative data was examined initially. SPSS was used to process the questionnaire's closed-ended items, which used a five-point Likert scale. Descriptive and inferential statistics were used to assess and analyze the raw data, further analyzing the independent and dependent variables to provide regression tables and correlations. Planning for the second phase, which included semi-structured interviews, was informed by the results of the quantitative phase. Python programming was used to import the interview data for thematic and content analysis.

The mixed-method analysis combined both the empirical evidence from the quantitative phase and the themes identified in the qualitative phase. The researcher integrated components from the theoretical frameworks, literature, and data from both methods to present the findings and discussions. The next section will explore the ethical considerations that were fundamental to this research.

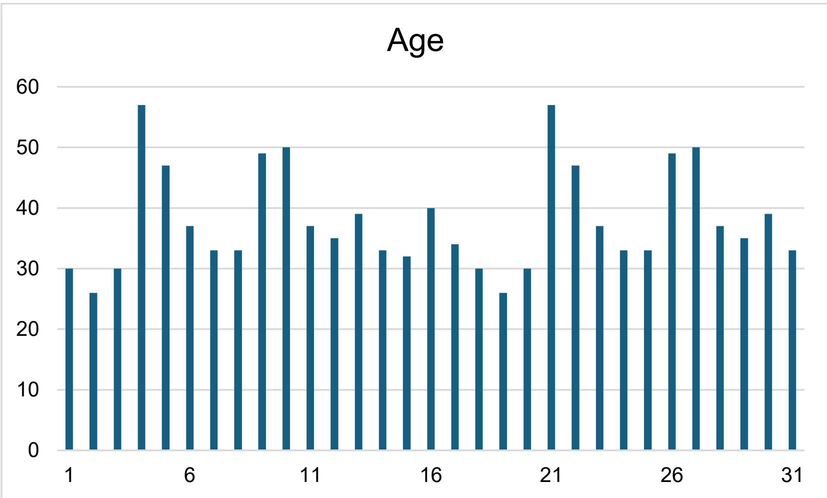
6.2.1 Data presentation

Sample and basic statistics

Thirty respondents, with an average age of forty and more than thirteen years of professional experience, were selected to participate in the study. About 37% of the sample consisted of women, while 63% consisted of men. A summary of the demographic data is given in Table 6.1.

Table 6. 1 Demographics

Gender



Number of Respondents

Number of Respondents

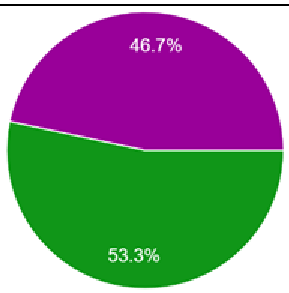
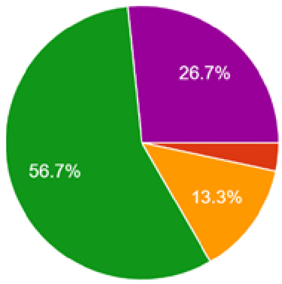
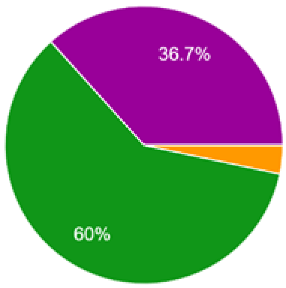
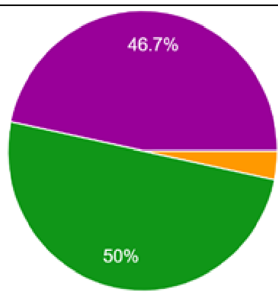
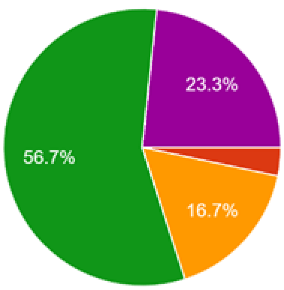
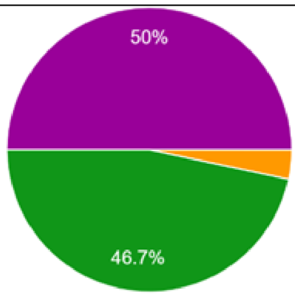
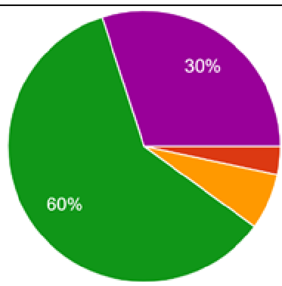
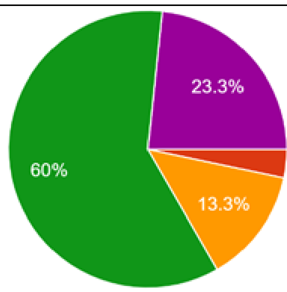
Source: Researcher.

6.2.2. Data analysis

Respondents were asked to answer fourteen questions (Q1-Q14) on a Likert scale from 1 to 5, where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree and 5 is strongly agree. The questionnaire is available in the Appendices. Considered questions relate to the main constructs in the model. A graphical representation of the mean values of the answers given by the respondents can be found in Table 6.2.

The vaguest constructs were Q11, Q12 and Q14. These constructs related respectively to inclusivity in the context of blended learning in MHET, teachers' intellectual property rights in relation to teaching materials, and South Africa's capacity to promote the wider adoption of blended learning in higher education, including maritime education and training. For other variables, the responses were more-or-less uniform, with the majority being confirmatory. Most responses were strongly agree, agree or neutral - a much smaller percentage than the previous two. In the second phase of the research, we attempted to explain noticed small inconsistencies in responses through qualitative research in the form of a questionnaire composed of several open-ended questions.

Table 6. 2 Mean values of the answers given by the respondents

			
Q1: Blended learning brings benefits to maritime higher education and training.	Q2: Maritime conventions, primarily STCW, support blended learning.	Q3: Blended learning is a good way for seafarers' knowledge refreshment and lifelong learning.	Q4: Blended learning enhances lecturers' and students' digital skills development.
			
Q5: Blended learning appraises students' critical thinking skills.	Q6: Blended learning allows integration of formal	Q7: Blended learning fosters students' curiosity and creativity.	Q8: Blended learning makes learning easier.

<table>
<tr><td></td><td>and informal learning styles.</td><td></td><td></td></tr>
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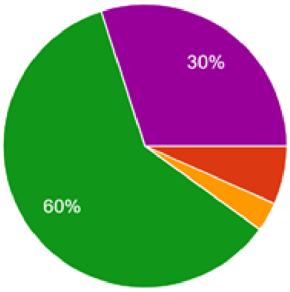
<td>
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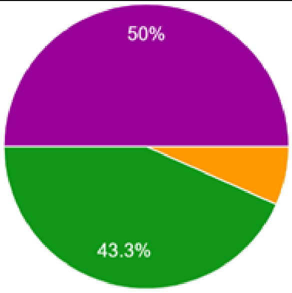
<td>
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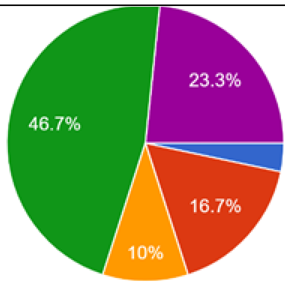
<td>
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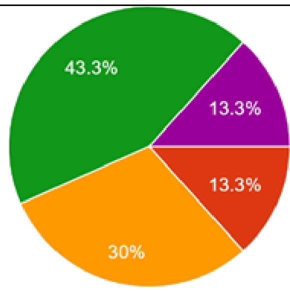
<td>
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<tr>
<td>Q9: Collaborative online learning (COIL) enhances learning.</td>
<td>Q10: Blended learning reduces the costs of space, energy, infrastructure, and commuting.</td>
<td>Q11: Blended learning provides access to higher education to those who are socially marginalized.</td>
<td>Q12: Instructional materials are not adequately protected in blended learning environment.</td>
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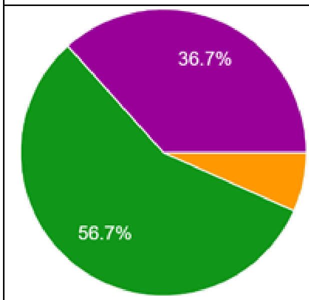
<td>
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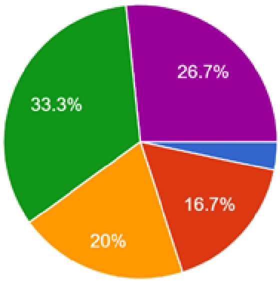
<td>
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</tr>
<tr>
<td>Q13: Blended learning requires permanent institutional maintenance and technical support.</td>
<td>Q14: South Africa is capable to cover the costs of blended learning wider adoption through providing facilities, gadgets, internet access and data to lecturers and students.</td>
</tr>
</table>

Source: Researcher.

The means of the constructs in the model are shown in Table 6. 3. These values were obtained by analysis in IBM SPSS.

Table 6. 3 The constructs' means

Rank	Item		Mean
1	Q10	BL reduces costs of space, energy, infrastructure 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 permanent institutional maintenance and technical support	4.20
8	Q7	BL fosters curiosity and creativity	4.07
9	Q9	BL fosters COIL	3.93
10	Q8	BL makes learning easier	3.87
11	Q5	BL uprises critical thinking	3.83
12	Q11	BL provides access to MHET to those who are socially marginalized	3.77
13	Q14	BL can be wider adopted in South Africa	3.63
14	Q12	BL does not protect intellectual property	3.57

Source: Researcher.

The bivariate correlation analysis between the constructs is presented in Table 6.4. Strong correlations are indicated by one or two asterisks. Rows corresponding to variables that do not have strong linear correlations with other variables in the model are highlighted in grey. These variables were later further analysed using factor analysis in SP

Table 6. 4 Correlation analysis

Correlations		*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*	*Q11*	*Q12*	*Q13*	*Q14*
Q1	Pearson Correlation	1	.524**	.593**	.537**	0.36	.593**	.622**	0.153	0.226	0.232	0.073	-0.257	-0.179	-0.257
	Sig. (2-tailed)		0.003	<.001	0.002	0.051	<.001	<.001	0.42	0.23	0.218	0.702	0.171	0.343	0.171
Q2	Pearson Correlation	.524**	1	0.141	.373*	0.204	.524**	0.033	0.266	-0.252	0.09	0.338	0.208	-0.084	0.017
	Sig. (2-tailed)	0.003		0.458	0.043	0.281	0.003	0.863	0.156	0.178	0.635	0.067	0.269	0.657	0.928
Q3	Pearson Correlation	.593**	0.141	1	.690**	0.187	0.186	0.273	-0.112	-0.011	0.232	-0.35	-0.104	0.045	0.228
	Sig. (2-tailed)	<.001	0.458		<.001	0.322	0.326	0.144	0.557	0.956	0.218	0.058	0.584	0.814	0.225
Q4	Pearson Correlation	.537**	.373*	.690**	1	.420*	0.081	0.046	.501**	0.312	0.304	0.305	-0.216	-.452*	.403*
	Sig. (2-tailed)	0.002	0.043	<.001		0.021	0.67	0.811	0.005	0.093	0.102	0.101	0.251	0.012	0.027
Q5	Pearson Correlation	0.36	0.204	0.187	.420*	1	0.101	0.296	0.299	0.033	0.025	.576**	-0.251	-.500**	.469**
	Sig. (2-tailed)	0.051	0.281	0.322	0.021		0.596	0.112	0.108	0.861	0.894	<.001	0.181	0.005	0.009
Q6	Pearson Correlation	.593**	.524**	0.186	0.081	0.101	1	0.273	-0.024	-0.247	-0.008	0.143	-0.028	-0.067	-.438*
	Sig. (2-tailed)	<.001	0.003	0.326	0.67	0.596		0.144	0.902	0.188	0.967	0.45	0.883	0.724	0.015
Q7	Pearson Correlation	.622**	0.033	0.273	0.046	0.296	0.273	1	-0.098	0.361	0.313	-0.069	-0.251	0.115	-0.322
	Sig. (2-tailed)	<.001	0.863	0.144	0.811	0.112	0.144		0.606	0.05	0.092	0.716	0.181	0.544	0.083
Q8	Pearson Correlation	0.153	0.266	-0.112	.501**	0.299	-0.024	-0.098	1	.549**	0.067	.552**	-.482**	-.524**	0.296
	Sig. (2-tailed)	0.42	0.156	0.557	0.005	0.108	0.902	0.606		0.002	0.723	0.002	0.007	0.003	0.112
Q9	Pearson Correlation	0.226	-0.252	-0.011	0.312	0.033	-0.247	0.361	.549**	1	0.204	0.226	-.392*	-0.169	-0.202
	Sig. (2-tailed)	0.23	0.178	0.956	0.093	0.861	0.188	0.05	0.002		0.28	0.229	0.032	0.371	0.285
Q10	Pearson Correlation	0.232	0.09	0.232	0.304	0.025	-0.008	0.313	0.067	0.204	1	0.017	0.004	-0.178	0.007
	Sig. (2-tailed)	0.218	0.635	0.218	0.102	0.894	0.967	0.092	0.723	0.28		0.931	0.981	0.347	0.97
Q11	Pearson Correlation	0.073	0.338	-0.35	0.305	.576**	0.143	-0.069	.552**	0.226	0.017	1	-0.159	-.558**	0.171
	Sig. (2-tailed)	0.702	0.067	0.058	0.101	<.001	0.45	0.716	0.002	0.229	0.931		0.4	0.001	0.367
Q12	Pearson Correlation	-0.257	0.208	-0.104	-0.216	-0.25	-0.028	-0.251	-.482**	-.392*	0.004	-0.159	1	0.353	-0.06
	Sig. (2-tailed)	0.171	0.269	0.584	0.251	0.181	0.883	0.181	0.007	0.032	0.981	0.4		0.056	0.752
Q13	Pearson Correlation	-0.179	-0.084	0.045	-.452*	-.500**	-0.067	0.115	-.524**	-0.169	-0.178	-.558**	0.353	1	-0.29
	Sig. (2-tailed)	0.343	0.657	0.814	0.012	0.005	0.724	0.544	0.003	0.371	0.347	0.001	0.056		0.12
Q14	Pearson Correlation	-0.257	0.017	0.228	.403*	.469**	-.438*	-0.322	0.296	-0.202	0.007	0.171	-0.06	-0.29	1
	Sig. (2-tailed)	0.171	0.928	0.225	0.027	0.009	0.015	0.083	0.112	0.285	0.97	0.367	0.752	0.12	
** Correlation is significant at the 0.01 level (2-tailed).															
* Correlation is significant at the 0.05 level (2-tailed).															

Source: Researcher.

We used an ANOVA or F-test to test whether the constructs related to cost reduction through blended learning, inclusiveness, and the constant need for institutional technical support influence significantly the readiness of the South African MHETs to embrace distance learning. The results are shown in Table 6.5. Since F Critical is smaller than F, and P-value is lower than 0.01, we can conclude that considered construct do influence the South African MHETs to adopt blended learning in teaching and training.

Table 6. 5 ANOVA test 1

Groups	***Count***	***Sum***	***Average***	***Variance***		
Q10	31	138	4.451613	0.389247		
Q11	31	120	3.870968	1.049462		
Q13	31	128	4.129032	0.382796		
Q14	31	112	3.612903	1.311828		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11.96774	3	3.989247	5.092656	0.002364	2.680168
Within Groups	94	120	0.783333			
Total	105.9677	123				

Source: Researcher.

We additionally used an ANOVA or F-test to examine whether constructs such as lifelong learning, digital literacy, critical thinking, blending formal and informal learning styles, and cognitive curiosity significantly support maritime higher education and training, and blended teaching and learning. We found this to be true.

Statistically, F Critical is smaller than F, while P-value is smaller than 0.01. The results are shown in Table 6.6. The calculations are done on the 13th Gen Intel (R) Core i5-1335U computer (20 GB, 1.3 Hz) in Excel (ver. 2406) Data Analysis Toolkit.

Table 6. 6 ANOVA test 2

Groups	***Count***	***Sum***	***Average***	***Variance***		
Q1	31	136	4.387097	0.245161		
Q3	31	137	4.419355	0.251613		
Q4	31	134	4.322581	0.225806		
Q5	31	120	3.870968	0.649462		
Q6	31	139	4.483871	0.258065		
Q7	31	124	4	0.666667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9.72043	5	1.944086	5.078652	0.000222	2.26431
Within Groups	68.90323	180	0.382796			
Total	78.62366	185				

Source: Researcher.

In addition to the quantitative research presented so far, we explored the relationships between the constructs in the framework and obtained results that are presented in Figure 6.1 and Figure 6.2. SPSS was used to create these maps.

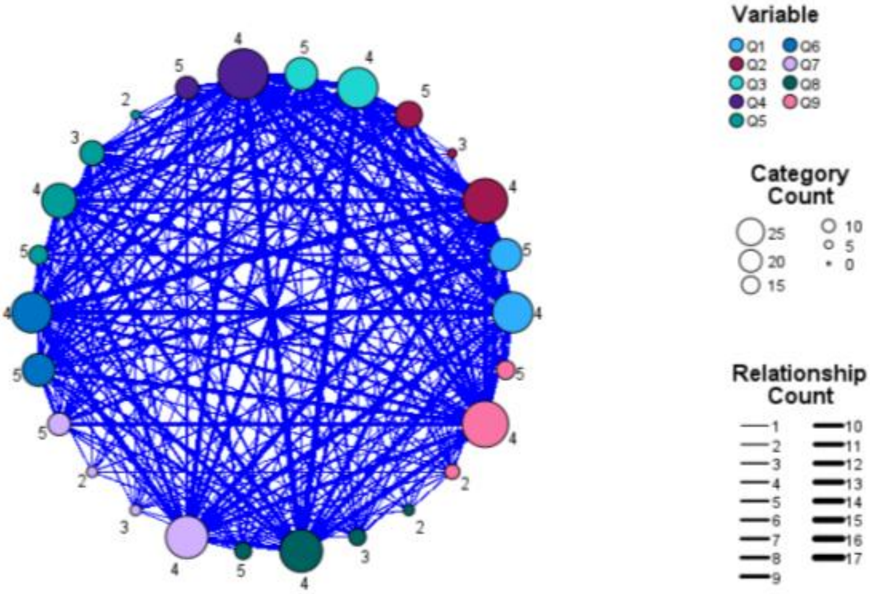

Figure 6. 1: Relationship map

Source: Researcher.

The strongest relationships among the variables are highlighted as follows:

Q1 – BL brings benefits to MHET1

Q2 – BL is supported by STCW (20, 4)

Q3 – BL supports lifelong learning

Q4 – BL enhances digital literacy (25, 4)

Q5 – BL uprises critical thinking

Q6 – BL merges formal and informal learning styles

Q7 – BL fosters curiosity and creativity

Q8 – BL makes learning easier

Q9 – BL fosters COIL (20, 4).

In Figure 6.2 we can observe that the strongest relationships are between Q2, Q4 and Q9 variables. This graph was automatically generated in SPSS over the primary data set analysed.

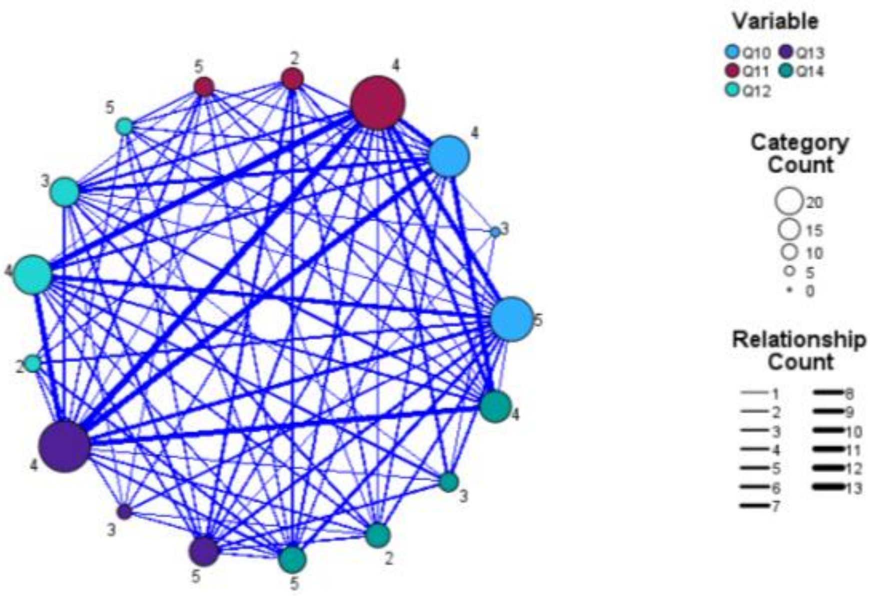

Figure 6. 2: Relationship map

Suorce: Researcher.

The strongest relationships were highlighted as follows:

Q10 – BL reduces costs of space, energy, infrastructure and commuting

Q11 – BL provides access to MHET for socially marginalized (20, 4)

Q12 – BL does not protect intellectual property

Q13 – BL requires permanent maintenance and technical support (20, 4)

Q14 – BL can be wider adopted in South Africa.

So, in this case the strongest relations can be observed among Q11 and Q13 constructs in the model. This relationship map is created automatically in SPSS.

Factor analysis

A factor analysis was performed in SPSS to further examine the interdependencies between the independent variables. We used licenced IBM SPPP Statistics software, ver. 29. The calculations are performed on the 13th Gen Intel (R) Core i5-1335U computer (20 GB, 1.3 Hz). Factor analysis showed that all independent constructs could be grouped into five categories, which we related to inclusion, maritime higher education, generic skills, virtual exchange and cost. The categorisation and the values of standard factor loadings (λ), average variance extracted (AVE), and composite reliability (CR) are given in Table 6.8 below. The AVE and CR are calculated by the respective formulae (1) and (2) as shown in Table 6.7, where, lambda (λ) represents factor loading.

Table 6. 7 AVE and CR formulae

AVE	$= \frac{\sum lambda^2}{\sum lambda^2 + \sum(1 - lambda^2)}$
CR	$= \frac{(\sum lambda)^2}{\sum lambda^2 + \sum(1 - lambda^2)}$

Source: Researcher.

Table 6. 8 Confirmatory factor analysis

Category	*Construct*	*Description*	*Lambda (λ)*	*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		
	Q5	Critical thinking	0.598		
MHET support	Q6	Formal and informal learning style	0.837	0.575	0.799
	Q2	STCW	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	0.581		
Costs	Q10	Reducing costs of space, time and energy	0.827	0.684	0.684

Source: Researcher.

The analysed coefficients are of satisfactory values, confirming the validity of the applied factorisation. Negative values of the loading factor of the Q13 construct means that this construct has a hindering effect on the smooth inclusion of marginalised students in maritime higher education. The same is true for the Q12 construct, which considers intellectual property concerns regarding the online availability of teaching materials within the blended learning environment. The scheme of relations between independent constructs Q1-Q13 and dependent one – Q14 is shown in Figure 6.3, which is based on factor analysis in SPSS and empirical consideration of the considered constructs.

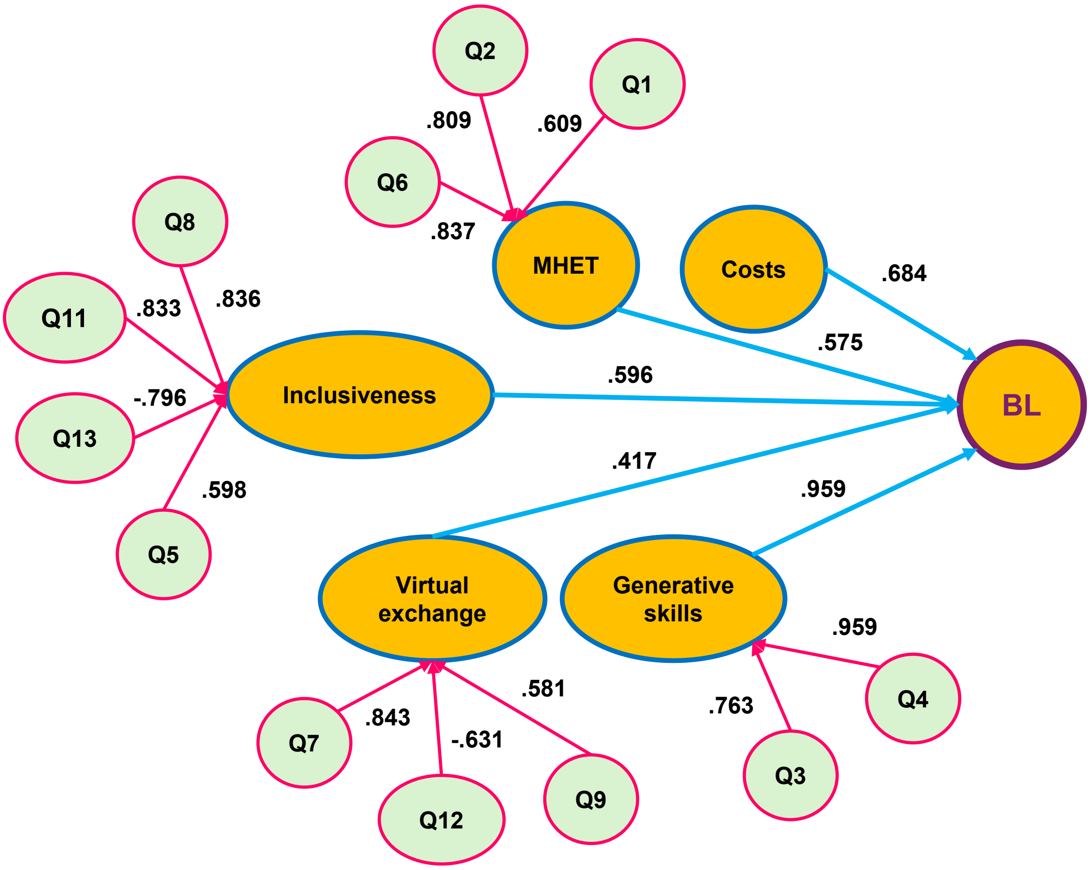

Figure 6. 3: BL adoption model in MHET

Source: Researcher.

Variations in standardised factor loadings may be due to the presence of latent constructs not included in this study. However, we expect that some of these will be uncovered by the subsequent qualitative research. The quantitative part of the study was based on questions and answers in a closed form, so the presence of hidden influences is not easy to reveal explicitly. However, the results tell us that they are present. 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 blended learning in South Africa's technology enhanced teaching and learning environment.

6.2 QUALITATIVE DATA ANALYSIS

Qualitative data is 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.

There are several methods for analyzing qualitative data, but the most often used is the theory of Miles and Huberman (1994). According to this approach, data reduction, data display, and conclusion drafting are the three phases of qualitative data analysis. Data reduction is the initial stage in qualitative data analysis. The process of selecting, categorizing, and coding the data is known as data reduction. Data display refers to the methods used to present the data. The researcher (reader) may find it simpler to comprehend the data if they have access to a matrix, graph, chart, or collection of quotes that highlight trends in the data.

Analysing qualitative data is a continuous, iterative process as opposed to a sequential, linear one. 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 identify through factor analysis. We also use a Python code to create word clouds of the most common words in the interviewees' responses.

6.3 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 can 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 as a full, associated, assistant professor, or as a lecturer in a maritime studies department at DUT; CPUT; NMU; and or UMA; 2) must hold a PhD degree; 3) and at least five years of working experience in maritime higher education.

Exclusion criteria for the study: included those, who did not comply with the three criteria specified above. If they could therefore not participate in the study, they were excluded. We also paid close attention to the size of the sample.

Sample: In determining an optimal number of samples, we used Slovin's formula (Glen, 2022). Namely, the sample size was determined using the following equation: Sample size = $N/(1+N*e^2)$, where N is the population size and e is margin error (0.05). Our sample size equalled ten lecturers and one professor fromDUT, eight lecturers from CPUT, eight lecturers from NMU, and five lecturers from UMA. If we assume that a common margin error is 5% or 0.05, then the calculation based on Slovin's formula led us to a sample size equal to 29.62. Thus, we concluded the sample of 30 participants is satisfying from the statistical point. Prospective respondents were contacted via e-mail for both survey and structured interviews. As experienced researchers, we established rapport with and gained the confidence and approval of the respondents before we started with surveying and interviewing processes. After 20 days, the interviewees sent us their feedback.

6.4. ANALYSIS AND RESULTS

The survey was carried out on a sample of 30 respondents.

6.4.1 Quantitative data analysis results

Within the quantitative part of the study, the respondents were asked to answer fourteen questions (Q1-Q14) on 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 6.3. 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 interface.

The analysis showed that the vaguest constructs were Q11, Q12 and Q14. These constructs related 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 blended learning in higher education, including maritime education and training. For other variables, the responses were more-or-less uniform, with the majority being confirmatory. Most responses were strongly agreed, agree, or neutral, but in a much smaller percentage than the previous two (strongly-agree and agree).

Table 6. 9 Analysed 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 uprises critical thinking	3.83
12.	*Q11:* BL enhances those who are socially marginalized	3.77
13.	*Q14:* BL can be wider adopted in South Africa	3.63
14.	*Q12:* BL does not protect intellectual property	3.57

Source: Researcher.

A factor analysis was performed to further examine the interdependencies between the variables. It has shown that all independent constructs could be grouped into five categories, which are related to inclusion, maritime higher education, generic skills, virtual exchange, and cost. The categorisation and the values of standard factor loadings (λ), average variance extracted (AVE), and composite reliability (CR) are given in Table 6.8

Table 6. 10 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		
	Q5	Critical thinking	0.598		
MHET support	Q6	Formal and informal learning style	0.837	0.575	0.799
	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

Source: Researcher.

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 is true for the Q12 construct, which considered intellectual property concerns regarding the online availability of teaching materials within the BL environment.

Variations in standardised factor loadings may be due to the presence of latent constructs not included in this study. However, we expect that some of these will be uncovered by the subsequent qualitative research. The quantitative part of the study was based on questions and answers in a closed form, so the presence of hidden influences is 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.

6.4.2. Qualitative data analysis results

Having analysed the quantitative data, a qualitative analysis was carried out. We used the Miles and Huberman's approach to analyse the interviews' responses. In fact, 30 respondents answered 8+2 questions. Table 6.10 shows the interviews, open-ended questions and summaries of responses. Respondents use the digital tools available at the MHET institutions where they work. However, they are aware that there is room for improvement in terms of online tools and simulator facilities. In addition, the respondents do not have access to the XR environment and tools, which would modernize the way they work in many ways and further motivate students to learn.

In addition to this summary, we merged all textual answers into two additional questions concerning the fourth and the fifth industrial revolution (4IR and 5IR) deployment in MHET into one textual file. We applied Python code to identify different words in the text and to count their number (Figure 6.6). Then, we use this dictionary to create a word-cloud composed of the most frequent words in the answers (Figure 6.7).

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 personalised learning experiences. These technologies prepare students to work with (semi-) autonomous ships, ML/AI systems, and IoT-connected devices, equipping them with future-ready skills. Enhanced simulation and remote learning capabilities make education more accessible and flexible, allowing students to continue their studies while on board ships. In addition, 4IR is revolutionising ship operations, particularly in navigation and logistics, improving safety, efficiency and sustainability in the maritime industry.

```
# 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 6. 4: Qualitative data analysis in Python

Source: Researcher.

Moreover, educators view the Fourth Industrial Revolution (4IR) as a transformative force in maritime education and training, creating new possibilities for innovation, sustainability, and flexibility in both learning and industry practices. The adoption of advanced technologies will enhance the relevance, accessibility, and adaptability of maritime education to meet the sector's evolving demands.

Table 6. 11 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.
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.
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.
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.

Source: Researcher.

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

Figure 6. 5: Word-cloud generated in Python

Source: Researcher.

The dominant words in the word-cloud (Figure 6.7) are: will (pointing to the future), maritime, data, human, technology, industrial revolution, education, integration, etc. We give 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 is unlimited, and further research is needed to get closer to solving the MHET puzzle in the developing environments.

6.5 Summary

This study shows that educators at MHET institutions in South Africa are aware of the possibilities and benefits of using digital technologies in education. The respondents mostly agreed with the statements concerning BL: Q1-Q14 (Table 6.2). However, a certain level of variations 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 four 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 including Moodle, Blackboard, and MS Teams. Additionally, they make use of Zoom, Facebook, WhatsApp, and YouTube 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 currently not available. Although they are aware of the advantages of 4IR and 5IR in teaching and learning, educators 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 this study was conducted with a rigorous methodological approach, it is not without its limitations. Further research should be carried out on a larger sample and the study should include, in addition to teachers, students and maritime stakeholders from higher education policy and the maritime economy sectors. Instead of being a closed, cross-sectional study, it should be a longitudinal study. Comparative analyses should be carried out in similar and more developed environments. These are all guidelines for possible future research in this area, which is crucial for sustainable development in society. The next chapter presents the findings emanating from the analysis of the data collected. A summary of major findings, including insights on digital adoption challenges, faculty readiness, and infrastructure.

CHAPTER 7 - FINDINGS AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter provides a succinct overview of the thesis's main conclusions, goes over the main goals and important queries that were developed to solve the research problem, and presents and evaluates the study's important findings using interpretations from Chapter 6 followed by conclusions, recommendations, and implications. It concludes with proposed steps for lecturers to effectively implement blended learning and innovative teaching approaches to enhance student success and retention in South Africa and beyond within the digital landscape. Additionally, the training model can be expanded to academic staff across various faculties and departments, with the flexibility to support diverse academic modules in a digital environment.
The purpose of this study was to increase the level of understanding regarding digitalization in South African higher education, with a particular emphasis on MHETs.

These research questions specify what we intend to find out through the study. They translate the problem of successful implementation of BL, ODL, and VE across the South African MHET institutions, into a specific need for data and information collection, coding, analysing, and adequate presentation. The results of this study must thus help South African MHET institutions model and assess the viability of accrediting ODL programs that combine cutting-edge digital technology, creative teaching approaches, and traditional pedagogy in the best possible way. The ODL programs can be used as a template by MHET institutions in various developing contexts after they are successfully implemented.

7.2 SUMMARY OF THE RESEARCH FINDINGS

This study revealed that educators at MHET institutions in South Africa recognise the potential and benefits of integrating digital technologies into education. Respondents from quantitative data analysis largely agreed with statements related to blended learning (BL) (Q1-Q14), However, some variation exists regarding (i) inclusivity within BL in MHET, (ii) teachers' intellectual property rights over teaching materials, and (iii) South Africa's ability to facilitate the widespread adoption of BL in higher education, including MHET. Factor analysis identified four key categories around which the measured variables are grouped: (i) inclusion, (ii) institutional support, (iii) generic skills, (iv) virtual exchange, and (v) costs. These underlying factors suggest that further analysis should focus on them, despite the challenges in measuring them directly.

Qualitative data analysis indicated that educators utilise various learning management, assessment, and communication systems such as Moodle, Blackboard, and MS Teams. Additionally, platforms like Zoom, Facebook, WhatsApp, and YouTube are used to support different aspects of instruction. Advanced Wärtsilä and Kongsberg deck and engine simulators are operational in MHET facilities across South Africa. However, XR environments and tools are currently unavailable.

Although educators acknowledge the benefits of Fourth and Fifth Industrial Revolution (4IR and 5IR) technologies in teaching and learning, they lack access to advanced tools that could enhance knowledge transfer. A word cloud analysis of respondents' perceptions of 4IR and 5IR highlights terms such as "will" (future-oriented), "maritime," "data," "human," "technology," "industrial revolution," "education," and "integration." This suggests a vision where advanced technology, driven by industrial revolutions, connects people and data to enhance maritime education and training.

7.3 DISCUSSION OF FINDINGS

This section analyses the study's findings in relation to the research objectives (ROs), evaluating the current state of digital transformation in MHET in South Africa.

RO1: Prerogatives for Implementing Digitally Enhanced MHET, Including BL, ODL, and VE

- Successful implementation of BL, ODL, and VE in MHET depends on institutional readiness, faculty competence, and digital infrastructure.
- Institutions with clear digital strategies integrate digital tools effectively, and collaboration with government and industry is crucial for supporting digital adoption.
- Use of LMSs improves access to education but is underutilized in underfunded institutions. Resistance to change and limited technical support are challenges.

- **Implications:** Prioritise strategic planning, upgrade digital infrastructure, and institutionalise faculty development programmes.

RO2: Optimal Mixture of Pedagogical Methods and Technology-Driven Approaches in BL and ODL

- A balanced model combining traditional education and digital tools works best for BL and ODL environments. Simulation-based learning, virtual labs, and interactive case studies enhance maritime training.
- Synchronous and asynchronous learning methods improve engagement and flexibility, while competency-based learning improves industry readiness.
- **Implications:** Adopt a hybrid pedagogical model, invest in simulation-based learning and AI-driven assessments, and train faculty in digital pedagogies.

RO3: Benefits and Challenges of VE in MHET

- **Benefits:** Virtual engagement enhances accessibility, reduces costs, and fosters global connectivity. It enables students to collaborate with international experts while minimizing the reliance on physical resources.
- **Challenges:** Poor internet access, technical limitations, and engagement issues are obstacles. Academic integrity in online assessments is a concern.
- **Implications:** Expand investment in virtual learning technologies, enhance student engagement, and implement proctoring and AI-driven feedback in online assessments.

RO4: Impediments Affecting MHET ODL Official Programs Accreditation

- **Findings:** Regulatory gaps, lack of standardised assessment frameworks, and industry scepticism hinder ODL program accreditation. There is a lack of quality assurance for online programs.
- **Implications:** Establish a national policy framework to standardise ODL accreditation, collaborate with international maritime bodies, and develop robust assessment and quality assurance systems.

7.4 RECOMMENDATIONS

Blended learning, which combines traditional classroom teaching with online education, has become increasingly popular. To effectively implement it and improve student success and retention, lecturers should:

1. Develop a clear plan with goals, strategies, and timelines, considering student needs, resources, and infrastructure.
2. Use data on student performance and preferences to tailor instruction.
3. Apply active learning techniques like collaborative projects and flipped classrooms to boost engagement and real-world application.
4. Create a supportive learning environment to help students adapt to online learning.
5. Incorporate regular feedback and assessments to track progress and adjust teaching.
6. Provide professional development to help educators stay current with teaching methods and technologies.

For South African lecturers with limited resources, strategies include using digital tools, leveraging social media for communication, adopting low-tech engagement methods, and using interactive and collaborative tools like Google Forms and Docs. Additionally, seeking funding opportunities can support the use of student engagement tools.

By incorporating blended learning and innovative teaching methods, lecturers can foster student success and retention, even with limited resources. Planning, personalized instruction, and creativity are key to overcoming challenges and enhancing student engagement

7.5 CONCLUSION

South Africa's digital transformation research findings are consistent with those of other developing nations. However, considering the growing globalization of education, there is an urgent need to improve higher education through e-learning. Qualifications from maritime higher education and training (MHET) should be accredited and recognized globally in order to satisfy safety, effectiveness, and efficiency requirements.

Notwithstanding these demands, South Africa's MHET policy creation and execution fall behind developed nations, impeding advancement and conformity to international norms. The necessity and benefits of online education have been highlighted by the COVID-19 epidemic. Future research should engage more scholars and key stakeholders, such as the Department of Higher Education and Training (DHET), the South African Maritime Safety Authority (SAMSA), and the European Maritime Safety Agency (EMSA).

Future research should prioritize in-depth interviews over surveys in order to obtain deeper insights. This will provide a more thorough knowledge of the needs, preferences, and difficulties associated with the adoption of e-learning in MHET. Research should also incorporate elements of instructional design, and best practices should be informed by benchmarking with MHET institutions in other developing regions (Africa, Asia, South-East Europe, and Latin America).

There has to be more research done on cooperative online international learning opportunities with both developed and poor nations. Since they hinder the adoption of e-learning, issues like lecturers' intellectual property rights should also be looked at. Furthermore, case studies on how COVID-19 affected MHE may offer insightful information on effective and ineffective e-learning strategies.

Beyond technical and economic considerations, future research should address the social and emotional dimensions of e-learning, particularly the isolation experienced by lecturers and students. This constructivist perspective is crucial for understanding and improving digital transformation in MHET institutions.

Finally, the findings indicate that digital transformation in MHET is both a necessity and a challenge. While BL, ODL, and VE offer significant benefits, institutions must overcome technological, regulatory, and pedagogical barriers to fully integrate digital education into maritime training. Strategic investment in digital infrastructure, faculty training, regulatory alignment, and emerging technologies will be critical in ensuring successful digital transformation in MHET.

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LIST OF APPENDIXES

ANNEXURE A: RESEARCH PROJECT PLAN

ACTIVITY	TIME FRAME
Topic approval	February 2021
Proposal submitted	January2023
Proposal approval (P G-2)	August 2023
Literature review/Theoretical framework – Write up Chapters 1-3	September 2023 – June 2024
Design of questionnaire	March 2024
Notification to academic lecturers of questionnaire	July 2024
Analysis of data from questionnaire	October 2024
Notification semi-structured interviews with academic	August 2024
Analysis of data from semi-structured interviews	October 2024
Research design/Findings write up Chapters 4-5	November 2024
Recommendations/Main findings write up Chapter 6-7	December 2024
Submission	March 2025

ANNEXURE B: TURNITIN REPORT

Date, 24th March 2025

Similarity Index Report

The attached overall Turnitin similarity index for Ms Masuku's dissertation "Digital Transformation of South African Maritime Higher Education and Training" is 7%.

Yours sincerely

Prof Sanja Bauk

~1

text

ORIGINALITY REPORT

7%	6%	4%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	commons.wmu.se Internet Source	1%
2	mdpi-res.com Internet Source	1%
3	oro.open.ac.uk Internet Source	1%
4	www.researchgate.net Internet Source	1%
5	graduateguide.co.za Internet Source	<1%
6	nectar.northampton.ac.uk Internet Source	<1%
7	cdn.ymaws.com Internet Source	<1%
8	Lecture Notes in Educational Technology, 2014. Publication	<1%
9	Sanja Bauk, Silvia Fajardo-Flores. "Matching Interaction Design Principles and Integrated	<1%

Navigation Systems in an Electronic Classroom", Transactions on Maritime Science, 2020
Publication

10	Sílvia Faria, Manuel Sousa Pereira, João M. S. Carvalho, Ruan Porto Marques. "Chapter 51 Brazilians' Acceptance of Multi-attribute Reverse Auction Model for B2C E-Commerce", Springer Science and Business Media LLC, 2025 Publication	<1 %
11	stax.strath.ac.uk Internet Source	<1 %
12	"Advances in Human Factors in Training, Education, and Learning Sciences", Springer Science and Business Media LLC, 2020 Publication	<1 %
13	Sabine Seufert. "Artificial Intelligence in Vocational Education and Training (VET): Evaluating VET Leaders' Acceptance of AI in Switzerland", Springer Science and Business Media LLC, 2024 Publication	<1 %
14	aga23.samk.fi Internet Source	<1 %
15	encompass.eku.edu Internet Source	<1 %

n0000

16	mafiadoc.com Internet Source	<1 %
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ANNEXURE C: LETTER OF INFORMATION AND CONSENT FORM

LETTER OF INFORMATION

Title of the Research Study:

Digital Transformation of South African Maritime Higher Education and Training

Researcher:
Mrs **Margaret Balungile Masuku**
(Bachelor of Education B ED, MSc in Maritime Education and Training)

Supervisor:

Prof **Sanja Bauk** (DSc)

Warm greetings,

My name is **Margaret Balungile Masuku**. I am currently the 3rd year PhD student at Durban University of Technology (DUT), Faculty of Accounting and Informatics, Department of Information Technology doing research for my Doctoral degree in Information Technology. Therefore, I would like to invite you to participate in the research:

Digital Transformation of South African Maritime Higher Education and Training

Brief introduction and Purpose of the Study:
The maritime industry, business, education, and training are among the key perpetuators of global trade and development. Maritime business and industry need skilled and competent workforce in administration, business, industry, research and development, including those who steer modern ships offshore and handle port equipment and cargo onshore. Maritime business and industry should respond effectively to growing demands of international trade and ongoing changes, especially in the context of advanced technology. Seafarers are in the forefront when it comes to implementation of the conventions and regulations developed by maritime authorities. Uplifting the quality of seafarers' education and competences would help enhance safety, security, efficiency and effectiveness of navigation and port operations, including marine environmental protection.

The International Maritime Organisation (IMO) reported that the human element and poor competence are among the main causes of accidents at sea. Competence of seafarers can be described as worthy performance on-board. This places emphasis on the need for effective maritime high education and training (MHET) to overcome the issue of human factor and keep pace with rapid technology driven changes in maritime. Ships are only as good as the seafarers who operate them. For this reason, the need for proficient seafarers seems to be a global concern for maritime effectiveness, especially in the light of shifting shipping trends, increasing ship sizes and capacities, as well as the overall demand for marine transport.

South Africa as a developing country can easy transition to become a developed country by raising citizens' education, knowledge and skills. Twenty-five years ago, the majority of the population in South Africa did not have access to higher education. Today, the situation has changed significantly although there is still a room for improvements. People need sound lifelong education and skills to keep up with a modern, technology driven and complex society. Life-long learning can be realised through formal and informal learning channels. As a huge virtual
library, the internet can help in this respect. However, people should have access and a certain level of knowledge and education in order to utilise the opportunities provided by the internet effectively. A good way of using internet smartly for educational purposes is through technology/ICT based, or online distance learning (ODL).

Aim of the Study:
The intention of the study is to explore the lecturers' awareness of the benefits and impediments of blended learning (BL) and online distance learning (ODL) versus face-to-face (F2F) teaching and learning at MHET institutions in South Africa, including their readiness to adopt this form of knowledge transfer. The research will be conducted among lecturers at selected MHET institutions in South Africa: Durban University of Technology (DUT), Cape Peninsula University of Technology (CPUT), Nelson Mandela University (NMU) and Umfolozi Maritime Academy (UMA). The selection of these institutions is motivated by the fact that these do not have yet any ODL officially approved programme. Maritime students/ex-students-seafarers have to upgrade their knowledge and skills continuously to be competent in the world maritime labour market. Since they have to work as seafarers, upgrade their knowledge and refresh their certificates of competences, at the same time, ODL might be an excellent solution.

Risk or Discomforts to the Participants:
There are no foreseeable risks or discomfort if you participate into this study.
The Reasons You may withdraw from the Study:

You can withdraw from the study if any of the questions make you feel uncomfortable. There will be no adverse consequences if you choose to withdraw from the study.
Benefits:

You may stand gain from this survey, in a sense that the quality of your working environment in maritime business can be improved in the future, thanks to the findings of the study.

Remuneration:
No remuneration will be offered for participating in this study.

Costs of the Study:

There are no costs associated with participating in this study.

Confidentiality:

All information gathered by this study is confidential. The **interview questions** will be analyzed by the researcher and all information will only be used for research purposes. No personal information will be published in the final dissertation of this study. All information that relates to your participation in this study will be treated confidentially and answers to the questionnaire will be processed anonymously.

Storage of All Electronic and Hard Copies including Tape Recordings:

This will be kept for five years and discarded afterwards.

Contacts in the Event of Any Problem or Queries:

Researcher: **Margaret Balungile Masuku** (Cell: 078 007 5188; Tel.: 031 373 2562; Email: 22176191@dut4life.ac.za)

Supervisor: **Prof Sanja Bauk** (Email: *bsanjaster@gmail.com*) or
DUT-Institutional Research Ethics Administrator on 031 373 2375.
Complaints can be reported to the **Acting Director: Research and Postgraduate Support** on researchdirector@dut.ac.za

Yours assistance is greatly appreciated

Margaret Balungile Masuku

CONSENT

Title of the Study:
Digital Transformation of South African Maritime Higher Education and Training

Researcher:
Margaret Balungile Masuku

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, *Mrs Margaret Balungile Masuku*, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ……**IREC 187/23**.…
- I have also received, read and understood the above written information regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerized system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant	**Date**	**Signature**

I, **Margaret Balungile Masuku** (name of researcher) herewith confirm that the above participant has been **fully informed about the nature, conduct and risks of the above study.**

Full Name of Researcher	**Date**	**Signature**

ANNEXURE D: PERMISSION TO CONDUCT RESEARCH AT DUT (GATEKEEPER LETTER)

DUT
DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE
DIRECTORATE FOR RESEARCH & POSTGRADUATE SUPPORT

Directorate for Research and Postgraduate Support

3rd Floor, Open House, Steve Biko Campus
Durban University of Technology
P O Box 1334, Durban, 4000

T +27 373 2577
E Gatekeeper@dut.ac.za
W https://www.dut.ac.za/research-ps/

22 July 2024

Ms M B Masuku
c/o Department of Information Technology
Faculty of According and Informatics
Durban University of Technology

Dear Ms Masuku

PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC) has granted **Gatekeeper Permission** for you to conduct your research "Digital Transformation of South African Maritime Higher Education and Training" at the Durban University of Technology. **Kindly note that this letter must be issued to the IREC for approval before you commence data collection**.

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

Upon completion of your research project, you are requested to share the summary of your key research findings.

Yours sincerely

[signature]

Dr F Akpa-Inyang
(for) Dr V Govender
Director (acting)
Research and Postgraduate Support

ANNEXURE E: ETHICAL CLEARANCE DUT

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

1 August 2024

Ms M B Masuku
P O Box 170
KwaDabeka
3612

Dear Ms Masuku

Digital Transformation of South African Maritime Higher Education and Training
Ethics Clearance Number: IREC 187/23

The DUT-Institutional Research Ethics Committee acknowledges receipt of your notification regarding the piloting of your data collection tool.

Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the DUT-IREC acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC SOP's.

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

It is compulsory for a student or researcher to apply for recertification on an annual basis. The failure to do so will result in withdrawal of ethics clearance. It is the responsibility of the researcher and the supervisor to apply for recertification.

Please note that you are required to submit a Notification of Completion of Study form together with an abstract to the DUT-IREC office on completion of your study.

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

ANNEXURE F: ETHICAL CLEARANCE – CPUT

Cape Peninsula University of Technology
creating futures

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

On **26 March 2024**, the Faculty of Engineering and the Built Environment Research Ethics Committee (FREC) of the Cape Peninsula University of Technology granted approval to **Ms Margaret Balungile Masuku,** staff number **22176191** to collect data in the Faculty of Engineering and the Built Environment of the Cape Peninsula University of Technology on the condition that results must be presented to the Faculty prior to publication.

Title of project	Digital Transformation of South African Maritime Higher Education and Training

Comments:
Data collection permission is required.

[signature]	15 May 2024
Prof Veruscha Fester **Assistant Dean: Research, Technology, Innovation & Partnerships (RTIP)** **Faculty of Engineering and the Built Environment**	**Date**

2024FEBEREC-ST-04

ANNEXURE G: ETHICAL CLEARANCE – NMU

NELSON MANDELA
UNIVERSITY

PO Box 77000, Nelson Mandela University, Port Elizabeth, 6031, South Africa mandela.ac.za

Chairperson: Research Ethics Committee (Human)
Tel: +27 (0)41 504 3624
Dalray.Gradidge@mandela.ac.za

NHREC registration nr: REC-042508-025

Ref: [H24-ENG-ITE-EAP-001] Approval: 9 October 2024 – 9 October 2025

9 October 2024

Dear Prof Bauk

DIGITAL TRANSFORMATION OF SOUTH AFRICAN MARITIME HIGHER EDUCATION AND TRAINING

PRP: Prof S Bauk
PI: Ms M Masuku

Your application for ethics approval to conduct research at Nelson Mandela University has been considered by the REC-H on the basis that the study has been duly vetted and approved by the Durban University of Technology, Research Ethics Committee.

Kindly use the following ethics reference number **H24-ENG-ITE-EAP-001** together with your university's ethics clearance number in any correspondence with gatekeepers and participants at the university. Ethics clearance is valid for one year.

Please inform the REC-H, of any changes that may arise during the execution of the study, particularly to the methodology.

It must be noted that the Nelson Mandela University assumes that the Research Ethics Committee responsible for providing the original ethics approval/clearance has undertaken both ethics and scientific review of the protocol according to the National Health Research Ethics Committee (2015) Guidelines and assumes primary responsibility for oversight regarding any ethical issues that may arise in the course of the study. The Nelson Mandela University would also wish to be provided with an executive summary of the findings from the research.

We wish you well with the project.

Yours sincerely

Dr D Gradidge
Chairperson: Research Ethics Committee (Human)

cc: Department of Research Development

ANNEXURE H: GATEKEEPER LETTER DUT

DUT
DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

01 February 2024

Dr Ayanda Meyiwa
Department of Maritime Studies
Durban university Of Techology
Steve Biko Campus
Durban
031- 3732144

Request for Permission to Conduct Research

Dear Dr Ayanda Meyiwa

My name is Margaret Balungile Masuku, and I am a Doctoral Studies student at the Durban University of Technology (DUT), Faculty of Informatics and Technology. The research I wish to conduct for my dissertation is:

Digital Transformation of South African Maritime Higher Education and Training (MHET)

I am hereby seeking your consent to conduct research on a target population of 30 full-, associate-, assistant-professors and/or lecturers at four MHET institutions in the South Africa, including your respected institution. As data collection instruments, interview and survey tools will be used. Both are enclosed.

All data and conclusions made from interviews, informal discussions, and questionnaires are kept strictly confidential and anonymity will be maintained.

Please tick (√) to confirm your understanding of the study and that you are happy for your organization to take part.

1. I confirm that I have read and understand the information provided for the above study. ☑
2. I understand that participation of our organization and attendees in the research is voluntary and that they are free to withdraw at any time. ☑
3. I understand that any personal information collected during the study will be anonymous and remain confidential. ☑
4. I agree our organization, staff, and attendees to take part in the study. ☑
5. I agree to confirm to the data protection act. ☑

ENVISION2030 transparency • honesty • integrity • respect • accountability fairness • professionalism • commitment • compassion • excellence

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the DUT-Institutional Research Ethics Committee (DUT-IREC).

If you require any further information, please do not hesitate to contact me [Cell: 0780075188, Email: margaretm@dut.ac.za]. Thank you for your time and consideration in this matter.

Yours sincerely,

Margaret Balungile Masuku

Lecturer at Durban University of Technology

Name of Gatekeeper: Dr Ayanda Meyiwa	Date: 01 February 2024	Signature:
Name of Researcher: Margaret Balungile Masuku	Date: 30/01/2024	Signature:

ANNEXURE I: GATEKEEPER LETTER – NMU

DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

01 February 2024

Dr Theunissen Howard
Head of Department: Marine Engineering
Nelson Mandela University
Summerstrand Campus North
Port Elizabeth
Tel: +27-(0)41-504 2011
Cell: +27-(0)82 7758 536

Request for Permission to Conduct Research

Dear Dr Howard

My name is Margaret Balungile Masuku, and I am a Doctoral Studies student at the Durban University of Technology (DUT), Faculty of Informatics and Technology. The research I wish to conduct for my dissertation is:

Digital Transformation of South African Maritime Higher Education and Training (MHET)

I am hereby seeking your consent to conduct research on a target population of 30 full-, associate-, assistant-professors and/or lecturers at four MHET institutions in the South Africa, including your respected institution. As data collection instruments, interview and survey tools will be used. Both are enclosed.

All data and conclusions made from interviews, informal discussions, and questionnaires are kept strictly confidential and anonymity will be maintained.

Please tick (√) to confirm your understanding of the study and that you are happy for your organization to take part.

1. I confirm that I have read and understand the information provided for the above study. [X]
2. I understand that participation of our organization and attendees in the research is voluntary and that they are free to withdraw at any time. [X]
3. I understand that any personal information collected during the study will be anonymous and remain confidential. [X]
4. I agree our organization, staff, and attendees to take part in the study. [X]
5. I agree to confirm to the data protection act. [X]

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fairness • professionalism • commitment • compassion • excellence

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the DUT-Institutional Research Ethics Committee (DUT-IREC).

If you require any further information, please do not hesitate to contact me [Cell: 0780075188, Email: margaretm@dut.ac.za]. Thank you for your time and consideration in this matter.

Yours sincerely,

Margaret Balungile Masuku

Lecturer at Durban University of Technology

Name of Gatekeeper:	Date:	Signature:
Dr Howard Theunissen	16/02/2024	
Name of Researcher:	Date:	Signature:
Margaret Balungile Masuku	30/01/2024	

ANNEXURE J GATEKEEPER LETTER UMA

DUT
DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

22 November 2023

Mr Elelwani Nemukula
Umfolozi Maritime Academy
Esikhawini Campus
Tel: ***035 902 9501***

Request for Permission to Conduct Research

Dear Mr Elelwani Nemukula

My name is Margaret Balungile Masuku, and I am a Doctoral Studies student at the Durban University of Technology (DUT), Faculty of Informatics and Technology. The research I wish to conduct for my dissertation is:

Digital Transformation of South African Maritime Higher Education and Training (MHET)

I am hereby seeking your consent to conduct research on a target population of 30 full-, associate-, assistant-professors and/or lecturers at four MHET institutions in the South Africa, including your respected institution. As data collection instruments, interview and survey tools will be used. Both are enclosed.

All data and conclusions made from interviews, informal discussions, and questionnaires are kept strictly confidential and anonymity will be maintained.

Please tick (√) to confirm your understanding of the study and that you are happy for your organization to take part.

1. I confirm that I have read and understand the information provided for the above study. ☑
2. I understand that participation of our organization and attendees in the research is voluntary and that they are free to withdraw at any time. ☑
3. I understand that any personal information collected during the study will be anonymous and remain confidential. ☑
4. I agree our organization, staff, and attendees to take part in the study. ☑
5. I agree to confirm to the data protection act. ☑

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fairness • professionalism • commitment • compassion • excellence

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DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the DUT-Institutional Research Ethics Committee (DUT-IREC).

If you require any further information, please do not hesitate to contact me [Cell: 0780075188, Email: margaretm@dut.ac.za]. Thank you for your time and consideration in this matter.

Yours sincerely,

Margaret Balungile Masuku

Lecturer at Durban University of Technology

Name of Gatekeeper:	Date:	Signature:
Capt. Elelwani Nemukula	12-02-2024	[signature]
Name of Researcher:	Date:	Signature:
Margaret Baulungile Masuku	22/11/2023	[signature]

ANNEXURE K: CERTIFICATE OF LANGUAGE EDITOR

<u>EDITING LETTER</u>

696 Clare Road
Clare Estate
Durban
4091
28 March 2025

To: Whom it may concern

Editing of Dissertation: MB Masuku (22176191)

Digital Transformation of South African Maritime Higher Education and Training

This letter serves as confirmation that the aforementioned dissertation has been language edited. The requisite grammatical conventions have been met/recommended. Suggestions have been made to the candidate where necessary.

Any queries may be directed to the author of this letter.

Regards

MP MATHEWS
Lecturer and Language Editor
Mercimathews4@gmail.com
083 676 4778

ANNEXURE L: QUESTIONNAIRES

In advance, I would like to thank you for your time, patience and commitment to access the survey.
By choosing one of the numbers from 1 to 5, including your comments if applicable, you give a contribution to the research aimed to investigate and analyze the feasibility and practicability of blended learning at Higher Maritime Education and Training (MET) Institutions, in general, and in the South African context.

Personal information:

Gender: …………

Age: ……

Years of experience: ……

Questions:

1. Blended learning brings benefits to maritime higher education and training.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

2. Maritime conventions, primarily STCW, support blended learning.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

3. Blended learning is a good way for seafarers' knowledge refreshment and lifelong learning.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

4. Blended learning enhances lecturers' and students' digital skills development.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

5. Blended learning appraises students' critical thinking skills.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

6. Blended learning allows integration of formal and informal learning styles.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

7. Blended learning fosters students' curiosity and creativity.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

8. Blended learning makes learning easier.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

9. Collaborative online learning (COIL) enhances learning.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

10. Blended learning reduces the costs of space, energy, infrastructure, and commuting.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

11. Blended learning enables access to higher education to the students living in rural areas.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

12. Blended learning provides access to higher education to those who are socially marginalized.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

13. Instructional materials are not adequately protected in blended learning environment.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

14. Blended learning requires permanent institutional maintenance and technical support.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

15. South Africa is capable to cover the costs of blended learning wider adoption through providing facilities, gadgets, internet access and data to lecturers and students.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5
Comments:				

Thank you for your time, in-kind and valuable contribution!

ANNEXURE M: INTERVIEW QUESTIONS

Interview

In advance, I would like to thank you for your time, patience and commitment to access the interview.

By answering the interview questions, you give a contribution to the research aimed to investigate and analyze the feasibility and practicability of blended learning based on advanced technology and digital tools at Higher Maritime Education and Training (MET) Institutions, in general, and in the South African context.

Personal information:

PART I

Pseudonym (A, B, C,…)

MHETI name

Age

Race

Gender

Years of experience at MHETI

Qualification

Major subjects

Quintile index rating of MHETI

PART II

Interview questions:

Q1	1. What of the following management learning systems do you use in teaching? Moodle Blackboard Canvas Brightspace Other ………………. None
Q2	2. Which of these digital platforms do you use for teaching purposes? MS Teams YouTube WhatsApp Facebook Zoom Meet GoToMeeting Slack Flipgrid Other… None
Q3	3. Do you have nautical/mechanical/electric-power simulators at your maritime education and training institution? Yes No I don't know

Q4	4. If your answer on question 3. Is Yes, who is producer of the simulator(s)? Wärtsilä (Transas) Kongsberg Other….
Q5	5. Do you use simulator in the Cloud at your institution as K-Sim? Yes No
Q6	6. Do you use any additional maritime simulator training facility/tool? No Yes (specify which one) …
Q7	7. Do you use extended reality (XR) facilities/tools like smart glasses, finger and hand trackers, etc. No Yes (producer of XR equipment)
Q8	8. Would you like to upgrade your training facilities and if yes – in which way? Please elaborate on this.
	PART III
Q1	1. Are you familiar with 4IR concept? No Yes (please elaborate)
Q2	2. Are you familiar with 4IR concept? No Yes (please elaborate)
Q3	3. Are you familiar with 4IR concept? No

	Yes (please elaborate)
Q4	4. How do you see the role of 4IR in education and training in maritime? – Please elaborate
Q5	5. Are you familiar with 5IR concept? No Yes (please elaborate)
Q6	6. How do you see the role of 5IR in education and training in maritime? – Please elaborate

Thank you for your time, in-kind and valuable contribution