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Interrogating the state of application of technology within the Malawi Maritime Force as maritime expression : a task-technology fit approach

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WORLD MARITIME UNIVERSITY

INTERROGATING THE STATE OF APPLICATION OF TECHNOLOGY WITHIN THE MALAWI MARITIME FORCE AS MARITIME EXPRESSION: A TASK-TECHNOLOGY FIT APPROACH

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

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Declaration

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

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

(Signature):

26/09/2023

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Abstract

Title of Dissertation: **Interrogating the State of Application of Technology within the Malawi Maritime Force as Maritime Expression: A Task-Technology Fit Approach**

Degree: **Master of Science**

The rapid technological transformation in the maritime industry to make operations more cost-effective, efficient, and environmentally friendly has led to the advent of smart and autonomous ships. With increased computerization of navigational and automation systems on board, there is a shift in the crew's tasks from being fully operation-based at different workstations on board to monitoring navigational systems on board or ashore. To realize the maximum potential of the provided technology, navigators' abilities must align with the functionalities and tasks that the technology serves to support. Therefore, cutting-edge technology adoption and implementation require prior and continuous assessments to determine their effectiveness. This study interrogated the state of technology applications with a focus on navigational technologies at the Malawi Maritime Force as a maritime entity. A mixed-methods research design was used in the conduct of this study, guided by the Task Technology Fit (TTF) model. The five-point Likert scale survey questionnaires, semi-structured interviews, and content analysis were the research instruments, and the data was analysed using Excel software and thematic analysis. The results showed that cutting-edge navigational technologies were in use, and such devices possessed some characteristics of Industry 4.0. Although the TTF component of the model was significantly influenced by individual characteristics, there was a disparity in the navigators' digital skills. It was concluded that the navigational technologies used were a good fit with the tasks they were meant to support. However, the study also highlighted the need for proper training and familiarisation with the devices being used if such navigational technologies were to bring optimal results.

KEYWORDS:
Navigational technologies, TTF model, Digitalization, Industrial Revolution, Industry 4.0

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LIST OF ABBREVIATIONS

4IR:	Fourth Industrial Revolution
AI:	Artificial Intelligence
AIS:	Automatic Identification System
ARPA:	Automatic Radar Plotting Aid
CPS:	Cyber-Physical Systems
ECDIS:	Electronic Chart Display and Information Systems
EOU:	Ease of Use
FIR:	First Industrial Revolution
GNSS:	Global Navigation Satellite System
GPS:	Global Positioning System
IBS:	Integrated Bridge System
IMO:	International Maritime Organization
IoT:	Internet of Things
LMS:	Learning Management System
LRIT:	Long Range Identification and Tracking system
MASS:	Maritime Autonomous Surface Ships
MMF:	Malawi Maritime Force
SONAR:	Sound Navigation and Ranging
TCNS:	Tactical Communications Network Systems
TTF:	Task-Technology Fit model
WMU:	World Maritime University

CHAPTER ONE

1.0 Background

Since nearly 90% of all commodities are transported by ship globally, the shipping industry is a critical component of the economy (Valentin, 2022). Similar to many other industries, the maritime industry is undergoing rapid transformation due to various technological advancements aimed at making operations more cost-effective, efficient, and environmentally friendly (Lam, 2020). Technology has been incorporated into everyday life and that it has been used to improve human lives, from the simplest invention to sophisticated systems that operate completely independently of human experience (Ford, 2021). Shipping technological developments have significantly enhanced navigation, safety, and communication (SHM Shipcare, 2018).

The maritime industry is undergoing continual and rapid technological growth as a result of Industry 4.0 at sea, also known as shipping in the digital era, which has disrupted all processes involved with shipping (Ichumura et al., 2022). Digitalization in the maritime sector is viewed as the application of different digital tools to increase the effectiveness, efficiency, accountability, and ecological viability of an organization's processes (Jović et al., 2022). Due to advancements in digital technology, people must use an increased degree of cognitive skills to stay current and deal with challenges in digital contexts (Aviram & Eshet-Alkalai, 2006). The motivating factors for digitalization in the maritime sector can be attributed to the introduction of international maritime laws to make shipping efficient and sustainable. For instance, the International Maritime Organisation (IMO) implemented new and stricter fuel pollution rules, limiting the quantity of sulphur in vessel oils and forcing proprietors of ships to explore alternatives that adhere to the new IMO standards (WMU, 2019).

The crew's tasks have moved from being physically hands-on to monitoring navigational systems on LCD monitors on board and ashore as the rate of digital innovation speeds up (WMU, 2019). Since implementing these state-of-the-art tools is a costly endeavour involving a plan of action, individuals, and equipment, it is necessary to assess these components for adoption to achieve the intended outcomes (Dash et al., 2023). This thesis, therefore, interrogates the state of the application of navigational technologies by the Malawi Maritime Force at its maritime Base at Monkey Bay in Malawi as a case study. The Malawi Maritime Force is a division of the Malawi Defence Force that operates maritime affairs on Lake Malawi's internal waters. It carries out its daily operations using ship technologies that have experienced several technological advancements over the years. The insights got from this case study, which happens to be a developing nation, could be compared to what other studies in developed countries can find on the same topic.

1.1 Problem statement

Navigational technology advancements are causing slight shifts in navigational functions and operations in the shipping sector (Fernando et al., 2017). To guarantee that cutting-edge shipboard devices are crafted and produced considering all users' requirements, competencies, and traits, the implementation ought to be informed by a systematic evaluation of the way technology may optimally satisfy specified and growing user requirements (IMO, 2018). The task technology fit model is a well-known tool for evaluating technology since it offers a perspective on its use and the value it generates (Spies et al., 2020). The approach was successfully used to evaluate m-payment, e-learning, blockchain technology, mobile information systems, and dialogue flow, inter alia. However, there has been little effort to briefly explain and demonstrate the TTF model's applicability in maritime navigational technology. This study fills a knowledge gap about the model's application in evaluating the use of navigational aids in the maritime industry.

1.2 Aims and Objectives

The study aims to examine the extent of the application of navigational technologies in the maritime industry in terms of individual user characteristics, technology characteristics, and task characteristics to determine if technologies support the users to optimise their performance.

The following were the objectives of the study:

1. To describe the features of navigational technologies used.
2. To determine its place in the evolution of technology from the First Industrial Revolution to the Fourth Industrial Revolution.
3. To analyse the individual abilities of technology users in the organization.

4. To assess how the technology is a good fit with the task it supports.

1.3 Significance

This research holds significance to decision-makers in the maritime industry to understand how the adopted technology can impact the individual users' performance to support their activities. The study has also the possibility to identify best practices, lessons learned, and the users' training needs to ensure that the navigational technologies are used to their maximum potential.

1.4 Research questions

To achieve the aforementioned goals, four sub-questions have been posed, which were as follows:

1. What are the features of navigational technologies used in the organization's vessels?
2. Where does it fit in the evolution of technology (industry 1.0 to industry 4.0)?
3. What are the individual characteristics of technology users that may affect performance and other outcomes?
4. How is the technology used a good fit (support) for the tasks performed?

1.5 Limitation

The research findings using the TTF model were from one case study. Results from a single case study have limited generalizability in other contexts. Marikyan and Papagiannidis (2022) state that the components of TTF behave differently when the model is used in different geographical places with diverse cultures, social conventions, and values.

1.7 Organization of the Dissertation

There are six chapters in this paper. The first chapter explained the study's background, purpose and objectives, significance, consequences, research questions, and constraints. The second chapter is a review of the literature on navigational technologies, the evolution of the Industrial Revolution, the individual characteristics of technology users associated with different Industrial Revolutions, and the theoretical framework of task-technology fit as employed in various IT systems. The study's methodology is explained in Chapter 3 of the report, along with how the TTF model was conceptualised, the mixed methods employed and their justifications, data collection instruments, population, and sampling procedures. The chapter ends with a statement on research ethical considerations. Chapter four is the presentation of the data collected and statistics. Chapter 5 addresses the study's main findings by way of the research questions and analytical framework. Finally, Chapter Six summarizes the study's main findings and concludes with a suggestion for future work.

CHAPTER 2

LITERATURE REVIEW

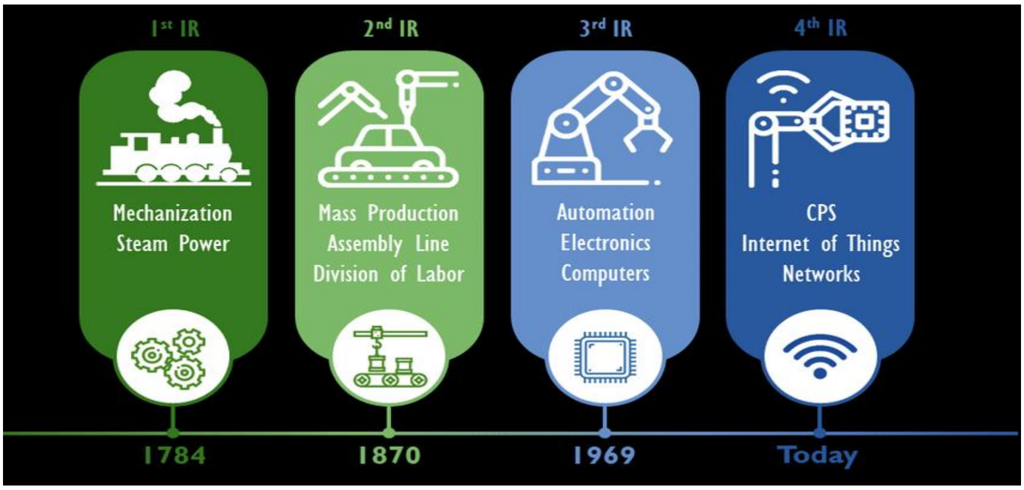
2.0 Introduction

This chapter reviews the existing literature regarding the development of the industrial revolution and the advancement of shipping navigation technologies in the digital age and examines the essential competencies that seafarers must possess in this digital era. Evaluations become a crucial tool for determining the effectiveness of new technologies since they must "fit" activities as they evolve in response to each innovation. The theoretical model, the Task-technology fit (TTF), that underpins the current study is discussed, including the rationale for its use. An analysis of these concerns provided insight into the elements that enhance efficiency when implementing and utilising technology, including task traits, technological proficiency, and personal abilities.

2.1 Evolution of Industrial Revolutions in the maritime industry

An industrial revolution is defined as a new technology having widespread industrial use and profoundly altering pre-existing practises (Wichmann et al., 2019). Stearns (2021) also defines the Industrial Revolution as a broad range of changes that start when dramatic organisational and technological advances are broadly adopted in the economy as a whole. It has three basic characteristics: technological, cultural, and social (Mathur et al., 2022). The innovation of the steam-powered engine led to the first Industrial Revolution, and since then more than four industrial and social revolutions have subsequently occurred, transforming industrial ideas and working methods (Shahbakhsh et al., 2021). Figure 1 below illustrates the evolution of Industrial Revolutions in all spheres including the shipping industry.

Figure 1: The evolution of Industrial Revolutions



Source: (Spernger & Scnelzer, 2019)

2.1.1 First Revolution of Industry

The 18th century saw energy production and water power, ushering in the First Industrial Era (Sharma & Singh, 2020). According to Mathur et al. (2022), the first industrial revolution was a shift to manufacturing methods that used steam and water. The Watt steam engine, which led to several later developments and uses, is responsible for the majority of the technological advancements made during the Industrial Revolution (Sharma & Singh, 2020). The transition included a move from handcrafted to machine-based means of manufacturing, novel substances and metal manufacturing procedures, greater water usage and steam energies, machine tool development, and the formation of the mechanised industrial layout (Groumpos et al., 2021). As people and goods could travel farther in less time thanks to the steamship or steam-powered locomotive, the average wealth and population started to see a remarkably sustained rise (Groumpos et al., 2021).

2.1.2 The Second Industrial Revolution

This was a period of swift standardization and industrialization (Groumpos et al., 2021). It all started in the 19th century with the inception of electrical energy and assemblers (Sharma & Singh, 2020). Mathur et al. (2022) mention that electrical technology was mostly employed to boost productivity. It was designed around an electric motor and internal combustion engine, enabling the electrification of homes and factories as well as the post-war growth of the motorised vehicle infrastructure

(Taalbi, 2018). The period from 1870 to 1914, with some features dating back to 1850, saw the integration of telegraphs and railroads into industries and the emergence of mass manufacturing as the main production method (Sharma & Singh, 2020).

2.1.3 The Third Industrial Revolution

The third industrial revolution, also referred to as Industry 3.0, started in the 20th century, a few years after the end of WWII, with partially computerised operations employing memory-programmable monitors and computing (Groumpos et al., 2021). It included information technology and electronics, primarily emphasizing factory automation (Mathur et al., 2022). Groumpos et al. (2021) state that a well-known example was robots that performed programmed sequences without human involvement. It is a shift from physical to electronic devices that occurred between 1950 and 1970, also referred to as the "Digital Revolution" (Sharma & Singh, 2020). Shahbakhsh et al. (2021) also call the period the "Information Age," as it is characterized by computers and automated products.

2.1.4 The Fourth Industrial Revolution

A German team of mechanical experts coined the term "Industry 4.0," or the Fourth Industrial Revolution, in 2011 to describe the widespread adoption and use of new technologies in manufacturing firms (Bongomin et al., 2020). Industry 4.0 was originally recognised by the German government as one of the ten top priorities of Germany's High-tech Agenda 2020 Action Plan in 2013 (Shahbakhsh et al., 2021). Industry 4.0 is an amalgamation of cutting-edge technology and application types with varying degrees of technological sophistication and systematic impacts (Bongomin et al., 2020). Bai et al. (2020) define Industry 4.0 as a sophisticated technical system made up largely of communication, incorporation, and factory digitization, with an emphasis on the potential for integrating all components into a configuration that adds value. Digitalization is the main goal of Industry 4.0, which uses intelligent systems and gadgets to computerise, communicate information, and even command each other without human involvement (Shahbakhsh et al., 2021). The key technologies that are essential to Industry 4.0 include Cyber-Physical systems, the Internet of Things (IoT), Big Data, Sensors, Automation, Robots, Virtual Reality, Augmented Reality, Artificial Intelligence, Machine learning, and Advanced/Smart materials inter alia (Wichmann et al., 2019). The most important technology for Industry 4.0 is thought to be cyber-physical systems (CPS), a hybrid of ICTs and manufacturing machinery that serves as the brains of a "smart factory" (Wichmann et al., 2019). The emergence of cyber-physical systems can be attributed to advancements in embedded systems, informatics, electronic systems, and artificial intelligence (Sharma & Singh, 2020). The shipping industry is moving quickly towards autonomous ships due to the implementation of novel technologies, which is igniting discussion on how digitalization will change the maritime sphere (Shahbakhsh et al., 2021).

List and definitions of Industry 4.0 key technologies

Industry 4.0 technologies are classified as either physical or digital. Physical technologies include additive manufacturing, sensors, and drones, whereas digital technologies include cloud computing, Blockchain, Big Data Analytics, and simulation (Bai et al., 2020). Table 1 summarizes the key technologies and their meanings:

Table 1: Key technologies of Industry 4.0 and their meanings.

Ser.	**Key technology**	**Meaning**
1.	A *cyber-physical system*	An integrated system that transmits data through a sophisticated network, facilitating automated production.
2.	*Internet of Things*	It describes several devices and approaches that hinge on the internet connection of physical items.
3.	*Artificial Intelligence (AI)*	is a subfield of computer science dedicated to building smart devices that perform tasks and act as individuals.
4.	*Augmented Reality*	A kind of multimedia setting rooted in the real world where the employment of digitally generated display, sound, and other aspects enhances the real-world experience.

5.	*Big Data Analytics*	It is the data-analysis approach used when traditional data mining and handling procedures fail to expose the insights and relevance of the underlying data.
6.	*Cloud*	Any IT solutions are provided and accessible through a cloud computing provider.
7.	*Simulation*	These are technological devices that mimic actual systems or operations.
8.	*3D Printing*	They are solid objects created using several additive or layered development techniques
9.	*Robotics*	It is the imitation of human behaviours in manufacturing.

Source: (Pereira & Romero, 2017; Bai et al., 2020)

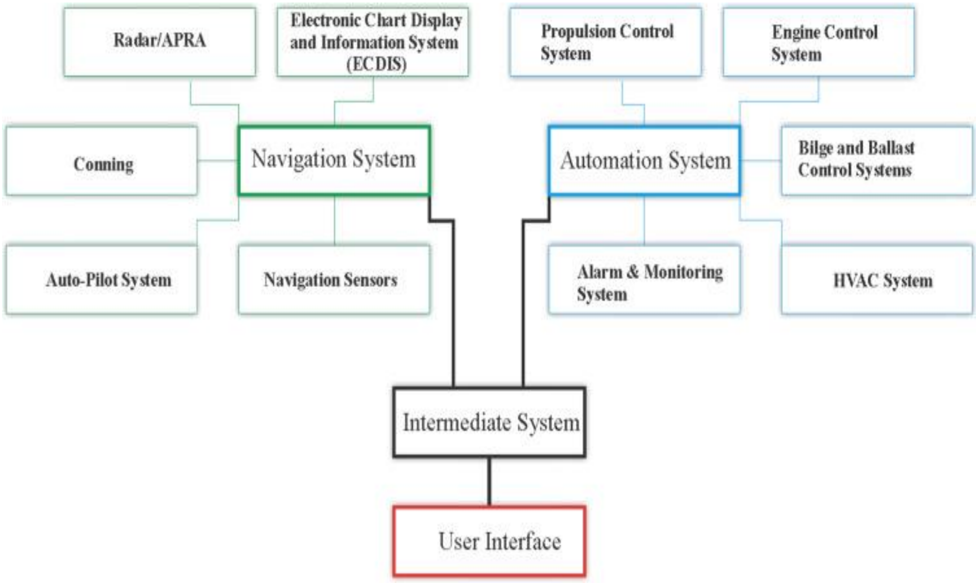
In a nutshell, four industrial revolutions have been analysed and evaluated. Every industrial revolution gets credit for the technological and economic achievements it makes. Industry 1.0 leveraged both steam and water to mechanise manufacturing; Industry 2.0 employed electricity as a technology to develop large-scale manufacturing; and Industry 3.0 employed electronics and information technologies; and Industry 4.0 employed information and communication technologies, with the Cyber-Physical System as the core technology. With the fast pace of technological advancement, it is possible to have an overlap of technologies in different industrial revolutions, which in turn might affect their applications in the industry.

2.2 Digitalization of navigational technologies in shipping

Like other industries, the maritime sector is embracing new digitalized technologies at various levels as it adjusts to Industry 4.0 (Shahbakhsh et al., 2021). Since digitization cannot happen overnight, in 2006, the International Maritime Organisation (IMO) developed electronic navigation to collect, exchange, assess, and incorporate information via electronic means on board and ashore in order to help crew members (Shahbakhsh et al., 2021). Furthermore, continuous technical breakthroughs in the industry have resulted in the emergence of smart ships and autonomous ships. WMU (2019) describes smart ships as the result of traditional ships becoming more digitally integrated, including greater system automation, the potential for fuel changes, and improved engine and nautical system monitoring. On the other hand, an autonomous ship, also known as the Maritime Autonomous Surface Ship (MASS), can function independently of human intervention to varied degrees (IMO, 2021).

Ship bridges are comprised of a variety of technology that serves a lot of tasks and purposes for the vessel's navigation and operation, with more advanced automation of navigational systems and rapid digitalization creating new needs for navigators (Mallam et al., 2020). The Integrated Bridge System is crucial since it serves as the vessel's central command and control platform. Perera and Guedes Soares (2015) state that the IBS is composed of a navigation and automation system. Only navigational systems were the subject of this investigation.

Figure 2: The Integrated Bridge System



Source: Perera and Guedes Soares (2015)

The navigational system is made up of an Electronic Chart Display and Information System (ECDIS), Navigational sensors, conning, an Autopilot system, and Radar/Automatic Radar Plotting Aid (ARPA) (Perera & Guedes Soares, 2015). These technologies are explained below:

i. *Electronic Chart Display and Information System (ECDIS)*

The International Maritime Organisation (IMO)-compliant Electronic Chart Display and Information System is an automated navigation system that provides nautical charts for navigation (Awan & Al Ghamdi, 2019). ECDIS has replaced traditional paper maps with advanced digital screens that produce full environmental information such as shore, ship, and hydrographic data for navigators (Perera & Guedes Soares, 2015). It shows data from electronic navigation charts or digital nautical charts and includes position, direction, and speed data from water points of reference and other available navigation sensors (Terpsidi et al., 2019). Radar and ECDIS systems are supported by the Long-Range Identification and Tracking (LRIT) systems and the Automatic Identification System (AIS), both of which are capable of sending vessel identification and navigation information between vessels and shore-based maritime officials (Perera & Guedes Soares, 2015).

ii. *Conning*

To foster safety at sea, contemporary Conning panels provide ships with location, heading, acceleration, rudder, propeller, thruster, eco-sounder, wind and trip information, and navigation signals (Perera & Guedes Soares, 2015).

iii. *Radio Detection and Ranging* (Radar)

Radar is an object-detecting technology that employs radio waves to measure an item's range, bearing, or velocity (Awan & Al Ghamdi, 2019). The ARPA (automatic radar plotting aid) component of standard radar systems provides exact data on the distance and bearing readings for ships in the vicinity in a digital chart display with additional target surveillance options (Perera & Guedes Soares, 2015).

iv. *Auto-Pilot system*

It is considered one of the most effective bridge navigation aids. It aids the operator in vessel steering by keeping the steering in auto-pilot mode and ensures a cost-effective means of ship direction, minimising the volume of fuel used and the wear and tear associated with the operating system's final control parts (Sedova et al., 2019).

v. *Navigational sensors*

The Integrated Bridge System consists of several interconnected navigational sensors, including the Global Positioning System, Radar, AIS, ECDIS Speed Log, and

Gyrocompass, that offer navigators precise and timely data about the ship's position, speed, and direction, which is crucial to secure and effective navigation (Perera & Guedes Soares, 2015).

vi. Global Navigation Satellite System (GNSS)

GNSS is a network of satellites that sends time and spatial data from the sky for general navigation purposes, while GPS in maritime circles is used for position-fixing data and is interconnected to other technical devices in an IBS (Awan & Al Ghamdi, 2019).

vii. *Echo Sounder*

It is a sort of sound navigation and ranging (SONAR) equipment that measures water depth using sound waves (Awan & Al Ghamdi, 2019).

To interact with these novel technologies there is a need to have well-trained and skilled navigators, also known as technology users in this study, to avoid accidents due to failure to operate such digitalized technologies. For instance, in 2017, the USS John S. McCain, a naval ship, collided with a fuel tanker in the Singapore Sea (Mallam et al., 2020), Some of the factors discovered were the bridge's design with various digital technology models, as well as an inadequate grasp of human system integration. In other words, the end users of these technologies were not adequately taught and were unaware of the technologies that were being deployed. The US Navy announced plans to eventually switch all digital throttles and steering instruments to traditional controls like joysticks. Mallam et al. (2020) argue that for Human Machine interaction, regular assessment of the human element and knowledge transmission to ending users is crucial.

2.3 Seafarers competencies in the digitalization era

Digitalization coupled with elevated levels of automation has resulted in major shifts in the operation of maritime businesses, as well as a rethinking of the function of seafarers (Demirel, 2020). The successful and safe operation of modern and technologically advanced ships heavily relies on seafarers who must possess proper skills and training to manage the complexity of the tasks involved (Mallam et al., 2019). Competency encompasses a blend of hands-on and mental abilities, expertise, familiarity, traits, and conduct to competently execute tasks in line with established norms, regulations, and protocols (Yeun et al., 2022).

Seafarers’ competencies have evolved with the passage of each industrial revolution. As mentioned by Shahbakhsh et al. (2021), the various industrial revolutions throughout history have highlighted distinct sailor skills, which include using stars, moon, and sun for navigation during the First Industrial Revolution, advancing celestial navigation during the Second, operating ships with automatic and electric navigation systems, and ultimately, managing ships using digital technologies during Industry 4.0. Upon examining the typical qualities of digital transformation, numerous academics argue that sailors must possess a combination of technical and interpersonal abilities (Mallam et al., 2019; Demirel, 2020).

Technical abilities are necessary for intricate duties and are split into three types: theoretical know-how and expertise, hardware capabilities, and software and algorithm proficiencies (digital competency) (Bongomin et al., 2020). Yuen et al. (2022) define digital competency as the ability to confidently, analytically, and innovatively utilize information communication technologies to attain professional objectives and it is regarded as a developing set of skills in reaction to the growth of digitalization.

Conversely, soft skills, which refer to interpersonal abilities, are vital for effective daily business interactions and teamwork (Bongomin et al., 2020). Several abilities like analytical reasoning, decision-making, innovation, collaboration, ethical values, adaptability, effective communication, honesty, and accountability are among the many skills needed (Robles, 2012).

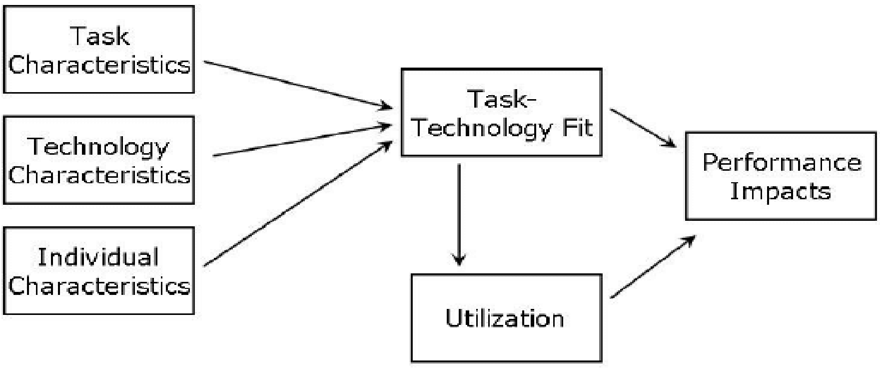
2.4 The Task-Technology Fit Model

The acceptance and implementation of novel technologies must always be assessed for their usefulness. One of the techniques of evaluating them is by using the task technology fit (TTF) model. Goodhue and Thompson (1995) developed the Task-technology Fit (TTF) conceptual framework to analyse how well user tasks and objectives match technology (Marikyan & Papagiannidis, 2022; Peters, 2023; Alyoussef, 2023). Cunha (2023) defines task-technology fit (TTF) as the level to which a specific device facilitates a person in accomplishing functions. Further research revealed that TTF is the link between task requirements, individual potential, and technological utility (Cunha, 2023). According to the theory, the effectiveness of a task and the devices employed to fulfil the goal are decided by performance and acceptance (Alyoussef, 2023). An organization's decision-making process about the type of technology to use to achieve its goals may be hampered by a mismatch between the tasks and technology features (Marikyan & Papagiannidis, 2022).

The TTF model is a well-liked conceptual structure for assessing how information technology affects performance, measuring usage impacts, and figuring out how well the characteristics of the task and technology work together (Alyoussef, 2023; Peters, 2023). TTF is commended for fostering creativity and flexibility, offering thorough perspectives of technological acceptance, technology use, and behavioural intents, and serving as a diagnostic tool in examining the implementation and acceptance of various technologies in both private and public enterprises (Dash et al., 2023; Marikyan & Papagiannidis, 2022).

There are various iterations of TTF's constructions since it encourages creativity and flexibility. The task-technology fit model, according to Peters (2023), consists of five main constructs: task characteristics, technology features, task-technology fit, utilization, and performance impacts. McGill and Klobas (2009) state that task, technology, and individual characteristics are all factors that affect TTF. Since adopted technologies are meant to assist individuals in accomplishing their portfolios, anything inconsistent with humans cannot be beneficial in an organizational context (Dash et al., 2023). The TTF version adopted in this study, therefore, includes the individual characteristics of the technology users as one of the constructs. Figure 1 below is the Task-technology fit model.

Figure 3: Task-technology fit model



Source: Goodhue and Thompson (1995).

Task-technology fit model’s constructs

i. **Task characteristics**

Task characteristics are requirements for users' work or study (Lu & Yang, 2014). Marikyan and Papagiannidis (2022) argue that task characteristics are the elements that could persuade people to depend on particular information technology features. From a task-technology fit perspective, Task characteristics refer to jobs that an individual may undertake using technological devices (D’Ambra et al., 2012). In other words, technology is designed to assist individuals in carrying out different tasks in different settings. For instance, navigational technologies in ships will help seafarers (users) to operate the ship in complex day-to-day navigation activities.

ii. **Technology Characteristics**

Technology is a device utilised by individuals to perform their jobs in a specific situation, and a better fit to what is believed to be beneficial (D’Ambra et al., 2012). Technology characteristics are traits of the instruments that users employ to do specific activities and are used as suitable substitutes for system quality (Omatayo & Haliru, 2020). Lu and Yang (2014) describe technology characteristics as the technology’s capabilities. In the context of shipping, sophisticated navigational aids provide precise voyage data, such devices include gyrocompass, radar, autopilot, Automatic Radar Plotting Aid (ARPA), automatic tracking aid, speed and distance logging device, echo sounder, Electronic Chart Display Information System (ECDIS), voyage/route planner, Global Positioning System (GPS), Automatic Identification System (AIS), and voyage data recorder. Omatayo and Haliru (2020) argue that to get the greatest system or technology fit for the designated activity, task characteristics, and technological characteristics can be combined.

iii. **Individual characteristics of technology users**

The human component is essential in the application and acceptance of any device. According to Omatayo and Haliru (2020), Individual qualities, such as demographics, attitudes, personality traits, and computer self-efficacy may influence how technology is to be used. As stated by the above scholars, technology use will be influenced by a person's mindset and Computer self-efficacy which measures how confidently individuals believe to do a task using computers. D'Ambra et al. (2012) contend that one's abilities, familiarity with the devices and accompanying software, and training in data literacy can all influence one's appraisal of a technology's fit and views on its performance. According to Wan et al. (2020), users will embrace and utilize a technology based on how well its features meet the demands of the work at hand. With the rise of digital technologies in modern ships, users (seafarers) must acquire digital abilities to ensure a connection between task needs, the functionality of technological systems, and personal abilities.

iv. Task-technology fit

Another aspect of the TTF model is task-technology fit. It is the coordination of technical functionality, an individual's abilities and job requirements (Omotayo & Haliru, 2020). It assumes that the fitness of technology with the job will influence performance outcomes (Nguyen & Nguyen, 2023). TTF, in particular, exists as a bridge between performance impact and technology-related components (Butt et al., 2023). Several statistical studies that examined the relationship involving task-technology fit and performance outcome discovered that the two variables are positively associated (Butt et al., 2023).

v. Utilization

Utilisation is a task-technology fit component that defines the manner a human being applies devices to complete a given assignment (Omotayo & Haliru, 2020). It can be evaluated by the regularity of use, disparities of tools used, and their advantages such as accessibility, security, quickness, and ease of use (Cunha, 2023; Peters, 2023).

vi. Performance impacts

The end-state of the Task-technology fit model is to realize performance impacts. Omotayo and Haliru (2020) define performance impact as how much a user analyses an information system concerning the task. High performance indicates a high degree of task-technology fit and technology satisfaction, and as a result, high TTF boosts the system's performance impact (D’Ambra et al., 2012). Perceived improvements in effectiveness, efficiency, and quality are seen as performance impacts when a particular task is carried out (Peters, 2023). Furthermore, it is stated that performance impacts will happen when technology satisfies users' wants and offers characteristics that help it suit the task's criteria (Omotayo & Haliru, 2020).

A substantial corpus of research has been done in a variety of sectors to examine how well technology performs and to forecast the adoption and use of particular technologies for particular tasks based on the concept of task-technology fit. Assuming that a good fit significantly affects task performance, Gebauer et al. (2010) provided a three-step conceptual model. It was discovered that the design of a mobile Information System was particularly difficult to use in conditions typified by high destruction and low network connection quality and that the user interface required special consideration. Additionally, TTF was used to study tourist robots, and the findings showed that it had a substantial impact on customers' eagerness to use as well as operational expectations, functioning as an intermediary linking the two (Liu & Chen, 2023). The article "Acceptance of e-learning in higher education" by Alyoussef (2023) evaluated the contribution of the task-technology fit model to the success of information systems. TTF was found to have the highest influence on the benefits of online education, preceded by perceived simplicity of use. Nguyen and Nguyen (2023) combined task-technology fit, service awareness, and final product quality with the Technology Acceptance Model to examine the elements that affect people's motives to utilise the Dialogue flow concept. They found that the perceived TTF had a statistically significant and beneficial impact on usability. The perception of usefulness was then positively and statistically significantly impacted by the perceived service awareness. Furthermore, the TTF model was used to study the connection concerning task-technology fit and human-AI collaboration performance (Peters, 2023). Cunha (2023) examined how m-payment fosters individual performance using TTF, and it was discovered that technology attributes have an impact on TTF and that TTF encourages use and personal accomplishments. This model was also used by Prockl et al. (2023) to look at how blockchain technology performed as measured by potential consumers' adoption for a particular usage. The theoretical framework was also employed to analyse the use of fitness applications in Taiwanese sports facilities, and it was discovered that there was a substantial correlation between the TTF and the perceived use (Chang et al., 2023).

Although a substantial body of research has used the task-technology fit model to evaluate the relationship between various constructs in the use of information systems or technology, not much is known about the fit between navigational technologies, their task characteristics, and the specific users of such technologies.

This study expands the TTF model to ships by concentrating on navigation systems and looking at how they are used.

2.5 Conclusion

Each industrial revolution is identified by its technology. The steam engine was key in the First Industrial Revolution. The steamship and locomotive allowed for faster travel. Seafarers navigated using celestial bodies. The combustion engine and electric motor enabled mass production during the Second Industrial Revolution. To manage ships, navigators needed great celestial abilities. The Third Industrial Revolution saw computers and automation taking centre stage, marking the shift from analogue to digital technology. Seafarers adopted electronic tools such as ECDIS and GPS. The Fourth Industrial Revolution used smart devices and systems to automate and exchange data without human intervention. Seafarers need digital competency to interact with advanced information systems. The TTF model is the analytical framework that is used to assess the usefulness of technologies to the purposes they serve. It has been successfully used in numerous ways hence extending its application into navigational technologies in the maritime field.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

This chapter describes the research model, design, and methodologies used in the study. The discussion of data-gathering methods, population, sample strategies, and ethical issues follows thereafter.

3.1 Research model

The study employs a Task-technology fit (TTF) model having six constructs namely; the task characteristics, technology characteristics, individual characteristics, the TTF, utilization, and the performance impacts (Peters, 2023). These constructs will be operationalized using different factors as below:

i. Task characteristics construct

One of the elements of the TTF model is task characteristics, which are based on variables including task complexity, dependency, and degree of routineness (Peters, 2023; El Said, 2015). The task characteristics used in this study are operationalized as the perceived complexity of tasks that navigation systems on a ship's bridge are meant to manage, the perceived unchanging recurrent of uniform tasks carried out by navigation systems at fixed or scheduled intervals, and perceived interdependence of systems to achieve a navigational objective.

ii. Technology Characteristics construct

Technology characteristics are the services offered by the technology (Lu & Yang, 2014), which will be operationalized as the perceived utility, usability, compatibility, availability, and significance of the various navigation technologies on the bridge (Pal & Patra, 2020; Peters, 2023).

iii. Individual characteristics construct

This idea is defined as the qualities of system users that may have an impact on or influence how technology is used (Omatayo & Haliru, 2020). It is characterized as the perceived experience, motivation, abilities, attitudes, beliefs, and knowledge of technology users (Peters, 2023; Chang et al., 2016). Similarly, these factors will be applied to the perceptions of navigators using different navigation technologies on the ship’s bridge.

iv. TTF construct

The task-technology fit construct measures how much technology helps a person do their portfolio of duties (Omatayo & Haliru, 2020). It is based on factors such as system stability, production deadlines, compatibility, simplicity of use, and linkages with other forms of technology (Peters, 2023; El Said, 2015). All these factors will be used to determine the TTF construct of the perceived tasks, functionality, and the users' characteristics using the bridge's navigation technologies.

v. The Utilization

The frequency and duration of use of information systems are employed to measure this concept (El Said, 2015; Peters, 2023). Therefore, the perceived frequency and duration of navigation technologies used by navigators will be investigated.

vi. Performance impact

The TTF model's performance impact is expressed as higher effectiveness, efficiency, and quality attained while performing a task using the specified technology (Peters, 2023; El Said, 2015). This construct will lead to the examination of the perceived output standard of work when navigational technologies are used to carry out their tasks.

3.2 Research Design

A mixed-methods research strategy was used in this study. A mixed-method research design is a methodology with conceptual underpinnings and procedures to direct the collection and analysis of information from multiple sources in one investigation (Dawadi et al., 2021). Qualitative, quantitative, and content analysis methods were combined to develop a full understanding of the examined problem. By integrating several methodologies to investigate the same issue, researchers may validate their findings across multiple data sets, lessening the impact of any possible prejudices that may exist in a single analysis (Armstrong, 2022).

3.3 Data collection

Qualitative and quantitative data collection tools like surveys, interviews, and document analysis were used. Surveys are the best tools to gather data in a large population (DeFranzo et al., 2019). Jones et al. (2013) argue that surveys offer the advantage of collecting a large amount of data, having a means of obtaining validated models and covering a significant number of people, which boosts their statistical ability.

Interviews were used in all the research questions alongside surveys. As explained by Clements (2021), Interviews provide direct, in-depth information about a topic or circumstance and allow the inquirer to acquire original, unique material from a source customised to the study's needs. Characteristics and perceptions about the entities under examination were collected in responding to different research questions. The mode of interviews was online because of the distance limitation between the researcher and the study population.

Content analysis was yet another data collection method that was employed. Content analysis is a systematic procedure for researching or assessing resources, both printed and electronic, to bring voice and the setting to an evaluative issue (Armstrong, 2022; Wilson, 2019). This method was applicable in answering research question two by comparing the technological features under study to the evolution of the Industrial Revolution. The data were collected by Google Scholar searching keywords like industry 1.0, industry 2.0, industry 3.0, and industry 4.0.

3.4 Data Analysis and Interpretation

To produce triangulated results, multiple methodologies such as qualitative, quantitative, and documents were blended. This means that these three separate types of data were collected simultaneously and independently analysed using the aforementioned methods. During interpretation, these results were combined, compared, and contrasted. The qualitative analysis entailed transcribing and coding texts while the quantitative data was analysed using Excel software.

3.5 Population and sample size

The persons employed by the Malawi Maritime Force at its Monkey Bay Base in Malawi who regularly engage in maritime endeavours were the study's population of concern. A total of 53 people were chosen to take part in the study. Malawi's innovative use of ship technologies in Lake Malawi's freshwater could provide valuable insights into navigational device performance in underdeveloped countries.

3.6 Sampling technique

The participants were chosen by a simple random method. Simple random sampling is a method of choosing respondents from a population in which everyone has an equal opportunity to be picked (Creswell, 2014). This method was adopted to have a representative sample that allows for population generalisation.

3.7 Ethical consideration

The researcher followed the worldwide standards for the ethical handling of people and the information collected by obtaining approval from the WMU Research Ethics Committee with a REC Decision number REC-23-040(M) before data collection. Again, a request letter for permission to conduct a study at the study area was sent and received the permission to go ahead. Such letters are included in appendixes 3 and 4. Participants were ensured that their information would be kept secure, and anonymous and that the data would be destroyed after the degree had been awarded.

3.8 Conclusion

The chapter detailed the study's methodology, which included the use of the TTF model and a mixed research design in which content, qualitative, and quantitative approaches were merged to provide triangulated results. It has also explained the chosen data collection tools, sampling technique, and their rationale. The chapter comes to a close with a declaration of ethical considerations that were adhered to.

CHAPTER 4

FINDINGS

4.0 Introduction

This chapter explains and evaluates the data gathered for this current investigation. To get a broad overview of the issue being studied, the quantitative method's results, which were gathered using a survey questionnaire, are first presented. Thereafter, the detailed information collected from semi-structured interviews is presented, followed by data from content analysis, depending on the study question they respond to. The Task Technology Fit model is being used as the analytical framework.

4.1 What are the features of navigational technologies used in the organization's vessels?

To answer this research question, survey questionnaires and semi-structured interviews were used. The quantitative data was collected by formulating sub-questions like "How often do you use the following ship's navigational technologies?". In addition, statements expressing tasks and functionalities of such devices were put alongside the five-point Likert scale. The full survey and semi—structured interview guide is available in Appendixes 1 and 2.

4.1.1 Data collected from survey questionnaires

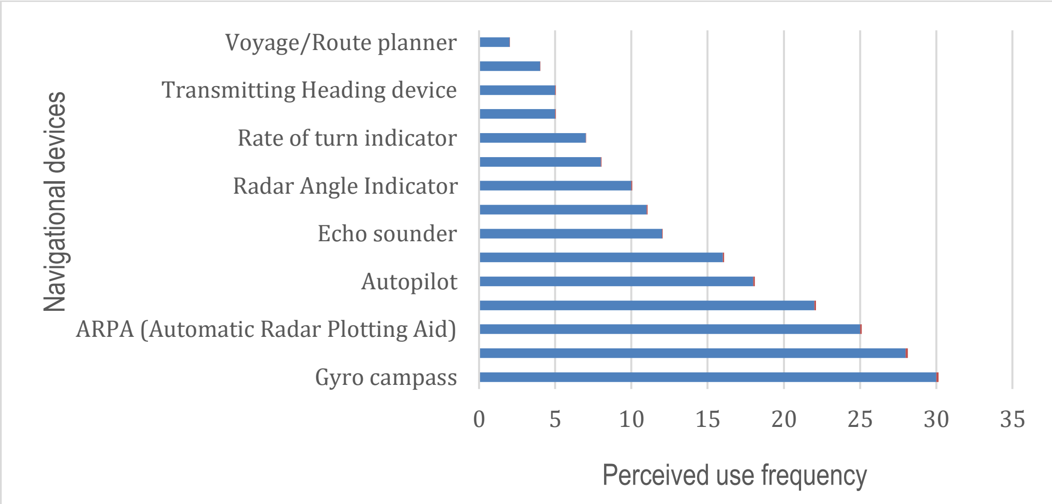
All the responses collected were from personnel working on board a vessel as navigators. Out of 53 responses, 51 were considered valid as two (2) participants opted not to take part in the study. The demographics of the participants included age, gender, rank on board, and working experience. 94.12% of the participants were over 22 years (n = 48) while those ages 18- 21 years were 5.88% (n=3). On the gender aspect, 92.16% (n =47) were males and 7.84% (n =4) were females. Their ranks on board included 50.98% (n = 26) officers and 49.02% (n =25) ratings. Lastly, the respondents had the following on-board experience; 21.56% (n=11) had 1 to 5 years of experience, 25.49% (n =13) had 6 to 10 years, 25.49% (n =13) ranged from 11 to 15 years, 9.82% (n =5) had 16 to 20 years, and 17.64% (n = 9) their experience ranging from 21 years above. **Table 2** below summarizes the characteristics of the participants who responded to the survey questionnaires.

Table 2: Demographics of the participants (N=51)

Characteristics	Value	Frequency (n)	Percentage (%)
Age	18- 21 years	3	5.88
	22- 25 years	9	17.647
	26-30 years	13	25.49
	31-35 years	13	25.49
	36-39 years	4	7.846
	40 years above	9	17.647
Gender	Male	47	92.16
	Female	4	7.84
Rank	Officers	26	52
	Ratings	25	48
Experience	1-5 years	11	22
	6-10years	13	26
	11-15 years	13	26
	16-20 years	4	8
	21 years above	9	18

A sub-question was interrogated to confirm what kind of navigational technologies exist on vessels and how often they are used. All the items listed as navigational devices on the vessel were confirmed to be available and used. However, it was found that these devices differed in how often they were used. The gyrocompass was recorded as the highest often used device with 14.78%, Radar with 13.79%, echo sounder with 12.32%, 10.84% was the speed and log device, radar angle indicator with 8.87% and the list goes on with the lowest percentage score of 0.99% obtained from how often the Electronic Chart Display and Information systems is utilized. Figure 5 below compliments and summarizes the findings on features of navigational devices and how often they are used.

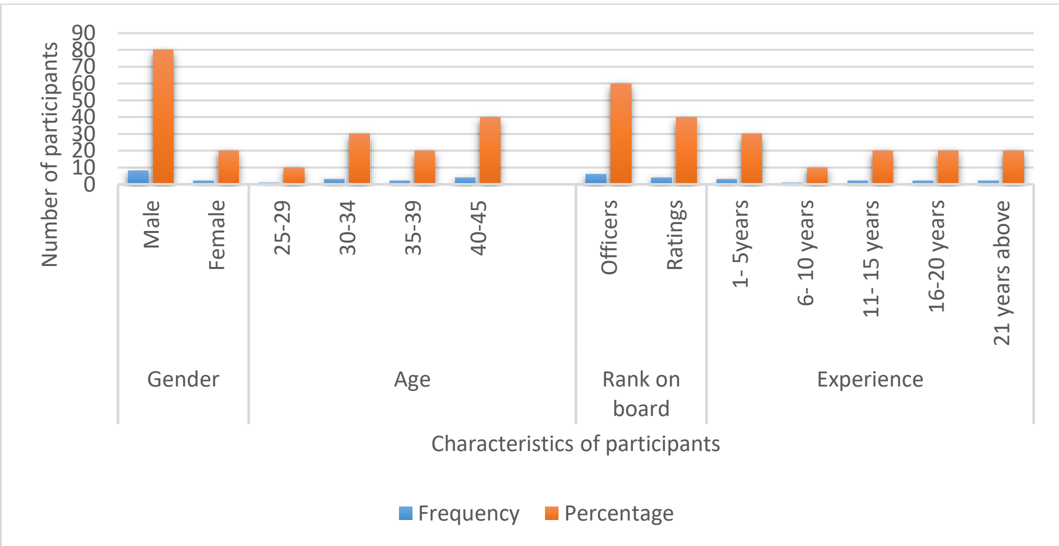
Figure 4: Ship's navigational devices and how often they are used



4.1.2 Data collected from interviews

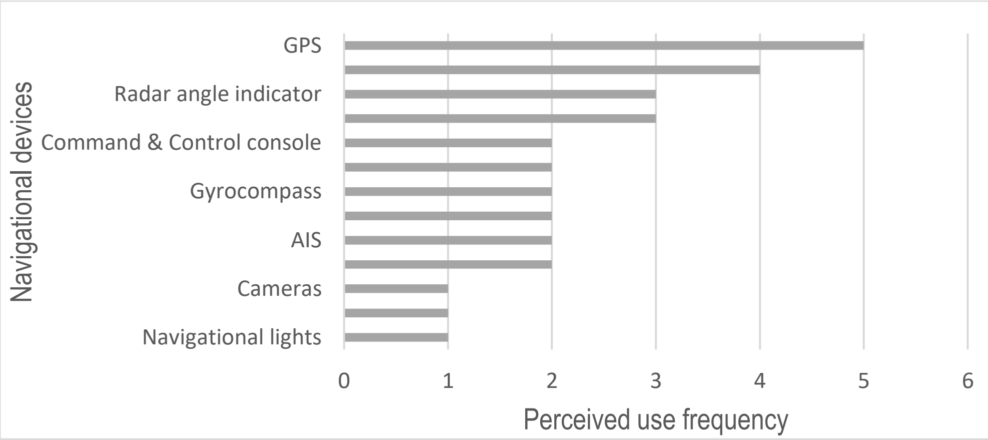
Interviews were also conducted to get an in-depth understanding of what was obtained through survey questionnaires. A total of ten (10) respondents were selected from the number of individuals who participated in the surveys. Figure 5 below is the bar chart illustrating the characteristics of respondents to the semi-structured interviews conducted.

Figure 5: Characteristics of semi-structured interview participants.



When they were asked what navigational technologies they use on the vessels, many devices presented in the survey questionnaire were also mentioned. However, a few other instruments were listed as the command and control console, mounted cameras, and the simulator. These technologies were also counted as to how many times they were mentioned by different participants to indicate how often they were used and known. Two (n=2) interviewees mentioned the command and control council, the AIS, the gyrocompass, and the simulator. The cameras, the radar angle indicator, radios and navigational lights were listed once, while the GPS had the highest frequency of five (n=5), the ECDIS was mentioned thrice (n=3), and finally, the echo sounder had a frequency of four (n=4). **Figure 6** is the bar chart that summarizes the navigational devices mentioned during the semi-structured interviews.

Figure 6: Features of navigational technologies that are used by vessels



Respondents detailed and discussed these navigational instruments' nature, tasks, and functionalities. According to Interviewee A, the shore-based command centre is powered by the Tactical Communication Network System (TCNS), which uses numerous frequency bands to ensure that information is transferred even if one frequency band fails. He further added that

> "*The centre serves the following purposes; providing situational awareness and mapping, voice and data integration, as well as tracking and monitoring of vessels using Global Positioning Systems (GPS) integrations and vessel tracking technologies. The system is capable of combining different navigation systems like the satellite and the initial navigation*" (Interviewee A, 2023).

The Electronic Chart Display and Information System (ECDIS) was explained as one of the navigational devices that is used to display navigational information on a computer screen about position, speed, and course (Interviewee B, 2023). Much as this device was mentioned by many, there was a mix-bag of perceptions on how it works while others named it as the simulator and the driving console. It was revealed that many navigators did not know much about it and that they opted to use other means other than the ECDIS. Asked how often they use the ECDIS, different interviewees responded as below;

> *"What? Ah, of course, we have it but many of us don't know how to use it. "(*Interviewee C, 2023).

> *"Yeah, yeah, you are right. Electronic charts we don't use. I don't know, is it that on the display is the chart or do you plot the chart electronically? Okay yeah, I think that provision is there because we usually just monitor the route on the console but what am not sure is about the electronic plotting of the route"* (Interviewee D, 2023).

> *"It's a new system that the old-school guys fail to operate"* (Interviewee E, 2023).

> *"Yeah, we plot the waypoints on the driving console. It is possible to leave the paper charts and follow the plotted waypoints on the driving console. If that fails, we use what we call the Automatic Identification System (AIS), it has a part of the GPS. It is a small device that shows all the routes that the vessel navigated ever since it was launched on water"* (Interviewee F, 2023).

As stated by all responders, these technologies collectively improve the safety, efficiency, and accuracy of ship navigation, assisting vessels in navigating through diverse situations and challenges while reducing the chance of accidents and incidents. For instance,

"The Echo sounder uses waves to determine the depth of water under the vessel and it informs the depth or shallowness of the waters to avoid running the vessel aground" (Interviewee B, 2023).

4.2 Where does it fit in the evolution of technology (industry 1.0 to industry 4.0)?

This study topic was answered by triangulating data from survey questionnaires, interviews, and content analysis. It is worth noting that the items found in question one (1) were utilised as input in analysing the place of ship navigational technologies in the emergence of the Industrial Revolution.

4.2.1 Quantitative data from survey questionnaires

The previous research question found and confirmed the use of modern navigational devices on the organisation’s vessels including the Electronic Chart Display and Information system (ECDIS), Radar, Automatic Radar Plotting Aid (ARPA), Automatic Identification System (AIS), and Global Positioning System inter alia. These are sophisticated navigational devices which offer precise trip parameters. The ECDIS, for example, is a complex and digital maritime navigation system with a wide range of data visualisation, analysis, and system integration capabilities (Weintrit, 2022).

4.2.2 Qualitative data from semi-structured interviews

Apart from the above-mentioned navigational devices, the shore-based centre was also found to be part of the vessels’ navigation. According to Interviewee A, the centre has a Command and Control console supported by the Tactical Communication Network System (TCNS). It was added that some of the functions include data transmission, network management, combined navigation and tactical information processing. *“It is capable of setting up communication parameters, networking working management, and network member management. It is also capable of combining different navigational systems such as satellite navigation and inertial navigation”* (Interviewee A, 2023). It is this facility that allows for information transmission from the crew on board to personnel ashore.

4.2.3 Data from Content Analysis

A close look at the literature on the evolution of the Industrial Revolution compared with the features of the navigational devices that the organization uses, five core technologies of Industry 4.0 were discovered to match those of the organisation under consideration. These technologies included Cyber-Physical Systems, the Internet of Things, simulation, Big Data Analytics, and networks, putting the organization's technologies in the Fourth Industrial Revolution, but with minimal features.

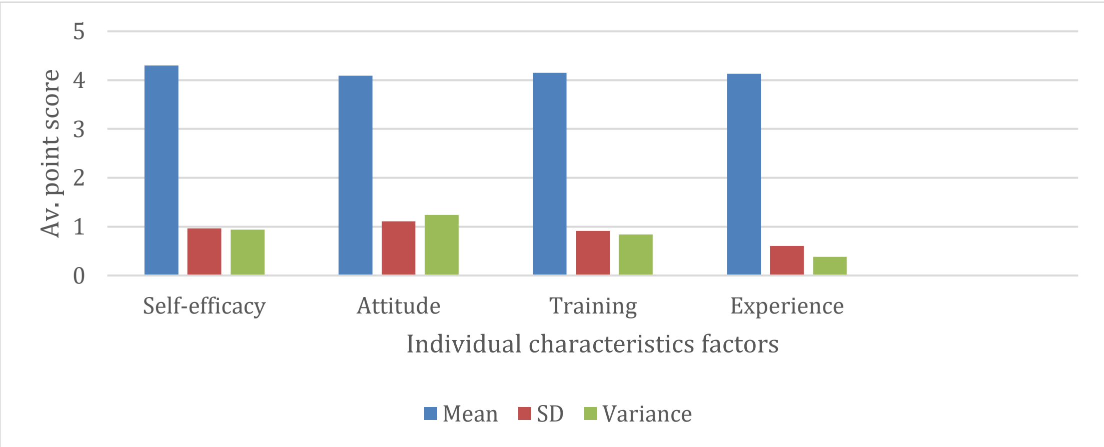
4.3 What are the individual characteristics of technology users that may affect performance and other outcomes?

Research instruments like the 5-point Likert scale survey questionnaire and semi-structured interviews were also used to respond to this research question to understand the perceived characteristics of the ship's navigational technology users. Presented below are the results from the already-mentioned research methods.

4.3.1 Quantitative data collected through survey questionnaires.

Statements in the survey were formulated to portray the different factors that are used in examining the individual characteristics of the TTF model namely, self-efficacy, attitude, training, and experience. The responses were rated one (1) strongly disagree, two (2) disagree, three (3) neutral, four (4) agree, and five strongly agree. It was found that the Self-efficacy factor had the highest average score of (4.3), the attitude was 4.09, training was 4.15 while the experience recorded an average score of (4.13). This data meant that Self-efficacy is an important aspect of the abilities of navigators who interact with different navigational devices. Figure 7 is a bar chart showing the perceived individual characteristics of navigators that enable them to interact with different navigational information systems in the vessel.

Figure 7: Individual characteristics of navigators by Self-efficacy, attitude, training and experience factors



4.3.2 Qualitative data from interviews

Interacting with modern navigational technologies on board a vessel requires the users to have digital competencies (WMU, 2019). However, based on information gathered through interviews, it was discovered that there was a digital competence disparity among navigators, which was related to their training, experience, attitude, and self-efficacy. The training was mentioned the most by those interviewed. They believed that the fundamental information gained from any type of training is essential for comprehending and dealing with advanced technology. For instance, one navigator was quoted as saying,

"…the basis is what matters. Every time you meet an advanced technology, you refer back to what the basics say about its use and application. What allows me and other colleagues to use the vessels with modern technology is the basic knowledge from Marine College compared to those who went to learn more about these vessels in China, as they did the training for a short period" (Interviewee B, 2023).

As other navigators use their employment experience to work with navigational gadgets, others become fascinated about them and establish initiatives to better understand and use them. According to Interviewee F, in addition to the various trainings, he utilises simulator games on his smartphone to learn how to sail a vessel using various navigational instruments.

This digital inequality of navigators' skills interface with modern navigational devices is a threat to the safety of navigation as it leads to accidents. It was mentioned by almost all the people interviewed that due to a lack of digital literacy, for example, some navigators who were on a voyage on the lake and were supposed to be heading the north but were found elsewhere southwards, hitting a rock, and damaging the propellers in the process.

"The problem was not the navigational equipment; it was just incompetence. Maybe the handlers were incompetent such that they did not know what to do or failed to interpret the information displayed on the screen. Because if the devices are showing that where you are going is shallow, you are still going. The problem is not the gadgets, but the handlers" (Interviewee H, 2023).

4.4 How is the technology used a good fit for the tasks they are performed?

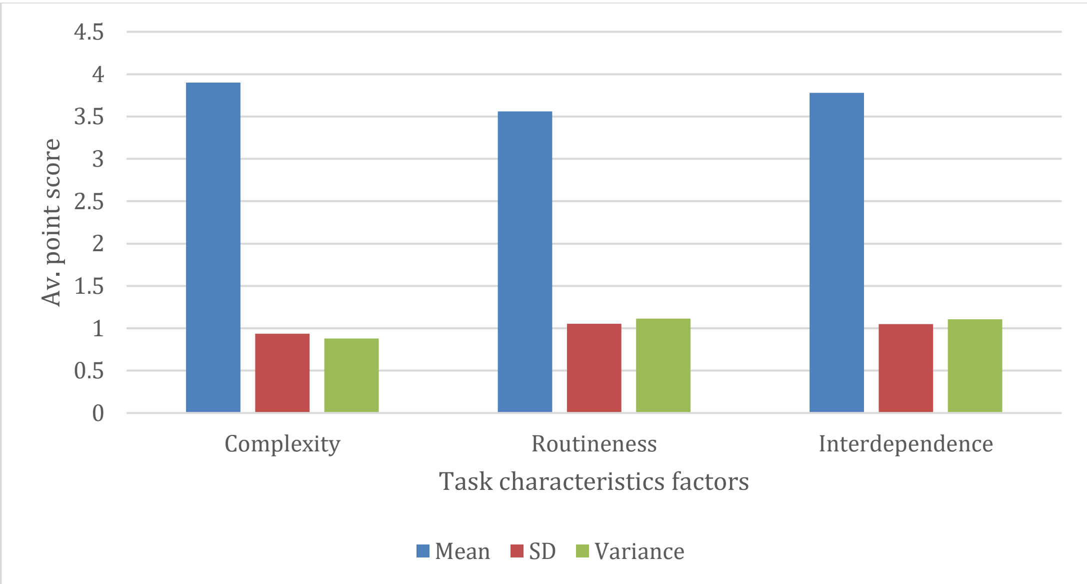
In this research question the findings from surveys were evaluated using the TTF model where the data collected from semi-structured interviews helped to explain why different constructs of the model had a varied correlation to each other to predict the effectiveness of the used devices.

4.4.1 Quantitative data from survey questionnaires

4.4.1.1 Task characteristics

This construct of the TTF model was tested using three factors such as complexity, routineness and interdependence of the tasks performed using the ship's navigational technologies. The perceptions of the respondents showed that navigational devices effectively handle complex navigational tasks with a high mean point of (3.9), routines recorded a mean point of (3.56) while the interdependence of tasks was (3.78). Figure 8 below shows the respondents' perceptions about the task characteristics the technology serves.

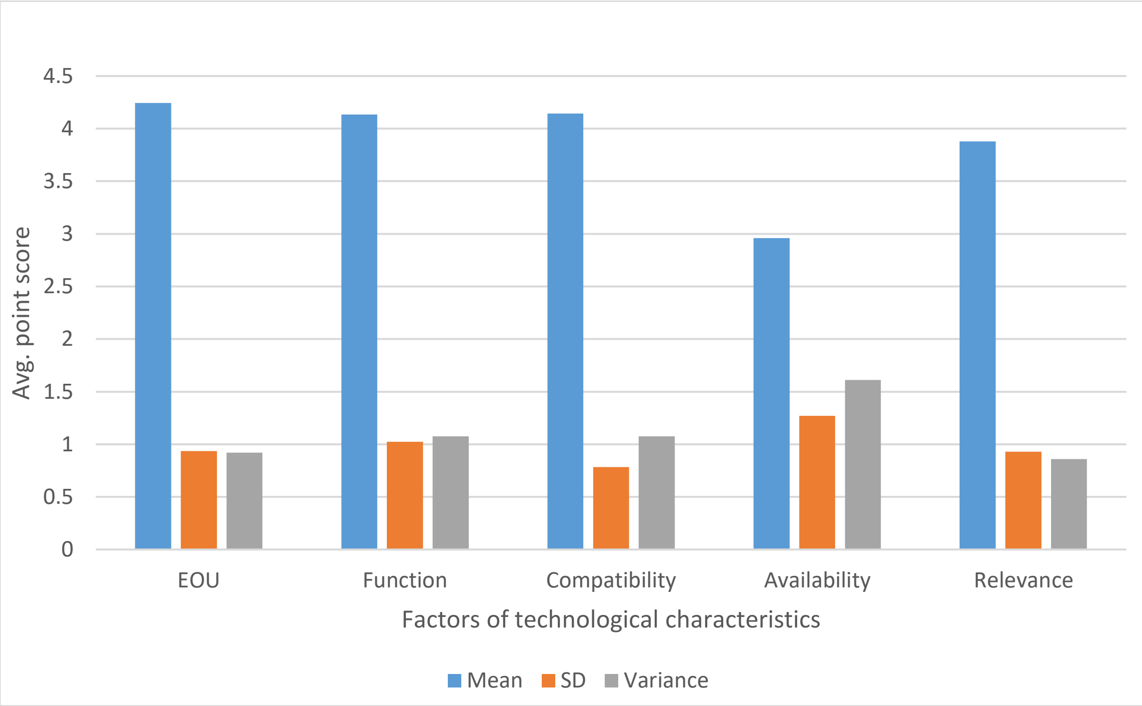
Figure 8: Mean point scores of perceived task characteristics



4.4.1.2 Technological characteristics

The perceived functionalities of the navigational technologies were tested using the Likert scale statements containing factors like ease of use (EOU), function, compatibility, availability and relevance. The findings indicate that EOU had the highest mean point value of (4.245), function was (4.135), compatibility was (4.145), Availability had the lowest mean point score of (2.96) and relevance was rated at (3.88). Figure 9 is a bar chart showing the factors of technological characteristics against their mean point values.

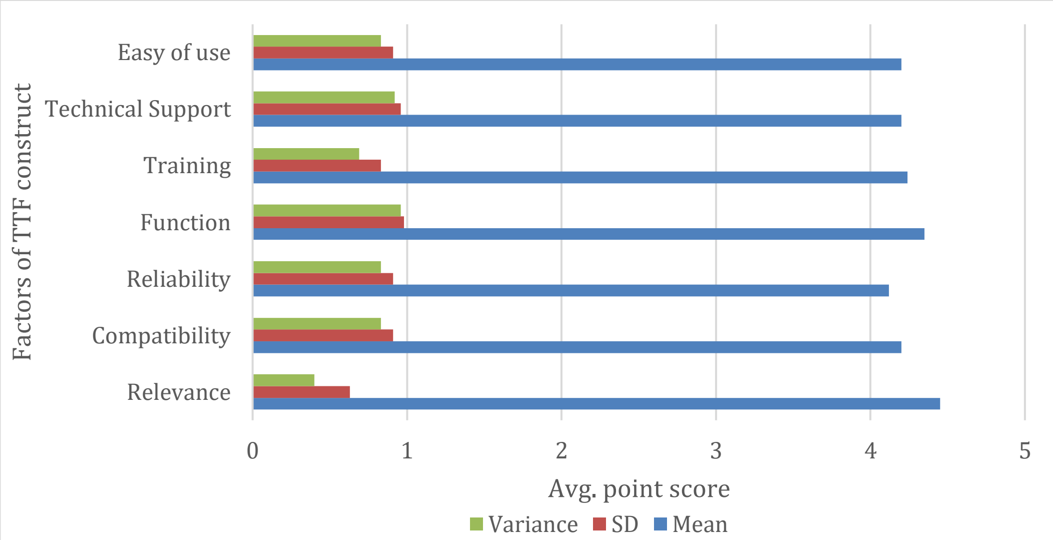
Figure 9: Factors of technological characteristic construct



4.4.1.3 TTF construct

Factors like Ease of use, technical support, training, function, reliability, compatibility and relevance were used to value the perceptions of the respondents on the TTF construct. The results showed that Relevance had the highest mean point value of (4.45), Function with (4.35), Ease of Use had (4.2), Training had (4.24), Technical support had (4.2), and Reliability with a low score of (4.12). Figure 10 below summarizes the findings on the TTF construct.

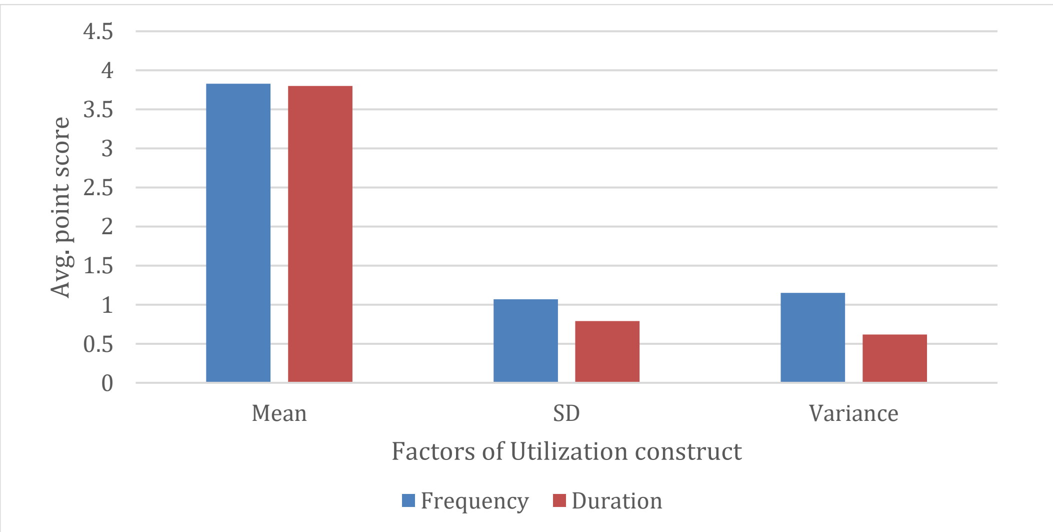
Figure 10: Results on TTF construct.



4.4.1.4 Utilization construct

This construct was examined using two factors; frequency and duration of the navigational devices used. It was found that frequency had a high mean score of (3.83) while the duration had (3.8). Graphically, Figure 11 shows the results of the perceived utilization of the navigational devices.

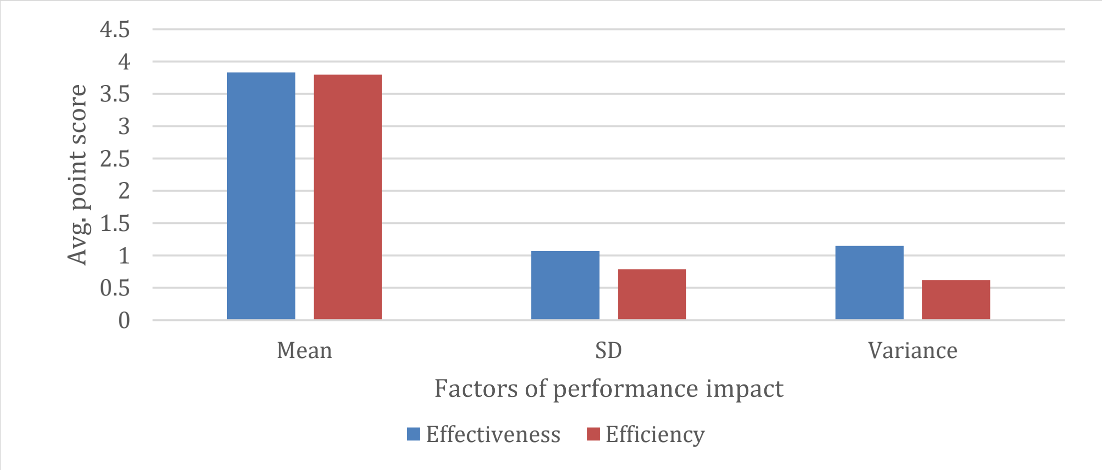
Figure 11: Results of the perceived utilization of the navigational devices.



4.4.1.5 Performance Impact

The Performance Impact construct was assessed using effectiveness and efficiency factors where Effectiveness had a high mean score of (3.83) and Efficiency had a mean score of (3.8). Figure 12 illustrates the perceived performance Impact of the navigators.

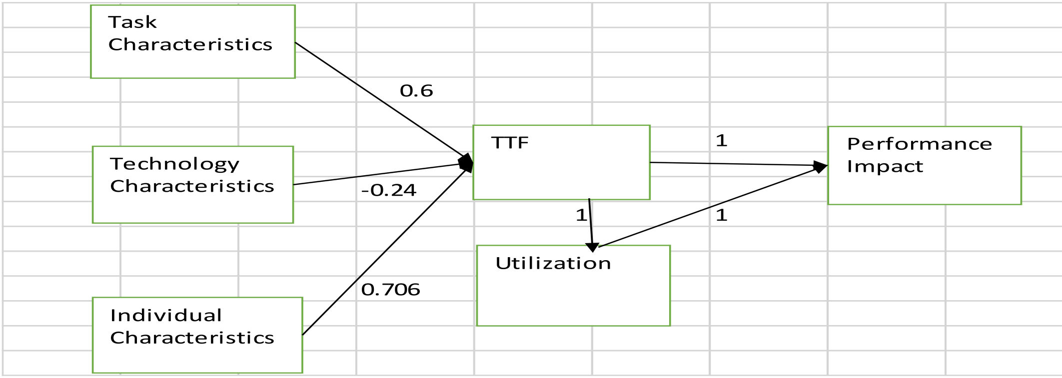
Figure 12: The perceived performance impact of navigators who use the navigational devices.



4.4.1.6 Correlation of TTF model constructs in the study

The Pearson correlation coefficient analysis was conducted to determine how the TTF model's many constructs relate to one another. Pearson correlation describes the link between two variables, and its value spans from plus one to minus one (r = +1 or -1) (Okwunu et al., 2020). The results showed that the task characteristics had a moderate positive linear correlation of (0.600) with the TTF construct, the technology characteristic indicated a weak negative linear relationship with the value of (-0.240) to TTF, Individual characteristics to TTF was (0.706) considered to be a strong positive linear relationship while TTF to Utilization, TTF to Performance Impact, and Utilization to Performance Impact well all calculated as one (1) indicating a perfect positive linear relationship between the indicated variables. Figure 13 presents the overview of how the different constructs match with each other to predict the Utilization and the Performance impact.

Figure 13: Correlation of TTF model constructs



4.4.2 Qualitative data obtained from interviews

Respondents acknowledged the significance of the navigational devices by mentioning that working with such devices does not require a lot of people, the accuracy is good, they provide real-time situational awareness, they can meet the timelines and stability, ship's speed and power are marvellous. *"The accuracy is good, unlike when we mainly used coastal navigation to estimate distances"* (Interviewee F, 2023).

However, it was also mentioned that using these navigational devices had its challenges. Such challenges included its vulnerability to weather conditions that is, during adverse weather conditions other functionalities are not available hence rendering navigation difficult. Interviewee F said, *"Navigational technologies are useful, though they give false information during adverse weather conditions*".

Secondly, it was found that there was a lack of familiarization with the navigational instruments as the vessels had limited movements coupled with some Standing Operating Procedures.

Again, the language on many displays proved to be a barrier to communication and use by the crew. 75% of the people interviewed were repeatedly recorded as saying the Chinese language on different devices is the source of human errors that are committed by the navigators because it cannot be understood and interpreted.

Training has also been a problem. It was acknowledged that some other knowledgeable colleagues possess different forms of knowledge but do not transfer them to others. This gap in training was the one that led to the incompetence of the technology users.

"Some people went for training in China to learn more about all the gadgets on the vessels. They stayed there for about two months. Both engineers and deck officers went there. So I think the challenge now is the transfer of knowledge to the rest, or to the ones who will be taking part in operating the vessels. Those who went to China are the ones who know how the vessels operate. But I think yes, the knowledge was not transferred to all of us" (Interviewee D, 2023).

4.5 Chapter Key Findings

RQ 1: What are the features of navigational technologies used in the organization's vessels?

Modern navigational technologies were discovered to be used by the organisation in its ships, which contained integrated information systems that offered accurate trip information, monitoring, and situational awareness. These tools included, among others, the usage of ECDIS, AIS, ARPA, Simulator, Command and Control console, GPS, and Echo Sounder.

RQ 2: Where does it fit in the evolution of technology (industry 1.0 to industry 4.0)?

Following a thorough examination of the technologies based on their features and functionalities, five main characteristics of Industry 4.0 technologies were identified such as Cyber-Physical Systems (CPS), Internet of Things (IoT), Simulation, and Big Data Analytics and networks.

RQ 3: What are the individual characteristics of technology users that may affect performance and other outcomes?

Individual attributes had an average score of (4.17). Self-efficacy had the highest mean point score of (4.3), followed by training at (4.15), experience at (4.13), and attitude at (4.09). Despite a high average score, qualitative data revealed a digital proficiency gap among individual navigators.

RQ 4: How is the technology used a good fit for the tasks they are performed?
TTF had a perfect positive linear association with utilisation and performance impact constructs, both of which had a (+1) value. The task characteristics to TTF constructs had a moderate positive linear connection of (+0.6), whereas the technology characteristics to TTF had a weak negative linear correlation of (-0.240). Individual characteristics revealed a substantial positive correlation (+0.706) with the TTF component of the model.

CHAPTER 5

DISCUSSIONS

5.0 Introduction

This chapter synthesizes the results from surveys, semi-structured interviews and content analysis depending on the research question where such instruments were used. The findings from the research questions were compared and contrasted with the existing literature on the topic. Features of the technology, its place in the evolution of the Industrial Revolution, individual abilities of navigators and the fit of the technology to tasks they perform were well discussed.

5.1 Features of ship's navigational technologies used at the organization

Modern navigational technologies were discovered to be used by the organisation in its ships, which contained integrated information systems that offered accurate trip information, monitoring, and situational awareness. These tools included, among others, the usage of ECDIS, AIS, ARPA, Simulator, Command and Control console, cameras, GPS, and Echo Sounder. According to Alsamhi et al. (2023), navigation in an Industry 4.0 context employs modern technology and data-driven methodologies to ensure accurate and trustworthy navigation. Today's integrated navigation bridge, for example, is centred on an Electronic Chart Display and Information System to give situational awareness during watch keeping (Baric et al., 2023). Furthermore, the current study findings confirmed that the shipbuilding sector continues to invest in automated navigation systems, such as collision avoidance technologies and navigation assistance systems supported by Radar ARPA, AIS, and Innovative cameras (Jeon et al., 2019).

5.2 Its place in the evolution of the Industrial Revolution

Following a thorough examination of the technologies based on their features and functionalities, five of the many main characteristics were identified as crucial for Industry 4.0 technologies: Cyber-Physical Systems (CPS), Internet of Things (IoT), Simulation, Big Data analytics, and networks.

Apart from the cutting-edge navigational technologies in vessels, the facility at the Shore-based command centre is crucial in the general functioning of vessels' navigation. As mentioned by Interviewee A, there is a Command and control console at the shore-based command centre powered by the Tactical Communication Network System capable of data transmission, network management and combined navigation. This narrative depicts Industry 4.0, which is defined as the adoption of digital technologies and the connecting of all industrial processes to create Cyber-Physical Systems (Groumpos et al., 2021). The ability of the TCNS to collect, store, process, analyse, visualise and interpret large and complex data to give meaningful insights, patterns, and trends confirms the notion of Big data analytics. Smaya (2022) describes Big data analytics as the sophisticated process of evaluating massive volumes of information to identify insights such as unnoticed trends, correlations, market situations, and client wants that can help organisations make informed decisions.

Additionally, the TCNS gets the ship's operating and navigational statuses and shows them on the big screen in real time. This is an illustration of simulation, which is described as computer-based tools that replicate actual procedures or systems (Pereira & Romero, 2017; Bai et al., 2020).

The TCNS and other devices use radio, satellite, and wireless networks including the Internet, to send and receive data (Interview A, 2023). Having different devices linked to the Internet brings on board the concept of the Internet of Things (Pereira & Romero, 2017; Bai et al., 2020). Hussein (2019) states that the major purpose of IoT is to facilitate communications between individuals and objects anywhere and via any form of network, method, or service.

Although the features of the navigational technologies of the institution were categorized into Industry 4.0, a limited number of features were proved to match the critical technologies of Industry 4.0 as mentioned above. CPS and IoT, according to Wichmann et al. (2019), are the most important features of Industry 4.0 as compared to the rest.

5.3 Individual characteristics of technological users that may affect performance and other outcomes.

Individual attributes had an average score of (4.17). On the factor side, Self-efficacy had the highest mean point score of (4.3), followed by training at (4.15), experience at (4.13), and attitude at (4.09). Despite a high average score, qualitative data revealed a digital proficiency gap among individual navigators.

Theoretically, all the factors of the individual characteristics construct proved to be significant having a score range of (4.09 to 4.3). Self-efficacy had a considerable impact on the individual characteristics of mariners, making it a critical performance element (Dishaw et al. 2002). This study backs up the findings of Gu and Wang (2015), who used the TTF model to investigate how the complexity of tasks, self-efficacy, and the instructional setting influence online education and discovered that all elements, including self-efficacy, had an impact on e-learning effectiveness. It also supports Huang and Wang's (2022) conclusions that, while the experience was scored top, the learners' self-efficacy was sufficiently large to reflect the students' motives when participating in a virtual classroom.

In this digital era, navigators must possess digital skills. However, after a thorough examination, it was shown that there was a digital proficiency gap among the navigators based on the factors of individual characteristics mentioned above including the lack of familiarization with the devices. This is consistent with D'Ambra et al. (2012) findings that the evaluation of technology's fit may vary due to a person's competencies, experience using the technology and accompanying software, education and training in information literacy. Navigators, who frequently use the devices and had some training on their application, had a perfect Human-Machine Interface as compared to those who lacked familiarization with the devices. In part, the digital skill disparity can be attributed to a lack of knowledge sharing in any form at the organization.

5.4 The fit of navigational technologies to the tasks they perform

TTF had a perfect positive linear association with the utilisation and performance impact constructs measured by the Pearson correlation coefficient, both of which had a (+1) value. The task characteristics and TTF constructs had a moderate positive linear relationship of (+0.6), whereas the technology characteristics to TTF element had a weak negative linear correlation of (-0.240). Individual characteristics revealed a substantial positive association (+0.706) with the TTF construct. All constructs of the TTF model were calculated for their mean point scores and the scores were as follows; task characteristics were (3.75), technology characteristics had (4.01), individual characteristics (4.17), TTF (4.24), Utilization (3.82), and Performance Impact (3.87). The TTF construct had the highest score out of the rest. According to D'Ambra et al. (2012), a high TTF score promotes the system's performance impact. When correlated with the Performance impact and Utilization constructs, it had a (+1) in all directions that is TTF to Performance impact, TTF to Utilization, and Utilization to TTF. The plus one (+1) value showed a perfect positive correlation among the constructs. These findings supported the results of McGill and Klobas (2009), who discovered that TTF contributed to the perceived effects on instruction in both ways through the degree of usage of Learning Management Systems (LMS).

The task characteristic showed a moderate positive correlation to TTF with a value of (+0.6) with the perceived complexity of tasks weighed at (3.9), routines at (3.56) and interdependence at (3.78). The high complexity score indicated that navigators use navigational devices to perform different complex tasks of navigation. In line with this outcome, Andersone et al. (2021) state that as individuals recognise that technology helps task execution, it translates to increased adoption, utilisation, and enhanced performance.

Although the technology characteristic construct had a high score (4.01) compared to the task characteristic (3.75), it produced a weak negative linear relationship to the TTF construct of (-0.24) due to a low Availability factor score of (2.96). The reason for the low score of Availability factor was revealed to be; the restricted movement of vessels, the language barrier of the device displays being in Chinese which many navigators do not understand at the institution and the effects of adverse weather conditions.

The individual characteristics had the greatest influence on the TTF component with a Pearson correlation coefficient of (+0.706) as compared to task characteristics (+0.6), and technology characteristics (-0.24). Pal and Patra's (2020) study on students' impressions of video-based instruction during COVID-19 similarly revealed that individual attributes had a greater impact on TTF structure than technological characteristics. These findings highlight the significance of individual qualities in transforming inputs into outcomes via navigational devices, and anything inconsistent with humans cannot be employed optimally (Dash et al., 2023).

5.5 Implications

5.5.1 Theoretical implications

This work adds to the body of knowledge on the applicability of the TTF model to maritime navigational technologies. In tandem with earlier studies, the current study reveals that the TTF model fits well with navigational devices. As such, the TTF model can direct navigational technology research and development activities, allowing designers to concentrate on developing technologies that better correspond with the distinctive responsibilities and constraints posed to navigators.

5.5.2 Practical implications

Firstly, the TTF model emphasises the value of user-centred design concepts. According to Baric et al. (2023), for a device to be productive, it must be developed with the operator's requirements and abilities in mind. Promoting an easy and efficient user experience implies that when building or implementing navigational technology, user requirements, preferences, and attributes should be essential to the decision-making procedure.

Secondly, the model also contributes to the necessity for training and familiarisation to the technology end-users. In the modern era of integrated bridge systems and e-navigation, navigators must be fully taught and familiarised with navigational tools.
In addition, the study emphasises the significance of organisational learning and knowledge management. Knowledge management is the practice of generating, disseminating, utilising, and managing information within an organisation (Girard & Girard, 2015). Through knowledge sharing, there can be no any gap associated with digital proficiency.

Also, the TTF model enhances safety and risk management by incorporating navigational tools to supplement risk evaluation and reduction responsibilities.

The concept also contributes to the maritime industry through cost-benefit analysis. When contemplating the deployment of new navigational technologies, ship owners and operators can utilise the TTF model to do cost-benefit studies. They can compare the implementation costs against the predicted advantages in task safety and efficiency.

Lastly, the TTF model as used in the maritime industry will serve as a regulatory compliance measure. The TTF model can assist in ensuring that specific navigational technologies are available and successfully incorporated into the navigation process, which is frequently mandated by international maritime laws.

CHAPTER 6

6.0 Conclusions, limitation, and Future Work

Navigational technologies in the maritime industry continue to be more digitalized amidst technological advancements and the push factors exerted by international maritime laws to make shipping safe, effective, and sustainable. The faster digitalization advances, the more the crew's activities move from operation-related roles to engaging with information systems, typically on computer displays both on board and onshore, complicating the already cognitively demanding seafaring profession. With an emphasis on the ship's navigational systems, this study employed the TTF model to gain insights into the current scenario of navigational technology usage at the Malawi Maritime Force. The investigation discovered that the MMF employs cutting-edge navigational devices having integrated information systems to provide precise voyage data, monitoring, and situational assessments. These devices included some of the major technologies required for Industry 4.0, such as Cyber-Physical Systems, Internet of Things (IoT), simulation, Big Data analytics, and networks.

The navigational technologies demonstrated to fit well with the work they support, as the TTF construct recorded a high mean score and a perfect strong linear relationship to the performance impact, predicting the high individual performance impact both directly and indirectly through the model's utilisation construct. Furthermore, the study's findings revealed various values and tips for the adoption and usage of maritime navigational systems. For instance, individual qualities had a stronger impact on the TTF concept than task and technology features, indicating that factors like training, experience, attitude, and self-efficacy should be taken into account when selecting a technology to utilise. Again, a very weak negative correlation between technological characteristics and TTF due to low-reliability factor mean point values shows that individual user performance can occasionally be influenced by outside factors like bad weather, standing operating procedures, and restricted vessel movement. The TTF model was generally a good fit for maritime navigational technologies after being fully evaluated with all of its elements and thus expanding the model for use in maritime navigational technologies as a theoretical framework when evaluating the performance of technology users.

This study does have some drawbacks, though. To begin, this study involved navigators from a single maritime organisation. Because the sample was collected from a single institution in the country, the current findings may have some specificity and thus have limited generalizability when applied to other institutions, countries, and regions with distinct cultures, values, and individual characteristics of their technology users. Future research must therefore concentrate on longitudinal studies across nations and compare it to the current study to examine for any variations. Second, while this study focused on navigators' views, engineers also deal with emerging technologies as part of their work. Therefore, in the context of contemporary ship technology, engineers' perspectives on using automation technologies will be another important subject to research.

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Appendix 1: survey questionnaire

Dear participants,

I am inviting you to participate in this study by completing the following survey: My name is **Gift William KAMWENDO**, a student at World Maritime University in Malmo, Sweden, studying for the MSc in Maritime Affairs (Education and Training) award. This research examines the state of application of ship navigational technologies within the Malawi Maritime Force to understand how the abilities of navigators, functions, and tasks performed using such technologies as ECDIS, AIS, ARPA, RADAR, Conning, and Autopilot are aligned to achieve optimum performance.

The following survey questionnaire will take approximately 10–15 minutes to complete. The data collected will remain confidential and be used solely for this research paper. Data will be stored on a secure server at the university, and it will be deleted after the award of the degree. Thank you very much for your participation in this study.

Consent to participate in the study. (Tick your choice)

1. I agree to participate and understand that this survey is completely anonymous.
2. I choose not to participate and will immediately alert a staff member.

A. Demographics of Participants

How old are you? …………

Are you male or female?

1. Male
2. Female

What is your rank on board?

1. Officer
2. Rating

What is your work experience on board?

1. 1-5 years
2. 6-10 years
3. 11-15 years
4. 16-20 years
5. 20 years above

B. Perceptions on navigational technologies

Which of the following devices on the bridge do you often use? (Choose all that apply to your situation.)

1. Gyro compass
2. RADER
3. Autopilot
4. ARPA (Automatic Radar Plotting Aid)
5. Automatic Tracking Aid
6. Speed and Distance Log device
7. Echo sounder
8. ECDIS (Electronic Chart Display and Information System)
9. AIS (Automatic Identification System)
10. Radar Angle Indicator
11. Voyage Data Recorder
12. Rate of turn indicator
13. GPS Receiver
14. Voyage/Route planner
15. Transmitting Heading device

Which of the following devices on the bridge do you often use? (Choose all that apply to your situation.)

1. Gyro compass
2. RADER
3. Autopilot
4. ARPA (Automatic Radar Plotting Aid)
5. Automatic Tracking Aid
6. Speed and Distance Log device
7. Echo sounder
8. ECDIS (Electronic Chart Display and Information System)
9. AIS (Automatic Identification System)
10. Radar Angle Indicator
11. Voyage Data Recorder
12. Rate of turn indicator
13. GPS Receiver
14. Voyage/Route planner
15. Transmitting Heading device

How strongly do you agree or disagree with the following statements about the tasks you perform using the ship's navigational technologies on the bridge? Tick your chosen item.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Navigational technology effectively handles complex navigational tasks	❑	❑	❑	❑	❑
The navigational technology provides accurate, real-time updates on weather conditions	❑	❑	❑	❑	❑
The navigational technology integrates data from various sources to support decision-making	❑	❑	❑	❑	❑
The technology facilitates seamless communication and coordination among the ship's crew	❑	❑	❑	❑	❑
Navigational technology automates routine navigation tasks effectively	❑	❑	❑	❑	❑
Navigational technology offers decision support for non-routine navigational situations	❑	❑	❑	❑	❑

How strongly do you agree or disagree with the following statements about the functionality of navigational technologies? Choose an option that fits your perception of each statement.

	Strongly Disagree	Disagree	Neutral	Somewhat Agree	Strongly Agree
Navigational technology on board is user-friendly and easy to operate (EOU)	❑	❑	❑	❑	❑
I find it easy to navigate through the menus and settings of the navigational technologies (EOU)	❑	❑	❑	❑	❑
Navigational technology in ships provides comprehensive features and tools for safe navigation (FX)	❑	❑	❑	❑	❑
The technology effectively supports route planning, collision avoidance, and real-time vessel tracking (FX)	❑	❑	❑	❑	❑
The navigational technology is compatible with the ship's existing gyrocompass and GPS receivers (COM)	❑	❑	❑	❑	❑
The technology effectively communicates and exchanges data with other navigation-related equipment on the ship (COM)	❑	❑	❑	❑	❑
The technology remains operational during adverse weather conditions or slow satellite visibility (AVAIL)	❑	❑	❑	❑	❑
The navigational technology caters to the specific needs and requirements of maritime tasks (RELEV.)	❑	❑	❑	❑	❑

How strongly do you agree or disagree with the following statements about your abilities that make you operate the technologies mentioned above?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I feel confident in my ability to effectively operate and utilise ship navigation technologies (Self-E)	❑	❑	❑	❑	❑
I am adaptable and open to learning and using new navigational devices. (Self-E)	❑	❑	❑	❑	❑
I have a positive attitude towards navigation technology, as it enhances my effectiveness and efficiency. (Att.)	❑	❑	❑	❑	❑
I am willing to embrace and explore new navigational technologies to improve my work. (Att.)	❑	❑	❑	❑	❑
I have received formal training in ship navigation, including courses, certifications, and experience using navigation technologies (TRG)	❑	❑	❑	❑	❑
I have received on-the-job training in ship navigational technologies, which has equipped me with practical knowledge and skills (TRG)	❑	❑	❑	❑	❑
I have extensive experience using ship navigational devices and am familiar with their applications and functions. (EXP)	❑	❑	❑	❑	❑
I have a background in traditional navigational methods, such as using nautical charts and celestial navigation, which compliments my use of technology. (EXP.)	❑	❑	❑	❑	❑

How strongly do you agree or disagree with the following statements about how tasks, functions of technology, and the abilities of navigators match?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Navigational technologies on board are recognised and accepted by relevant maritime authorities and industry standards (RELEV.)	❑	❑	❑	❑	❑
The ship's navigational technologies are compatible with existing systems and processes on board (COM)	❑	❑	❑	❑	❑
The technology demonstrates a high level of reliability in accurately providing navigation information (RELIA)	❑	❑	❑	❑	❑
Technologies provide timely updates and information for safe and efficient navigation (FX)	❑	❑	❑	❑	❑
Adequate training programmes are provided to ship personnel to effectively operate and utilise the ship's navigational technologies (TRG)	❑	❑	❑	❑	❑
Technical support is readily available to assist navigators with any technical issue or	❑	❑	❑	❑	❑

difficulty encountered while operating the navigational devices (TP)					
Devices are designed with user-friendly interfaces, making them easy to navigate and operate (EOU)	❑	❑	❑	❑	❑
Devices exhibit high quality in terms of performance	❑	❑	❑	❑	❑
The devices on board are strategically located and easily accessible, facilitating their efficient use during navigation operations	❑	❑	❑	❑	❑

How strongly do you agree or disagree with the following statements about your ship's navigational technology use experience?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I rely on these technologies frequently to perform my navigational tasks (FREQ)	❑	❑	❑	❑	❑
I spend a considerable amount of time using these navigational technologies during a single navigation session	❑	❑	❑	❑	❑

How strongly do you agree or disagree with the following statements about performance experience working with such navigational devices?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The devices I use are easy to understand and navigate, enabling me to perform my tasks effectively	❑	❑	❑	❑	❑
Overall, I am satisfied with the quality and performance of the ship's navigational technology in use, as it meets my expectations and requirements.	❑	❑	❑	❑	❑

Do you have anything to share about what we have been discussing?

Appendix 2: Interview guide

TOPIC: Interrogating the state of application of technology within the Malawi Maritime Force as a maritime expression: A Task-Technology Fit Approach.

This interview guide has been formulated and modified based on the study objectives to examine the extent to which the task, technology, and individual characteristics are aligned to realize the optimal performance of service at Malawi Maritime Force by employing different ship navigational technologies on the bridge.

Section A: Demographic information of participants

i. What is your age?
ii. What gender are you?
iii. What is your marital status?
iv. What is your sea-going experience?
v. What is your highest Qualification?
vi. What's your rank on board a ship?

Section B: Examining the characteristics of the ship navigational systems used, tasks supported by the technology, and the abilities of navigators enabling them to interact with the modern ship navigational systems on the bridge.

i. What are the primary categories of navigational technologies employed in your daily activities on board a ship?
ii. How do these devices differ in terms of functionality and purpose?
iii. Can you provide examples of specific navigational technologies within each category?
iv. Are there any notable advancements or recent developments in navigational technologies that enhance their features?
v. What navigational devices use internet connectivity to establish communication with shore-based centres?
vi. What enables communication between the vessel on board and the Visual Tracking System centre?
vii. How do navigators effectively interact with and utilize the ship's navigational technologies?
viii. Can you elaborate on the challenges navigators may face while working with these devices and how these challenges can impact their performance?
ix. Can you discuss any training or skill development programs that are available to help navigators enhance their interaction with the ship's navigational technologies and improve their performance?
x. Are there any challenges you faced in the past that are related skills or competency of navigators?

Section C: Additional views

Besides what we have discussed, do you have any additional thoughts?

Appendix 3: Request letter to conduct an academic study in the institution

WORLD MARITIME UNIVERSITY

Established under the auspices of the International Maritime Organization
a specialized agency of the United Nations

Disponentgatan 4
SE 211 57
Malmo
Sweden
Cell: +46 737790786
Email: w1012440@wmu.se

27th June 2023

Malawi Maritime Force HQ
P. O. Box 20
Monkey Bay
Mangochi
Malawi

Dear Sir/Madam

REQUEST TO CONDUCT AN ACADEMIC STUDY IN THE INSTITUTION

I am writing to request your permission to conduct an academic study in the institution entitled **"Interrogating the state of application of technology within the Malawi Maritime Force as a maritime expression: Task-technology Fit Approach"** as a partial fulfillment of the award of MSc in Maritime Affairs at the World Maritime University.

The study examines the use of navigational technologies in ships by navigators, their functions, and the abilities of the navigators to measure the extent to which the devices used, the tasks they perform, and the skills of the users are aligned for maximum performance at the workplace.

The significance of this study is that it will identify the training needs of the personnel and again help the decision-making process when adopting different technologies in the management of maritime affairs in the organization.

The data to be collected will only be used for academic purposes, treated as confidential and anonymous, and to be deleted soon after the award of the MSc degree.

Your prompt feedback will be highly appreciated.

Yours faithfully,

Gift William Kamwendo
W1012440
Student
World Maritime University

Appendix 4: Authorization to conduct the study within the Malawi Maritime Force area.

Tel: +265(0)1587683/420
Fax: +265(0)1587 334
Email:mmfhq@yahoo.com

MMF/A/145

Headquarters
Malawi Maritime Force
P O Box 20
MONKEY BAY

CAPT G W KAMWENDO
SE211 57
Malmo
Sweden
Cell:+46 73779086
Email:w1012440@wmu.se

28 **June 2023**

REQUEST TO CONDUCT AN ACADEMIC STUDY IN THE INSTITUTION

A. Reference your letter dated 27 June,2023.

1. Permission is granted to conduct academic study in the institution entitled **"Interrogation the state of application of technology within the Malawi maritime force as a maritime expression.**

2. Regards.

V M MANDOLOMA
Lt
For Commander
MALAWI MARITIME FORC

Appendix 5: Consent form of participants

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation that will be written by the interviewer, in partial fulfillment of the requirements for the degree of Master of Science in Maritime Affairs at the World Maritime University in Malmo, Sweden.

The topic of the Dissertation is **"Interrogating the state of application of technology within the Malawi Maritime Force as maritime expression: a task-technology fit approach"**

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymized research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

Student's name: GIFT WILLIAM KAMWENDO
Specialization: MARITIME EDUCATION AND TRAINING
Email address: w1012440@wmu.se

* * *

I consent to my personal data, as outlined above, being used for this study. I understand that all personal data relating to participants is held and processed in the strictest confidence, and will be deleted at the end of the researcher's enrolment.

Name: ....
Signature: ....
Date: ....

Rev August 2021