Lack of small business participation (small fishing companies SIC Code 13100) in the Transport Education Training Authority-Supported Schemes

Malcolm Alexander[‡]

ABSTRACT

The study focusses on the transport sector, where company participation level is measured at approximately 20% of levy paying enterprises, and this level is mostly based on relatively high levels of participation from large and medium-sized companies. The study explores the relationship between Sector Education and Training Authorities (SETAs) and the companies within the sectors they are mandated to serve by researching the Transport Education Training Authority (TETA) maritime subsector. The research focus is on small companies and the focus is specifically on the low rate of participation of smaller entities in the skills development landscape. The consequences of the lack of participation are investigated and the study concludes that the SETA's ability to effectively research its sector skills, as well as the SETAs ability to provide effective skills planning in support of the national agenda, are both negatively affected by current levels of poor participation. The research was conducted on small fishing companies registered with TETA, in order to determine the reasons for low participation in the government's mandatory grant scheme. The research is survey-based across participating and non-participating small companies.

In addition, it is proposed that the elements contained herein are transferable to other subsectors of the transport economy (e.g. air, road and rail), and to the multitude of other SETAs that have small companies registered with them. Succinctly, there is no financial incentive to a small company to participate, the SETAs should consider incentives schemes to increase participation that is project-based and allows for subsidised training.

The value of an improved Sector Skills Plan (SSP) that matches the skills needs of the sector increases the likelihood of projects having a meaningful impact on the sector and reduces fruitless and wasteful expenditure in the sector. The small business environment has huge potential to assist in skills development, a skilled workforce, improved productivity and reducing unemployment. The findings and solutions are important tools for taking the maritime development agenda forward.

Keywords: SETA, mandatory grant, employer participation, small business, fishing company

[‡] ETD Practitioner (Maritime), Transport Education Training Authority.

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I INTRODUCTION

According to the Quarterly Labour Force Survey released by Statistics South Africa,[1] around 24.7% of South Africa's working-age population is unemployed. This situation has led to the prioritisation of the development of small, medium and micro enterprises (SMMEs) to reduce unemployment. The SMME sector accounts for over 35% of the gross domestic product (GDP) and approximately 72% of all employment in the country.[2]

In order to develop SMMEs, a detailed understanding of the needs of the enterprises is critical to support them with relevant and fitting solutions. Sector Education and Training Authorities (SETAs) are well positioned to identify and develop SMMEs registered to a SETA, and skills challenges are identified as one of the top five reasons for small firms not growing their number of employees.[3]

The transport sector contributes significantly to South African economy in terms of the country's employment, and, since 2012, has contributed approximately 9% of the country's GDP. The sector's revenue contribution increased to about R256 billion in 2015 and accounts for approximately 6% of the country's labour force. Gauteng serves as the region with the highest economic and labour activity for the sector; the coastal provinces of KZN, Western Cape and Eastern Cape, which are largely driven by ocean business, fall behind Gauteng (TETA, 2018). TETA is the SETA that is responsible for supporting and developing the transport sector by way of skills development.

II PROBLEM STATEMENT, RESEARCH QUESTION AND OBJECTIVES

Problem statement

On average (2018), 80% of the transport-registered companies do not participate in skills development with the TETA. As a result, the development of the SSP is based on data sourced primarily from large and medium-sized companies that have the resources and to participate in the mandatory grant process. As the SSP is a critical document that prioritises projects and funding to address skills shortages in the sector, 20% participation is insufficient to inform the SSP with data relevant to addressing skills shortages in the sector. This results in a high risk of failure of projects implemented and funded by TETA, which is especially true where the non-participating companies are mainly small-sized companies, whose needs could be totally different to the needs raised by the large and medium-sized companies.

Aim, objectives and assumptions of the research

The research aim is to identify the reasons why participation is so low and to suggest solutions to increase participation. The rationale is to ensure that the TETA SSP and the annual funded projects match the sector's needs, and that projects implemented are both relevant and assist the employers and employees to access skills development opportunities. The research was conducted utilising semi-structured interviews in the Eastern and Western Cape with TETA-registered small fishing company owners and/or representatives.

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1 Statistics South Africa (Stats SA) 'Quarterly Labour Force Survey' Stats SA 2013 (available from: <http://statssa.gov.za/publication/find publication>.

2 CM Rogerson 'SMME Development in South Africa Priority Sectors. A Report for the Department of Trade and Industry' (Tshwane, Department of Trade and Industry 2008) at 142.

3 The Presidency National Planning Commission (NPC) 'Our Future: Make it Work: National Development Plan, 2030' *NPC* August 2012.

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Objectives of the research

In order to achieve the aim, the specific objectives of the research were:

- To provide a summary of the SETA environment including any applicable theories, literature and legislative considerations applicable to small companies.
- To identify the reason or reasons for low participation, as identified by the non-participating companies.
- To identify and quantify any training that is taking place in non-participating companies, and to assess how the unreported participation would influence the SETA SSP.
- To identify and provide solutions or potential solutions to increase company participation with the SETA.

Assumptions

The following preliminary assumptions were made:

- Participation is dependent on financial return and, where the cost to participate exceeds the benefit of participating is compounded by a one-year penalty (for first-time applicants), the environment provides a poor incentive to participate.
- Ineffective communication has resulted from the fact that there is no communication strategy or projects to encourage and support participation.
- Under-reporting of training in the SSP arising from the fact that significant training occurs in the small business companies, but is unknown to the SETA. This results in the SSP not reflecting SMMEs in the reported training, planned training or scarce and critical skills.

Exclusions and limitations

In order to reduce the size of the research area and to ensure a cluster of similar-type organisations, the research focussed on companies that fall under the SIC Code 13100 (ocean and coastal fishing). Geographically, the research is limited to the Eastern Cape and Western Cape provinces, where the bulk of fishing companies in the country are registered.

The decision to narrow the scope of the research to small levy-paying fishing companies registered to TETA SIC code 13100 automatically excluded the following organisations/entities:

- small-scale fishers (ie fishers with traditional rights that are not registered to a SETA)
- fishing cooperatives (ie cooperatives that are not registered to a SETA)
- fishing companies registered with another SETA
- fishing companies registered with TETA but exempt from paying the Skills Development Levy (SDL).

This decision was made intentionally in order to focus the research on increasing the participation of TETA and also to exclude additional levels of complexity that arise within the environment of the small-scale fishers and fishing cooperatives.

III IMPORTANCE OF THE SETA (TETA) SECTOR SKILLS PLAN (SSP)

SETA sector representation and role

The South African economy is represented by 21 SETAs and each SETA represents a sector of the economy. The functions of a SETA are set out in the Skills Development Act (SDA).[4] The Act defines the role of the SETA is to:

- develop an SSP to identify trends in the sector, skills that are in demand and priorities for skills development
- develop and administer learnerships
- support implementation of the National Qualifications Framework (NQF)
- undertake quality assurance.

[4] Section 10 of the Skills Development Act 97 of 1998, chap 3.

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SETA SSP-development and implementation

Development of an SSP is one of the most important roles of a SETA because it is the SSP that informs the SETA on how to prioritise funding and projects that address the skills shortages needed to grow the sector. The SETA data are reliant on the employers submitting an annual Workplace Skills Plan (WSP) and Annual Training Report (ATR). The data submitted is utilised to profile the sector. The relevance of the SSP to the SETA sector is dependent on quantity (percentage of employers that make a submission to a SETA) and the quality (completeness) of data submitted. Employers are incentivised to submit these plans by being able to recover a percentage of the SDL they pay to the SETA they are registered with. The percentage of SDL recovered is mandated by the Skills Development Levies Act[5] and is set at 20% of levies paid to the SETA.

Based on this structure, each SETA is responsible for formulating and implementing an SSP. The main purpose of the plan is to 'provide the sector with a strategic overview of trends and challenges for the given period, as well as to assist companies to develop and implement a framework that promotes economic growth and achieves the goals of the NSDS'.[6] Accordingly, the SSP includes a sector profile, an analysis of skills supply and demand, and a profile of the SMME environment. The plan forms the basis for reporting to the Department of Labour (DoL) regarding achievements against targets, as stipulated in a service level agreement (SLA) between the SETA and DoL. The system is funded by payment of an SDL by companies; current legislation has set this levy at 1% of payroll. Each company can reclaim a percentage of the levy by meeting the minimum requirements of the SDA, and any reasonable criteria added by the SETA. Collectively, these criteria are referred to as mandatory grant criteria and are used to determine whether a company will receive a percentage of their levy as a grant. This provides the financial incentive for companies to participate in the National Skills Development Strategy (NSDS) and the levy return is meant to fund training and development in employer organisations. The Department of Higher Education and Training (DHET) convincingly argues for an integrated post-school system and provides clarity on the next phase of the NSDS. DHET emphasises where the strategy should change the traditional role of SETAs from those that they had previously performed.[7] The intention is to simplify the role of the SETAs and to build capacity in line with its core functions. The SETA focus will be on developing skills within existing enterprises and also on developing the skills pipeline into these workplaces. This effectively narrows the focus of the SETAs that have historically suffered from target creep, and a dilution of their energies and funding pools. Renee Grawitzky deals well with the context of the SSP in the broader SETA environment and this is best summarised by: 'What you measure is what you get'.[8] Notably, Grawitzky notes that, while the SETA may have achieved the NSDS targets, this may not meet or match public expectations or sector needs. This has the effect that, while the SETA may appear to achieve the NSDS targets set per annum, the targets set out in the SSP is not necessarily accurate regarding the needs of the sector. Low employer participation has a direct impact on the SETA SSP and its use as a tool by role-players in guiding the sector with respect to skills development and informing national strategies. It becomes critical therefore that the SSP is informed by actual skills development information. This is required to ensure accurate sectoral planning and national economic growth.

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5 Skills Development Levies Act 9 of 1999.

6 Department of Higher Education and Training (DHET) 'Guidelines on the Implementation of SETA Grant Regulations' *DHET* 2013 (available from: < https://www.dhet.gov.za/>).

7 Department of Higher Education and Training (DHET) 'White Paper for Post School Education and Training. Building an Expanded, Effective and Integrated Post-School System' *DHET* 2014 (available from: <https://psetresearchrepository.dhet.gov.za/post/738>).

8 R Grawitzky 'SETAs – A Vehicle for Skills Revolution?' DPRU Working Paper 07/125 (Cape Town, University of Cape Town Development Policy Research Unit 2007) at 30.

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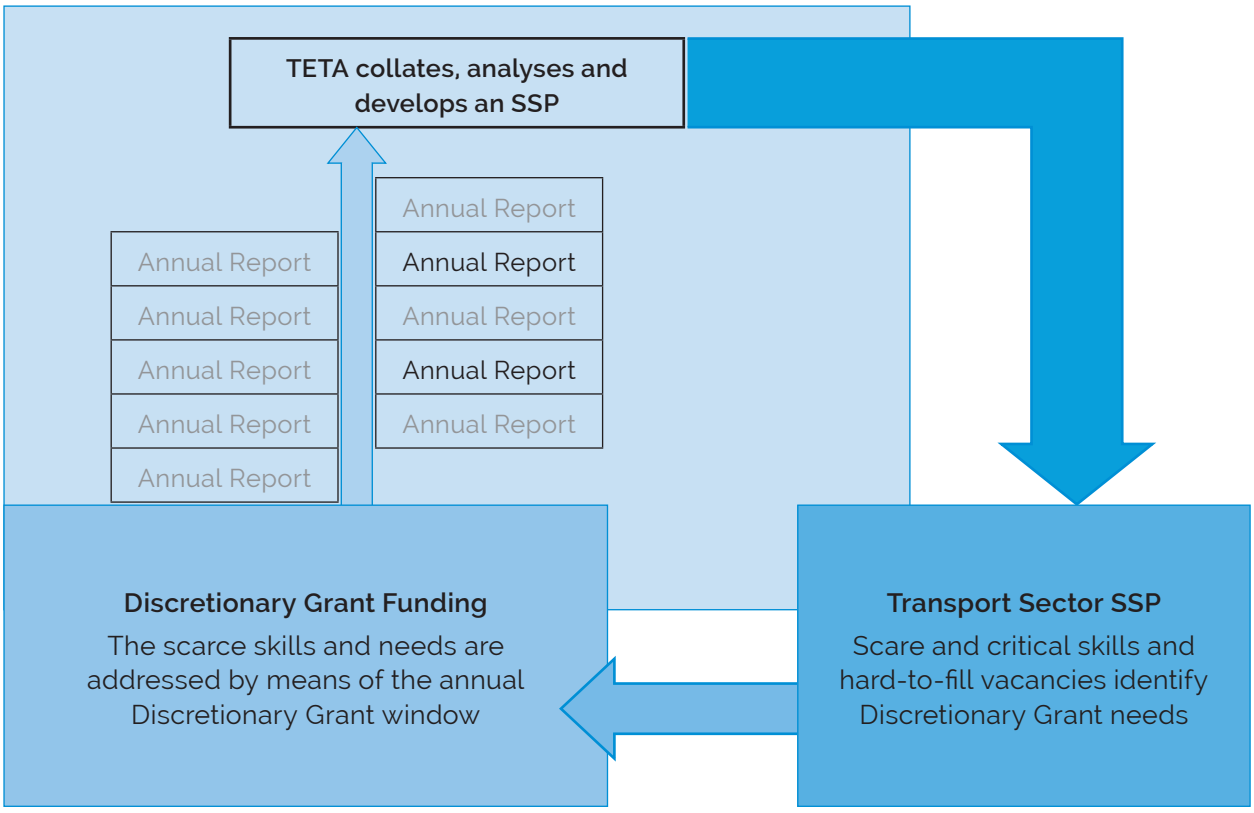

Figure 1: Source and Usage of Sector Skills Plan Information
Source: Author.

In the large blue square, representing TETA employers, the employer bodies submitting annual reports are indicated in black text, that is, 20% or 2 out of 10 are represented; while the grey text indicates employer bodies that do not submit annual reports. The SSP indicated in the red square draws data from participating employer bodies and uses this information to address scarce and critical skills by means of a discretionary grant window. The discretionary grant window indicated in the green square is made up of the skills requirements, as identified by the SSP, that are prioritised for funding by the SETA.

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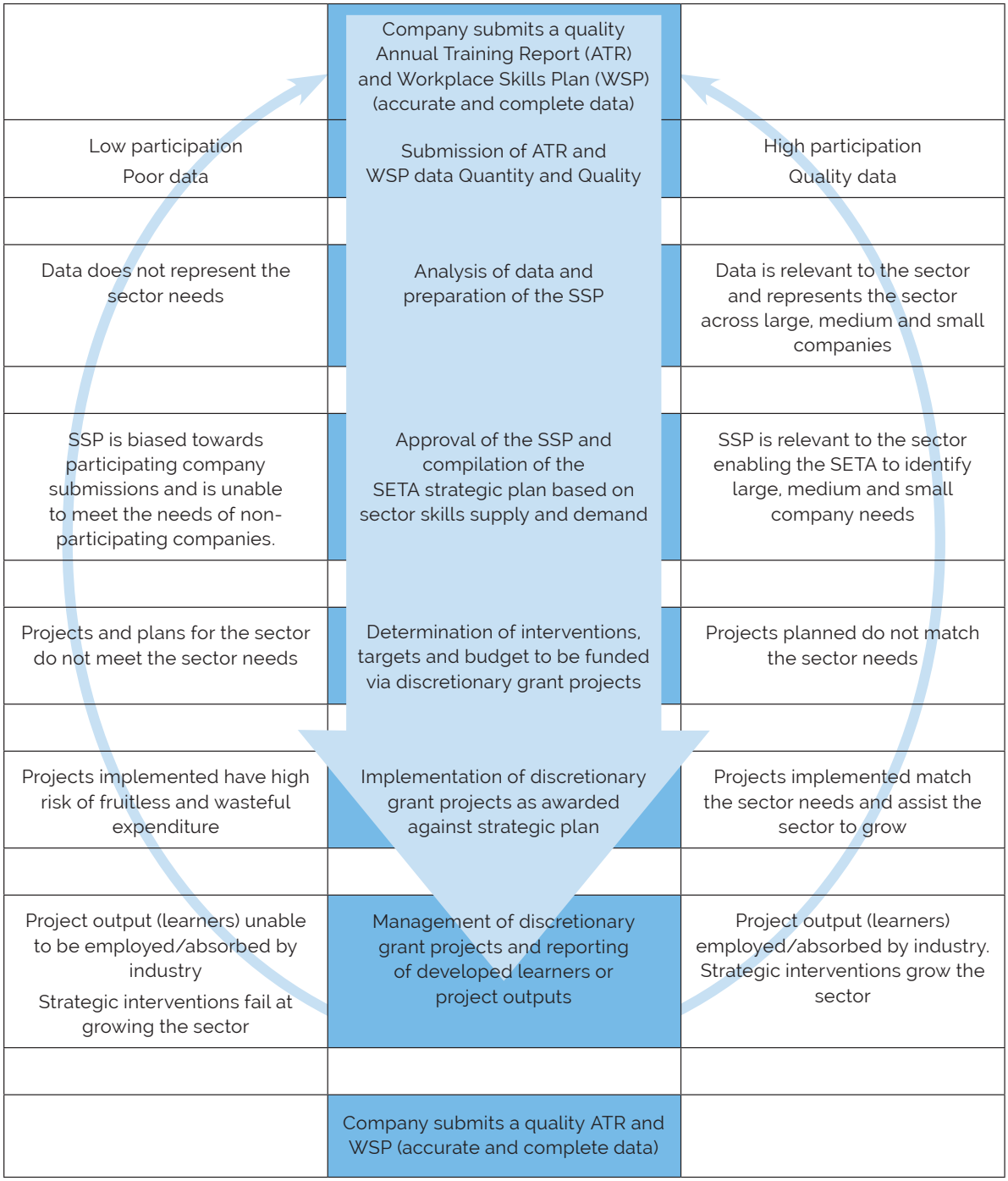

Figure 2: Mandatory Grant (MG)[9] Data, Development of SSP and SETA Annual Performance Plan (APP)
Source: Author's adaptation of the Wits School of Governance.[10]

[9] The mandatory grant (MG) is a grant payable against criteria as specified by DHET.
[10] Wits School of Governance *The WSP/ATR Data* [PowerPoint slides – slide 2] Wits School of Governance 2016.

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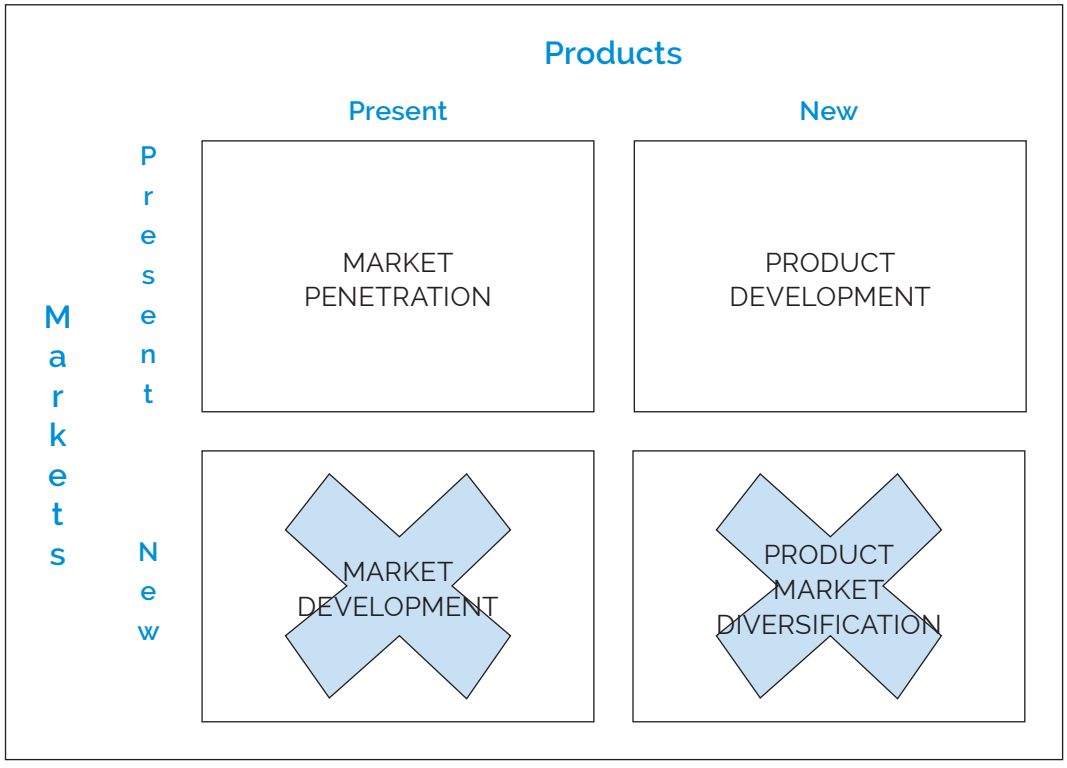
IV THEORETICAL FRAMEWORK

A review of the SETA websites and requests made by email to the SETAs were unfortunately unsuccessful in identifying or accessing any research related to SETA employer participation, as such participation is largely unexplored by researchers. No theoretical framework is directly applicable to this area of research. Business study theory has been referenced as a model to increase the SETA participation in the absence of any development studies model applicable to the SETA environment. This research belongs in development studies as the SETA SSP is a plan for the sector and profiles the employer organisations, with significant detail of the employee, including age, race and gender. The SSP also identifies scarce and critical skills with hard-to-fill vacancies and is a critical source of information to enable the sector to align to and implement national strategies, particularly the transformational agenda. This enables targeted skills development projects to reduce unemployment and grow the relevant sector through skills development.

The Ansoff matrix amended to fit SETA business model

This research intended to find ways in which to increase small company participation and the Ansoff matrix[11] provides a useful and relevant framework. As employer participation is low, the knock-on effect on the SSP is significant as one cannot profile a sector with low participation because the data is insufficient to profile the sector. Any SETA needs to follow business theory in their sector in order to grow participation. The Ansoff matrix is a strategic planning tool that provides a framework to help executives devise strategies for future growth. The model, devised by H Igor Ansoff, a mathematician with insight into business management, provides four alternatives of marketing strategy, namely market penetration, product development, market development and diversification.

Figure 3 (below): The Ansoff Matrix Applied to the TETA Business Environment
Source: Adapted from Ansoff.[12]



[11] HI Ansoff *Corporate Strategy: An Analytic Approach to Business Policy for Growth and Expansion* (New York, McGraw-Hill 1965).
[12] Ibid.

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Because of the legislative environment and the DHET reporting/validation requirements, TETA's market is defined as the transport sector and levy-registered companies. Accordingly, of the four strategies, those relating to market development and diversification are both excluded from any desire a SETA may have to increase participation. The Ansoff matrix applicable to a business environment can be considered as the 'next best' approach to SETA participation in the absence of any other model. The SETA is viewed as a business operating in a SETA-demarcated sector, the transport sector in this case.

Figure 3 shows the Ansoff matrix as it applies to a SETA business environment where, of the basic four strategies available, legislation precludes SETA creativity to its own defined sector. This leaves market penetration and product development as possible strategies to follow in order to increase participation. Market penetration and product development within the South African business environment must take account of the influence that the Broad-Based Black Economic Empowerment (B-BBEE) policy and codes have on the particular sector. TETA has felt the influence by way of increased participation of large and medium-sized companies that simply have to participate to maximise their B-BBEE score in order to do business with government in South Africa.

There has been a visible increase in self-funded workplace training (where a company funds a learnership, for example, without any TETA funding) because of a company's efforts to achieve an improved B-BBEE rating. However, the necessary skills and understanding required to change business practice in order to align to B-BBEE codes are simply not available or affordable in small companies. Of relevance to the small fishing companies is the quota allocation process that a company must go through with Department of Agriculture, Forestry and Fisheries (DAFF). This process is called the Fishing Rights Application Process (FRAP), which includes an allocation of points towards scoring a fishing company to determine whether a fishing right (or quota) should be awarded. The communication to the small business community needs to survey the small business environment and offer such companies an attractive user-friendly option that supports other sector imperatives or government legislation. An example would be the DAFF quota allocation process taking into consideration the fishing company's skills development history with the SETA.

V METHODOLOGY

Research philosophy

The context of this research study is the reality as experienced by company representatives as potential participants in the SETA relationship. The ontological position of the researcher is relativist within the understanding that our experiences are relative to our specific cultural and social framing being open to a range of interpretation.[13] This study follows a qualitative research design because the nature of the problem needs to be investigated in depth and needs to be based on the experience of the small company with TETA.

Data collection methods

Data collection is field-based, using interviews, documents and company/participant history of submissions. The research design provided for both exploratory and explanatory research. The study was exploratory to the extent that it would identify the profile of small companies' submissions (ie what the rate of participation is) and explanatory in that it would identify the reasons why they do not participate. Neuman[14] identifies that exploratory research identifies the 'what' and it is the 'what' that allows for extrapolation of, or at least insight into, the 'why' (explanatory).

A common error encountered in qualitative studies is the tendency of researchers to attempt to answer too broad a question or address a topic with too many objectives. Several authors, including Yin,[15] suggest

[13] N King & C Horrocks *Interviews in Qualitative research* (London: Sage Publications 2010).
[14] WL Neuman *Social Research Methods: Qualitative and Quantitative Approaches* 3 ed (Boston, Allyn and Bacon 1997).
[15] R Yin *Case Study: Research and Design Methods* 4 ed (Thousand Oaks, Sage Publications 2009).

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placing boundaries to prevent this from happening. The case study is limited to transport SETA-registered small fishing companies (SIC Code 13100), registered with a levy number as identified by the levy reconciliation received from DHET. This was made available to the researcher by the TETA's finance unit, with the agreement that the data provided would not be used for any other purpose than this research project.

Selection of participants

Convenience sampling was applied to generate data for this study. This is a technique widely used in qualitative research for the identification and selection of information-rich cases for the most effective use of limited resources.[16] In the approach followed, the company levy data for the period 2016/2017 defines the sample by SETA (code 26) and fishing subsector (13100). Geographically, the fishing company distribution is as follows: Western Cape (51); Eastern Cape (40); and one company registered in each of Kwazulu Natal, Mpumalanga, Northern Cape and Limpopo. The researcher focussed on the Western Cape and the Eastern Cape as provincial areas for the interviews. This resulted in a full census consisting of 91 companies in the Eastern and Western Cape out of a potential 94 companies nationally.

Identifying the population

Using company levy data for the period 2016/2017 (as provided by the TETA finance unit) in MS Excel, I sorted the data into the categories of the SIC code 13100. This process identified 121 fishing companies of which five are large, eight are medium-sized and 108 are small companies, as defined by skills development legislation. Currently, 100% of large companies and 87% (seven out of eight) medium-sized companies participate in the mandatory grant process. Interestingly the eighth medium-sized company was unknown to the maritime chamber until the levy data was analysed.

Fishing sector interviews

The initial research plan was to stratify the types of organisations into two groups, namely small fishing companies (group 1) and training providers of fishing companies (group 2). While conducting interviews, it became apparent that no simple groupings were possible because an individual may own multiple companies (ie fishing boats), each with their own levy number, or that a single consultant may represent multiple companies. It transpired that in every case where an owner had multiple vessels, they also had levy numbers registered with at least two SETAs (e.g. TETA and FOODBEV SETA). Training providers facilitated the SETA relationship and were appointed as Skills Development Facilitators (SDFs) by the companies.

The appointment as SDF is a formal agreement to represent the company at any SETA opportunity that the provider may have facilitated or is aware of. The SDF relationship is of a passive nature and activated only when small business opportunities are available, and typically does not include active participation of the companies in the online ATR/WSP submissions. As the interviews commenced, it became clear that the intention to interview a client per levy number would not be possible and the interviews would take place across groups of levy numbers held by a single SDF/company representative, with the company's participation ranging from:

- those currently actively participating in mandatory grants
- those currently actively participating in Small Business Development (SBD)
- those that had previously participated in SBD but no longer do so
- those that have never previously participated
- those that are registered with another SETA.

[16] N Patton *Qualitative Research and Evaluation Methods* 3 ed (Thousand Oaks, Sage Publications 2002).

https://doi.org/10.47348/SAJMET/2023/i1a1

Limitations

The scope of this research study was limited to the TETA fishing subsector-registered small companies in the Eastern and Western Cape, as these provinces have significantly higher numbers of small fishing companies than other coastal provinces. The research is bound within the skills development regulations and also TETA participation criteria, guidelines and templates. As a result, the findings are applicable to TETA-registered small business, irrespective of chamber of registration. Generalisations can be made within TETA, across TETA subsectors, because the skills development policy and criteria are standardised. While the findings will be transferrable to other SETAs in relation to small business participation, any solutions offered by this research will need to be reviewed within any other SETA's unique systems and criteria.

It must be noted that the interviewer was a TETA representative, and this may have influenced the responses by the company representatives, that is, the interviewer is the maritime practitioner responsible for monitoring and evaluating the company's mandatory and discretionary grants. It is likely that responses may have been tempered to ensure a positive working relationship in the future. Response consistency was assessed by means of triangulation of the responses to the questions, using different question statements. The TETA SSP also allowed for cross-referencing and validation of the data gathered from the interviews.

VI FINDINGS

SETA records of levy-registered companies prove that, despite small business being the largest number of companies registered to a SETA, they remain largely non-participating, with the result that the SETA-identified sector needs from the SSP will not match small business needs. This is a lost opportunity to grow small business to improve the economy, to reduce unemployment and to drive economic transformation.

The answers to increasing small business support are to be found in the registration of the small business with the South African Revenue Service (SARS), in improved government department communication and targets between the Department of Small Business Development and DHET, in improved communication and targets between DHET and the SETAs and, finally, in improved communication and targets between the SETA and the sector. Using a top-down approach, DHET should guide the SETAs to baseline registered companies (stratified into large medium and small), and then set annual targets off this baseline to increase participation. Part of this exercise would be ensuring that companies registered with the SETA do, in fact, belong to the SETA they are registered with.

Participation is dependent on financial return

A company's motivation to make a submission to its SETA is dependent on the perceived financial return it will acquire in exchange. The cost of submission, that is, appointing a consultant or attempting to submit data on their own, the time required to be up-to-date with respect to legislation and criteria, consolidation of the annual report and plan, the technical requirements to access the online system and make a submission, and the current mandatory grant criteria (ie recovery of 20% of levies paid) exceeds the potential return for small companies.

The cost to participate far exceeds the potential recovery of 20% of levies paid in purely time cost. This is even before the first-year penalty (no grant payable as no previous plan was submitted) and the company having to carry the cost of submission for two years before being eligible to recover the 20% of levies paid. Ultimately the participation cost would reduce the available training budget. The irony is that more training would be conducted by the company if they did not participate in the SETA.

Communication is not effective

The current communication strategy used by TETA is geared towards companies that are currently participating – and such communication is not heard or understood by small companies. There is no communication strategy targeting non-participating companies. Common across all the respondents' experiences were the related challenges of identifying and making contact with the SETA the company is registered with, and then also the general experience

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of delays when transferring from one SETA to another. None of the respondents had any positive experience in this regard.

General knowledge regarding the role and function of SETAs tended to be a simplistic notion that SETAs support training. Generally, all respondents prioritised their limited time to activities that would drive or support their business, they simply do not have the time to dedicate to trying to find which SETA they are registered with. Even if they are eventually successful, the low return on value simply does not make the exercise worthwhile to the company.

All respondents prefer to outsource the SETA activities to external SDFs or consultants to administer the process. The companies already outsource labour relations, B-BBEE reporting and fishing quota applications to consultants who add SETA relationships as a value-add product. Outsourcing to external SDFs has the negative effect of distancing the company from the SETA.

Aggressive targeted strategy to increase participation

As the most significant SETA for the fishing sector, TETA has no dedicated strategy to support or increase participation of levy-paying registered companies. Small companies form the largest segment of those companies that are not participating as levy-paying companies, and should be targeted for support and participation. Lyal White's[17] identification of Brazil's initiative, which provides for clear definition and categorisation of small businesses, is one that should be heeded in South Africa, and by SETAs in particular.

The SETA-specific targets allocated to small businesses should be categorised in order to help distinguish small companies that are survivalist against those that are commercialised. Currently, identification and support are muddled.

Annual target setting with DHET can easily define targets for small TETA-registered companies by distinguishing those that are registered (whether levy-paying or not) from those that are not registered. Section 2.1 of the SDA clearly identifies the purpose of the Act to develop the skills of the South African workforce and, in particular s 2(1)(*a*), to improve the quality of the life of workers, their prospects of work and labour mobility.

SETA levy data records received from DHET do not link companies to subsectors, unless a company has accessed the system previously and selected an SIC code. An additional 67 TETA-registered small fishing companies were identified by way of the interview process. The 67 companies were in the levy records but not allocated an SIC code and, therefore, were unknown to the maritime chamber.

The SETA levy records can provide the following data:

a. Identify companies that are economically active and with a payroll above R500 000.00, as these levy numbers will record levy payments.
b. Data sorting from highest to lowest levies paid will set a priority scale of companies that should be contacted to participate. Accordingly, the companies that are not submitting WSP/ATR need to be targeted for participation.

Under-reporting of training in the SSP

Recent changes to the South African Maritime Safety Authority (SAMSA) standards have necessitated that all crew at sea, and all crew/shore staff on board a vessel in harbour or working in the harbour, should meet certain standards. As a result, the companies plan and implement significant training in the maritime sector, whether supported by a SETA or not. The SAMSA requirements have a huge impact on the skills supply and the perception by fishing companies is the following:

> *It seems as if the short courses stop and are replaced by longer more expensive courses, especially officer training which is not accessible to the previously disadvantaged fishers due to cost of the training.*

[17] L White *Small Business: The Case of Brazil* (Braamfontein, The South African Institute of International Affairs 2005).

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This is a general summary of all ten respondents' comments relating to the SAMSA training requirement changes.

The SAMSA requirements inform minimum skills requirements at sea and in harbour. Two new requirements are the need for a Shore Safety Officer and the need for everyone who works on a vessel in harbour to obtain a pre-sea certificate. The increasing standards place a high financial burden on the fishing companies and the crew. As a result of the companies not participating in the SETA via the mandatory grant submissions, TETA is not formally aware of these challenges, and is unable to respond to specific skills shortages by supporting by means of funded discretionary grant projects to fund the identified skills need. The skills supply and demand are critical information required to inform the TETA SSP through annual mandatory grant submissions.

All respondents raised the challenge of low literacy because there remains a large number of fishing entrants (including youth) who do not have a strong educational background or level. The new fishers are challenged when training, particularly as the training increases in complexity up the different fishing levels (eg ordinary seaman, able seaman, motorman, mate and skipper etc). This results in a high failure rate, with re-writes and re-doing courses, meaning that training takes longer and costs more.

Figure 4 represents the 2018 WSP data reduced to maritime chamber-registered companies and compares the percentage of planned training in the workforce for large, medium and small companies. Large and medium companies plan to train less than a 1 000 employees each, while the small companies, albeit increased as a result of a new TETA intervention, planned to train just under 2 000 employees. This is critical information that the SSP requires, which is only available if small companies submit data. An analysis of the 2018 mandatory grant information submitted to TETA provided some interesting data regarding the maritime chamber-registered companies' employment profiles and planned training for the 2018/2019 period:

- 10 Large companies with 4778 employees and plan to train 937 employees
- 18 Medium companies with 1633 employees and plan to train 625 employees
- 143 Small companies with 3160 employees and plan to train 1728 employees.

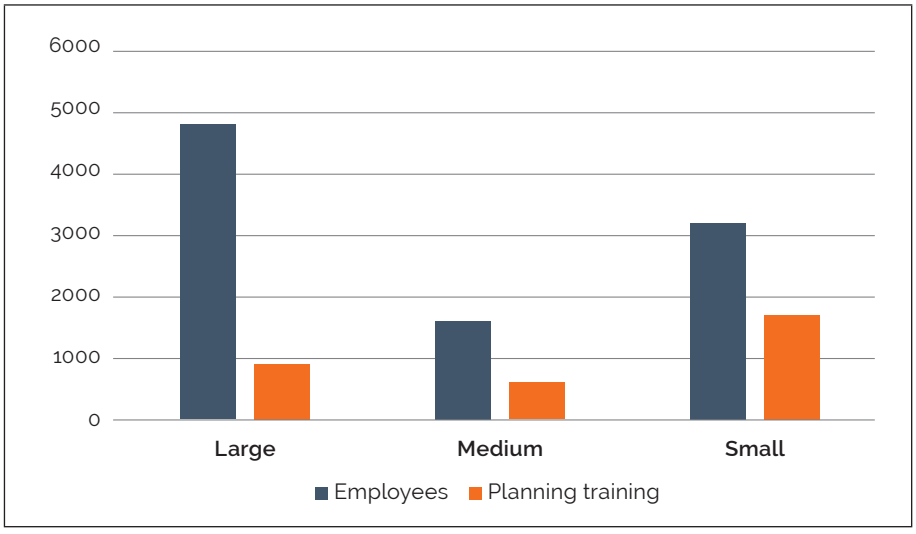

Figure 4: 2018 Report: Company Size and Planned Training per Category
Source: TETA 2018 08 Mandatory Grant Report.[18]

[18] Internal report held by TETA and used to compile TETA's annual reports.

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Figure 4 is a real indication of the amount of training happening in the small fishing company sector, which would not otherwise be available to the SETA. Where previously the large and medium companies seemed to train larger numbers of employees, the 2018 maritime increase in participation is the first year that the maritime fishing sector had a significant number of small companies submitting WSP data. This increase in small business data paints a very different picture of maritime-registered companies. Small companies had planned to train more employees on average than both large and medium companies had planned to train during the 2018/19 period. Small companies plan to train more employees than large and medium companies do, even when the planned numbers for large and medium companies are added together.

It is likely that small business participation will change the profile of the sector as currently represented in the annual SSP, based on the maritime example. Table 1 shows a size profile of participating maritime-registered companies for the period 2016–2019.

There are a number of interesting points in the data:

- 'Not payable' refers to a company submitting for the first time or a company that participates but does not pay levies (NLPE).
- 'Accessed but did not complete' refers to an SDF that accessed the system but did not submit the mandatory grant (ATR/WSP). These SDFs need support to use the system.
- Between 2017 and 2018, the mandatory grant submissions doubled as a result of the pilot SBD project.

Table 1: Maritime Registered Company Participation 2016–2019

YEAR	Large	Medium	Small	Total	Comments
2016	8	20	63	**91**	68 Approved (payable) of which 12 Approved (not payable). 3 Declined 20 Accessed but did not complete
2017	9	21	61	**91**	79 Approved (payable) of which 11 Approved (not payable) 12 Accessed but did not complete
2018	9	21	152	**182**	176 Approved (payable) of which 99 Approved (not payable) 6 Accessed but did not complete
2019	9	24	170	**203**	153 Recommended approved (payable) of which 24 Recommended approved (not payable New submissions) and 25 Recommended approved WSP (Not payable – NLPE)

Source: 2016–2019 TETA MG Levy History (TETA MG records).[19]

[19] Internal report held by TETA and used to compile TETA's annual reports.

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The pilot SBD project emanates from the researcher's study and was introduced during the course of the research work. Having adopted the preliminary finding, the TETA executive provided a budget of R2 500 000.00 for the maritime chamber to introduce the pilot SBD project to support small TETA maritime companies to submit the WSP 2018/19. The project objective was to increase the participation of small companies. It did so by incentivizing participation through funding the cost of the SDF to submit the WSP 2018/19 (ie planned training for 2018/19) and then again when submitting the ATR for 2018/19 (ie implemented training during the 2018 period) and WSP 2019/20 (ie planned training for 2019). In addition, the training planned in the WSP for 2018/19 would be funded to a maximum budget limit of R50 000 per participating company with a planned number of 50 new small companies. This was later increased to 99 new companies as a result of demand.

As can be seen from Table 1, the participation rate has grown exponentially between 2017–2019. This is triggered by funded support to companies in submitting the 2018 WSP and the funded training as identified in the WSP. The growth continued in 2019, and this can be attributed to compliance with the funded support contract whereby the 2018 ATR and 2019 WSP submission continued to be funded and the training reported would be paid for by TETA. An added incentive is the preparation of fishing companies for the 2020 FRAP requirements which will assess a company's skills development participation. Twenty-five of the new submissions were from NLPEs, that is, companies that are unable to claim grants back as they do not contribute levies.

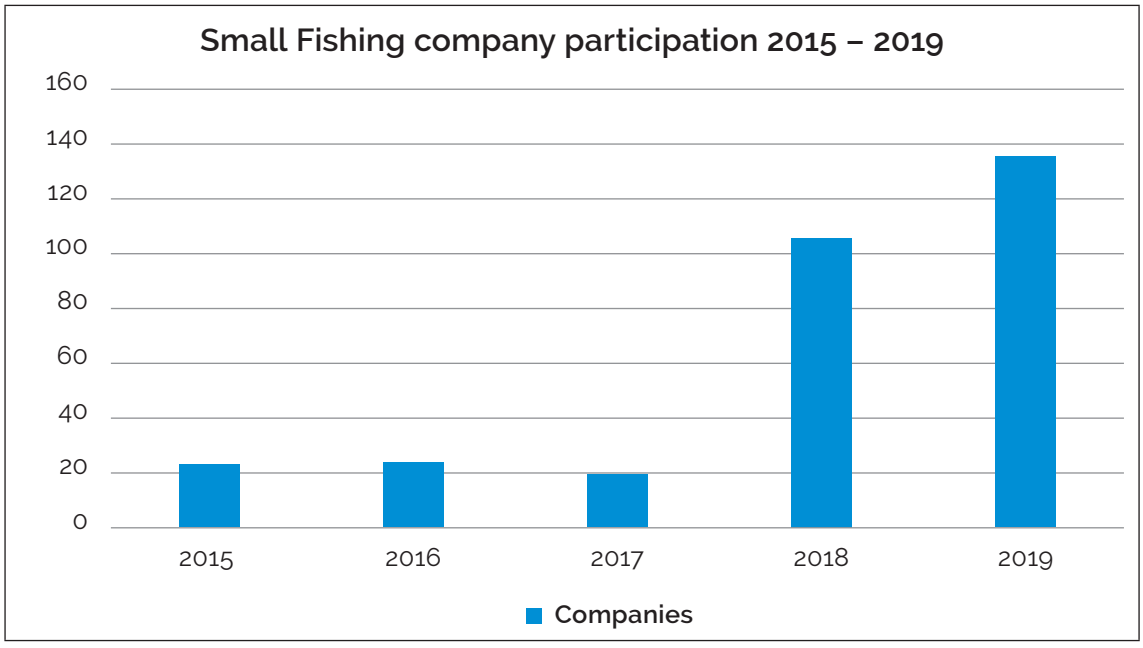

Figure 5: Small Fishing Company Participation Growth 2015–2019
Source: 2015–2019 researcher data – Small fishing company participation.[20]

The increased participation illustrated in Figure 5 proves the viability of SETA-funded projects to target small company participation within existing funding models (SBD funding model). The company-submitted ATR/WSP reports on the company profile (number of employees), planned training and achieved training. This is critical data needed by a SETA to develop an SSP, particularly in profiling the sector and identifying the training trends and scarce skills.

[20] Internal report held by TETA and used to compile TETA's annual reports.

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The scarce skills and hard-to-fill vacancies form the basis of the discretionary grant projects that aim at addressing skills shortages. Significant skills development occurs in maritime-registered small fishing companies and Figure 6 shows how the increase in participation results in improved employment and training data (planned and achieved).

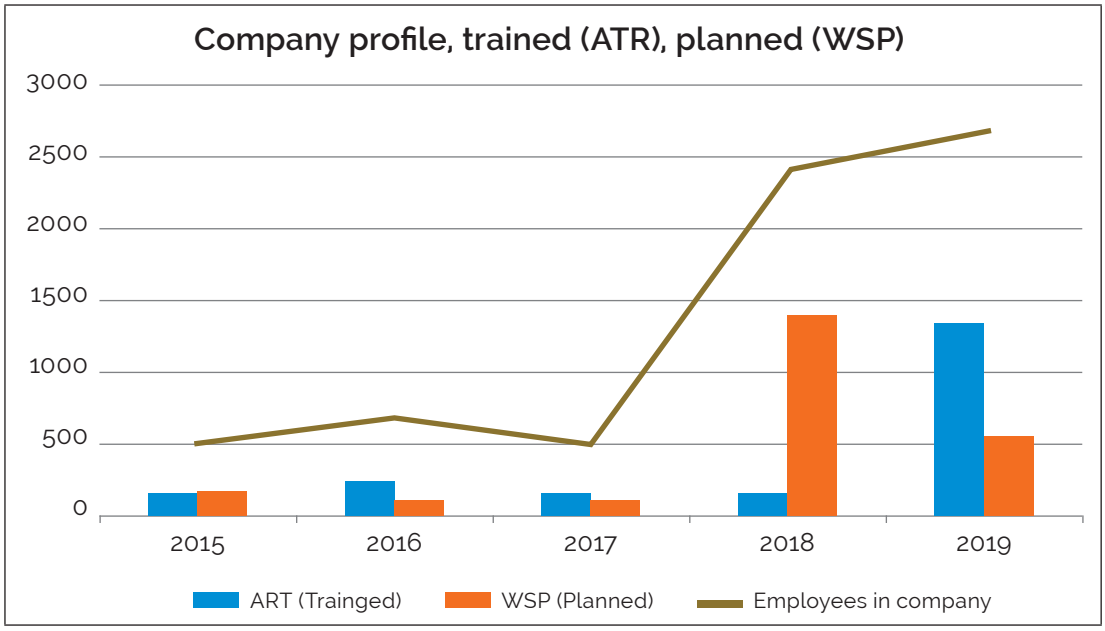

Figure 6: Small Fishing Company Data Increase 2015–2019
Source: 2015–2019 Small Fishing Company MG Records (TETA).[21]

Figure 6 proves the importance of increased participation in improving the quantity of data available to a SETA that can be used in annual sector updates. The increase in real sector data makes a valuable contribution to the data sources utilised to develop and update the SSP, and the small business data is especially useful in a SETA's ability to profile and analyse small business needs.

Some examples of increased data are listed below:

- Company employment profile data increased from 500 to over 2 500 employed fishers. The data includes age, race, gender and occupation details.
- Occupational profile (based on the 2017 Organising Framework of Occupations (OFO) codes) increased from 500 to over 2 500 employees.
- Completed training data increased, and this data includes age, race, gender, occupation details, training type and training level.
- Planned training data increased, and this data includes age, race, gender, occupation details, training type and training level.

SETA–employer relationships

The fishing responses represented the following types of relationships based on the company representative's experience of participation with a SETA.

[21] Internal report held by TETA and used to compile TETA's annual reports.

https://doi.org/10.47348/SAJMET/2023/i1a1

Company lose/TETA lose

This relationship is characterised by a zero relationship between the fishing company and the SETA. The fishing company does not participate in any way and does not receive any funding or support from the SETA, either directly (mandatory grant or SBD contract) or indirectly (through a discretionary grant contract awarded to a local provider). The SETA has no relationship with or knowledge of the company skills needs or activities. There is no annual data submitted via the ATR/WSP and this results in less fishing data to inform the SETA SSP. As the SSP does not contain these companies' skills needs, the discretionary grant funding, targets and projects cannot meet these unknown needs. These companies have no financial incentive to participate as the cost to make a submission, the first-year penalty and the 20% return of levies paid in year two only effectively serve as a disincentive to participate. Nonparticipation with the SETA actually allows for a larger training budget in year one (no cost accrued by submitting), as the training budget is wholly spent on training when measured against an MG return of 20% of levies paid. TETA is unable to support or report under mandatory grants or discretionary grants.

Company win/TETA lose

The non-participating companies previously benefited from the SBD contracts and this 'easy access' to funding actually served as an incentive to not participate, as the levy returns were of a lower financial value than the SBD contracts awarded. TETA, while supporting the companies via SBD, does not gain any new company-employment information needed to strengthen the SSP, so TETA benefits with regard to the APP performance (small business support) but loses the opportunity to gain data needed for SSP development. This includes TETA reporting low mandatory grant participation due to the company being supported under the discretionary grant.

Company win/TETA win

Fishing companies mandatory grant participation, that is, the company submits data for the purposes of compliance to the fishing quota application and, where due, levies are recovered (ie the long-term fishing quota goal is the incentive and levy recovery is mostly an added benefit).

Ten respondents representing 171 fishing companies were interviewed. Thirteen of these companies are registered to other SETAs and eight of these are trying to transfer to TETA. Forty of the companies are not SETA-registered and are not registered to pay levies. Sixty-nine of the companies registered to TETA, are participating in the mandatory grant system – even when, as in the case of a few companies, the levy return is zero. The SDFs (two internal and three consultants) all submit their data in order to best position the company with regard to the fishing quota application process.

Turning fishing company relationships to win/win

From a SETA perspective, mandatory grant participation is crucial to profiling and developing sector plans and, as a result, any small company incentive must include the mandatory grant submission. Conversely, the small company cannot see the rationale in paying for the submission and then waiting a year to submit again (and pay again) in order to then receive 20% of levies paid by the company.

Creative solutions are needed, much like the pilot SBD project developed in this study. The SETA can run small business support projects whereby the submission costs are covered for the WSP (year 1) and ATR/WSP (year 2). The incentive should include financially supporting the planned training in terms of the WSP for year 1. This was piloted in 2018 and resulted in an additional 99 small fishing companies participating in the mandatory grant. This increase doubled the maritime chamber company participation for 2018.

Additional findings

During the research, additional areas were identified that could play a significant role in 'freeing up' the skills development environment across a range of areas.

https://doi.org/10.47348/SAJMET/2023/i1a1

SARS registration and SETA transfer

During the interview process, additional findings were made outside the scope of the original research. These findings contribute to the challenges encountered by companies within the skills development environment, which commence at the point of first registration and the allocation and choice of a SIC code. This first step is critical in ensuring that a company is homed in the correct SETA. Companies that are incorrectly homed (registered to the wrong SETA) experience delays and frustration when moving to the correct SETA. As long as the company is with the incorrect SETA, both the company and the SETA lose because the company's submissions may be challenged by unique SETA criteria, while the SETA has an inflated company count against which participation is measured. Any data used by the SETA will dilute the SETA SSP as the company skills profile, supply and demand do not fit that SETA.

If the registration with SARS can be improved to ensure the correct SIC code and SETA are identified, all SETAs will benefit as the companies registered with the SETA will be correctly homed, and no further identification and transfer will be required. In some cases, small companies have been trying for over a year to transfer SETAs, which serves to exasperate companies trying to transfer as they are unable to participate fully until transferred. Until the company consistently submits their data for at least two years, no grants will be paid. B-BBEE verification has, of late, been very useful in advising the company whether they are correctly registered and this has assisted greatly in prompting the inter-SETA transfer (IST) process.

SARS company registration and SIC code

Generally, companies only start paying attention to the SETA relationship when it is measured for B-BBEE coding or if, for example, an accountant notices that a relatively high value of levy is being paid – and should not be written off as a tax. This is far too late in an organisation's life; at the point of registration, the SARS has an important advisory role to play in advising the company as to its best fit to a SETA. This is based on the core business of the company and the SIC code which is ultimately selected.

Initial registration and SIC code

Guidance from SARS is crucial and will pay dividends in the future when the company grows and starts contributing levies exceeding the R 500 000 payroll threshold. At the point that the company commences investigating how to recover the levy, it is immediately penalised by a year for not having submitted an application previously, unless they have registered the company, or have commenced paying levies, within six months prior to submission to the SETA. The trend is that by the time a company commences participation there is an automatic one-year penalty when commencing participation.

SIC code–SETA alignment

From the above, the SIC code 13100 (TETA) is the best fit for any fishing company that utilises vessels in order to catch fish. The SIC Code 13100 should be set by SARS as the default for any fishing company.

Central database access to SETA – company registration

There are challenges experienced when a company is trying to determine the SETA they are registered with. DHET should make baseline levy data available to all SETAs, where the company name, levy number and levy history (paying or not) can be checked by SETAs. Currently, when a company calls into the SETA, the SETA staff are limited to levy numbers registered with their SETA. This means that, if the company querying their levy number is not registered with the SETA they have contacted, the SETA can only state *'not registered to us'* and then provide some guidance as to how likely SETA is to call.

IST efficiency

The summary of types of small companies identifies that 8% of companies (ie 13/167) are known to be registered to an incorrect SETA and have been waiting up to 18 months to be transferred to TETA. The company representatives were frustrated by the delays and poor customer service experienced. The consultants raised

https://doi.org/10.47348/SAJMET/2023/i1a1

the issue regarding delays experienced when requesting an IST. Some examples were discussed where the IST had been submitted as far back as 2016. Any SETA-registered company may submit an IST and motivate why they are incorrectly registered. This process should be between 60 and 90 days, and the request to transfer must be submitted to the SETA that the company is currently registered with.

SETA transfers are planned between April and June, annually. The delays in transferring to the correct SETA results in the company being excluded from any opportunities arising within the SETA they should be registered with (ie they are not on the database), while not being able to participate with the SETA they are incorrectly registered to (ie scarce skills and priorities do not align). A number of companies are currently registered with SETA 99 (SETA unknown); this alone indicates that there are issues at registration if a default position is an unknown SETA. There simply cannot be an option of an unknown SETA as these companies are effectively in the wilderness. Who do they contact if each SETA can only check companies that are registered with them?

Company–SETA fit (SIC) and participation

Every SETA has an unknown quantity of incorrectly registered companies. The vast number will be small companies that have no incentive to submit their data and will be identified in the SETA levy data as non-participating and paying levies. Unless SETAs take proactive action to analyse the levy contributors and to verify they are correctly registered, SETA participation will always be a challenge and profiling of the sector will be diluted by any data submitted by incorrectly registered companies.

As the submitted data is used to develop the SSP and fund discretionary grant projects, the data compromises the relevance of any discretionary grant projects implemented to address any skills shortages, with the risk of wasteful or fruitless expenditure.

Company relevance to sector profile

A SETA must aggressively interrogate the levy data received from DHET to categorise the organisations based on: a) sector fit, that is, are they correctly registered; and b) identify and prioritise companies based on levy return to proactively engage with them in order to encourage and support participation. The Wits study provides a perfect example of how a story can be misinterpreted if the data is not understood.[22] The report indicates that only 5% of transport companies participate in mandatory grants; this from a total of 16 252 registered companies. The number of participating companies (ie 852) is, indeed, correct, and this can be measured. It is, however, impossible to measure the non-participating companies using registered companies as the baseline; because only companies that pay levies (ie 4 228) will potentially submit data to recover the 20% of levy paid. This changes the participation to 20% (ie 852 out of 4 228).

This measurement is still incorrect as there are an unknown number of companies within the 4 228 that are not relevant to the TETA SIC codes and should be transferred to their correct SETA. There is also a large number of companies that are just over the threshold and pay very low levies, making the levy recovery cost higher than the levies recovered. Bearing in mind that the return of levy is designed to support the training of employees, the value returned after the cost of submission must incentivise the company to submit data. Even at 50% levy recovery, the levies paid are so low that there is no incentive to submit data and the levy is merely written-off as another tax. This emphasises the importance of SARS's advice when registering a company. To clean a database of thousands of companies is a huge challenge, to correctly register a single company at SARS is a simple solution.

The total number of companies registered with TETA (ie 16 252) is inclusive of non-transport sector companies, shelf companies and holding companies; in addition to the 12 024 (74%) companies that do not pay skills development levies. This means that no less than 74% of levy numbers registered to TETA have no

[22] Wits op cit note 10 at 4.

https://doi.org/10.47348/SAJMET/2023/i1a1

incentive to submit data whatsoever. It is difficult to determine the number of relevant and valid (operating) small transport sector companies that are represented in this number, and it would take dedicated research to clean the SETA data in order to develop a more accurate and reliable baseline level which could be used as an indicator of participation.

Four thousand two hundred and twenty-eight companies do pay the skills development levy to TETA and, of these, 852 currently participate in the mandatory grant system. Within this group, there are nevertheless companies that are not transport-related companies and are erroneously registered with the SETA, some of which participate in the SETA mandatory grant process. This poses some risk to the relevance of the SSP that is developed from the submitted ATR/WSP data, however, it is a low risk, as many participating companies are B-BBEE-verified and the B-BBEE verification process assists the company to identify the correct SETA (based on SIC code) and to transfer to the correct SETA, if necessary.

TETA SBD strategy (pre-2018) counter productive

The TETA SBD strategy implemented by the awarding of small business contracts had the unintended consequence of incentivising the companies not to submit an ATR/WSP. The reason for this is that the SBD contract could claim up to R50 000, while the ATR/WSP would only ever pay a maximum 20% of levies paid by the company from year two of participation. This effectively encourages companies not to submit ATPs and reports and this reduces the data informing the SSP, which, in itself, serves to guide TETA on how to support and develop the transport sector. Small business is severely under-represented in the SSP and TETA should encourage and support small business WSP/ATR reporting in order to strengthen the SSP relevance to small business needs. However, the SBD strategy can be revised to include financial support mechanisms aimed at increasing the participation of small companies. The 2018 pilot SBD project targeting TETA small fishing companies has shown that product development can make a huge difference to participation (the maritime chamber doubled participation in 2018).

Interpretation of the Ansoff matrix in light of the empirical results

As concluded already, the strategies for market development and diversification are both excluded from any desire a SETA has to increase participation. This leaves market penetration and product development as possible strategies to follow in order to increase participation. Market penetration (in the TETA context to increase small business participation) is to focus on the TETA-registered companies to identify the non-participating companies and to target the companies in order to encourage them to participate. Product development (in the SETA context to provide a unique product tailored to small business) is possible in the SETA environment. This requires TETA to develop reports and plans specifically for small business.

Market penetration

Aspects that SETAs should consider when pursuing a strategy of market penetration include:

- market identification by analysing levy data received from DHET
- identifying new companies and contacts to verify company correctly registered
- transferring companies to the correct SETA if not correctly registered
- connecting the company to the relevant unit within the SETA (if correctly registered) in order to assist with regard to participation
- classifying the levy numbers registered to the SETA in order to determine relevance (transfer if required)
- Analysing levy income so that it can guide in incentivising companies to participate. A simple approach is to data sort levy income from highest to lowest value and prioritise high values for attention.

While the above is a huge task, it will define the market into categories and ranking within each category will allow the SETA to identify the companies with the greatest incentive to participate. The task will require specific attention but, over a period of time, will ensure that the SETA databases are clean and that companies

https://doi.org/10.47348/SAJMET/2023/i1a1

have been transferred to the correct SETA. Participation can be increased by means of product development.

Product development and market penetration

SETAs would be required to develop product offerings that are unique to the small business environment and that incentivise small businesses to participate. The current product and service on offer have essentially been the same for a number of years. Despite the 20% recovery, B-BBEE alignment has assisted in increasing participation – this is mainly due to companies wanting to increase their scorecard rating. The pilot SBD project implemented in 2018 showed an increase of 99 small fishing companies, where both the company and TETA benefited. As a pilot, this project was very useful in product development, realising increased market penetration.

Application of product development and market penetration pilot

Small business is recognised as a sector with significant opportunities for economic growth in South Africa and also an area where many employees can derive benefit from the skills development legislation. Maritime chamber categorised and prioritised the company levy data, identified companies per province and hosted workshops to capacitate the companies regarding the benefits of participating.

As most of these companies had indirect relationships with a SETA via consultants, the workshops included the consultants who also fulfilled the role of SDF but generally steered the company towards SBD contracts (highest return).

The SDFs were advised of the pilot SBD project, the intention being to increase submissions and the incentive was that TETA would pay for each submission (offset cost of submitting) and also fund the training submitted in the WSP. This incentive worked for both TETA, the small companies and the consultants, as evidenced through 99 new company submissions to maritime for the 2018/2019 submission period.[23] Because of the small size of the company and the relatively small size of the first submission (WSP only), a flat rate of R750 was paid to the SDF upon TETA acceptance and verification that the WSP submission met the required standard. The first submission is recorded as a submitted plan, but the grant will be rejected.

The submitted WSPs allowed for simple budgeting, R750 per WSP and up to R50 000 per company for training as identified in the WSP. One year later, the SDF will submit the ATR/WSP and again be paid R750. The submission process is via an online platform and the management of the WSPs at TETA level is primarily driven by the system rules. The project was implemented via the interviewed respondents and was open to all small fishing companies registered with TETA. During implementation, the increased participation required the planned number of companies to be increased to 100, of which 99 submitted. The project was budgeted utilising the TETA SBD funding model (R50 000) per company.

The pilot project directly resulted in increased participation of small maritime companies. One hundred and forty-three small companies submitted a WSP, of which 99 were first-time participating companies. As 2017/18 period reported 35 small companies, to increase participation to 143 is a huge increase. As a direct result of the small company data entered into the TETA online mandatory grant system, the TETA SSP includes small fishing company needs.

It is unknown is whether the company will continue to submit after the first year of funded support has lapsed and the participation costs revert to the company. Only if the SETA is able to prove that the SETA relationship has benefits to the companies will the companies participate and maintain participation.

Ironically, the current national skills development company 'free' training, as offered in their product, will not benefit the maritime subsector, where SAMSA

[23] Transport Education Training Authority (TETA) 'Mandatory Grant Submissions Report' (Randburg, TETA 2019).

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regulatory training is the main priority. Currently, national SDF companies do not offer regulatory training in their product offering and this may limit the value-add to any company with a high demand of regulatory training.

VII CONCLUSION

The research conducted has raised a number of topics with solutions discussed below. The topics are arranged from SETA/DHET-specific areas of improvement, followed by the importance of communications. Topics include the unintended consequences of a SETA-specific SBD product and close with the Ansoff matrix, with reference to product development and market penetration solutions.

Some of the solutions (single IT provider and system for SETAs) have the potential to save the country large amounts of money, reduce complexity and facilitate standardisations across SETAs. The benefits that accrue are almost exponential. Leaving the monetary costs aside, improved sector reporting and the availability of consistent quality data across all SETAs would be a huge step forward in having reliable and consistent quality data available to inform sector development and national plans.

Small business participation SETAs – generic

Each SETA would need to define its own appetite to increase participation and this would be budget-dependent. The SETA would annually establish small businesses targets and these should increase incrementally each year; thus allowing support to be maintained to participating companies by means of both training and SDF services.

This study proves the importance of increased participation in improving the quantity of data available to a SETA that can be used in annual sector updates. The increase in real-sector data is a valuable contribution to the data sources utilised in developing and updating the SSP. Some examples of increased data are listed below. Small business data is especially useful in a SETA's ability to profile and analyse small business needs for prioritising support. This would improve the SSP data and enable many employees, currently denied skills development opportunities, to be trained and advanced, as intended by the skills development legislation. The maritime chamber example reflected the increase in small companies submitting in 2018 and identified that small companies plan to train more employees than large and medium companies added together.

Small business strategy TETA

The small business pilot project has indicated that relatively small changes to an existing strategy can bring about large increases in participation. The TETA small business strategy for TETA registered levy companies would do well to consider offering SDF roles and subsidised training as a package funded by TETA. The cost is already budgeted for annually, it's the methodology and implementation that differs slightly.

Small business participation TETA – maritime

The maritime sector has the additional incentive that fishing companies will be assessed on SETA participation in order to be considered for an award of a fishing quota. This provides incentives to the fishing companies to participate, which is evidenced by the high rate of submissions by fishing companies in the Eastern Cape, irrespective of levy recovery. This message alone needs to be communicated to the subsector from DAFF, the National Fishing Forum and TETA, and will serve to further increase participation. In addition, fishing subsector workshops should be conducted in Port Nolloth (Northern Cape), Saldanha (Western Cape), Cape Town (Western Cape), Mossel Bay (Western Cape), Port Elizabeth (Eastern Cape) and St Francis Bay (Eastern Cape).

These workshops should target registered small fishing companies and would aim to capacitate fishing company and vessel owners with skills development, as well as introduce them to SDFs or SDF partnerships with TETA. Using lessons learned from the current pilot project and small business support, the only effective and efficient way forward is to partner with a national skills development consultancy and define

https://doi.org/10.47348/SAJMET/2023/i1a1

the requirements for TETA. Using the current small business target and funding model will provide the mandate and budget to seriously target small business participation.

The partnership will define the quality and quantity of the annual ATR/WSP submission, with a special focus on scarce and critical skills. This will significantly improve participation and SSP relevance. The SSP information, especially scarce and critical skills and hard-to-fill vacancies, will inform the discretionary grant targets. Added to the partnership should be the option for each small company to implement one learnership. This would assist the fishing companies with quota allocations, assist the employees in achieving a qualification, access tax rebates and assist TETA with rolling out learnerships to address skills shortages and transformation.

The recommendations of dedicated small company-support by means of facilitated and incentivised SDF relationships will likely prove to be the most efficient solution to increasing participation in the small fishing company environment. We simply cannot expect any participation in the absence of an incentive to participate. Without increased participation from the SETAs and government, plans will always mean fishing in waters without knowing what fish they intend to catch.

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Malcolm Alexander

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Modern shipping needs to be cybersecure: A South African perspective

Rossouw von Solms[†] and Suné von Solms[‡]

ABSTRACT

The traditional standalone operational technology systems that control multiple mechanical systems on board a ship get increasingly integrated with modern information and communications technology (ICT)-related systems. These ICT systems that continuously become interconnected with operational technologies and systems include the Internet-of-Things (IoT), autonomous technologies and the internet with adequate bandwidth etc. The IoT typically employs numerous sensors and captures vast amounts of data, which is processed, transmitted and turned into trusted intelligence to the advantage of all parties involved. Furthermore, modern navigational systems utilise global positioning systems (GPS), radar, sonar and computerised maps. These are used in conjunction with modern communication systems to communicate related data used for accurate navigation. In addition, autonomous technologies are highly dependent on accurate data communicated to them. Thus, it is clear that data is rightly termed 'the new gold' in the shipping industry. On the other hand, the maritime industry, like most other industries, is highly vulnerable to cybersecurity attack. As more data is captured, processed and communicated for the more critical shipping activities, the more vulnerable the industry will become to modern cybersecurity threats. Therefore, the interfaces between sensors, devices and different technologies, and the communication of captured data need to be properly secured. Furthermore, many of the shipping industry staff working with technologies where data are captured and communicated need to be educated on how to assist in securing this data. This paper will emphasise the continued use of ICT-related systems in the shipping industry, and how this digitalisation and smart use of ICT solutions will benefit the maritime industry. In light of this, the purpose of this paper is to highlight the continued vulnerabilities to modern cybersecurity threats, and to discuss some solutions to securing these technologies towards securing the industry as a whole. The paper will also address aspects of educating maritime staff in technology-related areas ranging from the ICT- and cybersecurity-related topics that need to be included in maritime curricula, on the more formal side, to making all staff members more cybersecurity aware, on the more informal side.

[†] Emeritus Professor, Centre for Research in Information and Cyber Security (CRICS), School of Information Technology, Nelson Mandela University; South African International Maritime Institute

[‡] Head of Department, School of Electrical and Electronic Engineering Science, University of Johannesburg; South African international Maritime Institute

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I INTRODUCTION

Modern shipping may not use technologically advanced ICT systems such as used on passenger airplanes, but certainly the shipping industry is continuously introducing highly advanced ICT-related systems to modern vessels.[1] The traditional standalone operational technology systems that control multiple mechanical systems on board a ship have become increasingly integrated with modern ICT-related systems. These ICT systems that are continuously interconnected to operational technologies and systems include IoT, autonomous technologies and the internet with adequate bandwidth etc. The IoT typically employs numerous sensors to capture vast amounts of data, which is processed, transmitted and turned into trusted intelligence to the advantage of all parties involved.[2] As ICT-related systems become increasingly integrated and more data is captured, stored, analysed and transmitted, it is logical that these systems and data become increasingly vulnerable to cyberattacks. Furthermore, the staff working with these systems or on these vessels are increasingly exposed to cyberattacks.

The main objective of this paper is to investigate and research the current use of ICT in the maritime industry and related cybersecurity issues. The core deficiencies, application and protection of related ICT systems in the maritime industry, specifically from a cybersecurity point of view, will be reported on, along with the identified use and integration of ICT.

First, this paper will report on current advances in the maritime industry, followed by the integration of ICT into modern shipping systems. The generation of high volumes of data by these ICT systems and possible future advances will then be discussed, along with the typical vulnerabilities this data is exposed to. The situation regarding the education of maritime professionals is South Africa will briefly be reported on, specifically with regard to the ICT- and cybersecurity-related aspects of technology covered in these curricula. Lastly, possible interventions, which include awareness, will be proposed to ensure that ICT-related systems in the maritime industry are better protected from a cybersecure point of view.

II ADVANCES IN THE MARITIME INDUSTRY

Shipping has evolved by leaps and bounds over the last number of decades. Modern ships have advanced in terms of design, materials, propulsion and navigation, among other areas. Gone are the days of wooden, wind-propelled ships that were navigated by star maps and astrolabes.[3] Communication with the shore was extremely limited once at sea.

Today the propulsion, navigation, supplies and maintenance etc of modern ships employ advanced equipment and machinery. Fuel and oil flow rates, revolutions per minute, temperature changes and other parameters need to be monitored, recorded and analysed continuously. Computers and ICT systems are used nowadays and integrated into the workings of a ship to capture vast amounts of data to assist and improve the performance of a modern ship.[4]

III ICT IN MODERN SHIPPING

Data that is captured from numerous IoT systems and sensor equipment all over the ship goes along way but this is not enough. This data needs to be analysed, stored and/or transmitted to prove useful and beneficial to a ship and the related industry.[5] In some cases, the processed

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1 JP Apud 'Information Technology Applications in the Maritime Industry' *The Maritime Review* 1 November 2016 (available from: <https://maritimereview.ph/information-technology-applications-in-the-maritime-industry/>).

2 M Lind-Olsen 'ICT Solutions Bring Ship and Shore Closer' *Dualog* 30 July 2019 (available from: <https://www.dualog.com/blog/ict-solutions-bring-ship-and-shore-closer>); R Larsen 'What's the Value of Maritime-specific Software?' *Dualog* 23 October 2019 (available from: <https://www.dualog.com/blog/whats-the-value-of-maritime-specific-software>); J Cusimano, M Ayala & G Villano 'Navigating Cybersecurity Challenges in Maritime Operational Technology' *The Maritime Executive* 10 November 2020 (available from: <https://maritime-executive.com/editorials/navigating-cybersecurity-challenges-in-maritime-operational-technology>).

3 Apud op cit note 1.

4 Lind-Olsen op cit note 2.

5 Ibid.

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data is used on board for aspects of operation such as preventative maintenance, opening and closing of valves and steering etc. On the other hand, in most cases, this data needs to be transmitted in a trustworthy manner to the shore, where it will be further analysed, processed and used for the well-being of the ship or the related industry.[6] Transmitting the data safely from ship to shore and from shore to ship has become critically important.[7] Thus, the smart use of ICT, on and off a ship, provides for effective business flow by connecting ships at sea to shore-based operations, maintenance service providers and customer support centres etc.[8] The advances in ICT systems create vast amounts of data for analysis and integration into decision-making at various levels.[9]

The advantages that ICT offers assist shipping owners and operators to meet the demands of their customers and to deliver on global and sustainability expectations.[10] Digitalisation and the smart use of ICT systems not only contribute to the shipping industry on an operational basis, but also strategically. Added value contributes to making operations at sea smarter, safer and more sustainable.[11] Shipping companies that aim to harness the power of 'big data' and advanced analytics, will move and stay ahead of competitors in future.[12] The digital future will increase business opportunities and create a competitive advantage to sustain the business in a global market.

IV ICT AND RELATED DATA USAGE

It is clear from above that data is continuously captured, transmitted and analysed by means of various ICT systems. Following are some of the more popular areas where this data is used:

- Improve vessel performance: Modern ships are dependent on the continuous monitoring of and reporting on systems such as the engine, electrical power and climate control. Data on aspects of performance, such as revolutions per minute, fuel and oil flow rates and temperature changes, need to be recorded and analysed and used to improve the performance of the ship.[13]
- Supply chain management: Cargo systems today make extensive use of sensors. As part of the IoT-based solutions, these sensors are integrated into monitoring systems to allow customers, captains and crew members to monitor temperatures or position etc in real time.[14]
- Navigational purposes: Modern navigation makes use of GPS, radar, sonar and computerised maps. Navigational information is used in conjunction with radio- and satellite-based communication systems. These systems assist navigation officers in dark, inclement weather, or low visibility.[15]
- Environmental compliance: By utilising cargo, port and environmental data captured continuously, ships can plan voyages, take shorter routes and adapt the speed to port availability, and, accordingly, save fuel.[16] Various technologies that rely heavily on ICT are used to measure, manage and report on the environment-related aspects of each ship. This is important because ships need to be compliant with ever-increasing environmental regulations. These regulations support the United Nations Sustainable Development Goals (SDGs).[17]

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6 Ibid.
7 Ibid.
8 Ibid.
9 S Moan 'The Value of ICT in the Maritime Industry' *Dualog* 26 June 2022 (available from: <https://www.dualog.com/blog/the-value-of-ict-in-the-maritime-industry#:~:text=ICT%20systems%20add%20value%20to%20the%20maritime%20industry,shore-sea%20collaboration%20and%20the%20best%20possible%20business%20flow>).
10 Ibid.
11 R Larsen 'How ICT Solutions Can be Used Strategically in Shipping' *Dualog* 17 January 2020 (available from: <https://www.dualog.com/blog/how-ict-solutions-can-be-used-strategically-in-shipping>).
12 Ibid.
13 Apud op cit note 1.
14 Larsen op cit note 11.
15 Apud op cit note 1.
16 Moan op cit note 9.
17 Larsen op cit note 11.

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Thus, the effective use of ICT-based systems contributes to, among other things, the delivery of supply chain transparency, assists with effective navigation, reduces the ecological footprint and minimises the operational costs associated with ship inspections and maintenance. The aspects of data use highlighted above are just a few of the many reasons for the proliferation of data-capturing sensors and related ICT systems that are integrated into modern shipping vessels and associated cargo.

As 'data is the new gold of the shipping industry', more effective ways and means will be found to ensure data are captured, processed, analysed and turned into trusted intelligence.[18] Data that is captured in isolation or at random, has little value today.[19]

V THE POWER AND VULNERABILITIES OF DATA

Data become valuable when used to obtain understanding, and to strategically integrate operations and decision-making from the information.[20] It is clear that data needs to be accurately captured, processed and analysed to be turned into trusted intelligence. Furthermore, for data to deliver operational value, information needs to be standardised, properly and securely distributed, and transmitted from ship to shore, and vice versa. Reliable, seamless internet connectivity that guarantees the safe and secure flow of business traffic intelligence becomes a must-have.[21]

With the proliferation of data-capturing devices, mostly by way of the further introduction of IoT, the following ICT-related utility aspects will add value and become very important.

Predicative maintenance

Currently, the following types of maintenance are predominantly prevalent in the shipping industry: periodic or scheduled maintenance, which is mostly time-based; preventative maintenance that depends on regular inspections and services etc; emergency maintenance, which normally takes place following a breakdown or failure; and condition-based maintenance that depends on accurate data that gets captured and used pre-emptively to determine whether any maintenance is required. Thus, predictive maintenance is dependent on IoT data for proactive analysis of the condition of the related machinery or equipment.[22]

Sensors, robots and smart condition monitoring technologies capture large volumes of real-time data from equipment, systems and machinery etc about the 'health' and status of the ship.[23] This captured big data is then collated by the on board ICT systems[24] and sent ashore, where it is assessed and analysed.[25] Depending on results and parameters set, early warnings can be given that might eliminate costly inspections and possible downtime.[26] Predictive maintenance can be classified of one of the major benefits of IoT integration on board ships.

Artificial intelligence (AI) and machine learning (ML)

From the above, it is clear that quality data that are processed and analysed are used in high-level decision-making for the well-being of the organisation. It is here that AI and ML come to the fore. AI is the science and engineering of making computers behave in ways that resemble human intelligence. AI has the potential to improve standard vessel operations,

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18 Larsen op cit note 2.
19 Ibid.
20 Ibid.
21 Ibid.
22 Marine Digital 'Predictive Maintenance for Marine Vessels' *Marine Digital* (available from: < https://marine-digital.com/article_predictive_maintenance_for_marine_vessels#:~:text=Maintenance%20prediction%20is%20a%20proactive%20approach%20to%20dealing,that%20is%20strictly%20adhered%20to%20on%20board%20ships>).
23 Larsen op cit note 11.
24 Moan op cit note 9.
25 Larsen op cit note 11.
26 Ibid.

https://doi.org/10.47348/SAJMET/2023/i1a2

reduce organisational expenses and optimise business processes and decisions.[27] The high level of 'intelligence' stemming from ML algorithms and industry experience can create significant advantages for shipping companies. The higher the level of investment in AI and ML, the greater the benefit of big data analysis capabilities.[28] Typically, ML is used in voyage planning, cargo optimisation, marine network planning and estimating fuel consumption etc. At this stage, the use of ML in the maritime industry remains limited.[29]

Stena Lines, one of the world's largest ferry companies, uses AI and ML for reducing plastic on board, managing crew members, passenger accidents and fuel usage.[30] The port of Rotterdam uses ML-based systems to accurately determine vessels' time of arrival.[31] While ML is used extensively elsewhere in the digital world, its adaption to the maritime industry remains limited to date.[32]

Securing the data and related cyber systems

Operational technology (OT) systems are becoming increasingly integrated with modern ICT systems, which causes numerous vulnerabilities. The proliferation of the adoption of cloud computing, the IoT and the autonomous technologies used to interconnect OT and ICT will lead to more cybersecurity risks coming to the fore. Therefore, the maritime industry is increasingly being exposed to cyber-related risks and cybersecurity has become an issue of increased vulnerability.[33]

With the continued integration of IoT and related ICT systems into the maritime industry, cybersecurity has become a new focus in the industry.[34] IoT devices are not necessarily secure by nature and need to be secured. Cybersecurity is concerned with securing ICT systems, onboard hardware and sensors, and data leaks from unauthorised access, manipulation and disruption.[35] Cyberattacks on navigational systems by means of interference with automatic identification systems and electronic maps, the jamming of GPS and manipulating cargo and ship management systems are well-known. Many of these take place by introducing malware, ransomware software and viruses.[36] Cybersecurity should be implemented at all levels of the organisation, from top management onshore to onboard crew members. All of these contribute to the safety culture for the safe and efficient operation of a ship.[37]

Governing data usage in the maritime industry

As a result of the proliferation of ICT-related components and systems in the maritime industry, and the related cybersecurity risks, regulatory agencies, industry associations and standards bodies all deem it critically important to address maritime cybersecurity.[38] The International Maritime Organisation (IMO) regulations and the International Standards Organisation (ISO) standards for IoT and sensors have certainly changed the focus and calls for proper governing thereof.[39] Shipping companies have a deadline to introduce specific cybersecurity in their vessels' safety management systems.[40] It is clear that the integration and protection

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27 Marine Digital 'Artificial Intelligence (AI) and Machine Learning (ML) in Maritime Logistics' *Marine Digital* (available from: <https://marine-digital.com/article_ai_and_ml>).
28 Ibid.
29 Ibid.
30 Ibid.
31 Ibid.
32 Ibid.
33 Cusimano et al. op cit note 2.
34 Ibid.
35 Marine Digital 'The Importance of Cybersecurity in the Maritime Industry' *Marine Digital* (available from: <https://marine-digital.com/article_importance_of_cybersecurity>).
36 Prinston, P 'Top 4 Trending Technologies in the Maritime Industry' *Searates Blog by DP World* (available from: <https://www.searates.com/blog/post/it-technologies-in-the-marine-industry>).
37 Marine Digital op cit note 35.
38 Cusimano et al. op cit note 2.
39 Lind-Olsen op cit note 2.
40 Cusimano et al. op cit note 2.

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of OT and ICT systems, and the relatively new regulatory compliance, calls for maritime organisations to develop a comprehensive cybersecurity strategy to govern the environment properly.[41]

Skilling of employees

As more data is captured from onboard sensors and used, increasingly more operational decisions by crew members will be based on captured data streams. As a result, data science skills have become essential for modern crew members.[42] Adopting new ICT solutions will assist in attracting young professionals to enter the maritime industry as an attractive workplace.[43]

From a cybersecurity point of view, understanding what is required to create, implement and maintain a cybersecurity programme is just the start. Specialised skills and expertise are needed to successfully perform all these cybersecurity-related tasks.[44] Adding to this, cybersecurity is a relatively young focus area in the maritime industry. Maritime organisations mostly lack the experience and expertise to identify, assess, manage and respond to cyberthreats.[45]

From the above, it is clear that the maritime industry must, indeed, embrace ICT solutions to become more effective. The above-mentioned five ICT-related aspects have been identified and motivated as important areas that will receive attention in future. Cybersecurity probably stands out as an overarching issue that needs to be addressed because all the other ICT-related issues somehow depend on secure data.

VI MARITIME TRAINING AND EDUCATION IN SOUTH AFRICA

Education and training in ICT-related topics, especially cybersecurity, should be a core competence of the future maritime employee. For this reason, a brief study was conducted into some of the more prominent South African education and training institutes and centres offering maritime educational programmes.

As far as could be established from literature available and interviews with a number of role-players in tertiary education in South Africa, only three South African universities currently offer maritime-related higher education qualifications.

a. Durban University of Technology offers a one-year Advanced Diploma in Maritime Engineering. This qualification is accredited by the Engineering Council of South Africa (ECSA). Little detail on the curriculum could be found, but it seems that little, if any, ICT-related content is offered.
b. Cape Peninsula University of Technology offers a three-year ECSA-accredited Bachelor of Marine Engineering. A module called 'Computer Science for Marine Engineers' is offered, but the exact content could not be established.
c. The Nelson Mandela University offers a three-year ECSA-accredited Bachelor of Engineering Technology in Marine Engineering. This offering does include some data acquisition by means of digital devices and some low-level controls. Thus, it can be argued that limited content on data capturing it taught, but very little ICT and no cybersecurity.

Various institutes, academies and training centres offer maritime-related training. Examples include the South Africa Maritime Training Academy (SAMTA), the Maritime School, the Sea Safety Training Group (SSTG), the SA Maritime School, the Maritime School of Excellence (MSOE) and the Marine Oil & Gas Academy (MOGA). It would seem that the focus of all of these institutions is on general sea safety and seafarer skills. No ICT content or related skills training could be identified.

41 Ibid.
42 Larsen op cit note 11.
43 Ibid.
44 Cusimano et al. op cit note 2.
45 Ibid.

https://doi.org/10.47348/SAJMET/2023/i1a2

From the above it is clear that little, dedicated and focussed ICT education and training is offered to students studying maritime studies in South Africa. Furthermore, as far as could be established, no cybersecurity content is taught at all. This is in direct contrast to the findings earlier in this paper that the modern maritime employee corps should be properly schooled in specific ICT and, in particular, cybersecurity content.

From a short course or short learning programme point of view, definitely no maritime-focussed offering that includes any specific ICT-oriented content could be identified.

Thus, taking into account the importance of related ICT and cybersecurity knowledge and skills highlighted in this paper, it definitely seems as though related higher education curricula should include such content. In addition, there is probably a place for short learning programmes focussing on ICT and cybersecurity in the maritime industry.

VII TRIANGULATING THE FINDINGS ABOVE

During November 2022, a meeting was held with BW Offshore, a large shipping company that is based in Norway.[46] The meeting took place via MS Teams and was attended by four senior ICT staff members from BW Offshore who work in the IT, OT systems and cybersecurity domains. Three ICT staff members from Noroff University College in Kristiansand, Norway and one staff member from Nelson Mandela University in South Africa attended the meeting.

The objective of the meeting was to discuss the ICT- and cybersecurity-related developments in the maritime industry and to validate some of the theoretical findings made from literature, as discussed above. The following are a few extracts of some of the major IT and security aspects discussed and statements made by these professionals from the maritime industry.

- Integrating 'OT and IT environments'
- 'OT and legacy systems integrating with modern IT systems'
- Transmitting data 'from offshore to onshore'
- 'Cybersecurity awareness and training is a big focus area but is also very challenging'
- 'Cybersecurity training has not been part of their (offshore crew members) education agenda'
- 'Hire competence in cybersecurity'
- 'Most incidents triggered by user faults and lack of (cybersecurity) awareness'
- 'IT governance documentation project', specifically 'procedures and documentation'
- 'Mandatory for cybersecurity awareness and training'
- IT governance issues as 'IMO 2022 regulations will soon get audited'
- 'AI-penetration testing'.

These quotations were abstracted from the meeting and summarise some of the major issues that stemmed from the discussion. Certainly, this discussion confirmed almost all aspects and issues identified earlier in literature.

From this discussion it is clear that, IoT proliferates in the modern shipping industry, and more OT and IT systems integrate and transmit more and more information between on- and offshore. The fact that cybersecurity dominated the discussion highlights that this area is a huge problem and concern, from technical system infiltration and vulnerabilities ('AI-penetration testing') to incompetent on- and offshore staff members (see quotations above). Furthermore, as more and more regulations and standards are introduced, it becomes imperative to properly govern ICT in the maritime industry ('IT governance documentation project', specifically 'procedures and documentation' and 'IMO 2022 regulations will soon get audited').

[46] BW Offshore Meeting – Noroff and Visiting Professor – 202221108_144412 – Meeting Recording (available from: <https://www.dropbox.com/s/v8ej0iccdx0ohtw/Meeting%20BWOffshore%20-%20Noroff%20and%20Visiting%20Professor-20221108_144412-Meeting%20Recording.mp4?dl=0>).

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VIII CONCLUSION

From a technology point of view, shipping has evolved by leaps and bounds in recent times.[47] Modern ships are dependent on equipment and machines that operate around the clock. Systems that control the engine, fuel delivery, electrical power and climate control etc need to be monitored continuously.[48] Integrated into these systems are IoT modules and sensor equipment that continuously capture and transmit data to be processed, analysed and stored elsewhere, most probably onshore. Thus, ICT is core to modern vessels and their operations. Furthermore, as vessels are dependent on the accurate capturing, processing, transmission and storing of this data, it is imperative that data needs to be secured. Therefore, the personnel developing and operating these highly technical systems need to be well-schooled and trained to ensure the security of the data, the systems using the data and the vessels that are totally dependent on the security of these systems. As almost all the transmission of the data takes place via the internet, sound cybersecurity should be an imperative.

The curricula of South African higher education institutes and of maritime training centres that educate and train mariners contain hardly any relevant ICT-related content taught to students, not to even mention highly critical cybersecurity content. With the need for modern-day mariners and related maritime personnel to be well-schooled in ICT and cybersecurity to ensure the secure operation of modern vessels, it is important that these people are, indeed, schooled in this subject, either at the initial education and training stage or skilled by means of further education and training. There exists considerable documentation, including the International Maritime Organization International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (IMO STCW) and the International Port Security Code (ISPS) Code Requirements for Seafarers, Ships and Ports that can be relevant in the development of cybersecurity educational and training material.

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[47] Apud op cit note 1.
[48] Ibid.

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Marine Digital 'The Importance of Cybersecurity in the Maritime Industry' *Marine Digital* (available from: <https://marine-digital.com/article_importance_of_cybersecurity>).

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Rossouw von Solms

Suné von Solms

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Maritime skills development in KwaZulu-Natal: 2022

Leticia A Grimett† *and Sihle Mzileni*

ABSTRACT

The Operation Phakisa: Oceans Economy mandate, in line with the United Nations (UN) Sustainable Development Goals, calls for the extension of the benefits of maritime sector development to disadvantaged rural communities. This mandate can only be realised if the rural communities can actively partake in the sector. Research has shown that the coastal rural communities were unaware of the maritime sector, and few were prepared to partake in the maritime value chain. This maritime skills audit sought to determine the skills required by the maritime sector and the ability of the rural community to provide them. The research also sought to determine the geographical and educational gaps within the sector. Initially, the intention of the research was, to discover specific areas where skills shortages and education gaps were found. While the Protection of Personal Information (POPI) Act[1] proved to be a limiting factor, the study still uncovered the structural issues affecting the education and training of rural learners. The maritime sector is primarily urban. Maritime training is also done within the urban sectors. While it should be a simple matter of the rural learners moving to urban centres to study, the deficiencies in the education of the rural populations have created a major systemic bottleneck. This paper provides the results of the maritime business audit, together with the issues facing the rural education sector and the obstacles they present.

Keywords: maritime skills development, rural education, maritime skills shortages, critical skills, scarce skills

I INTRODUCTION

The Operation Phakisa: Oceans Economy document of 2014 provides for the growth and development of the maritime sector, targeting six maritime subsectors. These are coastal marine tourism, marine transport and manufacturing, aquaculture and fisheries, oil and gas exploration, marine protection, legislation and small harbour development.[2] The areas targeted are mainly coastal areas. By creating value within coastal communities through maritime development, the Operation Phakisa strategy plan seeks to establish a proper foundation for economic development within the urban and rural areas.

Economic development requires skilled individuals to undertake the relevant tasks and/or create sufficient value to grow these sectors.[3] The ability to source sufficiently qualified people to grow the maritime sector is a problem that the Operation Phakisa strategists sought to rectify by means of continuous skills development.[4]

† Honorary Research Fellow at the University of KwaZulu-Natal School of Law, South African International Maritime Institute.

1 Protection of Personal Information Act 4 of 2013.

2 South African International Maritime Institute (SAIMI) *Oceans Economy Skills Requirement, Employment and Skills Development Assessment for South Africa* (Gqeberha: South African International Maritime Institute 2018).

3 Ibid.

4 Ibid.

https://doi.org/10.47348/SAJMET/2023/i1a3

Maritime employment in the coastal rural areas has been hindered by the lack of youth skills and inadequate youth schooling, which has impacted the youth unemployment rate. According to Statistics South Africa's 2021 fourth quarter statistics,[5] youth unemployment rate across all sectors in the fourth quarter of 2021 was 66.5%. Of this, 2.4% were university graduates, 51.6% had less than matric and 38.6% had matric.

The unemployment rate for youth between 15 and 34 had decreased slightly to 46.5% in the second quarter of 2022.[6] To meet the Operation Phakisa goals, government must adopt targeted intervention programmes. Without relevant information regarding the level of education of rural communities or their skill sets, it is difficult to adequately intervene. There is the additional question of why the youth appear to be so badly affected by unemployment, given that the education system is being upgraded and apartheid-related legacy issues are being rooted out of the system.[7]

II PROBLEM STATEMENT

There is an increasing gap between the direction that the economy is taking and that which it needs to take due to a shortage of skilled people. This conclusion can be reached from the research done on reasons for skills shortages in South Africa.[8] They uncovered a clear link between the scarcity of critical skills and the inability of businesses, and hence the economy, to grow at the required pace. Within both the public and private sector, communities struggled with the impacts of the lack of service delivery due to insufficient skilled labour. In the same way, businesses were hindered from implementing growth strategies. As such, the skills that potential job entrants must have to be able to make a meaningful contribution to the economy, and the rapidly changing global environment, need to change and align with global economic trends and the economy's shifting needs.[9] Increased automation, together with the Internet of Things (IoT) requires labour to have some understanding of technology and technological processes. The margin for absorption of unskilled labour into the economy is diminishing and, as automation increases, many semi-skilled jobs are falling away. Statistics indicate that the youth unemployment rate can be partly attributed to the lack of adequate education, insufficient or lack of skills, and lack of work experience.[10] Without a proper understanding of the dimensions and causes of this problem, it will be difficult for government to prepare for the interventions needed to redirect the South African economy.

III RATIONALE OF THE STUDY

While there are clear statistics on the nature of the unemployment crisis, the details relating to these statistics are unclear. As the unemployment crisis has impacted the youth sector the most, emphasis is being placed on youth employment and the development of rural areas, where the unemployment rate is highest.[11] While the Operation Phakisa: Oceans Economy document has identified activities in the maritime sector as a means of creating jobs, there is little known about the status of maritime education or the skills gaps that will need to be addressed.

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5 PoliticalAnalysis 'Youth unemployment rate in South Africa 2022' *PoliticalAnalysis* 6 April 2022 (available from: <https://www.politicalanalysis.co.za/youth-unemployment-rate-in-south-africa-2022/#:~:text=Unemployment%20affects%20the%20whole%20population%2C%20but%20the%20youth,fourth%20quarter%20of%202021%2C%20released%20in%20March%202022>).

6 Statistics South Africa (Stats SA) *Quarterly Labour Force Survey Q2:2022* (Pretoria: Stats SA 2022) (available from: <https://www.statssa.gov.za/?p=15685#:~:text=Quarterly%20Labour%20Force%20Survey%20%28QLFS%29%20%E2%80%93%20Q2%3A2022%20The,Quarterly%20Labour%20Force%20Survey%20%28QLFS%29%20for%20Q2%3A%202022>).

7 TD Thobejane 'History of Apartheid Education and the Problems of Reconstruction in South Africa' (2013) 3(1) *Sociology Study* 1–12.

8 AD Mateus, C Allen-Lle & CG Iwu 'Skills Shortage in South Africa: Interrogating the Repertoire of Discussions' (2014) 5(4) *Mediterranean Journal of Social Sciences*.

9 C Shaw 'The Digital Skills Revolution, McKinsey and Company Operations Blog' *McKinsey* 30 November 2018 (available from: <https://www.mckinsey.com/capabilities/operations/our-insights/operations-blog/the-digital-skills-revolution>).

10 SAMI op cit note 2.

11 Department of Planning, Monitoring and Evaluation *Executive Summary of the National Development Plan, 2030* (Pretoria: National Planning Commission 2022) (available from: <https://www.gov.za/sites/default/files/Executive%20Summary-NDP%202030%20-%20Our%20future%20-%20make%20it%20work.pdf>.

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IV OBJECTIVES

As there is little information available on the maritime sector education and skills gaps, the survey objectives sought to:

- Discover the educational and geographical areas with maritime skills shortages.
- Identify which are the:
  - core maritime skills
  - most critical maritime skills
  - future skills required by the maritime sector.

V RESEARCH METHODOLOGY

In researching this paper, a mixed-research methodology was adopted, with both primary and secondary data being utilised. The survey was conducted during June and July 2022 and was a targeted probability study, with a list of maritime-related companies having been acquired online and lists of maritime firms sourced from the Moses Kotane Institute partner organisations.

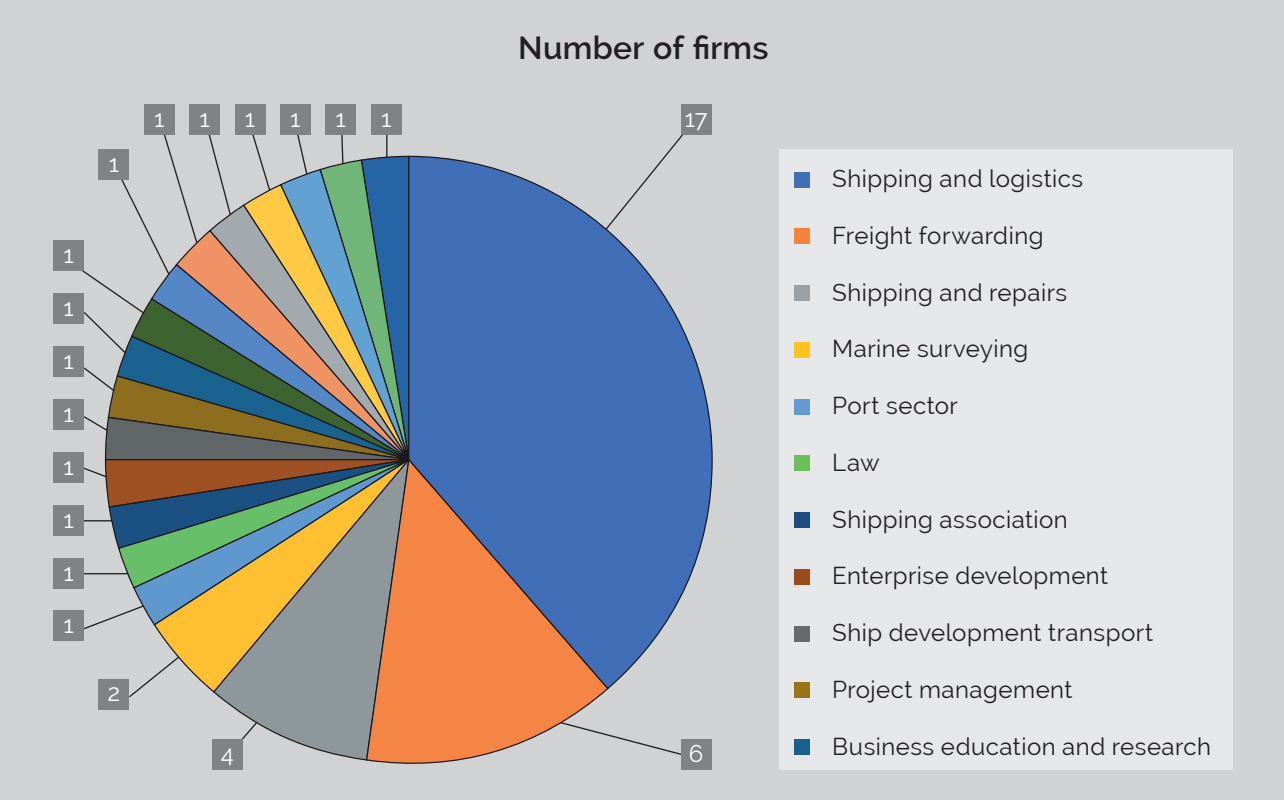

Figure 1: Number and Types of Firms in the Maritime Firms' Audit

In Richards Bay, semi-structured face-to-face interviews were conducted. Durban participants preferred to answer questionnaires online. The face-to-face interviews yielded more in-depth information, with participants explaining their reasoning in greater depth. While abstentions, narrowed the scope of the survey, the responses obtained are still substantial because many firms had substantial market share, while others were monopolies. The marine engineering sector did not participate, although several large firms were approached. Secondary sources were used to fill this gap. Research indicated that the engineering subsector was represented throughout the maritime sector. The validity of the information was determined by referring to secondary sources and the results of previous research. The Transport Sector Education

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and Training Authority (TETA) and the Department of Higher Education and Training were approached to verify information and to obtain the latest statistics. For up-to-date statistics, the study sought secondary data from the Statistics South Africa website. A reflexive approach was adopted to prevent bias, with data being analysed using a content and exploratory approach.

VI ETHICAL CONSIDERATIONS

The POPI Act prevents the sharing of personal information with external parties without a party's permission. This has become an obstacle to detailed research. All information obtained was treated with the utmost care, with the information provided being used to secure data for the research paper. To prevent breaches of confidentiality, participants gave permission for their inputs to be used in the study. In addition, participation was voluntary, with participants being aware of the purpose of the survey.

VII LITERATURE REVIEW

According to a Government Communications Insight Newsletter No 13,[12] South Africa's high unemployment rate is partly due to a skills mismatch, with a large proportion of the potential labour force being either semi-skilled or unskilled. This also contributes to the inability of the economy to absorb new job seekers. In the current economic climate, employers are reluctant to train new job seekers. Where government previously provided employment to unskilled youth and employment seekers by way of government projects such as roads and infrastructure projects, technology is changing this situation. Even basic jobs require some level of skill and expertise. Within the maritime sector, supply chain developments and global trade advancements are being affected by climate change provisions and trade-related conventions, such as the Trade Facilitation Agreement which requires rapid adoption of digital technologies, efficient renewable energy solutions, automation and other digital solutions.

The Maritime Sector Skills Technical Task Team (MSSTTT) Report of 2014[13] was the last complete maritime skills audit. The MSSTTT report[14] outlined the primary and secondary maritime industry clusters. The three primary clusters are:

1. shipping and transport, which includes maritime logistics infrastructure, shipping transport and ports, marine services and coastal administration.
2. marine resources, which include, fishing; pharmaceuticals, aquaculture, offshore energy and mining.
3. marine tourism, which consists of boating, cruising, sports, recreation and leisure. This sector has been publicised and encouraged, with tourism being taught at school level. This sector is a mass employer and includes hotels, bed and breakfasts, game reserves, gift shops, logistics, tour guides, food and beverages, clothing, farming and fishing, as well as road and beachfront infrastructure, construction, lifeguards, security and sports.

The four secondary industry clusters include:

1. operational support services, which include shipping logistics and marine technologies.
2. manufacturing and construction, which include civil engineering, marine manufacturing (ship/boat building, component manufacturing); ship repair and maintenance (ship modifications, oil and gas structures etc)
3. business services, which include maritime professionals within the banking, legal, insurance, information and communications technologies (ICT) and the consulting domain. These ancillary services support the maritime sector.

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[12] Government Communications 'Understanding the root causes of unemployment' *Insight Newsletter* Issue 13 (Pretoria: Department of Government Communications 2014) (available from: https://www.gcis.gov.za/content/resourcecentre/newsletters/insight/issue13>).

[13] Human Resources Development Council of South Africa (HRDS) *The Maritime Sector Skills Technical Task Team (MSSTTT) Report* (Pretoria: HRDC 2014) (available from: <http://hrdcsa.org.za/wp-content/uploads/publications-report/Maritime%20Sector%20Skills%20Technical%20Task%20Team%20Report.pdf>).

[14] Ibid at 8.

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4. the public interest cluster, which deals with maritime regulation, naval defence, enforcement, emergency and disaster management.

Table 1 shows the gaps within the maritime education system, identified by the 2014 HRDC MSSTTT survey.

In South Africa, training is done through the different Sector Education Training Authorities (SETAs). These include the Transport Education Training Authority (TETA); Manufacturing, Engineering and Related Services SETA (MERSETA); Culture, Arts, Tourism, Hospitality and Sports SETA (CATHSSETA); Chemical Industries Education and Training Authority (CHIETA); Media, Information and Communications Technologies SETA (MICT SETA); Mining Qualifications Authority (MQA); Agriculture SETA (AGRISETA), Food and Beverages Manufacturing SETA (FoodBev SETA); Wholesale and Retail Sector SETA (W&R SETA); Insurance Sector SETA (INSETA) and Banking Sector SETA (BANK SETA).

Table 1: Gaps Within the Maritime Education System

Industry	Scarce skills	Relevant SETA	Proposed solutions to address problems
Shipping and ports	Navigation officers; ship's engineers; engine and deck ratings; hydrographers; oceanographers; maritime technologists; marine ecologists; meteorologists; dockmaster; transport and logistics management; vessel traffic management; sea-watch and rescue operators; port captain/ harbour manager	TETA; MERSETA; CATHSSETA	Skills transfer programmes • Increase capacity for training at public and private institutions • Import priority (eg ship masters and architects) skills as a short-term measure • Retired experts for training and skills transfer • More funding for skills development • Increased career awareness • Reskilling the unemployed graduates and upskilling the employed
Offshore oil and gas	Geologists/geophysicists; engineers (chemical, geotechnical, drilling, structural, marine, mechanical); deck officers; artisans	TETA; CHIETA; MICT SETA; MERSETA; MQA	
Fisheries and aquaculture	Aquatic health or aquaculturalists; deck officers; marine engineers; artisans; ratings, Engineers	TETA; AGRISETA; FoodBev SETA; W&R SETA	
Vessel construction and repairs	Naval architects; production managers; designers; electricians; electronics; metal fabricators; fitters, boiler makers and welders; riggers; technicians; boat builders and repairers	TETA; MERSETA	

https://doi.org/10.47348/SAJMET/2023/i1a3

Industry	Scarce skills	Relevant SETA	Proposed solutions to address problems
Commercial services	Marine and environmental lawyers; maritime economists; marine financiers/underwriters; maritime consultants; crewing; training; research and innovation; business consultants	TETA; MERSETA; INSETA; BANK SETA	
Maritime tourism	Hospitality officers (chefs, stewards etc); marine conservation officers; dive videographers/photographers	TETA, FoodBev SETA; MERSETA; CATHSSETA; W&R SETA	

Source: MSSTTT Report[15]

A list of critical skills identified by TETA include:[16]

- business practices and management
- compulsory standards for training, certification and watchkeeping (STWC) revalidation
- occupational health and safety
- long- and short-range operations
- navigation skills
- fishing technologies
- fishing and merchant marine
- fish hunting
- pilotage
- leadership and management
- project management (shipping).

Despite the changes brought about by advances in technology, the World Economic Forum's The Future of Jobs Report[17] validates the MSSTTT report. It also provides the following additional inputs for South Africa:

Jobs that will be required include:[18]

- process automation specialists
- data analysts and scientists
- social psychologists
- management and organisation analysts
- business development professionals
- big data specialists
- assembly and factory workers
- compliance officers
- chemists and chemical laboratory scientists
- artificial intelligence (AI) and machine learning specialists.

These jobs apply across all sectors, including the maritime sector. The United Kingdom (UK) Maritime 2050 strategy document[19] states that the maritime sector will have changed by 2050. Factors affecting sector changes include climate change legislation, smart port development, digitalisation of supply chains, the movement away from analogue to digital systems, the need for seafarers to be able to handle shore-based and sea-based roles using transferable information technology (IT)-based skills and continuing professional development that allows them to update skills in line with technological advances. Maritime roles will have highly specialised elements. Science, technology, engineering and mathematics (STEM)

15 Ibid.
16 Ibid.
17 World Economic Forum (WEF) *Future of Jobs Report 2020* (Cologny: World Economic Forum 2020) (available from: <https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf>).
18 Ibid.
19 Department of Transport (United Kingdom) *Maritime 2050: Navigating the Future* (London: Department of Transport 2019) (available from: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872194/Maritime_2050_Report.pdf>).

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skills will come to the fore. The future professional must be highly skilled and capable of occupying multiple roles. As technology changes, learning will have to evolve, often over short time frames. The movement towards autonomous shipping and the technology that will enable the navigation of these vessels will totally change the face of shipping and affect port development as will the movement towards alternative fuel usage.[20]

With regards to maritime skills development and training, the UK government report emphasised the following:[21]

- The skills profile of the maritime sector will change significantly over the next 30 years. The importance of science, technology, engineering and mathematics (STEM) subjects will increase as jobs become more skilled and data-driven in response to new technology. Industry roles will be multidisciplinary, potentially requiring the ability to create, operate and maintain autonomous and technological systems Upskilling the workforce to utilise emerging technologies such as robotics and AI, the agility to adapt training packages in a timely manner and regular review of skills needs will allow countries to capitalise on their skilled workforce.
- The pace of technological change is expected to continue into future years, requiring workforce skills to keep pace. Without continuous learning the industry risks increased costs from high staff turnover, and individuals could suffer in terms of career progression. Mapping career paths and building professional development into training programmes will allow a proactive approach to career planning and support cross-sector mobility. Better internet connectivity at sea would remove an existing obstacle to lifelong learning, while the application of technologies such as virtual reality could facilitate retraining in new systems and potentially change the way in which traditional training programmes are delivered.
- Seafarers suffer a high incidence of mental health conditions, primarily due to the pressures, nature, and isolation of working at sea. Changing technology could be utilised to improve sea connectivity.

As critical as education is, the skillsets required within the maritime sector are just as important. The World Economic Forum (WEF) Future of Jobs report of 2020 referred to the following attributes that will be required of the future workforce:[22]

- analytical thinking and innovation
- critical thinking and analysis
- troubleshooting and user experience
- leadership and social influence
- complex problem-solving
- systems analysis and evaluation
- creativity, originality, and initiative
- technology use, monitoring and control
- quality control and safety awareness
- persuasion and negotiation
- emotional intelligence
- technology installation and maintenance
- resilience, stress tolerance and flexibility
- reasoning, problem-solving and ideation
- active learning and learning strategies.

Strategic learning will need to move beyond the classical rote learning and regurgitation methodology currently found in schools to one that embraces the whole person and builds into the learning systems the development of character and resilience. Unfortunately, many of these attributes cannot be taught but developed through life experience. As far as possible, where they can be, intelligent taught, systems will need to be created.[23]

From the MSSTTT Report of 2014,[24] it was clear that the maritime education sector has focused more on the shipping sector, with the following four sectors receiving the greatest attention:

[20] Ibid.
[21] Ibid.
[22] WEF op cit note 17.
[23] Ibid.
[24] MSSTTT op cit note 13.

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1. **Port industry** (deals with shipping and handling of cargo)

Cargo handling and storage, stevedoring, cold storage operators, terminal operations, equipment operators, terminal management, marine services, vessel traffic services, marine pilots, tug masters, engineers, ratings, berthing masters, berthing shore hands bunkering services barge masters

2. **Freight and logistics** (services supporting the import/export of cargo)

Freight forwarding, international trade and logistics, clearing and forwarding customs clearance, warehousing and storage, logistics management.

3. **Vessel operations** (management, crewing and facilitation)

Vessel management and crewing vessel manager, crewing manager, ship superintendent, vessel planning, vessel planner, ship chartering, maritime economics, international trade.

4. **Vessel operational support industry**

Ship repair and maintenance, dockmaster, boilermaker, welder, millwright, vessel bunkering, bunker trading, bunker handling, vessel agency, ship agency, stores and victualing supplies (ship chandelling) and stores management.

The report also referred to two distinct types of maritime activities in the country, namely local (domestic) and international maritime activities. Domestic activities are governed by domestic laws that do not have to comply with international instruments. These include training for port operations, ship repair skills, professionals, cargo and terminal operations, oil, and gas operations etc.[25]

The conduct and operations at sea are governed by several multilateral instruments and institutions as the sector is subject to international, continental and regional governance and frameworks. These institutions include:

- the UN and its specialised agencies such as the International Maritime Organization (IMO)
- the International Labour Organization (ILO)
- the UN Food and Agriculture Organization (FAO)
- the World Trade Organization (WTO)
- the United Nations Conference on Trade and Development (UNCTAD)
- the United Nations Convention on the Law of the Seas (UNCLOS)
- the International Hydrographic Organization (IHO)
- the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)
- organs such as the African Union (AU), Southern African Development Community (SADC) and South African government departments at various levels of governance
- the Offshore Petroleum Industry Training Organization (OPITO)
- the Industrial Rope Access Trade Association (IRATA).

As a result of this distinction, some modes of education can be governed by recognised South African channels such as the South African Maritime and Shipping Authority (SAMSA), universities, the Department of Labour and the various SETAs. This influences access to maritime sector training. Without bursary support and/or scholarships, it is difficult for disadvantaged communities to enter some maritime sectors, given the cost of training.[26]

Another challenge is the difficulty of placing learners on ocean-going vessels for practical experience and time at sea. For other maritime training, learnerships require that learners receive training with companies in the industry. As many companies have their own on-site training, there are few openings available for outside learners.[27]

[25] Ibid.
[26] Ibid.
[27] Ibid.

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Kuhlase[28] emphasised the importance of both formal and informal education for societal and economic development. He highlighted the need for maritime awareness and skills development in South Africa, particularly in previously disadvantaged communities through funding establishing maritime skills centres in those communities.

In a 2018 article for Safety4Sea,[29] the editors highlighted the skillsets that will be required, together with the types of jobs for which there is now increasing demand. These include ship automation specialists, cybersecurity specialists, 3D printing technicians, energy efficiency optimisation specialists and data protection specialists.

In KwaZulu Natal, the ports of Durban and Richards Bay have been the centre of maritime-related activities. Employment opportunities have thus been linked to urban areas. The Centre for Education Policy Development (CEPD) Booklet on Education (Gardiner, 2008),[30] referred to the historical background of urban versus rural development and the corresponding educational differences and difficulties. Traditionally, under the apartheid dispensation, the urban areas were reserved for the development of the white population, while rural areas were reserved for the black majority. The education systems were unequal, with the white population being groomed for gainful employment opportunities, while the black population were doomed to suffer from inadequate access to opportunities, greater costs of accessing mostly urban-based employment opportunities and much lower education and skills levels.[31]

A 2019 study by Du Plessis and Mestry[32] on teachers in rural areas addressed the issue of rural education in greater detail. At the heart of the survey lay the question of whether the current educational policies adequately address the inadequacies of rural education. Despite the time frame between the CEPD report and this 2019 study, the status of rural education was still poor. Contributing factors, according to Du Plessis and Mestry, were the following:[33]

- The difference between the administration, governance and attendance of school governing bodies in rural and urban areas. Urban parents generally had a greater understanding of school processes and paid more interest to the schooling of their children. As the role of the school governing body is policymaking and governance, affluent parents were more likely to contribute towards the schooling of their children and the needs of the school, especially in private and semi-private schools. Within the rural areas, meetings were mostly attended by grandparents and, where parents attended, many were not well educated. Without an understanding of the role that they were meant to play in these bodies, the vision of the schools would be left to a school principal.
- Because many educators viewed teaching in rural areas as being detrimental to their careers, younger, more ambitious teachers chose not to work in the rural areas. Conditions and pay in urban areas were deemed to be better. Rural schools were generally understaffed, with average class sizes of 45 or more leaners. They also found themselves teaching multiple subjects over different grades. Their increased workload, combined with lower pay, affected teachers' ability to properly attend to their lesson preparation and their learners. The quality of training received by teachers placed

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[28] PM Kuhlase 'The importance of maritime education and training within the secondary education system in South Africa' (Unpublished Master's dissertation: World Maritime University 2020) (available from: <https://commons.wmu.se/cgi/viewcontent.cgi?article=2449&context=all_dissertations>).

[29] Editorial Team (Safety4Sea) 'Drivers of the 4th Industrial Revolution in maritime industry' *Safety4Sea* 17 September 2018 (available from: <https://safety4sea.com/cm-drivers-of-the-4th-industrial-revolution-in-maritime-industry/?__cf_chl_jschl_tk__=pmd_iagP9SSrFUiYOWP.tYDiUMPB5PYIJHFgmKun1uYbwVk-1633516624-0-gqNtZGzNAiWjcnBszQhl>).

[30] M Gardiner 'Education in Rural Areas' (2008) 4 *Issues in Education Policy* Center for Education Policy Development, Layout 1 (saide.org.za) (available from: https://www.saide.org.za/resources/Library/Gardiner,%20M%20-%20Education%20in%20Rural%20Areas.pdf.).

[31] Ibid.

[32] P du Plessis & R Mestry 'Teachers for rural schools—A challenge for South Africa' (2019) 39(1) *South African Journal of Education*.

[33] Ibid.

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an additional burden on learners. Older teachers were trained under the old, segregated training systems, unlike younger teachers who received their training at universities or integrated teaching colleges. It was also difficult to attract teachers of science, technology, engineering and mathematics (STEM) subjects and other professionals to rural areas. Rural teachers often taught subjects they had not specialised in. There was the additional challenge of learners not wanting to engage in these topics.

- Practical issues such as lack of amenities, up-to-date equipment, access to water and electricity, and internet connectivity all affect the quality of education within the rural areas. An additional challenge was the lack of access to computers. Within many schools, insufficient security enabled computer theft.
- The language barrier was deemed to be one of the biggest obstacles. Prior to Grade 3, learners are taught in English; from grades 3 to 7, there is the option of dual language tuition and from grades 8 to 12, there is mother tongue tuition. When English is taught by non-mother tongue speakers, and learners return to homes where parents or grandparents do not speak English, their foundational training is impacted. This hinders their schooling career, resulting in learning frustration and underperformance in later years.

The Department of Basic Education's Action Plan to 2024: Towards the Realisation of Schooling 2030[34] confirms the Du Plessis and Mestry's[35] survey findings. According to this report,[36] although KZN has improved its educational status, these changes are mostly limited to urban areas. Rural education remains problematic. Audit findings included the following:

- Just under half of South Africa's school learners do not earn their National Senior Certificate (NSC). If this figure is stable over 10 years, that would mean that about half of job seekers within South Africa are unskilled, without a Grade 12 pass.
- With regard internet usage, in 2017 access by principals, teachers and learners to the internet in secondary schools was 68%, 59% and 21%, respectively. In primary schools, the figures were slightly better at 72%, 66% and 36% respectively. The 2016 Community Survey of Stats SA[37] indicated lower figures, namely that 7% of learners at the primary level – grades 1 to 7 – and 9% at the secondary level – grades 8 to 12 – had access to the internet at their schools.
- Currently, around 10% of public school Grade 12 learners attend schools where no learner achieves a mark of 50% or more in mathematics and physical science. Around 2% of public-school learners are in schools where no one takes mathematics as a subject, while the figure for physical science is 5%.
- KwaZulu-Natal displays a below-average traditional pass rate.

With the status of education as it is, the skills gap in KwaZulu-Natal is unlikely to be bridged without radical reform of the current rural education system. The NDP seeks to target 450 000 university-level NSC passes by 2030 in South Africa. Of learners with a university-level NSC pass, it is likely that a small percentage will study science and mathematics courses because few will be qualified to do so.

VIII RESEARCH RESULTS

This section of the report presents the feedback from the survey conducted. Employers of maritime-related firms in Durban and Richards Bay, the maritime centres of KwaZulu-Natal, were interviewed.

[34] Department of Basic Education (DBE) *Action Plan to 2024: Towards the Realisation of Schooling 2030* (Pretoria: DBE 2020) (available from: <https://www.education.gov.za/Portals/0/Documents/Publications/Sector%20plan%202019%2015%20Sep%202020.pdf?ver=2020-09-16-130709-860>).

[35] Du Plessis & Mestry op cit note 32.

[36] DBE op cit note 34.

[37] Statistics South Africa *Community Survey 2016* (Pretoria StatsSA 2016) (available from: <https://www.statssa.gov.za/?page_id=6283>).

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Depending on the size of the firm, participants were either human resources (HR) managers, company owners or operations managers as these groups of respondents were deemed to be most able to respond to the survey questions. Of the 44 firms surveyed, 12 employed more than 250 people, five employed between 50 and 250 people, 11 firms employed between 11 and 50 people and 16 firms employed 10 or fewer people. The distribution of firms was well balanced in terms of business since, enabling data to be collected from micro, small, medium and large firms. Participants from all of the 44 participating firms answered all the survey questions.

The types of skillsets, attributes and qualifications most desired by these maritime-related firms are displayed in Figure 2.

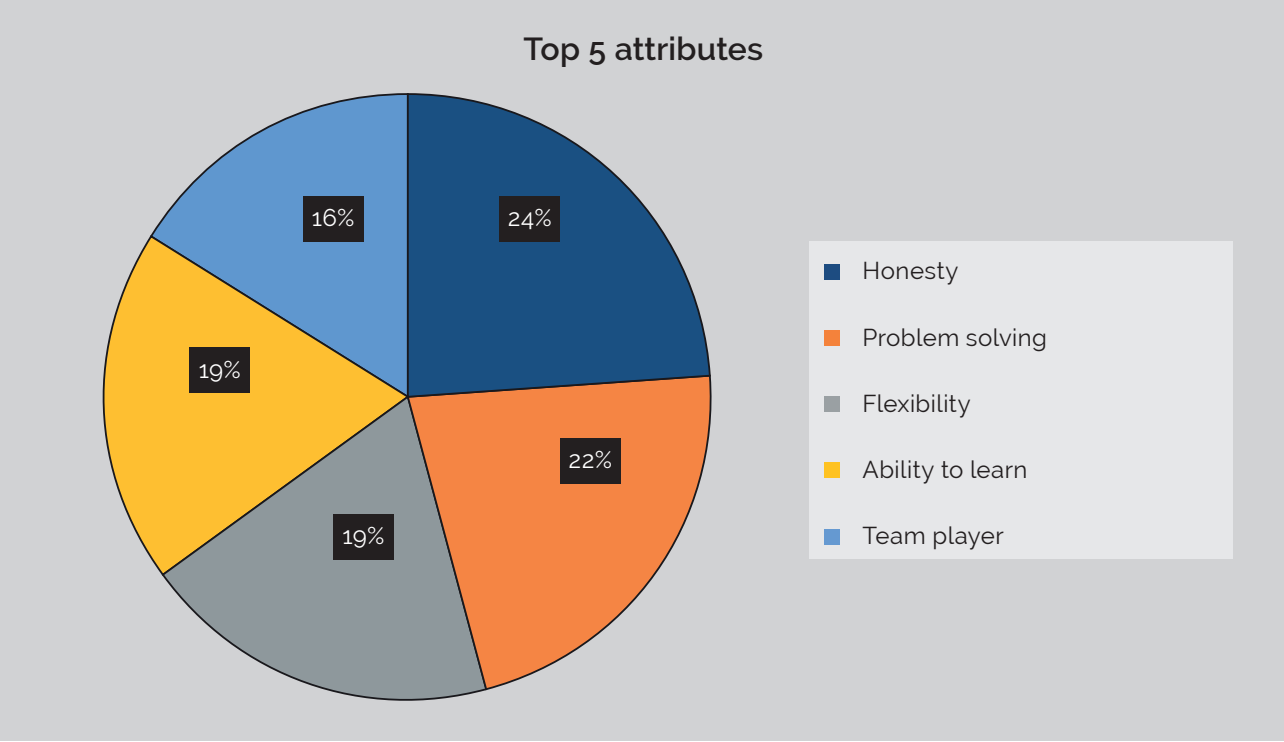

Figure 2: Top Five Attributes Most Desired by Businesses

The purpose of this question was to determine whether the requirements of South African firms aligned with the changing requirements of global maritime employers.

With regard the importance of IT skills, 24 companies said they were very important, 13 said they were moderately important and only seven companies said that they were not important (Figure 3).

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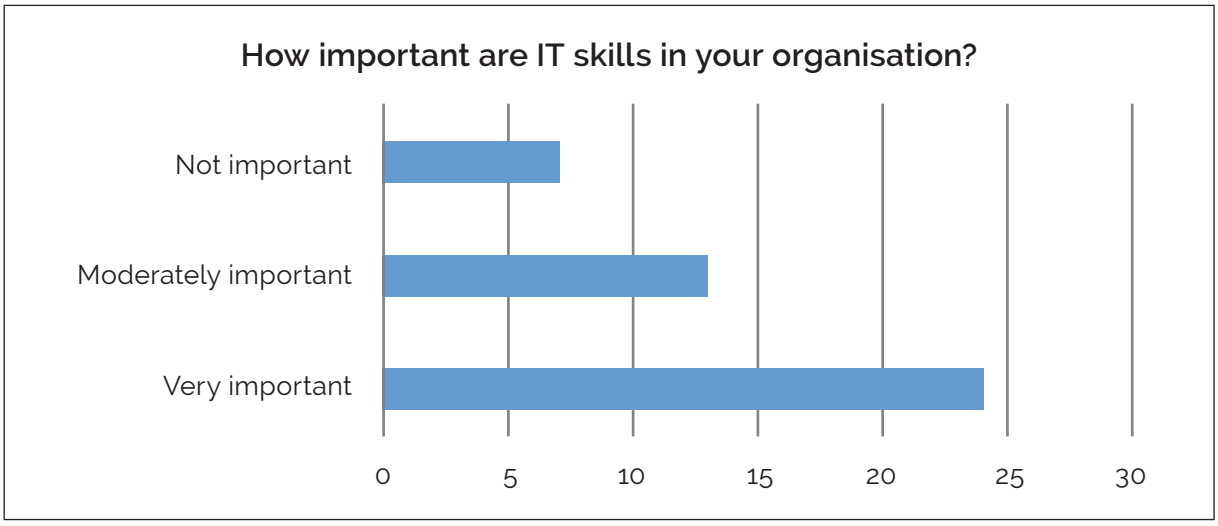

Figure 3: The Importance of IT Skills in the Organisation

Figure 3 illustrates the importance and relevance of IT skills in the various organisations.

On the question of whether the firms employed learners without experience, 27 firms said that they did, while 17 indicated that they did not employ learners. This is a worrying response because it means that more than a third of the maritime firms are closed to new entrants and would not employ inexperienced new job seekers. Employment by the firms was subsector-specific, with firms seeking experienced employees.

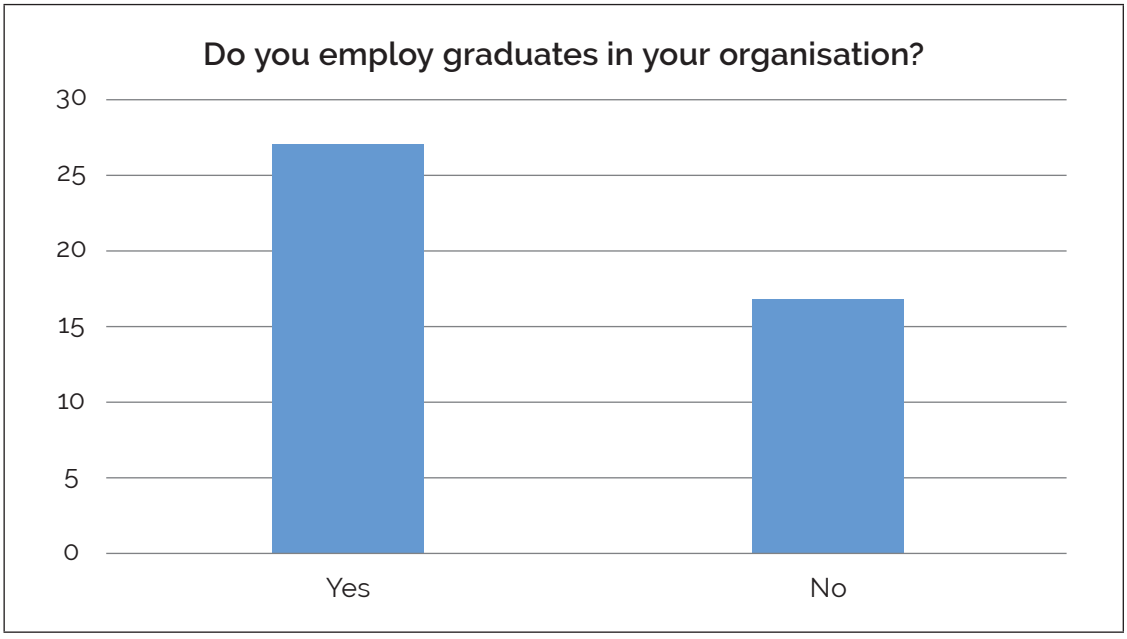

Figure 4: Employment of Graduates in the Organisation

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Figure 4 illustrates that the majority of organisations (27 of the 44) employ graduates with no working experience.

Of the firms surveyed, 26 had in-house training academies. This is a welcome insight as it means that these firms could facilitate the development of desired skills in-house.

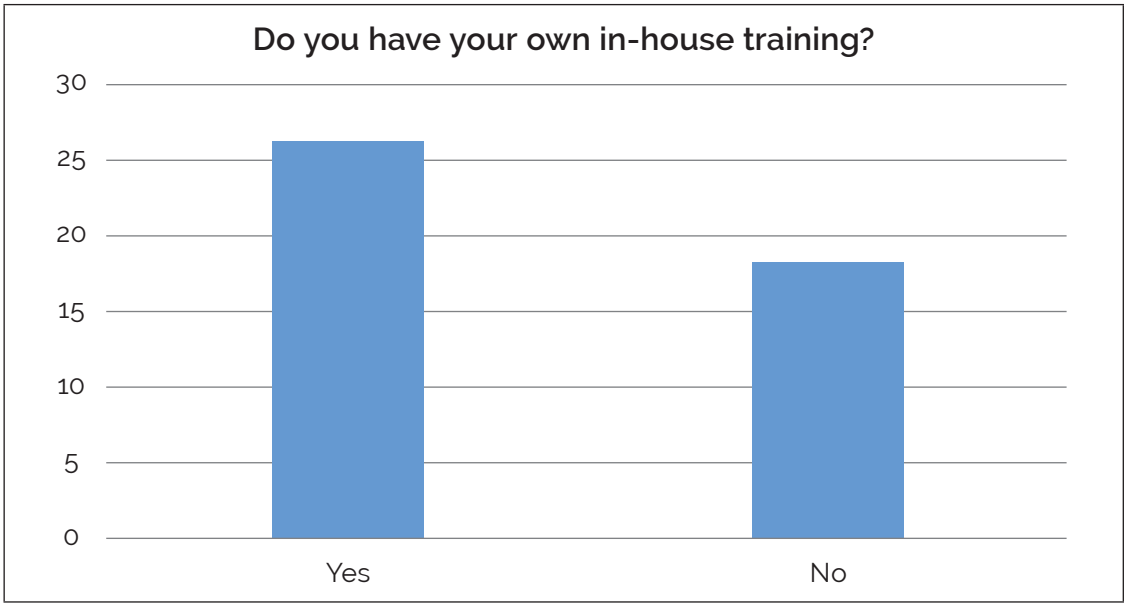

Figure 5: Number of Organisations That Have Their Own In-house Training

As illustrated in Figure 5, most of the organisations have their own in-house training that they offer their employees.

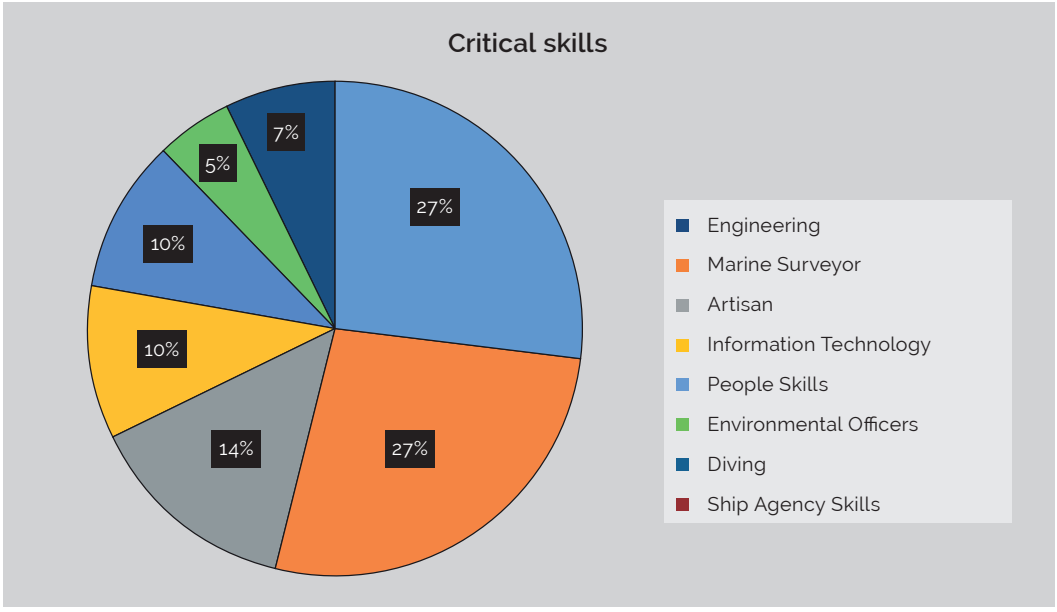

Figure 6: Critical Skills in the Maritime Industry

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As indicated in Figure 6, marine surveying skills, engineering skills and artisan skills are highlighted as the top three scarce skills within the current labour force. These skills are required throughout the maritime sector, except for the maritime skills and training sector.

A number of skills are deemed essential to the success of maritime companies. As most maritime firms surveyed had multiple departments, the skills that are deemed essential overlapped. In many of these firms, management-related skills were also highlighted. As most of the firms were involved in either shipping and logistics, freight forwarding or shipbuilding and repairs, there were many elements that they had in common. As indicated in Table 2, support functions were deemed as important as direct functions.

Table 2: **Skills Essential for Company Success**

Skills directly related to company mandate	Support skills
Drivers, mechanical, environmental officers, research, cargo surveyors, marine engineers; safety and quality officers; artisans (carpentry, welding and painting etc), stevedoring, deck officers, diving, STWC/port ops, ratings, nautical supps, freight forwarding, clearing and forwarding.	IT supply chain planning specialist, logistics operations specialist, operations manager, warehouse managers, transport manager, sales and marketing, customer service, technical skills; communications, technical superintendents, discharge advisors, contract managers, crewing & HR, finance, legal, fleet operations, procurement, finance, commercial manager, marketing; knowledge management.

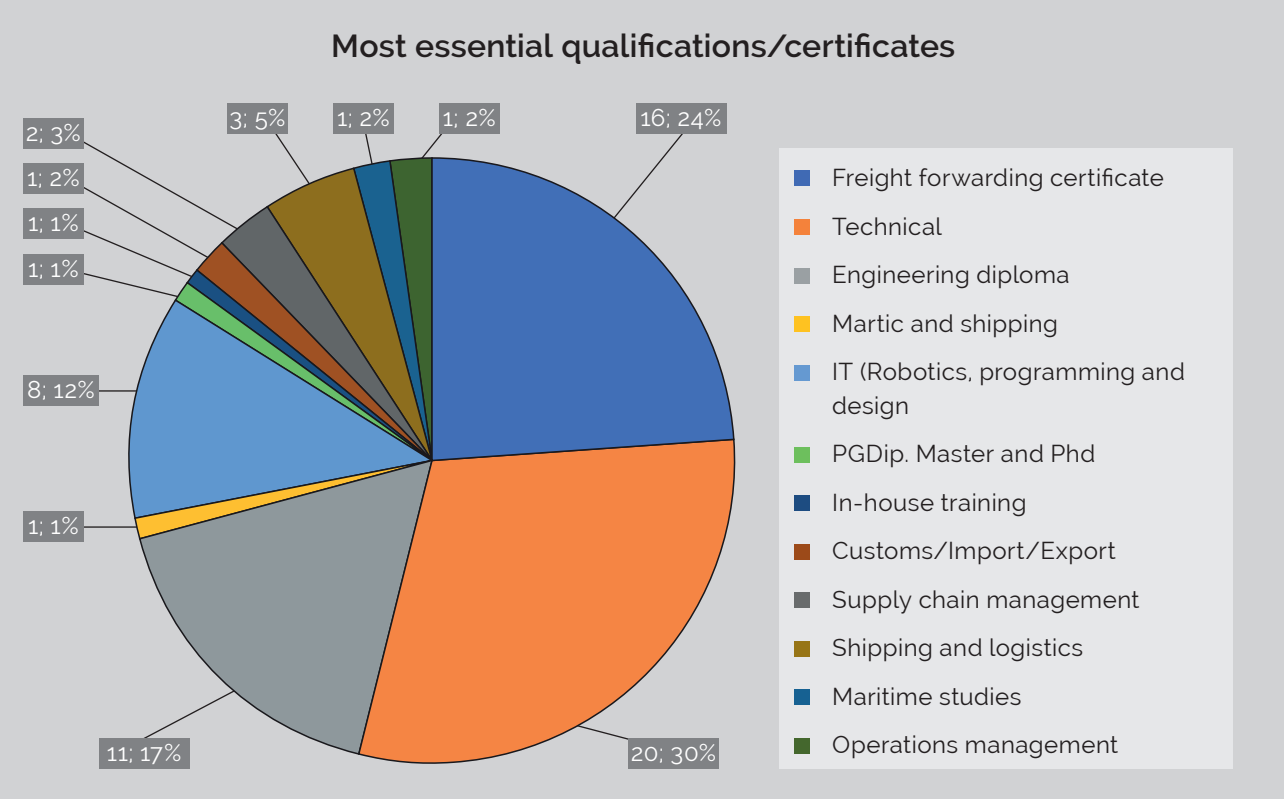

Figure 7: Most Essential Qualifications/Certificates

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Figure 7 indicates those qualifications deemed most relevant to the industry. The percentages obtained are directly related to the number of respondents in the different sectors. Within the freight forwarding sector, freight forwarding certificates were required. Freight forwarding firms also required technical certificates, although these were required across most sectors. Engineering qualifications were also required across multiple sectors. Of the companies surveyed, fifteen required internationally recognised training.

The skills that participants deemed to be of increasing importance to the growth of their companies include the following:

- IT
- Data engineering
- Shipping background
- Mariners' technical insurers
- Project management, financial and budget management, marine and mechanical pipefitting
- Sales and marketing, business development and business planning, warehousing – technical
- marine manufacturing, fish farming, technology
- Forwarding controllers, customs brokerage, and invoice clerk
- Research
- Logistics and management
- Personal development in terms of upskilling
- Experience and understanding of vessels
- Entrepreneurship skills, more international language such as Swahili, French and Portuguese, etc
- Artisans
- Tanker, mooring masters, diving
- Freight forwarding
- Diving, operators (machinery), technicians
- Global logistics and freight forwarding viewpoint.
- Black skippers
- Environmental sensitivity mapping and economic evaluation
- Welding, bronco cutting and dredging
- Leadership, analytics, controlling
- Both deck and engineering officers
- Ships agency skills
- Customer service
- Chief marine engineering officers, chief dock masters

Skills such as IT, data engineering, management and sales, and other support-related skills were required across the maritime sector. Other skills, such as crewing and black skippers, are specific to the shipping and logistics sector. The freight forwarding sector deemed communication essential, with firms seeking multilingual employees.

A number of soft skills and attributes are sought by maritime firms. Within the shipping and logistics sector, communication was emphasised. Employees were also required to have high levels of emotional intelligence. The main soft skills required are:

- Level-headedness, dedicated and able to follow procedure

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- Communication
- Understanding of logistics supply chain
- Strong personality
- Patience, flexibility and dedication.

Table 3 lists the different types of training offered by the organisations. These results address the third objective of the research, which was to identify the current training offered. Some maritime firms prefer to train their own employees. The training obtained in-house may not necessarily be available in the mainstream education sector.

Table 3: Types of In-house Training Provided by the Industry

Sector/department	Skills and training programs offered by the maritime industry
The shipping logistics and shipbuilding and repair sector	Work learnership programmes Shipping, logistics – warehousing, transport operations, clearing and forwarding, port and stevedoring operations, sales and marketing, logistics administration Boat building, entrepreneurship Safety, procedure in accident reporting, first aid Introduction to shipping through the Institute for Chartered Shipbrokers ICS Company/industry-specific hospitality-related programmes. Cadetship for deck and engine, rating learnership, dive trainee programme, Courses offered to students. These provide access to vessels for on-board work and exposure to port authority Set programmes with marketing, communication skills, introduction, and exposure to the logistics sector
Legal firms	Contract chains, maritime background, litigation
Projects based on scarce skills identified by the sector	Artisan recognition of prior learning ARPL–SAMSA courses Apprenticeships in fitting and turning, mechanical fitting, boiler making, welding, pipe fitting, plumbing and electrical
Maritime education sector	The University of KwaZulu-Natal has a Maritime Law and Maritime Studies Unit.
Freight forwarding sector	Learnership in freight forwarding. Customs clearance, transport management
Other/across sector	Basic commercial diving skills Internship, cadetship and maritime study bursaries. Maritime survey Port state Bunkering Oil spill response Deck and engineering cadetship for seafarers Technical skills, engineering skills

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IX ASSESSMENT OF RESULTS

The results portrayed in the tables and figures, especially tables 2 and 3 and figures 5 to 7, align with the information obtained from the literature review. Survey results indicate that there is still a lack of skilled labour in the basic maritime portfolios. Because domestic employers have not yet fully embraced the digital revolution, many of the global digital portfolios are not yet required by domestic firms, although survey results indicate a move towards more digital skills, like 3-D printing and IT. it is also clear that many skills deemed critical by the maritime sector, apart from robotics and officer training, are available for study at most tertiary learning institutions. The qualifications required by the maritime sector are available either through tertiary institutions or in-house training. The maritime industry places as much importance on support functions as it does on core functions and skills. Support functions required include managers as well as people with a deeper understanding of the shipping industry.

Most support qualifications can be studied at universities or technical vocational education and training colleges. The survey also highlighted the importance of soft and leadership skills within the sector. While some of these characteristics are taught, attributes such as honesty, flexibility and ability to learn are not. Other important soft skills are people skills, communication skills and language skills. These, too, are based on innate ability and character, although they can be trained.

Although not all job categories require STEM subjects, there is an increasing trend towards technology, science and engineering. An objective of the study was to determine critical skills, essential skills and the skills that are becoming more important. In-house training provides for some of the needs of the maritime sector that are neglected by the mainstream academic sector. Boatbuilding and artisan or technical skills are the least catered-for skills segments. Other neglected areas are maritime law, commercial diving, navigation, maritime engineering and ship building and repair. There is a clear gap between understanding the industry and its needs and the preparation of students for potential employment in the industry. The maritime sector may be deemed to be too small to be catered for on a larger scale. The lack of educational capacity could also be due to the lack of interest in the sector by potential employees, who are steered towards more mainstream jobs or more popular areas within the maritime sector.

The overall purpose of the study was to determine the bottlenecks in the current system. The first objective was to determine the areas of education and geographical skills shortages. The research area included the King Cetshwayo, uMkhanyakude, iLembe and Ugi Districts of the Eastern Cape. The literature reviewed uncovered a rural–urban education and skills gap. Most maritime-related firms are found in the urban areas, as are the training institutions. Rural learners struggle to transition into the job market because of a lack of the required skill sets. The transition gap is directly linked to the quality of rural education. Communication skills, especially good English and other language skills are lacking in rural and some urban schools. These communication difficulties impact negatively on the ability of youth to find employment in the urban maritime context. Without exposure to STEM education, they are deprived of the opportunity to enter many maritime professions. This is an unfortunate reality for 59% of KZN's rural youth. Learners attending semi-private or private schools are in a better position, as they can acquire the skills needed for the relevant maritime qualifications The Operation Phakisa: Oceans Economy mandate seeks to include rural populations into the maritime value chain. Given the obstacles that the rural population faces, policy initiatives must begin with the upgrading of rural education. As these challenges are deeply entrenched, they cannot be overcome overnight. Additional challenges are linked to connectivity, cost of data and electrification in schools and houses. There are many challenges in rural areas and, without proper government assistance, they will be difficult to overcome.

As the maritime industry, schools and universities are primarily urban, it is difficult to incorporate rural populations into the maritime value chain. While rural students can migrate to urban areas for tertiary education, the statistics are not promising. The available literature indicates that learners who obtain

https://doi.org/10.47348/SAJMET/2023/i1a3

mathematics- and science-based university-level matric passes are few in number. A better option would be for learners to obtain artisan or technical training. There are, unfortunately, few institutions offering technical training. An issue seldom raised is the cost of education. As many qualifications are specialised, they are costly. Industry is unlikely to pay for the cost of learner training unless they can obtain bursaries. Even where aid is available, there are restrictions and limitations. Within the SETA category, learnerships usually require pure mathematics. Given that almost 51% of rural learners do not pass matric, the future is even bleaker. From the survey and the literature review, it can be concluded that learners from urban areas with access to practical STEM training and with good communication abilities are the most likely to be absorbed by the maritime industry.

X CONCLUSIONS

Conclusions that can be drawn from the above include the following:

- Except for the identified areas, the current tertiary education sector can provide most of the skills required by the maritime sector.
- The skills deficit appears to be related to a lack of interest of graduates in maritime career paths.
- Four of the eight areas identified as critical require that learners are proficient in STEM subjects.
- The maritime sector is practical and requires skilled or semi-skilled employees. It cannot be relied on to absorb unskilled labour. Even though many maritime firms do train in-house, this training is basic, with employees expected to invest in their own training and become lifelong learners.
- Awareness of the maritime sector is highest in the port cities of Durban and Richards Bay. The rural areas are less likely to invest in maritime skills education. The biggest education failure can be attributed to the schooling system, especially within the rural areas, where STEM subjects are lacking.
- There is a scarcity of managers Reasons for this lack will need to be investigated.

XI RECOMMENDATIONS

1. The training of rural populations and the extension of maritime skills is linked to the entrenched issues of poverty, unequal schooling and other administrative failures. Overcoming these issues requires radical government intervention. The process of eradicating structural issues must be accelerated. Factors such as connectivity, electrification, provision of water to schools and changing school body governance approaches in rural schools and rural areas can provide short-term victories.
    - Electrification and connectivity: The pre-paid payment system in rural areas has made access to electricity easier. There are, however, still areas without such access to electricity. Rural areas are known for their poor telephone connectivity. While optical fibre is being laid in the urban areas, few rural areas have benefitted from this. While this could be linked to a lack of financial incentives, it remains substantially unjust. Even though the urban areas call forth greater investment, the rural areas need more intense interventions. For this reason, it would be reasonable to suggest that the government put together a subsidy or tax incentive package to encourage optical fibre companies to extend their reach into the rural areas to encourage economic development.
    - Access to water is another major issue. To assist, the government could provide boreholes, were this is feasible. Other options are rainwater harvesting at the schools and creating dams.
    - To deal with the school body administration problem in rural areas, government could make provision for an alternative governing approach. As rural parents struggle to shoulder the responsibilities placed on urban parents, a grading system can be introduced to evaluate the level of intervention required. This same system can be used to prevent misuse and provide for the graduation of rural areas to the acceptance of greater responsibility.
2. The development of artisan training centres in the rural areas to provide alternatives for rural school learners. This will provide them with access

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to both mainstream industry and the maritime sector. Artisan training is not only needed in the rural areas, however. More research is needed to determine why there is this lack and how this education and training gap can be addressed. With regard the scarcity of available skills, where possible there is a need to align the requirements of the maritime industry with education centres in surrounding cities. This can be done by way of awareness training and skills development planning within industry and the education sector.

3. The need for linguists is not often stressed, however, language learning is also something that can be encouraged in learners in both the rural and urban areas. As global trade increases, this is a skill that could provide learners with opportunities outside of the normal value chain and enable them to travel. There is also a need for educators to address the development of soft skills in learners from an early age, with learning packages being introduced that facilitate attributes like people skills, honesty, teamwork, adaptability and problem-solving. Given that future employees will need to be adept at both learning and interpersonal skills, the education system must adapt.

XII CONCLUSION

The skills required by the maritime sector are diverse, including technical, technological, scientific and engineering categories. Although there are many overlapping skills, there are also many sector-specific training requirements. The need for both domestic and international training, together with the fact that some segments of the maritime sector do not take inexperienced employees, makes it a difficult sector to penetrate. The fact that employees are required to be skilled or semi-skilled means that new unskilled entrants are not easily absorbed, although the learnership programmes provide some hope for young school leavers. Besides specialised shipping qualifications, there is also room for operations and supply chain management practitioners. Companies are also looking for honest employees, with ethics being important to the industry. Because of the complexity of the industry and the challenges facing learners, there are no quick fixes. Time and development will assist with the elimination of the skills crisis, if the correct measures and interventions are consistently adopted and rural learners are given the attention they deserve.

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Leticia Grimett

Sihle Mzileni

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Smart Ports: Is SADC positioned for Transition?

Leticia A Grimett‡

ABSTRACT

Whereas international trade was previously the preserve of organised business, the digital revolution and the increased popularity of online purchases on the internet has meant that international trade is now easily accessible at an individual level. At both a domestic and international level, the Covid-19 crisis amplified the pressure placed on businesses and consumers to adopt digital technologies, and this has been catalytic in moving the public towards greater reliance on online transactions and a movement away from traditional purchasing practices. Increased global trade at an individual level has put greater pressure on global supply chains, with every link in the supply chain being called upon to perform more effectively and efficiently. Ports, as gates of entry into domestic markets and transshipment routes, have been under increased pressure to conform to the needs of the international trading community.

Greater trading volumes have put ports at risk of higher levels of crime by international and domestic criminal syndicates. The changing environmental landscape has meant that ships are being transformed for compliance purposes. Increased concern about water quality and impacts on sensitive habitats has put additional pressure on port authorities. These pressures have led to the creation of smart ports, which are fully automated, taking advantage of the latest technologies, blockchain and artificial intelligence (AI), and state of the art monitoring software and processes, while adhering to and promoting compliance with both the latest environmental protocols and the United Nations (UN) 2030 Sustainable Development Goals (SDGs).

In this contribution to the conference, the discussion centres on the challenges facing ports in the Southern African Development Community (SADC) region, in the light of the latest global developments. Smart ports and the drivers towards greater changes are discussed and analysed. Finally, the state of ports in the SADC region are evaluated in the light of the latest global developments in order to determine whether our ports are prepared to transition and changes that can be made to facilitate the process.

Keywords: port development, smart ports, transformation, generations of ports

‡ Honorary Research Fellow at the University of KwaZulu-Natal School of Law, South African International Maritime Institute.

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I INTRODUCTION

Change is often driven by need and inescapable circumstances, and the movement towards the establishment of smart ports is no exception. Global trade has been both a catalyst for and a beneficiary of increased technological breakthroughs. It has also, unfortunately, been a major contributor to the climate change crisis. Shipping companies are known to contribute towards increased carbon dioxide (CO_2), nitric oxide and greenhouse gas (GHG) emissions, spillage of fossil fuels and hazardous waste, as well as waste matter, thus polluting the marine environment.[1] Ships at port are also responsible for air pollution, which affects both the surrounding communities and the sensitive marine ecosystems surrounding the ports.[2] The needs of multinational companies have facilitated the speedy development of both the supply chain sector, risk management policies and legislation, as well as information technology (IT) and data management breakthroughs, and the use of artificial intelligence to expedite manufacturing processes and secure data management systems, amongst others.

Increased trade volumes have placed greater pressure on ports to perform more efficiently and effectively.[3] In addition to their gateway function, ports are also customs access and exit points, with government agencies facing additional pressures to their normal customs functions. As the 9/11 terrorist attack clearly indicated, increased global trade has provided more opportunities for criminal syndicates and terrorist cells to move contraband, weapons and illegal animal and human cargoes.[4] The endogenous and exogenous pressures placed on ports and the competition faced by governments, with the fast-changing balance of power between western and eastern ship owners, together with more stringent trade, shipping and supply chain regulations, has led to the rise of the smart port.[5] In this paper, smart ports will be defined and the many elements influencing their adoption will be explained. Against this backdrop, the development of the ports of Maputo in Mozambique, Walvis Bay in Namibia and Durban in South Africa will be discussed and analysed to determine whether they are positioned to take the next step to transition successfully as smart ports.

II THE TRANSFORMATION OF PORTS

The Collins Dictionary defines a 'port'[6] as a harbour where goods or passengers are loaded or unloaded. Although this definition describes the basic activities at a port, it can hardly be relied upon to adequately describe the many aspects of modern ports. With time, the functions of ports have changed and evolved, with each successive generation fulfilling a new role.

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5 Public–Private Infrastructure Advisory Facility (PPIA) *Port Reform Toolkit* Modules 1 and 2 2 ed (Washington, DC: World Bank 2007) (available from <https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/Portoolkit/Toolkit>) at 5.

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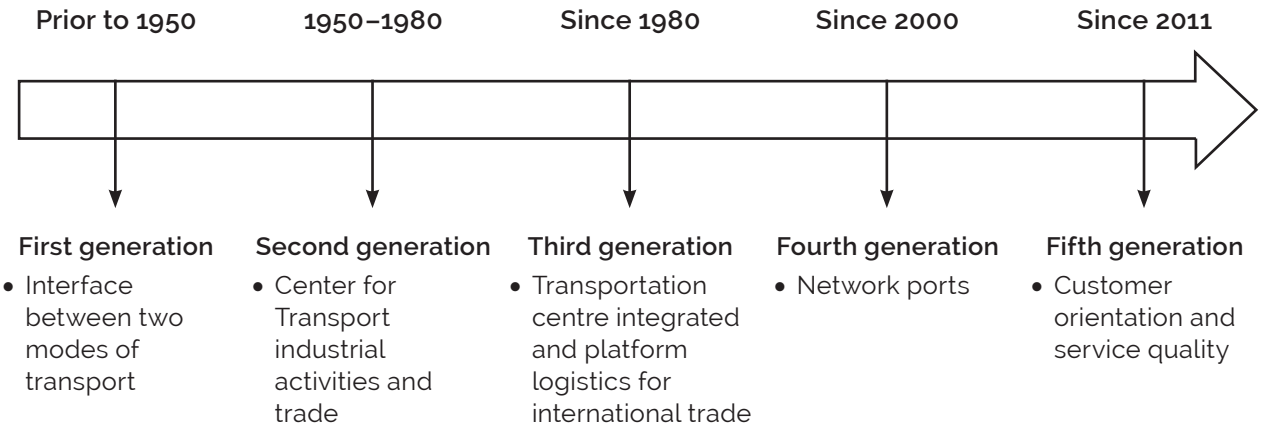

Figure 1: The Five Generations of Ports[7]

The Public-Private Infrastructure Advisory Facility (PPIA) and World Bank Toolkit[8] refers to three main forces driving port reform. These are:

- External forces of competition and technology from the shipping industry
- The acknowledged financial and operational benefits of private participation in infrastructure development and service delivery
- The diversification and globalisation of investors and operators in the port industry.

The first force has driven the need to restructure port operations to deal with the external factors affecting port viability. These include national competition for global markets, changes in port and transport technology, and increased competition among ports.[9] The impact of technology on ports has become a powerful differentiating force between ports and radically increased the ability of ports to perform. The fourth industrial revolution (4IR) technologies, such as AI, the Internet of Things (IoT), cloud, big data and blockchain, are common modern smart port technologies.[10]

According to an ALG newsletter,[11] the following elements are the basis for smart ports:

Industrial IOT and blockchain:

- Blockchain integration
- Private LTE networks
- Wireless control
- Integrated sensors

Automation:

- Self-driving vehicles
- Automated cranes
- Interrmodal transfers
- Autonomous vessels
- Drones for prearrival inspection

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7 A Hlali & S Hammami 'Seaport Concept and Services Characteristics: Theoretical Test' (2017) 11(1) *The Open Transportation Journal* (available from: <https://benthamopen.com/FULLTEXT/TOTJ-11-120/>).

8 PPIA op cit note 5 at 4–8.

9 Ibid at 5.

10 Transport Connectivity and Logistics Section, Transport Division *Smart Port Development Policies in Asia and the Pacific* (Bangkok: United Nations Economic and Social Commission for Asia and Pacific (UNESCAP) 2021) (available from: <https://www.unescap.org/sites/default/d8files/event-documents/SmartPortDevelopment_Feb2021.pdf>) at 15.

11 ALG 'The Future of Ports: How to Stay Competitive' *ALG Newsletter, Shaping the Future* (n.d.).

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Artificial intelligence:

- Real-time berth planning
- Predictive maintenance
- Automated yard planning
- Demand planning at the gates

Sustainability:

- Integrated renewable resources
- E-mobility market
- Quay to vessel power
- LNG/electric vessels

The costs of these technologies have increased the cost of efficient performance, rapidly altering the competitive landscape. Port models developed in the 19th and early 20th century were simpler and had many drawbacks.[12] However, these models significantly constrained ports from competing effectively on a service quality basis, limited their agility and market responsiveness in mobilising resources, and constrained their ability to share risks with private sector partners. As many of the challenges facing modern ports had not been envisaged, the models for port development were appropriate for the period in which they were developed. In planning how responsibility for future port development and operations will be divided, policy makers now have the option of both public sector and private sector participation. In deciding on desired levels of investment to be funded or guaranteed from public sources, policymakers must increasingly weigh the competitiveness of their port(s) in relation to other ports in their region and, in comparison, to the supply chain alternatives available to their users. These alternatives are now more abundant than they were 15-plus years ago. The port business is therefore more competitive now than it was prior to the 4IR. New institutional models are therefore needed for this new era of increased competition.[13]

The second force generating momentum for reform is private sector participation in infrastructure and superstructure development. In this era of decentralisation, many sectors that were protected by governments have been outsourced to the private sector. Governments and lending agencies have come to acknowledge that private sector participation can be a powerful force for enhancing the performance of port assets, as with other infrastructure assets. National and regional seaports have accepted that they cannot compete effectively without the efficiencies offered by private operators and without access to capital provided by private investors. There has thus been a steady increase of private sector participation in port operations around the world. Countries with recent experience of port reform include Argentina, Brazil, Canada, Chile, China, Colombia, Egypt, Estonia, Germany, India, Indonesia, Japan, the Republic of Korea, Latvia, Lithuania, Malaysia, Mexico, Mozambique, Nigeria, Oman, Panama, the Philippines, Poland, Russia, Tanzania, Thailand and the United Kingdom. In addition, the pace of private investment in the sector is accelerating.[14]

The third force affecting reform is the development of a global market for port development services. Each specialised niche contains several international companies that offer specialised service capabilities. The sector contains four groups of operators:

1) The first wave comprising of 'global stevedores', the first to have expanded their operations internationally from a strong home base.
2) The second wave comprising regional operators now entering the international market following the success of their predecessors.
3) Shipping lines investing in terminals.
4) Niche investors looking more specifically at small- to medium-scale facilities.[15]

In addition to providing core port services, ports are increasingly delivering nontraditional services to their

[12] PPIA op cit note 5 at 6.
[13] Ibid.
[14] Ibid.
[15] Ibid at 7.

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customers. These nontraditional services have expanded the role of port service providers in the supply chains of shippers and create value for shippers by expanding the scope of markets they can economically access by reducing the delivery cost of products they sell, or by reducing the cost to complete buy/sell transactions. Ports can now participate in specialised port service niches and differentiate themselves from other more traditional ports.[16]

In addition to the changes afforded to the operational port functions, modern ports are under pressure to conform to global operational standards on risk management, supply chain management and environmental standards. The level of pressure depends on the stringency of the regional laws and the level of development of the countries involved, as well as their level of commitment to the net zero targets of the Paris Agreement on Climate Change. Countries within the European Union are moving at a rapid pace to ensure that both their ports and their ships are environmentally compliant.[17] Where ports are extremely busy or situated close to cities, fishing waters, ecologically protected areas or within rivers, there would be greater pressure for them to conform to standards as the risks and pressures facing the ports, rivers and cities are greater.

The development of ports would therefore, to some extent, be related to the pressures which they face and their commitment to change, as well as the access to capital required to ensure that these changes are made and maintained. In addition to regional challenges, there are the global commitments by governments to the UN SDGs to which 185 UN member states bound themselves to implement and uphold in 2015.[18] These 17 SDGs aim to support environmental preservation, economic development and social integration, and to improve the quality of life for the present and future generations. The International Association of Ports and Harbors (IAPH) launched the World Ports Sustainability Programme (WPSP) in February 2019 to integrate the SDGs into the business strategies of and governance by port authorities, and help align them with global sustainability standards. The five WSPS themes are climate and energy, community outreach and port—city dialogue, resilient infrastructure, governance and ethics, and safety and security. With the inclusion of the SGDs, the development of ports cannot be rejected by any forward-thinking government, as all global players are affected by change and committed to being part of the change.[19]

In addition, the World Bank's Port Reform Toolkit[20] provides five factors that are expected to affect future ports:

- Intensifying global competition: Trade and the growing trend towards globalization of production, expanding the geographical scale or logistics reach
- Changing technology: The need for container port productivity improvements, and the growing role of information technology
- Changing distribution patterns: Looking for strategic hub locations. Generating income of a transshipment hub by the double handling of containers. Inland container terminals replace activities from the port to enhance intermodal efficiency
- Increasing importance of environment, safety and security concerns
- Change in the bargaining power of stakeholders due to port changes – consolidation among ocean carriers, and the emergence of a global logistics service provider environment.[21]

Furthermore, a rapidly changing global trading environment, including increasing vessel sizes and cargo volumes, has made it necessary to revise the business

[16] Ibid.
[17] Ministry of Environment (Finland) *EU Climate Change Policy* (European Union 2022) (available from: <https://ym.fi/en/eu-climate-policy>).
[18] UNESCAP op cit note 10 at 13.
[19] Ibid at 14.
[20] PPIA op cit note 5 at 21.
[21] UNESCAP op cit note 10 at 15.

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model (service) and introduce the technological innovation needed to strengthen port competitiveness. Most ports should therefore try to move towards becoming smart ports in order to maintain productivity, customer-friendliness, efficiency and competitiveness.

While it is tempting to see the smart port model as complete, it is important to realise that, together with changing technologies, smart port development is in its infancy and is likely to face even more challenges. The latest 2022 DNV report, *Maritime Forecast to 2050*, looks at the efficiency of alternative fuels and the movement to the use of ammonia as a ship propulsion fuel post 2035.[22] According to this report, the efficiency of these non-fossil fuels is much less than that of fossil fuel. Ships will therefore need to refuel more often. In addition, ammonia needs more storage space than traditional fossil fuels. This will impact both the ships that are running on these fuels and the ports receiving them. Greater refuelling needs will mean greater opportunities for ports to make themselves available.[23] Ports along global shipping routes that would not normally receive ships in transit may now be within the refuelling path of these ships and, if they are equipped, have opportunities to trade afforded them. Because alternative fuel technology is still in its infancy, however, no one can accurately predict the potency of alternative fuels come 2035. Additional to the issue of alternative fuels is the issue of the technology needed to launch and receive automated ships. This will require the technology, resources and appropriate skills. The movement to smart port status is therefore one of continual change and improvement.

III SMART PORTS DEFINED

The fifth-generation smart port has the following five distinguishing characteristics:[24]

(a) smart port services and applications such as vessel and container management

(b) technologies such as data centre, networking and communication, and automation

(c) use of sustainable technology to increase energy efficiency and reduce greenhouse gas emission

(d) cluster management such as a shipping cluster that consists of geographically proximate companies and stakeholders with their main activity being shipping

(e) development of hub infrastructures to foster collaboration among different ports.

In their definition of smart ports, Molavi et al[25] have identified the following domains and subdomains as being attributed to smart ports:

According to Molavi et al,[26] smart ports have the following four domains:

1. Operational domain
2. Environmental domain
3. Energy domain
4. Safety and security domain

The key sub-domains for operational efficiency:

- Productivity: are operations timeous, within budget and according to available space and facilities?
- Automation: Do the control systems (set of devices that manages the behaviour of other devices or systems) for operating equipment with minimal or reduced human intervention operate efficiently?
- Intelligent infrastructure: Is technology, including hardware and software operate efficiently?

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[22] Det Norske Veritas (DNV) 'Energy Transition Outlook 2022: Transport in Transition' (2022) (available from: <https://eto.dnv.com/2018/maritime>) at 55.

[23] Ibid at 57.

[24] K-LA Yau, S Peng, J Qadir, YC Low & MH Ling 'Towards Smart Port Infrastructures: Enhancing Port Activities using Information and Communications Technology' (2020) 8 *IEEE Access* (available from: <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9079821>) at 1–2.

[25] A Molavi, G Lim & B Race 'A Framework for Building a Smart Port and Smart Port Index' (2020) 14(9) *International Journal of Sustainable Transportation* (available from: <https://www.tandfonline.com/doi/abs/10.1080/15568318.2019.1610919?journalCode=ujst20>) at 9.

[26] Ibid at 10.

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The key sub-domains for environmental efficiency:

- Environment management systems (EMSs): is there an EMS to improve their environmental performance and environmental impacts.
- Emissions and pollution control: is there a system in place?
- Waste management: is there a system in place?
- Water management: is here a system in place?

The key sub-domains for energy efficiency:

- Efficient energy consumption: is it possible for direct and indirect energy users to reduce their energy consumption?
- Production and use of renewable energy generated from natural processes: do these resources partially or totally address the port's energy demand and significantly reduce pollution?
- Energy management: are there strategies and systems to make efficient use of the available energy?

The key sub-domains for safety and security:

- Safety management systems: is there a system to administer safety principles in the workplace?
- Security management systems: is there a system to identify potential threats to the port and to develop procedures and then initiate, monitor, review, and maintain them to deal with security risks.
- Integrated monitoring and optimisation systems: are there integrated software and hardware systems to guarantee the port's safety and security?

Using all the elements attributed to smart ports, Molavi et al.[27] subsequently defined a smart port as 'a port having all the elements of a digital port, knowledge port, intelligent port and humane port'. In addition, 'a smart port gathers better-educated individuals, skilled workforces, intelligent infrastructures, and automation to facilitate knowledge development and sharing, optimize the port operations, enhance the port resiliency, lead a sustainable development, and guarantee safe and secure activities'.

The UNESCAP article [28] referred to the Korean Maritime Institute's definition of a smart port. This definition defines a smart port as a comprehensive concept, aiming at automation, logistics optimisation, energy efficiency, eco-friendliness and reinforcement of connectivity with hinter cities by means of process innovation and the introduction of information technologies (IT) such as IoT, AI, robotics etc. This definition aligns with the definition of Molavi et al. We can see from these definitions and descriptions that for a port to qualify as a smart port it needs to be more than technologically proficient and contain elements relating to all four domains listed.

In addition, there are levels of technological proficiency or stages which a port has to pass through before it can be considered to have reached the level of technological proficiency required of smart ports.

Below are the four phases of technological progress which ports pass through before they attain smart port status.[29]

1. Phase 1 – port information:
   - use of paper documents, manual processing
   - less systematic port procedures
   - willingness to transform to a computerised port.
2. Phase 2 – automatic port:
   - paperless transactions by e-documents
   - use of an information system, such as port-EDI (electronic data interchange) and terminal operating systems (TOS) to handle port operations
   - willingness to change semi-automated port operations to fully automated.

[27] Molavi et al. op cit note 25 at 7.
[28] UNESCAP op cit note 10 at 18.
[29] Ibid at 86.

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3. Phase 3 – digital port:
    - construct an automated port using radio frequency identification (RFID), sensors, cameras etc
    - use of port collaboration models such as Single Window, port community system PCS etc
    - willingness to interconnect with other organizations or countries for information sharing
    - Prepare a nationwide logistics masterplan or roadmap for smart ports.
4. Phase 4 – smart port:
    - a fully automated port that uses nascent, automation and innovative technologies
    - digital transformation with the 4IR technologies.
    - the objective is an optimised, unmanned and autonomous port
    - comply with international regulations and/or standards.

IV SMARTPORT DEVELOPMENT IN SUBSAHARAN AFRICA

The development of smart ports is not a phenomenon limited to the biggest, busiest global ports. The changes brought about by global trade and the technological adaptations made throughout global supply chains have meant that all ports must adapt or be left behind. In light of these requirements and developments, the question of transition of the ports within the SADC region is raised. More specifically, the readiness of the ports of Durban, Maputo and Walvis Bay to participate in the global smart port movement is questioned. The answer to this question lies not with the three main ports under discussion, but with an understanding of the dynamics behind the top ten global smart ports, the majority of which are in Europe. According to the Sinay,[30] the world's top ten ports, in progressive order, are the ports of Rotterdam, Hamburg, Antwerp, Singapore, Shanghai, le Havre, Los Angeles, Copenhagen, Valencia and Barcelona. From the list, we can see that Europe is at the forefront of smart port development. What has made these ports unique is their commitment to the SDGs and their incorporation into all aspects of port operations.[31] Be it the Digital Twin at the Port of Rotterdam, complete automation, as in the Singapore Tuas mega port project, or digital sensors and intelligent use of 5G technology and digital systems, the relevant ports have fully integrated environmental and ecological goals into their daily operating systems, ensuring that the cities in which they operate are not negatively affected by port operations.

Commitment to change does not happen in a vacuum, however. The top ten smart ports are among the busiest ports in the world and, with increased global trade, have been pushed beyond their normal capacity. They have had to find methods to improve port operations, increase productivity, decrease port congestion and satisfy all their stakeholders, all of whom are operating under tremendous pressure. The proximity of European ports to each other has meant that shippers have many alternatives to choose from, thus increasing the level of inter-port competition. These ports, as portals to global trade within the region, must answer to their customers, many of whom depend on just-in-time processes to manufacture goods. As vital supply chain partners, port operators have had to align with European and other global multinationals that are already using the most advanced technology to streamline manufacturing, service and administrative processes. The culture of business within these countries has transferred to the port authorities. In addition, the level of skills development and the prevalence of highly skilled labour has assisted the transition and progress of these ports towards their smart port status.

In addition, there are structural efficiencies working in the favour of these ports. Rather than playing the traditional landlord role, these port authorities have long worked in partnership with the private sector to ensure efficient port functions. Not only do ship owners and shipping companies own their own berths at these

[30] Sinay 'Top 10 Smart Ports around the World' *Sinay* 29 June 2021 (available from: <https://sinay.ai/en/top-10-smart-ports-around-the-world/>).
[31] Ibid.

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ports, but service providers work autonomously from and harmoniously with port authorities to ensure the smooth running of port operations and other services. This arrangement assists with the raising of finances, as port authorities have not had to bear the burden of raising finances alone. The fact that these ports are among the busiest ports in Europe, the USA and Asia has meant that they are able to maximise their income and raise funds needed to finance change through port operations. This, in turn, does not put a tremendous burden on governments to invest in port development, even though the port authorities work hand-in-hand with government. At the Antwerp port, the port house, a unique residence for the governing port authorities, is found on the port premises.

The dynamics of the SADC ports are very different. In the South African context, the Transnet Port Authority (TNPA) is the government entity in charge of port operations. In addition, the South African port system still works on the landlord system. The ports of Maputo and Walvis Bay have been assisted by their cooperation agreements between DP World (an international terminal operator) and the national ports administration. This has enabled these countries to leverage international private sector resources for their domestic port development programmes. In preparation for this paper, the port websites for Namibia, Mozambique and South Africa were visited. Much of the information on these websites is for publicity purposes and does not provide in-depth insights into the port processes. More accurate information was sourced during interviews with port officials, SADC officials and private sector port-related bodies in Namibia, Mozambique and South Africa. In the Durban port, the digitalisation of processes has already begun, as the port authorities seek to align themselves with the needs of their global customers and global legislative requirements. Despite these advances, the ports suffer from delays due to old machinery and the lack of resources, both human and financial, required to develop the port. The ports of Walvis Bay and Maputo have also expanded and begun to use more advanced technology, according to their country's standards. While these developments are encouraging, the ports of Maputo and Mozambique are not currently working at maximum capacity. They are, instead, in the process of positioning themselves for greater trade, competing among themselves for trade from South America, China and Europe. We have seen from the European and Asian examples that increased competition is a driver of development and that smart port development was largely driven by inter-European and inter-Asian competition, in addition to the needs of businesses within the regions. Three factors were highlighted during discussions with industry and port authorities:

1. The first factor was the difficulty in adopting a Single Window approach in South Africa, Mozambique and Namibia. Because of the fragmentation of government and private sector processes, where processes often overlap without the relevant transparency, creating a dedicated and secure trade portal is difficult. This relates to other monitoring and evaluating functions as well.
2. The second factor relates to the processing hubs, which are directly linked to international supply chain just-in-time manufacturing goals. While most of the products assembled in these processing hubs are for export purposes, there is still a percentage of the product that needs to be absorbed by the local economies by way of domestic trade. Without the assurance that this product can be absorbed by developing countries like Namibia, Mozambique or South Africa, it is unlikely that investors would choose them, thus removing a vital step in smart port creation.
3. The third factor is linked to the infrastructure required for smart port development, like reliable, dedicated and cheap internet, reliable, cheap and clean energy, an enabling legislative environment as well as highly skilled tech-savvy individuals. These requirements are lacking in South Africa, Namibia and Mozambique.

While our governments have been proactive in transforming our ports, port development cannot happen in a vacuum. Smart port development is dependent on the goodwill of major stakeholders within the international trade value-chain. From the data provided relating to smart port development, as global trade has developed, so ports have become important connectors for the global supply chain

https://doi.org/10.47348/SAJMET/2023/i1a4

development. The port of the future is fully integrated into the global supply chain and the city in which it operates, working with city authorities, global industry, shipping lines and international terminal operators, global police structures, governments and end users. Whereas most undeveloped ports are separate bodies, with little impact on their environment and under the control of their individual governments, the loss of complete sovereignty and control, and a commitment to transparency, international cooperation and the adherence to increasingly stringent environmental, supply chain, trade and risk compliance legislation, and policies will be the price of inclusion into global supply chains for ports and governments. Shipping companies have already begun to collaborate and merge, forming extremely powerful lobby groups, with the ability to choose compliant ports or boycott ports that are not deemed suitable. Besides the goodwill of governments to comply with the needs of global supply chain administrators and shipping lines, is the fact that countries should have a suitable environment for port development. Development of the ports will therefore be dependent upon the following:

- The development of the South African business sector and the speedy change to a 4IR-enabled economy. Smart port development must be linked to a stable and growing economy that can support the demands of a developing smart port environment and ancillary requirements. Problems with the supply of energy, the reduction in the cost of airtime and data, fibre and fibre speeds, and other basic energy and communication infrastructure will need to be addressed if these economies are to grow and integrate into an increasingly fluid global trading system. Currently, the urban areas are beneficiaries, but the rural areas are still dead zones. To ensure that digital technologies become mainstream, the movement towards alternative fuels and energy sources will have to be prioritised by government.
- Alignment to global supply chain trends and legislative requirements will require more education of the business community about these requirements and the importance of alignment for the development of the South African economy and ports. More importantly, the Southern African economies will need to adopt procedures and legislation that allow complete compliance with global supply chain procedures, risk compliance and environmental measures, being fully committed to increasing transparency in administrative and business processes. As integrated supply chains are dependent on honesty and ethical processes, these countries will need to commit to a culture of ethical business and governance.
- Alignment with the greening of global trade initiatives will have a serious impact on the readiness of the SADC ports to receive and service new-generation ships. As global shipping moves to full automation, this is a priority area because smart port development is been driven by the greening of Europe and climate change undertakings. From a development perspective, environmental initiatives have been viewed with suspicion because they are often seen as conflicting with development goals. With the adoption of the UN SDGs, there will need to be a shift in the culture and the business mindset.
- A major impediment to change is government employment goals and the need for skills development. Traditionally, state-owned enterprises were used to absorb labour, especially unskilled labour, where there are activities that require more physical labour. In the ports, automation will require a complete restructuring of labour, with a movement towards more skilled labour. Given that the largest pool of unemployed labour is young and unskilled, the movement towards automation and digitalisation of the port and business will create a short- or medium-term skills shortage. There will therefore be a need for rapid upskilling initiatives. The speed at which the labour force and the school system can be transformed and repurposed will therefore affect the speed at which the ports in the region can transition. What is apparent, however, is that, without a suitably skilled labour force with emphasis being placed on technology and science, the ability to grow and develop these ports will be hampered. These skills development initiatives are urgent and require rapid intervention by

https://doi.org/10.47348/SAJMET/2023/i1a4

governments. The 4IR and technological era requires a skilled labour force able to meet the changing global work environment needs. As ports, the international trading system and the shipping environment all adopt technology for more efficient business processes, the core and support maritime systems will need multi-skilled individuals. In the maritime education and training context, several interventions will be required:

- Conduct an audit of the current training systems, institutions and processes to determine their suitability and ability to address changing global employment needs and norms.
- Because the maritime sector is a niche sector, it has requirements that are not easily understood. As the sector becomes more advanced and reliant on technology, there will be an even greater need for training institutions to understand the sector's requirements, anticipate the needs of the global maritime players and prepare the workforce with the skills and the mindset required to address these employment needs.
- Where institutions had previously worked in isolation, there will be a need for greater cooperation with industry. As the industry has both core and support roles, the way general functions can be modified to meet maritime industry needs must be understood and met. Training institutions must adapt their approach to imparting practical and theoretical understanding.
- Institutions and schools should also adapt their curriculums to ensure that learners are more equipped for the changing working environment by providing learning programs that enable learners to choose more skilled career paths.
- Understand the stumbling blocks in rural education and devise strategies that facilitate the introduction of rural populations to more advanced learning systems, so that the gap between skilled and unskilled employees can be closed.

Another major issue is that of sourcing finances. The current landlord system in South Africa does not serve the country and there must be a complete rethink of the governance structures of ports in the SADC area. Going forward, a greater commitment by government to public–private partnerships and the way in which partners and service providers are chosen will be required. Given the power held by the shipping sector and sector requirements, financing of smart ports through public–private partnerships will require that governments demonstrate their goodwill and commitment by relinquishing their commitment to absolute control of their ports and adopting real partnership commitments.

All these factors, taken together, are required to create the foundation of an enabling environment.

V CONCLUSION

The adoption of the smart port methodology cannot be avoided and is required if ports are to survive. The speed at which change occurs is dependent on the current status of the business community, the policies of the various governments and their willingness to align with current and future global business and administrative legislative requirements and processes, as well as their willingness to relinquish administrative power to the private sector, where required, for funding of port development initiatives. At present, within the context of the transition of ports, our governments are still dealing with the major structural issues that affect the rapid transition of domestic economies and, hence, the development of the ports. The transition of our ports towards smart port status will therefore depend on the speed at which both the public and the private sector can adapt to the new global trading climate, and make the required internal changes. With new technologies comes new opportunities and, while transition will require changes within the labour force, a radical repurposing and skills development programme can assist with the transition and create job opportunities within new sectors. There is therefore a need to rethink

https://doi.org/10.47348/SAJMET/2023/i1a4

the current approach to skills development throughout the education value chain. A skilled labour force is critical for advanced business growth and will enhance the region's ability to align with global developments. This is a very important fact, as port development occurs together with the business community and adjusts to the needs of the business community. The speed at which the business community develops will therefore impact on the demands made on the port authorities. Without these demands, transition will be much slower.

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Learning opportunities for further career development and enhancement of seagoing professionals: A South African perspective

Malek Pourzanjani[†]
Hashali Hamukuaya[‡]
Tanaka Mugabe[§]

ABSTRACT

Maritime education and training (MET) institutions have experienced major changes in their structure, and provision of services over the past four decades. These changes have come about partly due to national and international requirements concerning the seafarers' standards of competence and partly due to financial regimes under which these institutions are funded, forcing them to diversify into other areas and activities, such as consultancy, research, shore-based training programmes and mergers with larger Institutions.

Today's seafarer is also markedly different to those who went to sea some 30 years ago. The differences in seafarers' attitude and approach to a seafaring career manifest in a desire to spend less time at sea and treat this as a steppingstone in their working life career. This is true for developed nations, and is more and more becoming the norm, even for the developing countries.

With above in mind, one can argue that MET institutions have an excellent opportunity to provide a range of programmes and bitesize courses that can be undertaken by seafarers to prepare them for the next stage of their career.

Distance learning and web-based programmes are now commonplace in many institutions, including MET institutions, especially after the recent pandemic and long periods of lockdown. This paper will discuss some of the issues involved in web-based and distance learning, and use a leading global provider of distance learning education to highlight some of the possible opportunities for South Africa as a case study.

† Head of Naval Education, Marine Learning Alliance (MLA) College; South African International Maritime Institute
‡ Honorary Research Fellow at the University of KwaZulu-Natal School of Law, South African International Maritime Institute
§ Researcher, South African International Maritime Institute; Nelson Mandela University

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I INTRODUCTION

The training of seafarers (officers) has traditionally been a matter of national pride, and has evolved and matured differently in seafaring countries due to local (national) requirements and circumstances. Until the mid-1970s, training and education of seafarers in these countries were provided under a varied set of standards that had developed over the years. These variations included both the content and structure of the training and educational programmes provided, which eventually led to the development of the International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) in 1978, with major revisions in 1995 and 2010 (Manila amendments). It is also worth noting here at the outset that up until that time most developed countries manned their ships with nationals from their own countries, as well as providing qualified officers for the international fleet.

In terms of structure, some countries, mainly Commonwealth members, followed the United Kingdom (UK) model, where candidates entered the programme following completion of their high school, at the age of 16 or 17. The programmes were of a 'sandwich' nature, where the training programmes were enhanced by periods of sea service sandwiched in between college periods, at the end which candidates were qualified to sit for examinations conducted by the various maritime administrations.

Other models that were practised included the 'front loaded' model, where a candidate entered the programme after graduating from school, and spent three or four years in a college, without any periods of sea service. In most cases, these systems did not require seafarers to return to college for examination for higher certificates of competency. Some courtiers also had a 'dual purpose' or 'polyvalent' certification system, where candidates would go through a programme at the end of which they would qualify to sail as either deck or engineering officers. In France, for example, this is taken to the extreme and successful individuals would be qualified to serve as masters or chief engineers.

There is an emerging need for MET institutions to effectively respond to the increasing demands of international trade and transformation of the maritime sector, mostly related to technological advancements. Seafarers are at the forefront of implementing the standards developed by maritime institutions in a rapidly changing context. A series of events, some of which will be highlighted in this paper, caused these arrangements to be changed and forced a global, harmonised system of education and training to come into effect. These changes have had a significant impact on the operation and running of MET systems, as well as on seafarers' attitude and approach to working at sea.

II CHANGES IN THE GLOBAL MANNING REGIME

Flagging Out

The most remarkable change in the ship-owning and management sector over the past fifty years is the way that shipowners and operators have changed their approach to registry (nationality) and flag of their vessels. The flag that ships fly has always been important because ships, like people, are required by law to belong to a country and to have their port of registration identified. There is nothing new about shipowners using flags that suit their specific requirements. Looking back in history to a few centuries ago, one can note instances where shipowners changed their flags at times when their ships were in some sort of danger, or when trading in parts of the world where certain flags were not welcomed.

In recent times, and around the period immediately following the Second World War, a mass migration of ship registries from the country of ownership to other flags took place. The main purpose for this revolved around commercial gains. Reputable owners have used the flag of convenience (FoC) or open registers for a variety of reasons. They may well appreciate the freedom from bureaucracy in their own country or wish to avoid paying heavy corporation taxes. They might wish to have more freedom over who they employ on ships, perhaps preferring crews of a certain nationality, or wish to avoid trade embargoes that apply to ships of their country. This has had major implications for countries such as the United Kingdom, Germany, and the Netherlands. These countries have traditionally been major ship-owning countries and suppliers of

https://doi.org/10.47348/SAJMET/2023/i1a5

officers, not only for their own ships, but also for the international fleet. The popular and major owning countries are now Panama, Liberia and Singapore.[1]

South Africa aspires to be a major ship-owning country but, to date, its ship registry is unable to compete with the benefits offered by other ship registries. These benefits include competitive incentive schemes offered to ship owners, preferential treatment, discounted fees for use of ports and tax benefits. Other deterrent factors relate to the inefficiency in the ship registration process and uncompetitive ship registration costs. By the end of 2022, there were only 29 ships registered under the South African Ship Register[2] Subsequently, most South Africa-trained seafarers work in international shipping. Therefore, continuously upskilling seafarers' competences aids is increasing their employability.

Changes in sources of manpower

Seafaring as a profession was an attractive career for nationals of most developed countries as it provided a relatively high level of income, the possibility of travelling and visiting foreign countries, and respect in the society. These primary reasons for choosing a seagoing career are no longer valid. The differential salary levels between shore-based and seagoing professions have eroded over the years. The attraction of visiting foreign countries is also no longer valid because transportation systems have become so widely and cheaply available that most school leavers do not consider this as an important issue, as well as the fact that port stays are much shorter than what they used to be. The life onboard has also changed, from small communities of 40 or 50 persons to a very small number of crew, perhaps less than 15, which does not allow for social interactions, gatherings and other activities. The respect in the society has also been eroded over the years, as the media highlighted the major maritime disasters, giving the shipping industry a poor image in society.

FoC, described earlier in this paper, is another catalyst for number of seafarers from nationals of developed countries dropping dramatically in recent years. Until early 1990s, this was an observation that was made by most developed nations, without realising the full impact of the situation on the shore-based maritime sectors. The same is applicable to South Africa, even though it is a developing country. A series of studies that highlighted the global manning problem for international shipping were sponsored by the Baltic and International Maritime Council/ International Chamber of Shipping (BIMCO/ICS) and have been reported to the community since 1990,[3] and then updated every five years. The last report was published in 2021. These reports are analysed by national governments, and it appears that most developed nations do not seem to be concerned about the nationality of seafarers supporting their shipboard requirements because they have accepted the hard fact that there are not enough nationals for these jobs. What seems to be the main cause of anxiety in these countries is the realisation that, in the near future, some of the sensitive shore-based jobs (such maritime administrations, classification societies, pilotage etc), which have traditionally been filled by former seafarers from these countries, will now either remain unfilled or that foreign nationals will be considered for these posts. These regular reports have highlighted the potential shortage of skilled labour in the maritime industry and advised an increase in training in order to offset the losses due to retirement and wastage.

The 2021 BIMCO/ICS report[4] noted that the worldwide supply of seafarers was estimated at 1.89 million

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1 L Grimett 'Understanding the Plight and Challenges facing South African Seafarers' *American Journal of Industrial and Business Management* (2023) 13(6) (available at <https://www.scirp.org/journal/paperinformation.aspx?paperid=126131> accessed 20 July 2023).

2 South African Maritime Safety Authority (SAMSA), *SAMSA Annual Report 2021/2022* (Pretoria: Department of Transport 2022) (available at <https://nationalgovernment.co.za/entity_annual/3196/2022-south-african-maritime-safety-authority-(samsa)-annual-report.pdf> accessed on 20 July 2023).

3 Baltic and International Maritime Council (BIMCO) *The Worldwide Demand for and Supply of Seafarers* (Coventry: Institute for Employment Research University of Warwick 1990).

4 Baltic and International Maritime Council (BIMCO) and International Chamber of Shipping (ICO) *Seafarer Workforce Report: The Global Supply and Demand for Seafarers* (Livingstone: Witherby Publishing Group 2021).

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seafarers operating over 74 000 vessels in the global merchant fleet. The report also noted that the shipping industry was already struggling with crew shortages due to Covid-19. The Delta variant of the coronavirus had hit parts of Asia with a significant force and this had led to many nations stopping land access to sailors, which left captains unable to rotate crews. About 100 000 seafarers were stranded at sea beyond the expiration of their contracts. The 2015 report[5] predicted that an additional 89 510 officers would be needed by 2026, based on projections for growth in shipping trade. It said that there was a shortfall of about 26 240 certified officers at the time. Growth in demand for seafarers outpaced any growth in supply in 2021. Although there has been a 10.8% increase in the supply of officers since 2015, the current shortfall could be due to a reported increase in the number of officers needed on board vessels, with an average of 1.4 officers required per berth. There was a particular shortage of officers with technical experience, especially at management level, and in the tanker and offshore sectors, there was a reported shortage of management-level deck officers.

Taking the UK as an example, Tarver and Pourzanjani[6] reported their findings and analysis of the measures taken by the UK government to deal with this issue. These measures included the introduction of a 'tonnage tax' in 1997, which replaced the normal corporation tax for UK ship owners. The UK's register of shipping increased in size by 20% in tonnage terms in the months following the announcement of the tonnage tax. This system, based upon a Netherlands scheme, has shown positive results in levelling the playing field for ship owners that register their flag in the UK and, in turn, increasing UK ship registrations. Although not intended to be a panacea for all the industry's ills, the UK government intended that the tonnage tax would also have a positive effect on the recruitment levels of cadets. It was thought that an increase in ship registrations would provide greater opportunities for officers, increase the number of cadet officers being recruited and make more training berths available on registered ships. It therefore made it a condition of an individual shipowner's re-registration that, for every 15 officers employed on their UK vessels, there must be a minimum of one trainee officer. South Africa has adopted a similar approach since 2014, with positive results being recorded, such as an increase in ship registrations.[7] Unfortunately, South Africa does not own a national merchant fleet and therefore it relies on foreign vessels operating within its waters to provide training berths. However, due to the global scarcity of training berths, South Africa competes with the international community.[8]

The industry, shipowners, shore-based institutions, unions and some philanthropic bodies have also put into place their own initiatives to boost the training of officer cadets. These efforts have led to some success. Recruitment of cadets has increased, but is still half the number that is required to sustain numbers into the future. In South Africa, the South African Marine Safety Authority (SAMSA) plays a crucial role in accrediting seafarer training authorities, verifying result, and enforcing training compliance with the latest International Maritime Organization (IMO) requirements. SAMSA also collaborates with various stakeholders to place cadets for their one-year practical training experience. Cadets who apply for placement through the national cadetship programme do not have to pay for this training as the government covers their placement costs.[9]

At a regional level, the European Commission (EC) considered the issue of the declining number of European Union seafarers, in particular the shortage of well-qualified officers, in its Communication to the Council of Ministers and the European Parliament, adopted in April 2001 (COM (2001)188 final). This report provided an update on the shortage of seafarers

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5 Baltic and International Maritime Council (BIMCO) and International Chamber of Shipping (ICS) *Manpower Report 2015* (Bagsværd: BIMCO 2016).

6 S Tarver & M Pourzanjani 'Measuring and Sustaining the UK Maritime Skill Base: A Review' (2003) 2(1) *World Maritime University Journal of Maritime Affairs*.

7 SAMSA op cit note 2.

8 Grimett op cit note 1.

9 Ibid.

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on the basis of the 1998 joint study by the Federation of Transport Workers' Unions (FST) and European Community Shipowners' Association (ECSA).[10] The general interest in the dramatic decline in EU seafarer numbers is also reflected in a number of other studies, research projects and network of experts, including some funded by the EC, such as the Harmonization of European Maritime Education and Training Schemes (METHAR), a research project funded by the EC, and Maritime Education and Training Network (METNET). In its conclusions for improving the image of EU shipping and attracting people to the seafaring profession, adopted on 5 June 2003, the Council of Ministers invited the EC to continue monitoring the evolution of the training and recruitment of seafarers based on data provided by the member states.

II INTRODUCTION OF GLOBAL STANDARDS

Until 1978 the standards for MET, certification and watchkeeping of officers and ratings were established by governments, without much reference to what was happening in other countries. As a result, standards and procedures varied widely, even though shipping is a truly global and international industry. The IMO convention, STCW 1978, was to establish basic requirements for training, certification and watchkeeping for seafarers at an international level. The convention prescribed minimum standards relating to training, certification and watchkeeping for seafarers that countries are obliged to meet or exceed.

One important feature of the convention is that it applies to ships of non-party states when visiting ports of states that are parties to the convention. Article X of the convention requires parties to apply the control measures to ships of all flags to the extent necessary to ensure that no more favourable treatment is given to ships entitled to fly the flag of a state that is not a party to the convention than is given to ships entitled to fly the flag of a state that is a party to the convention. The difficulties that could arise for ships of states that are not parties to the convention is one reason why the convention has received such wide acceptance. By December 2000, the STCW Convention had 135 parties that ratified the convention, representing 97.53% of world shipping tonnage.

The 1995 amendments, adopted at a conference, represented a major revision of the convention in response to a recognised need to bring the convention up-to-date and to respond to critics who pointed out the many vague phrases, such as 'to the satisfaction of the Administration', which resulted in different interpretations being made. Others complained that the convention was never uniformly applied and did not impose any strict obligations on parties regarding implementation. The 1995 amendments entered into force on 1 February 1997. However, until 1 February 2002, parties were able to continue to issue, recognise and endorse certificates that applied before that date in respect of seafarers who began training or seagoing service before 1 August 1998.

The 2010 Manila amendments to the STCW Convention and Code were adopted in June 2010, marking a major revision of the convention and code. These entered into force on 1 January 2012 under the tacit acceptance procedure and were aimed to bring the convention and code up-to-date with developments since they were initially adopted, and to enable them to address issues that are anticipated to emerge in the foreseeable future.

Among the amendments adopted, there are several important changes to each chapter of the convention and code, including:

- measures to prevent fraudulent practices associated with certificates of competency and strengthen the evaluation process
- requirements on hours of work and rest and new requirements for the prevention of drug and alcohol abuse, as well as updated standards relating to medical fitness standards.

[10] Federation of Transport Workers' Unions in the European Union (FST) and the European Community Shipowners' Association (ECSA) *Improving the Employment Opportunities for EU Seafarers: An Investigation to Identify Seafarers Training and Education Priorities* a Joint Study (1998).

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- certification requirements for ratings
- requirements relating to training in modern technology such as ECDIS
- requirements for ME awareness training and training in leadership and teamwork
- training and certification requirements for electrotechnical officers
- updating of competence requirements for personnel serving on board all types of tankers, including new requirements for personnel serving on liquefied gas tankers
- requirements for security training and provisions to ensure that seafarers are properly trained to cope if their ship comes under attack by pirates
- use of modern training methodology including distance and web-based learning
- training guidance for personnel serving on board ships operating in polar waters
- training guidance for personnel operating dynamic positioning systems.

Ensuring compliance with the convention

Parties to the convention are required to provide detailed information to the IMO concerning administrative measures taken to ensure compliance with the convention. This represented the first time that the IMO had acted in relation to compliance and implementation; generally, implementation is down to the flag states, while port state control also acts to ensure compliance. Under chapter I, regulation I/7, parties are required to provide detailed information to the IMO concerning administrative measures taken to ensure compliance with the convention, education and training courses, certification procedures and other factors relevant to implementation.

The information is reviewed by panels of competent persons nominated by parties to the STCW Convention, who report on their findings to the IMO Secretary-General, who, in turn, reports to the Maritime Safety Committee (MSC) on the parties that fully comply. The MSC then produces a list of parties in compliance with the 1995 amendments.

The first list of countries was approved by the MSC at its 73rd session held from 27 November to 6 December 2000, which included 71 countries and one associate member of IMO.

Port state control

The revised chapter I (1995 and 2010) includes enhanced procedures concerning the exercise of the port state to allow intervention in the case of deficiencies deemed to pose a danger to persons, property or the environment. This can take place if certificates are not in order, or if the ship is involved in a collision or grounding, and in instances where there is an illegal discharge of substances.

At intervals of five years, masters, officers and radio operators are required to meet the fitness standards and the levels of professional competence contained in section A-I/11 of the code.

III CURRENT ISSUES

Impact on MET institutions

As indicated in the previous section, the changes in learning opportunities for further career development of seafarers should consider the STCW convention amendments, which, according to the IMO (IMO, 2021), emphasises the importance of continuing professional development for seafarers, encouraging them to undergo refresher training and update their technical and non-technical skills regularly. This approach has resulted in better-prepared seafarers, contributing to safer navigation and reducing the risk of maritime incidents (IMO, 2021).

Additionally, the revised convention has strengthened the requirements for the training and certification of maritime instructors, ensuring the delivery of high-quality training programmes. Therefore the STCW convention amendments have modernised and improved MET programmes, making them more relevant to the evolving needs of the maritime industry. The changes have had a reported impact on the seafarer as a professional.

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MET institutions have traditionally been established to address the needs of the industry and are funded by regional or central government funding mechanisms. Programmes provided by these institutions had to have the approval of their country's ministry of transport, the organisation are responsible for issuing certificates of competence (CoC) and, in addition, in some countries, that country's ministry of education, if these programmes also led to an educational qualification, for example, a diploma or bachelor's degree. The introduction of the STCW had no significant impact on this arrangement. Events mentioned in previous sections, however, have had a major impact in some countries, where the demand for national seafarers has dropped dramatically, causing some of these institutions to close their doors. In the UK, for example, by the late 1960s and early 1970s, there were more than 20 nautical colleges, each having three or four cohort intakes per year. This was reduced to three main colleges in the 1980s, which has now increased to four.

In recent years, we have observed that in most countries a move from the old state-funded regimes to more privatised and independent institutional regimes, where institutes must compete to get enough students to make them viable. In some countries, the state funding continues but more accountability is required from the institutions, where they need to demonstrate that they are providing a service that meets a minimum set of training and education standards. The introduction of quality assurance and quality evaluation requirements, which is also part of the STCW 1995, is an example of how institutions are required to demonstrate that they achieve set standards and what systems they have in place to enhance the quality of their education or training provision. The STCW mandates that seafarers receive approved education and training, which includes the integration of virtual learning, considering the rapid technological developments and advancements in the maritime sector. This assertion is confirmed in paragraph 14 of chapter II, section B-II/1 of the STCW Manila amendments, which provides that competence is not just about practical skills but also includes knowledge, theory, principles and cognitive skills. These are integrated at all levels of competence and inform what to do, how and when to do it, and why it needs to be done. Applied correctly, this knowledge ensures that seafarers can successfully operate on a diverse number of ships and in diverse situations, handling emergencies and can adapt to evolving requirements and environments. Significantly, the latest amendments to the STCW strongly advocate for the use of modern training methodologies, which include distance learning, for the enhancement and updating of seafarers' knowledge. Furthermore, a system that seems to be limited to the UK and very few other countries, and has had excellent results, is the participation of the shipping companies themselves in education and training of seafarers. Potential candidates are interviewed and assessed by shipping companies, and introduced to colleges who will provide the educational element. As part of this collaborative effort, shipping companies provide the opportunity for sea service and cover some of the costs incurred by the colleges. It is surprising that other countries have not adopted similar practices, which have resulted in almost zero dropout rates.

The main issues that need to be addressed and are frequently asked about by those who are funding these institutions are:

- Is there demand for services provided?
- Is the institution financially viable?
- Is the subject area 'academic' or 'vocational'?

In responding to the first issue, some institutions have diversified into other non-maritime subject areas, such as management and engineering, and other activities, such as research, consultancy and short courses.

In raising the second issue, and what makes it difficult, particularly for MET institutions that are part of a bigger organisation, for example faculty as part of a university, is that a comparison is made between maritime subject areas and other disciplines. Maritime departments are intrinsically expensive to run and manage. They are different from humanities departments, where there is a high demand, and most teaching is classroom-based, in large groups.

The last issue, that of 'maritime' being an academic or vocational subject, is also an important one and should be defended strongly because, if this subject area is classified as a purely vocational subject area, there is a danger of high-level work not being funded.

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A South African perspective: The role of the South African International Maritime Institute

South Africa is a developing nation. So far, we have established some facts that need further considering in respect of the opportunities that they provide for the South African International Maritime Institute (SAIMI) and its stakeholders.

The most important issue is the period of sea service. It is now accepted that most seafarers from developed countries have a short span of service at sea. METNET and METHAR findings indicate that, for the European Union, seafarers this is about seven years. Other studies from the seafarer supply countries, such as the Philippines and China, also indicate that, for different reasons, nationals from these countries also do not have a lifetime ambition of working at sea, and their length of service is around 12 years.

What happens to this population of workforce when they finish their seagoing careers? The answer is simple; they come ashore and get shore-based jobs. The challenge and opportunity for SAIMI and South African member universities is to redefine services that are more in line with the needs of current seafarers.

The EC-funded network of experts on MET, METNET, made a series of recommendations to the EC, some of which are equally applicable to International Association of Maritime Universities membership. These included:

- Making the seagoing profession more attractive by improving the image of shipping industry; developing a career path in the maritime industry where sea service is an element.
- Enhancement of the current courses leading to seagoing certification by identifying and providing subject areas that would benefit the seafarers, both at sea and ashore.
- Provision of postgraduate courses specifically designed for ex-seafarers to work in the shore-based maritime industries (maritime cluster).

Identifying the maritime cluster

Various sectors of the maritime industry that, put together, form what is known in some countries as the maritime cluster, are probably the most divers and varied within transportation systems. Most of the sectors within the cluster benefited in the past from an inflow of well-educated and disciplined practitioners who, after serving at sea for a number of years, would take up shore-based positions. Previous studies[11] have identified the shore-based maritime sectors that traditionally used to benefit from an inflow of ex-seafarers as follows:

- ports sector: port authorities; terminal operators; stevedore companies; contract labour suppliers; ferry companies; pilotage organizations; vessel traffic service
- marine equipment supplies and manufacturers
- commercial maritime and insurance; loss adjusters
- regulatory authorities; maritime administrations
- education and training
- ship management
- ports and related services
- dredging and hydrographic services
- surveying, classification societies
- shipbuilding
- maritime law
- offshore (oil and gas)
- yachting and recreational craft
- fishing and aquaculture.

In addition to the technical subjects that employers identified as essential for their sector, they also identified several core skills that they regarded as important for their staff:

- organisational/analytical skills
- marketing and public relations skills
- customer awareness

[11] M Pourzanjani 'Maritime Career Path Map' Presentation to the European Maritime Industries Forum Plenary Session, Naples, Italy, 2002; M Pourzanjani, S Tarver, A Graveson, R Raposo, Odd-Magne Skei & J Haavisto *Issues Related to the Mobility of Seafarers in the EU* Special METNET Report to the European Commission, 2002; M Pourzanjani, S Tarver & Dodds *A Review of the United Kingdom's Marine Industries Skills Needs and Supply* METNET Special Report to the European Commission, March 2003.

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- communication and interpersonal skills
- human resource expertise
- environmental awareness
- safety
- leadership and teamwork
- communications (written and oral)
- numeracy and problem-solving
- advanced information and technology and e-commerce skills
- engineering skills.

IV DEVELOPMENTS IN DISTANCE AND WEB-BASED LEARNING

The education sector has witnessed an explosion of new ideas and approaches to learning, following the global acceptance of 'lifelong learning' as a concept. The technological advances in information and communications technologies are providing new routes and tools for the delivery and management of learning, and the recent pandemic and periods of lockdown forced academic institutions to consider alternative modes of delivery.

Distance learning is defined by the UK former Quality Assurance Agency for Higher Education as:

> *provision of higher education that involves the transfer to the student's location of the materials that form the main basis of study, rather than the student moving to the location of the resource provider*

This agency also outlines four dimensions of distance learning as follows:

> **Materials-based learning**. *This dimension of a system of distance learning refers to all the learning resource materials made available by the programme provider to students studying at a distance.*
>
> **Programme components delivered by travelling teachers.** *This dimension refers to staff of the providing institution travelling on a periodic basis to the location of the student to deliver components of the programme.*
>
> **Learning supported locally**. *This dimension involves the providing institution employing persons specifically to undertake certain defined functions for the local support of students following the programme.*
>
> **Learning supported by the providing institution remotely for the student.** *This dimension refers to defined support and specified components of teaching provided remotely for individual distant students by a tutor from the providing institution.*

Distance learning has been increasingly considered by institutions as an economical way of expanding their activities, widening opportunities for students around the world and making effective use of the new technologies that are rapidly emerging. What is most important in making such provision is an assurance that rigorous quality systems are in place, along with well-founded reasoning and justification that the usual ways of 'on-campus' provision are not necessarily appropriate or possible in the current geo-economic context. These are particularly important and relevant, when considering provision of courses for shore-based destinations, where at least part the programme can be delivered via distance learning, either due to a lack of on-campus resources, or availability of seafarers to attend courses.

Prof. John Chudley, Rector of MLA College made a presentation during the recent SAIMI maritime leadership conference in Gqeberha (former Port Elizabeth), outlining the range of programmes on offer at MLA and its approach to supporting marine professionals who seek higher/different qualifications to further their careers, some of whom are active seafarers. This is achieved by using modern training methodologies, which include distance learning for the enhancement and updating of seafarers' knowledge.

The College has a range of postgraduate programmes, including postgraduate diplomas, a Master of Science degree and a Master of Business Administration degree, all focused on the maritime discipline and the United Nations Sustainable Development Goals. An interesting aspect of entry to the college is the recognition given to candidates' prior learning and work experience. For example, for a master mariner or chief engineer to gain entry into the Master of Science and/or the Master of Business Administration programmes, they only have to do the dissertation part of the degree programme and will be exempt from the taught modules of the programmes.

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All learning material is provided via a total learning platform and, although they can study off-line, the learning material has an on-line feel about it. Each student is assigned to a tutor, who will meet with them regularly on the MS Teams or Zoom platform and respond to their needs.

Successful candidates will receive their qualifications from the University of Plymouth, which is the awarding partner institution with MLA College. Further details about the college can be found on their website https://www.mla.ac.uk/programmes/. SAIMI and other stakeholders have an opportunity to develop a similar approach and foster meaningful partnerships with institutions, such as MLA, to enhance seafarers' training.

V SUMMARY AND CONCLUSIONS

This paper examined the underlying reasons for changes in supply and demand of human resources in the shipping industry. In doing so several issues were discussed and some fundamental facts established. These include:

- There continues to be a shortage in the number of officers for the international fleet.
- Regardless of their nationality, there is a desire by almost all seafarers to spend less time at sea.
- MET institutions are under pressure to diversify into new training and education activities.
- Current MET courses based on STCW do not equip the seafarers for shore-based positions.
- There is a lack of postgraduate courses, specifically designed for ex-seafarers.

Changes in MET institutions were also discussed, indicating that most MET institutions should prepare themselves to diversify into other areas of activity in order to remain viable.

What can be concluded from the above is the opportunity that this gives SAIMI and its partner institutions to provide better undergraduate programmes, along with new postgraduate opportunities to satisfy the shore-based industries' human resources needs and those of current and future seafarers.

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Malek Pourzanjani

Hashali Hamukuaya

Tanaka Mugabe

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The rise of digitalisation and automation in the shipping industry and their impacts on training and system safety

Scott N MacKinnon[*], *Reto Weber*[†] *and Monica Lundh*[‡]

ABSTRACT

The ubiquitous application of digitalisation and automation within the maritime shipping industry will create disruptions that will have profound effects on how work is performed in the industry. The practice of safe navigation will require an evolution and subsequent evolvement of how operators and technologies interact in a complex sociotechnical system if a better understanding of system safety is to be achieved. Predictions of how actors and agents in the same workspace will emerge. This paper focuses on the current levels of automation prevalent in the navigation sector, a futuristic prediction and foresight of challenges related to the emergence of technologies, automation and artificial intelligence, and the competencies required related to the training of future seafarers.

I INTRODUCTION

Artificial intelligence (AI) has presented the world with many innovations and solutions to address very complicated problems. Proponents of AI have offered much foresight into more changes to come.[1] Like other transportation industries, the role of AI and procedural automation in core activities of shipping are developing at a rapid rate; perhaps a rate that creates as many problems as it does solutions. However, digitalisation, AI and automation are desirable technologies because they can support stakeholders in the management of operational complexity, time constraints, uncertainty and anomaly detection beyond the functional capacity of normal human decision-making. The ubiquitous application of AI in vessel navigation is rapidly garnering the attention of innovators, researchers, regulators and shipping companies alike.

The International Maritime Organization (IMO) began work to examine how safe, secure and environmentally sound maritime autonomous surface ships (MASS) operations may be evaluated in today's shipping industry.[2] MASS is defined as a ship that, to a varying degree, can operate independently of human interaction. To facilitate the progress of the regulatory

* Professor in Human Factors, Department of Mechanics and Maritime Sciences, Maritime Human Factors Research Group, Chalmers University, Gothenburg, Sweden

† Simulator Manager/Lecturer, Department of Mechanics and Maritime Sciences, Maritime Human Factors Research Group, Chalmers University, Gothenburg, Sweden

‡ Professor in Human Factors, Department of Mechanics and Maritime Sciences, Maritime Human Factors Research Group, Chalmers University, Gothenburg, Sweden

1 K Schwab *The Fourth Industrial Revolution* (New York: Crown Business 2016)

2 International Maritime Organization (IMO) '*IMO* Takes First Steps to Address Autonomous Ships' IMO 25 May 2018 (available from: <https://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx#:~:text=For%20the%20purpose%20of%20the,operate%20independently%20of%20human%20interaction>).

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scoping exercise, the degrees of autonomy are organised (non-hierarchically) as follows:

- Level 1: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
- Level 2: Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location, but seafarers are on board.
- Level 3: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Level 4: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

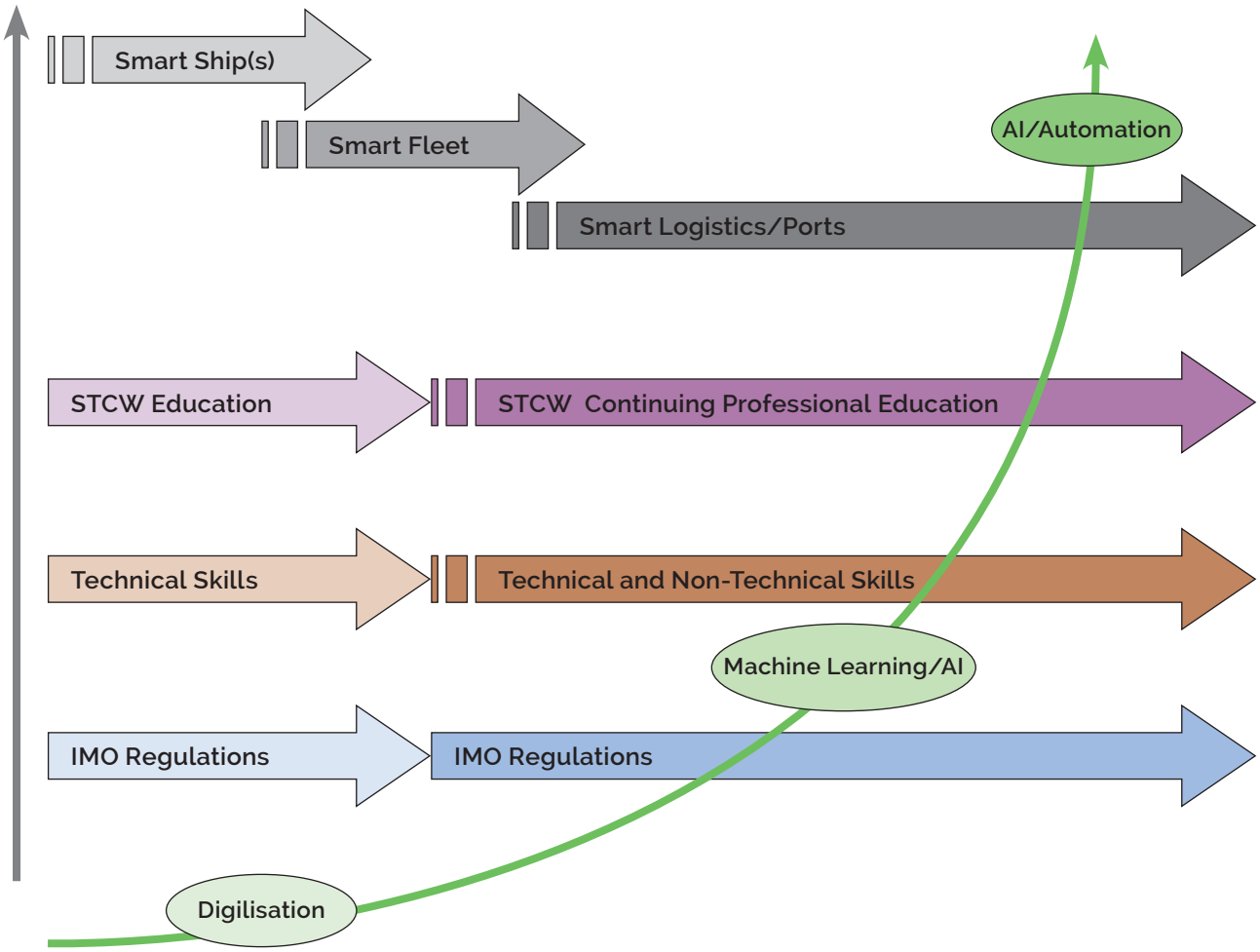

Figure 1: Interaction of Elements Implicated in the Safety of Navigation[3]

To progress through these levels of autonomy will require significant reliance upon continuous advancements in sound AI and ML and Human-Machine Teaming decision support systems. To achieve these goals, several research groups in both the academic and professional domains have identified the elements

[3] Modified from MacKinnon & Lundh op cit note 3.

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to be examined for autonomous technologies to be successful in their application within the industry.[4] These foresight papers identified that the future of an autonomous shipping industry requires a foundational step, an analysis to determine the most appropriate approaches to address MASS operations, 'taking into account, inter alia, the human element, technology and operational factors'.[5] Taking this foundational step would formally set the stage for guiding the innovation, digitalisation and automation race in the new age of shipping (Shipping 4.0), looking to automation and AI to conquer this wicked problem (see Figure 1).

However, there are researchers who forewarned that the growth of automation may create more problems.[6] Humans will always be involved with autonomous agents, regardless of what the public media suggests. There will always be a trade-off between a machine's capacity for self-directedness and self-sufficiency. The need for human–machine collaboration will forever be required because, in any safety-critical sociotechnical system, the human operator must make the final decisions, particularly in critical fail-to-safe situations.

II CAN AI BE THE METHODOLOGICAL PARADIGM TO ADDRESS SAFETY OF NAVIGATION NEEDS?

The successful development of 'general' AI (the form of AI that could have a remote possibility to autonomously navigate a vessel in highly autonomous traffic situations) is decades, if not centuries, away from realisation. One might think that lessons learned and methods derived from AI applications that have consistently beaten human champions in the games of chess or Go, or on multi-player gaming platforms, could be exploited to solve these complexities of increasing levels of autonomy. However, these lessons and methods are not easily transferable to navigation because the objective of these particular AI methods applied to a gaming environment is to win, in other words, to beat an opponent.[7] Traffic safety within a highly complex sociotechnical system requires creating a 'level playing field' so that the environment for all agents (eg ships, vessel traffic services and recreational crafts) is sufficiently equitable for a successful outcome.

III AN EXPERIMENTAL APPROACH TO UNDERSTANDING LOW-LEVEL NAVIGATION AUTOMATION

The following is a summary of the results of an experiment undertaken to understand the influence of low-level automation on collision avoidance.[8] To prevent collisions (or near misses) in traffic situations, navigators are bound to follow the International Regulations for Preventing Collisions at Sea (COLREGs), which are the 'rules of the road' for ships and other vessels at sea, that is, making it clear as to which ship is the 'stand on' ship and which is the 'give-way', ship and what correct action should occur in order to avoid a collision. To support the navigator in ascertaining whether a risk of collision exists, an automatic radar plotting aid (ARPA) and an automatic identification system (AIS) are used. ARPA is a radar system with the capability of tracking and obtaining information about plotted targets (TG), such as (among others) the closest point of approach (CPA) and the time to CPA (TCPA), and

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4 See D Lane & R Clegg, R 'Foresight Review of Robotics and Autonomous Systems: Serving a Safer World [online]' (2016) Lloyd's Register Foundation (available from: <https://www.lrfoundation.org.uk/en/publications>); SB MacKinnon & N Lundh 'Gaps in Regulations, Pedagogic Needs and Human/Automation Interactions in the Shipping Industry' *Lighthouse Reports* 20 March 2019 (available from: <https://lighthouse.nu/2019/03/02/gaps-in-regulations-pedagogic-needs-and-human-automation-interactions-in-the-shipping-industry/>); and World Maritime University (WMU) 'Transport 2040: Automation, Technology, Employment – The Future of Work' (WMU Reports 2019) DOI: 10.21677/itf.20190104 (available from: <https://commons.wmu.se/lib_reports/58/>) as examples.

5 IMO 2018 op cit note 2.

6 L Bainbridge 'Ironies of Automation' (1983) 19(6) *Automatica*; JM Bradshaw, RR Hoffman, DD Woods & M Johnson 'The Seven Deadly Myths of "Autonomous Systems"' (2013) 28(3) *IEEE Intelligent Systems*.

7 SJ Russell *Human Compatible: Artificial Intelligence and the Problem of Control*. (New York: Viking 2019).

8 R Weber, K Aylward, S MacKinnon, M Lundh & M Hägg 'Operationalizing COLREGs in SMART Ship Navigation: An Algorithm-based Decision Support System Study' Ergoship 2021 Conference, Busan, Republic of Korea, September 2021 (available from: <http://www.ergoship2021.org/eng/main/files/ERGOSHIP_2021_Proceedings.pdf>).

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includes a trial manoeuvre function, where the effect of an own ship (OS) manoeuvre on all tracked TGs can be simulated. AIS is an automated tracking system in which a ship transmits information about itself, such as name, position, size, course and speed, to other AIS-receivers (and vice versa) and can be depicted on the radar and on the electronic chart display and information system (ECDIS). AIS is regarded as an useful source of information supplementary to that derived from other navigational systems (including radar) and is often considered an important 'tool' in enhancing situation awareness in traffic situations.

A decision-support system, currently under commercial development, provided AI-driven navigation suggestions for collision and grounding avoidance in a simulated bridge environment. This decision-support software is being developed as a smart addition to standard ARPA and TM, with functions covering all working cycles of operations, including situation monitoring, problem detection, suggesting a manoeuvre and monitoring the execution of the manoeuvre based principally on mathematical calculations. Based on the assumption that other ships keep their course and speed, this system provides a graphical solution on how to solve a given traffic situation either by changing the own ship's course or by reducing speed. The platform includes an additional feedback system that 'plays ahead' the manoeuvre before its execution, in other words, a depiction of the traffic scenario in the near future. It should be noted that, at the time of data collection, the software was being further developed and that the following description is based on the available software version used during the trials. The application performs the following functions:

- Producing a system analysis and informing the watch officer of situations in which a collision of ships is possible.
- Calculating a manoeuvre recommending the course and/or speed required in order to avoid a collision with dangerous targets, in compliance with the COLREGs.
- Displaying manoeuvring suggestions graphically and textually on the screen (see Figure 2).

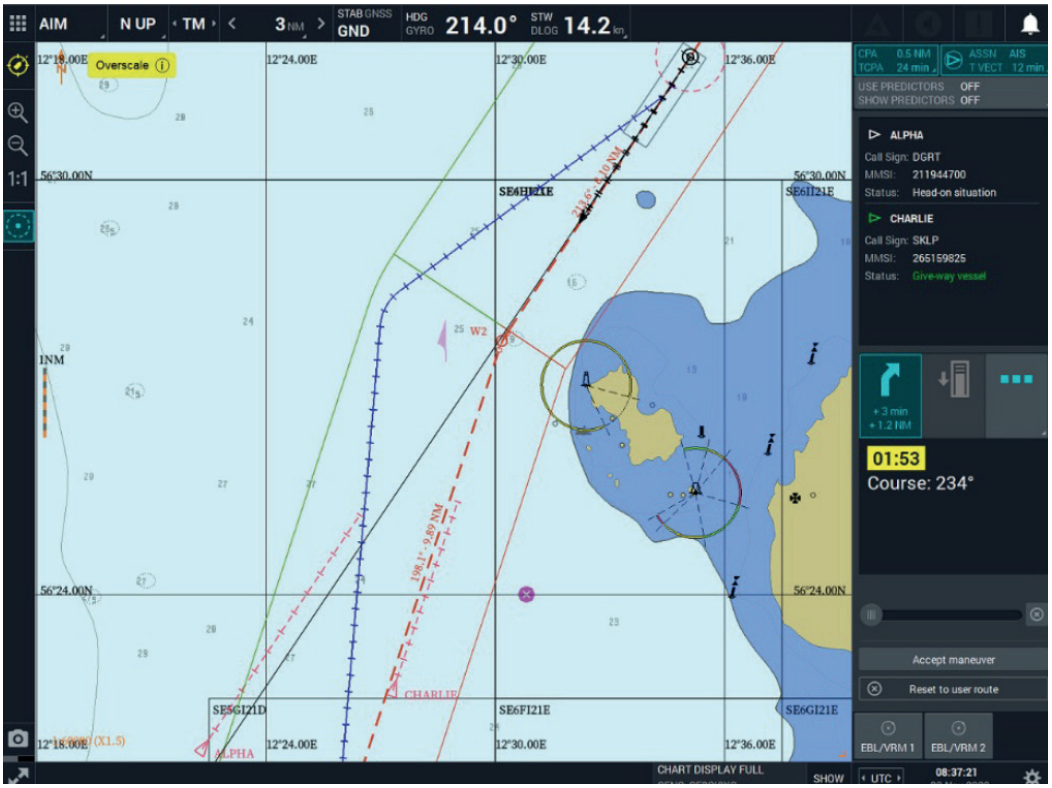

Figure 2: Example of a Change-of-Course Suggestion (blue line) Provided by the Support Tool

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For reasons of property rights and commercial considerations, the software developer did not disclose the algorithms used in the decision-support system in any detail, only stating that the system is based on COLREGs, anti-grounding and the normal 'behaviour' of ships according to statistics obtained from piloted research. The decision-support system presents suggested manoeuvres based on:

- the application of the COLREGs based on all identified vessels (AIS, ARPA and other connected sensors), including their course, speed and navigational status as received by AIS
- nautical chart information
- the ship's route
- The manoeuvring capabilities of the vessel, that is, ship dimensions, maximum speed, stopping/acceleration values, ship loading and turn parameters.

Subject matter experts (SMEs) were involved in creating, implementing and testing various traffic scenarios for this research in a full mission bridge simulator (FMBS). The goal was to develop scenarios that were realistic and somewhat challenging for both the participants and the software. The scenarios had to meet the following criteria: include meeting, overtaking and crossing situations; within a geography described as 'semi'-open waters, good visibility, calm weather conditions, manageable for one single officer on the bridge; and have a duration of approximately 20 to 25 minutes, allowing the test person enough time to assess and act upon a situation. All scenarios involved three ships, namely Alpha, Bravo and Charlie, and each scenario was set in three different geographical areas: the Anholt, Fehmarn and Halland areas.

IV HUMAN–AUTOMATION INTERACTIONS

Blunt but useable system

This research identified two seemingly contradictory themes when the participants were debriefed on the support software, namely (1) it is a blunt tool and (2) it is user-friendly. It was evident among the participants that the software was limited in what it could do, resulting in the blunt description. The support system was effective from the bridge operator's perspective in that it had an 'egocentric' perspective but lacked a birds-eye overview of the entire traffic situation in order to consider situations between other ships. This was seemingly something the participants had hoped for from this type of technology.

Automation transparency

Participants identified that, in order to develop trust in a technology, there must be a proper foundation laid and training regarding the system's opacity, with a clear understanding of the capabilities and potential risks of the system. This would lead to better human–automation interaction, where an appropriate level of reliance can be placed on the technology.

Decision support or decision-making?

According to the participants, the support tool allowed the navigators to check whether their plan agreed or conflicted with the rules, and that one of the primary benefits of this decision-support system was to be able to visualise a manoeuvre in a potential future traffic situation, based on suggestions generated by the software. This feature, called 'play-ahead;, can contribute to a more complete overview of a situation and the ways in which it could unfold, while keeping in mind that this function is based on the target vessels keeping their course and speed (which may not always be a correct assumption). Although the support tool was described as a blunt tool that primarily contributed to the mathematical calculations or strict application of the COLREGs, the participants believed that even its basic functionality has an important role to play in the safety of navigation. The participants also described the support tool as an 'option generator', 'buddy' or 'co-pilot', aligning closely to the synonyms presented for such systems. It is interesting that the participants almost seemed to humanise the technology, an indication of some level of trust in the automation.

V CAN HUMANS BE REPLACED ALGORITHMS?

One of the core rules in the COLREGs is that any action taken to avoid collisions shall, if the circumstances

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permit, be positive, made in ample time and with due regard to the observance of good seamanship (Rule 8). This rule states that if ships meet and there is a risk of collision, the action of the give-way ship shall be timely and readily apparent to the other ship.

While the wording of the COLREGs is sufficiently precise regarding what action(s) ships should take to avoid collisions, the lack of quantifiable distance and time values for what is deemed to be positive, ample time and good seamanship requires interpretation by the navigator. These safety margins depend on many factors, such as traffic density, geographical area, ship hydrodynamics, weather and sea state, which, in practice, results in different safety limits throughout the course of a voyage.

By being able to adjust the CPA and TCPA, the support tool does provide some means to actively set values that may reflect the operator's interpretation of at least 'positive' and 'ample time'. The CPA value in the support tool can be regarded as the ship's safety domain (meaning that no other ships or collision threats should be within this zone) and may be depicted as a surrounding circumference; whereas the TCPA value may be considered as the timing device useful for when the operator receives a suggestion. The TCPA value is not to be confused with the same term used in ECDIS or ARPA as, among others, a threshold limit for generating alarms. As soon as other ships are within the CPA/TCPA parameters, the support tool starts calculations and provides a solution. The implication of the TCPA setting is that the higher the value, the earlier a suggestion is provided; while the higher the CPA value, the more distinct the manoeuvre suggestion will likely be, that is, greater course and/or speed changes (Figure 3).

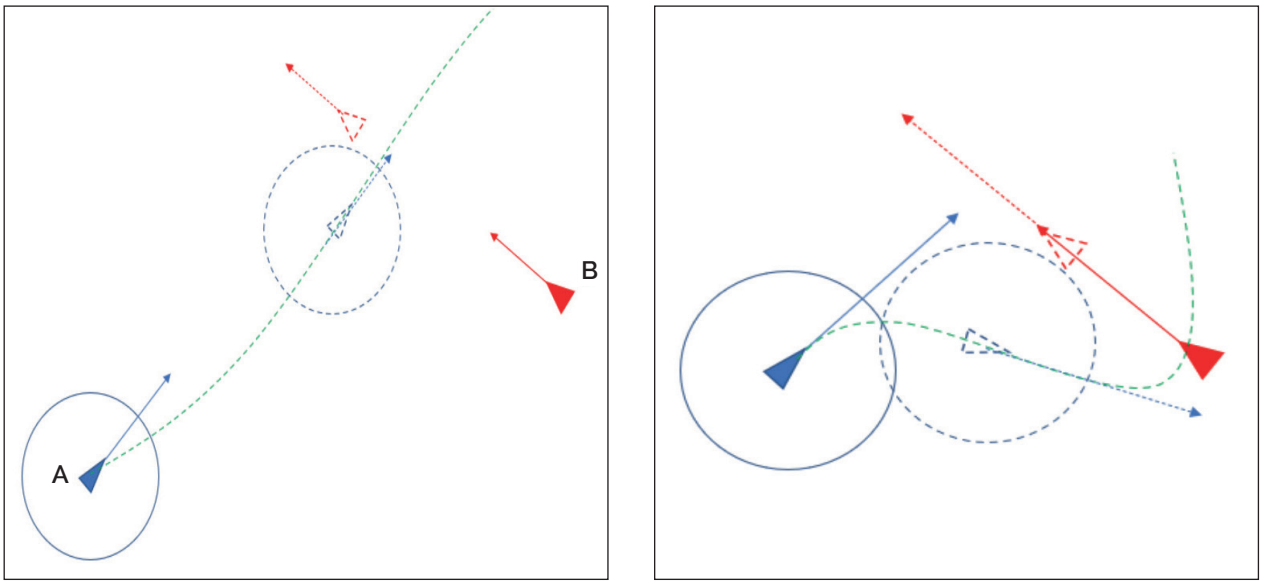

Figure 3: Effect of TCPA Setting (high value left, low value right, dotted lines are predicted states)

As these values are presently set by an operator, a fully autonomous algorithm will need to have the capability to 'choose' reasonable and safe settings, reflecting the deliberations made by an experienced navigator. With sufficient historical voyage data and appropriate machine-learning methodologies this 'may' be possible, however, it may result in traffic situations that involve autonomous ships with different values, established from different operational limits, as to what is deemed 'ample time' and 'positive', with unknown effects.

VI WHAT IS GOOD SEAMANSHIP?

The term 'good seamanship' could be synonymous with the expression 'ordinary practice of seamen', as reflected in Rule 2, which states that:

https://doi.org/10.47348/SAJMET/2023/i1a6

> *Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.*

Using the terms 'good seamanship' or the 'ordinary practice of seamen' will not contribute to the development of a fail-proof algorithm because these terms are even harder to define than 'positive' and 'ample time', and may only be intuitively meaningful to a navigator. Virtually all navigators associate something with good seamanship and ordinary practice of seamen, and potentially assume that other navigators have the same understanding and interpretation of the terms. Unfortunately, this is not necessarily true and there may be traffic situations involving conflicting interpretations of 'good seamanship' or different views on whether the situation requires to be solved 'by the ordinary practice of seamen' at all, instead of applying the steering rules. The art of good seamanship may become even more opaque as the implementation of higher levels of automation occurs.

Deriving algorithms that do not consider the factor 'good seamanship' will not necessarily be a solution either, as traffic situations are sometimes solved (or even must be solved) under the 'good seamanship' umbrella in a more safe and efficient way, rather than by a literal application of the steering and sailing rules stated in the COLREGs. In one of the experimental scenarios, ship Alpha was overtaking ship Charlie, but also meeting ship Bravo in a head-on situation (see Figure 4). All ships had their projected CPA off the island.

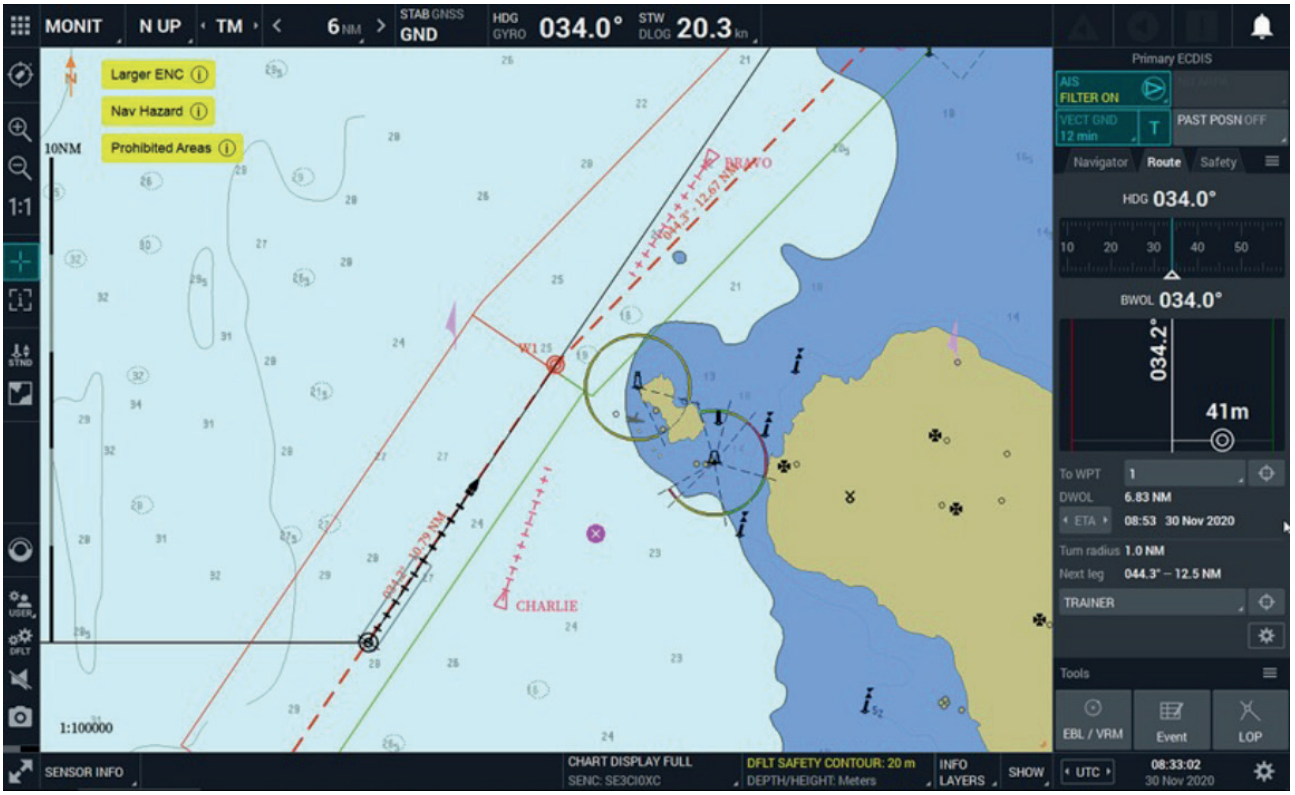

Figure 4: Traffic Situation in the Halland Scenario as Seen on Alpha

https://doi.org/10.47348/SAJMET/2023/i1a6

The situation that ship Alpha faces is that she was a give-way ship to both Charlie (overtaking situation) and Bravo (head-on meeting situation). According to the rules, overtaking can be done on either side (Rule 13) but a head on meeting is to be solved by both ships changing their course to starboard (Rule 14). However, the problem Alpha faced is that she would need to alter course quite a bit to starboard to overtake Charlie and meet Bravo, according to the rules. That manoeuvre would take her close to the shore and shallow waters. The support tool suggested as the primary manoeuvre a course change to port and, as an alternative, to starboard (see figures 5 and 6).

Figure 5: Primary Support Tool Suggestion on Alpha

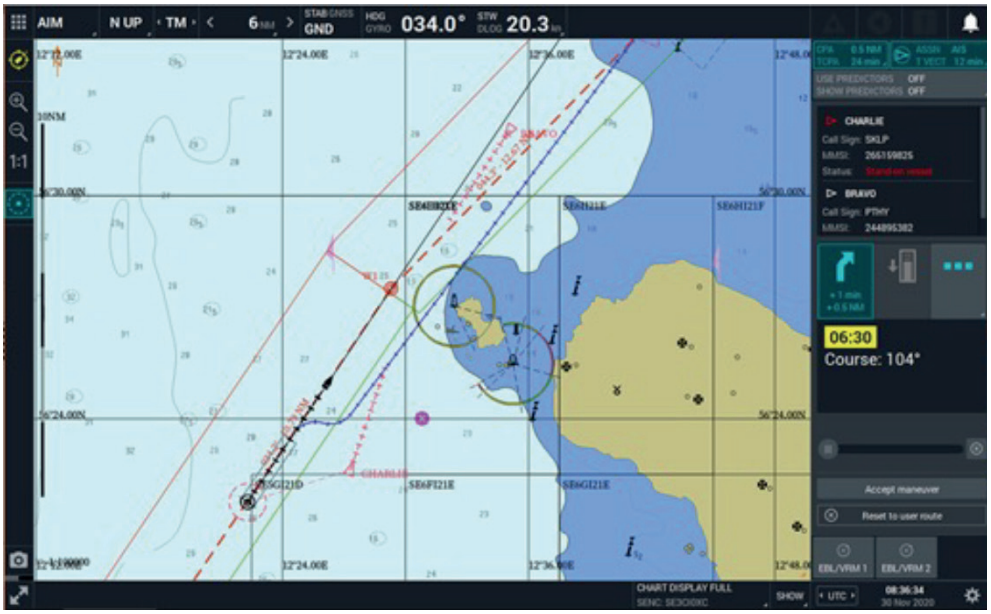

Figure 6: Alternative Support Tool Suggestion on Alpha

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The support tool's suggestion that Alpha changes course to port may be against Rule 14 but, considering that Bravo was at a distance of 12 NM, it may be argued that, although the ships were in sight of one another, the COLREGS do not (or should not) apply at such distances, or that making a bold alteration in course to keep away from land would be acceptable from the 'good seamanship' point of view. However, looking at the support tool's primary suggestion on Bravo (the head-on meeting ship) (see Figure 7) such a manoeuvre would not solve the situation but rather create another situation, as both ships were still likely to be in a close-quarters situation.

Figure 7: Primary Support Tool Suggestion on Bravo

The preferred option taken by most participants to solve this traffic situation, according to the logged tracks, seems to assume that Bravo, having due regard to the constraints of Alpha and Charlie (having land on their starboard side), would sufficiently alter course to starboard, allowing Alpha to overtake Charlie on her port side with a safe CPA. Figures 8 and 9 show all the simulation tracks of Alpha and Bravo, where the thin red and green lines depict the suggestions made by the support tool and the thin white lines depict the monitored route of the respective ships.

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Figure 8: Tracks of Alpha from Simulation Runs (runs with support tool in yellow)

Figure 9: Tracks of Bravo from Simulation Runs (runs with support tool in yellow)

The data from the trials are not statistically significant due to the limited number of trials, but it raises the question whether the assumption that Alpha may rely on Bravo's distinct action can or even should be programmed explicitly into an algorithm. It also needs to be remembered that the suggestions provided by the support tool were based on certain CPA/TCPA values being identical on all involved ships and different pre-selected settings for each vessel would have resulted in different suggestions and solution approaches. Regardless, humans may rely and act on potentially well-founded assumptions that other ships act according to the poorly operationalised and possibly geographically dependent term 'good seamanship'. Algorithms will need significant data based on deep machine learning, which is likely difficult to obtain. However, even if such data may eventually become available, the fundamental question of what is considered as possibly violating the steering and sailing rules within the COLREGS versus acting according to 'good seamanship' remains.

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VII IS ADAPTABILITY CRUCIAL?

Before starting the exercise, the scenario was uploaded on the bridges and set to pause mode. Each participant was given approximately 10 minutes to complete the pre-scenario questionnaire, which was an assessment of the situation, including the OS plan of action and expectations of how the other ships' navigators in the scenario would act. The results show that in 57% of the cases, participants followed their intended plan and in 12% of the cases they needed to change their original plan, that is, make a different manoeuvre. However, in 31% of the cases, a moderate change or adaption of the original plan (which could be by way of changing the course and/or speed to a lesser degree) was deemed sufficient to solve the situation. Whether this was due to participants being careless in drafting their original plan, or whether such flexibility and moderate adaption of a plan constitutes a major factor in avoiding a close-quarters situation, could not be answered in this study. However, considering the inherent dynamics in traffic situations with multiple ships, one may safely assume that the adaption of planned manoeuvres and flexibility are critical ingredients for safe navigation. Whether appropriate machine-learning algorithms could or should be tuned, or not, to incorporate such flexibility and minor adaption capabilities is not necessarily self-evident and needs further investigation.

VIII TRAINING SEAFARERS FOR A DIGITALIZED AND HIGHLY AUTOMATED WORKPLACE

Given the challenges digitalisation and an increase in automated functions striving towards fully automated and autonomous operation of ships, the training requirements and vocational competencies should be revised.[9] Recent research has made attempts to identify future training needs for seafarers by comparing the shipping industry to other domains, such as aviation, rail, nuclear and mining.[10] Three key areas within these domains' training needs were identified:

- **cognitive**: the skill to think faster and learn easier through exercise
- **communicative**: in addition to read and write, the nonverbal communication by way of observing to infer the meaning
- **operational**: the skill that includes analytical thinking, effective communication and taking efficient action.

The authors argue that the future training of seafarers would also has to focus on these three key areas. The Human Maritime Autonomy Enable (HUMANE) project[11] identified important future skills chosen by experts within the maritime domain. The top seven important skills listed are (a) emergency response; (b) communication; (c) well-trained and multiskilled; (d) safety awareness; (e) seamanship; (f) tool handling; and (g) IT and cybersecurity.[12] These skills are considered to be related to the need for the ability of future operators´ to learn and relearn, and to adapt and manage new situations, such as those resulting from emergent AI-based technologies and resultant operational procedures. Scanlan et al.[13] have also identified cybersecurity as a skill gap and suggest a revision of the existing bridge and engine resource management courses as a way of providing the necessary skills and awareness to address these challenges.[14] The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)[15] mainly focuses on technical and operational skills, although the Manila amendments to the STCW Convention and Code added changes to the training requirements concerning, inter alia,

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9 MacKinnon & Lundh op cit note 3; WMU 2019 op cit note 3.

10 GR Emad, H Enshaei & S Ghosh 'Identifying Seafarer Training Needs for Operating Future Autonomous Ships: A Systematic Literature Review' (2022) 14(2) *Australian Journal of Maritime & Ocean Affairs* 114–135 DOI: 10.1080/18366503.2021.1941725.

11 <https://www.hvl.no/en/project/591640>.

12 A Hynnekleiv, M Lützhoft, & JV Earthy 'Towards an Ecosystem of Skills in the Future Maritime Industry' The Royal Institution of Naval Architects International Conference on Human Factors 19–20 February 2020, London, UK.

13 J Scanlan, R Hopcraft, R Cowburn, R, JM Trovåg & M Lützhöft 'Maritime Education for a Digital Industry' (2022) 7(1) *NECESSE*.

14 International Maritime Organization 'Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention and Code' (London: IMO 2011) (available from: <https://www.imo.org/en/ourwork/humanelement/pages/stcw-conv-link.aspx>).

15 Ibid.

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leadership and teamwork, together with modern training methodology, including distance learning and web-based training.[16] These recommendations are detailed in Tables A-II-III.[17] However, given that the above-mentioned research results mainly focusing on soft-skill development, one might argue the necessity to revisit the SCTW Convention to be able to meet the anticipated future training needs for seafarers operating in a digital and highly automated environment.

IX POTENTIAL FOR DESKILLING

The participants almost unanimously agreed that, while seafarers remain on the bridge and in control, education, training and "core navigational knowledge" remain essential. It was further identified that the potential dangers associated with the use of any automated system, including complacency and over-reliance, should be taken seriously. These risks are also present with existing navigational aids, including ECDIS and radar, which were clearly noted in IMO MSC 82/15/2.[18] The participants were clear that the technology manufacturers should not market these systems to inexperienced, fatigued or poorly educated officers. Instead, at early adoption stages of automation and operational integration, decision support should be advisory in nature and provide well-trained officers with rule-based information (COLREGs) to make and execute a final decision for safe navigation. Paradoxically, even with the risks described eloquently as the 'ironies of automation'[19] in mind, most participants argued that knowledge of the COLREGs might be even more critically considered when using similar support tools. As such, the core knowledge of navigation in education may be improved because of these types of supportive technologies.

X CONCLUDING REMARKS: THE REGULATORY ELEMENT AND THE ROLE OF CONTINUED PROFESSIONAL EDUCATION IN MANAGING HIGHLY COMPLEX AND DIGITALISED SOCIOTECHNICAL SYSTEMS

In many respects, navigation is social in nature. Is this because navigators project themselves into the 'shoes of a navigator on another vessel's bridge'? Is the human operator trying to use past data or experiences from the other vessel to try and understand the future intentions for both bridges? What about the next vessel to be encountered? Does a navigator necessarily allow the ship to be placed in a vulnerable position, one that relies on the 'common sense' of other agents in the traffic situation to remain safe? Tacit knowledge, critical thinking and other non-technical skills are clearly required to answer these questions. Current regulations and training tend to be more explicit and prescriptive in nature. It would appear that a more constructivist approach to the education of future seafarers and other maritime stakeholders (eg shore control systems and intermodal logistics) will be in demand.

Will ships and the shipping system become fully autonomous in the future? Given today's state of technology development and training paradigms, the answer is a considered 'NO'! It would likely be too dangerous to create an environment in which humans may be barred from making safety decisions. Decision-support systems will have some utility in the near future, but not without considerable reflection of the current regulatory, environment and the training standards. Continuing professional education will also be critical to solving these issues, in order to identify how the continuous disruptions brought about by new technologies will be managed.

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[16] Ibid.
[17] Ibid.
[18] International Maritime Organization (IMO) 'Role of the Human Element' MSC 82/15/2 (London: IMO 2006) (available from: <http://merchantmarine.financelaw.fju.edu.tw/data/IMO/MSC/82/MSC%2082-15-2.pdf>).
[19] Bainbridge op cit note 6.

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Scott N MacKinnon

Monica Lundh

Reto Weber

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Maritime education and training – responding to the changing role of the seafarer

Tebogo A Mojafi[†]

Abstract

Maritime transport carries more than two-thirds of the world's total cargo and plays an important role in the sustainable development of the global economy. As a derivate of trade, the shipping industry allows citizens of the world to trade and people to gain meaningful employment. According to the 2021 BIMCO ICS Seafarer Workforce Report,[1] there are about 74 000 vessels in the world merchant fleet, employing a total of 1.9 million seafarers (UNCTAD, 2021; Tang and Zhang, 2021).[2] Abidin and Ismail[3] sum the relationship between seafarer and ships by indicating that seafarers play a critical role in facilitating trade, whereas shipping is a critical element in the promotion of international cooperation.

Like other industries, shipping is also impacted by changing developments around the world. The dawn of the fourth industrial revolution (4IR) brings about challenges concerning how the industry ensures that tomorrow's seafarers have the necessary skills to ensure efficiency of the maritime industry. With the changing technologies, Emad, Enshaei and Ghosh[4] caution against simply focusing on the development of technology and forgetting about getting the seafarers ready for the future maritime landscape. Over time, the role of the seafarer has changed, requiring the shipping industry to devise strategies aimed at developing seafarer skills and competencies. Acomi and Acomi[5] found that maritime and offshore oil and gas graduates lacked some of the expected competencies including soft skills and industry experience.

Whereas, the BIMCO Workforce Report[6] estimates seafarer shortages, there are still many seafarers who are still battling to find employment. How should the country manage its seafarer development programme to ensure South African seafarer relevance into the future? This paper explores how the maritime industry should respond to the changing role of the seafarer. It establishes the challenges faced by South African seafarers regarding placement and explores the role of education and training in addressing the competitiveness of the seafarers.

Keywords: seafarer shortage, seafarer education and training, maritime education and training, cadetship, seafarer role change, technology, digitalisation

† South African Maritime Safety Authority

1 BIMCO & International Chamber of Shipping (London) *Seafarer Workforce Report: The Global Supply and Demand for Seafarers in 2021* (London: Witherby Publishing Group Limited 2011).

2 United Nations Conference on Trade and Development (UNCTAD) *Review of Maritime Transport* (New York: United Nations Publications 2021); L Tang & P Zhang *Human Resource Management in Shipping: Issues, Challenges, and Solutions* (Abingdon: Routledge 2021).

3 ZZ Abidin & A Ismail 'Challenges and Opportunities for Malaysian Seafarers' in R Harun and S Ja' far (eds) *Malaysia: A Maritime Nation* (Kuala Lumpur: Maritime Institute of Malaysia 2021).

4 GR Emad, H Enshaei & S Ghosh 'Identifying Seafarer Training Needs for Operating Future Autonomous Ships: A Systematic Literature Review' (2022) 14(2) *Australian Journal of Maritime & Ocean Affairs* 114–135.

5 N Acomi & O Acomi 'Diversification of Seafarers' Employability Paths' (2016) 15 *European Proceedings of the Social and Behavioural Sciences*.

6 BIMCO Report op cit note 1

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KNOWLEDGE
EDUCATION
SKILL
PLAN
GOAL
TRAINING
ABILITY
COMPETENCE
STUDY

I INTRODUCTION

Shipping operates in the globalised environment and, as such, it faces the same challenges that other industries experience. The sector must transcend and adjust to challenges, which include, among others, political, environmental, social, legal and technological. There is a need for shipping to take cognisance of these challenges, continually assess them and take steps to ensure relevance and value provision to the globe. With seafarers being at the forefront of driving shipping operations, it is uncontested that they are the heartbeat of the sector, thereby requiring attention amidst the global challenges that shipping is faced with.

Technological developments in shipping

The changing work environments and structures are a result of technological advancements.[7] Anvari[8] posits that the incorporation of information communications and technology (ICT) into the workplace has had a significant impact on human resources utilisation in sectors such as manufacturing and financial services, as well as in other sectors, including shipping, which has transformed its operations and embraced technology.[9]

Shipping companies and operators are constantly seeking ways to reduce costs[10] and ensure compliance with regulatory requirements, while efficiently and effectively delivering services. Shipping companies must ensure that they deliver their services timeously and safely whilst reducing their carbon footprint and contributing to a clean environment.

Improved shipboard technology is instrumental in reducing the size of the crew required to maintain operations.[11] Numerous shipping companies have invested in improved technologies For economic reasons,[12] thereby opting to reduce their ships' crews.[13] However, this same technology has created boredom and job dissatisfaction, and, with seafarers' work becoming routine and mundane, many choose to depart for opportunities on land.[14]

The increasing dependence on technology for automation and competitive advantage requires shipping companies to upgrade their security capabilities. In considering the threats and vulnerabilities brought about by the developments in technology, Caralli et al.[15] posit that shipping companies will be required to educate their employees about technological security.

Digitalisation

The environment in which seafarers work is constantly changing[16] and globalisation has accelerated these changes. Shipping is international and cannot be seen to be immune to the technological developments that

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7 M Anvari 'Impact of Information Technology on Human Resources in Healthcare (2007) 10(4) *Healthcare Quarterly* 84–88; CC Lee, SJ Czaja & J Sharit 'Training Older Workers for Technology-based Employment' (2008) 35(1) *Educational Gerontology* 15–31.

8 Anvari op cit note 7.

9 H Ghaderi 'Autonomous Technologies in Short Sea Shipping: Trends, Feasibility and Implications (2019) 39(1) *Transport Reviews* 152–173.

10 Ibid.

11 L Caesar, S Cahoon & J Fei 'Challenging the Current Paradigms of Seafarer Training and Careers' (2014) 27 *IAMU AGA 15 Looking Ahead Innovation in Maritime Education, Training, and Research* 348–356.

12 M Ljung 'Function based Manning and Aspects of Flexibility (2010) 9(1) WMU Journal of Maritime Affairs 121–133; JM Silos, F Piniella, J Monedero & J Walliser 'Trends in the Global Market for Crews: A Case Study (2012) 36(4) *Marine Policy* 845–858.

13 M Oldenburg & H Jensen 'Merchant Seafaring: A Changing and Hazardous Occupation' (2012) 69(9) *Occupational Environmental Medicine* 685–688; Caesar et al. op cit note 11.

14 S Cahoon & H Haugstetter 'Shipping, Shortages and Generation Y' in *Proceedings of the Maritime Technology and Training Conference* (MarTech 2008) 13–14; Oldenburg & Jensen op cit note 13.

15 RA Caralli, JH Allen, J Stevens, BJ Willke & WR Wilson *Managing for Enterprise Security* (Pittsburgh: Carnegie-Mellon University 3004) (available from: <https://apps.dtic.mil/dtic/tr/fulltext/u2/a430839.pdf>).

16 LD Caesar, S Cahoon & J Fei 'Exploring the Range of Retention Issues for Seafarers in Global Shipping: Opportunities for Further Research (2015) 14(1) *WMU Journal of Maritime Affairs* 141–157; M Kitada & P Baum-Talmor 'Maritime Digitisation and its Impact on Seafarers' Employment from a Career Perspective' *Proceedings of the International Association of Maritime Universities (IAMU) Conference: AGA20* International Association of Maritime Universities, October 2019 259–267.

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are in evidence across the globe.[17] Across the world, smart vessels and automation are being witnessed[18] and many people are likely to think this provides a fixed solution to the global seafarer shortage.

With the world embracing digitalisation and the 4IR, maritime industry players must keep themselves abreast with technological trends and changes.[19] Such developments are understood to be accompanied by a new set of skills, knowledge and attitudes towards work that will further challenge the industry in how it should respond to digitalisation. There is a need to prepare seafarers to the changes that may be brought by the 4IR, envisioning that seafarers, together with other workers, might find themselves being replaced by artificial intelligence and other future cognitive software.[20] Maitland[21] highlighted that future ships will be different from what we know and currently imagine, warning that robotics onboard vessels will bring sudden, traumatic and far-reaching changes. The future seafarer must have the skills required to handle the requirements and demands of digitalised vessels.

As a result, maritime businesses are investing in research, development and technologies to cut their operational costs and improve their efficiencies in the current competitive market. These organisations are compelled to stretch the utilisation of their crew members, especially officers, to maintain and operate these assets for enhanced efficiency.[22]

While there is an understanding that remotely controlling a vessel will be a crucial aspect of smart ship operation, humans will still be the ultimate decider in most of the processes. For example, for customer service, safety and reassurance, cruise ships will have to continue being fully manned.

These developments require that seafarers be able to independently solve problems and not rely on the technology but rather use it as an aiding factor. This requires that these new vessels be operated by highly skilled and experienced seafarers. The professionals with maritime background will still be required to work on advancing navigational equipment, robotics, modelling, and automation.[23]

While Abidin and Ismail[24] are of the view that school leavers are likely to be discouraged from considering seafaring as a possible career because of automation and digitalisation, and that the demand for seafarers is likely to be reduced due to digitalisation and vessel automation, Belcher, Wojnarowicz and Lehmacher[25] are adamant that technology cannot replace seafarers, as seafarers are required to conduct maintenance, assist in berthing the vessel, mooring and in emergency operations. What is evident is that technology does not compete with people but is useful in aiding the seafarer to work more efficiently and improve onboard communication. It is worthwhile noting that the industry appears to have embraced the current technological advances.

Maritime autonomous surface ship

A Maritime Autonomous Surface Ship (MASS) is defined as a ship that, to varying degrees, can operate independently of human interaction.[26]

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17 R Apostol-Mates & A Barbu 'Is Maritime English the Key in Solving Communication Problems within Multinational Crew?' (2015) 21(2) *International Conference Knowledge-based Organization.*

18 Kitada & Baum-Talmor op cit note 16.

19 Abidin & Ismail op cit note 3.

20 Ibid.

21 Cited in Abidin & Ismail op cit note 3.

22 Kitada & Baum-Talmor op cit note 16.

23 Abidin & Ismail op cit note 3.

24 Ibid.

25 Cited in L Kinthaert 'Digital Transformation: How will it Change the Seafarer's Role (2017*) Informa Connect, Published, 4* (available from: <https://knect365.com/maritime/ article/842b789d-aa16-411f-95c9-6393715daf35/digital-transformation-how-will-it-change-the-seafarers-role>).

26 International Maritime Organization (IMO) 'IMO Takes First Steps to Address Autonomous Ships' *IMO* 25 May 2018 (available from: <https://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx>).

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The IMO has the responsibility to put in place regulations that will ensure a standardised global approach in the shipping industry. To facilitate this process, the IMO has organised degrees of autonomy, as follows:[27]

- Conventional ship with automated processes and decision support – a ship with some automated operations with a crew on board to operate and control shipboard systems and functions.
- Remotely controlled ship – a ship with a crew on board but the ship is controlled and operated remotely.
- Remotely controlled ship without crew on board – the ship is controlled and operated remotely.
- Fully autonomous ship – the ship's operating system can make decisions and determine actions without human intervention.

On land, manned shore control centres (SCC) will need to be established to drive the safe and efficient operations of autonomous ships without crews.

The market for autonomous ships is projected to reach US$12.2 billion by 2030.[28] Many shipping companies view these developments as providing significant potential, with the vessels expected to promote safe, efficient and sustainable operations. Countries such as South Korea have established projects aimed at developing safe navigation technologies for autonomous vessels, estimating that in commercialising such, the country will be able to capture 50% of the global market by 2023.[29]

The automation of vessels is accompanied by an increased risk[30] for online threats and attacks and hackers threatening[31] the safety of operations. Integrated technology platforms such as those introduced by Kongsberg Maritime in 2018 are aimed at supporting situational awareness using sensor fusion technologies and combining radar and sonar with cameras and lasers. It is evident that marine automation systems are complex and operate in coordination with several other systems such as radar, Electronic Chart Display and Information Systems (ECDIS) and gyrocompasses.[32]

Mallam, Nazir and Sharma[33] posit that it is critical to develop an understanding of how autonomous maritime operations will impact the future role of seafarers. They assert that technological advances are continually redefining and transforming the role of humans within complex socio-technical systems.

To safely operate autonomous vessels, designated personnel operating the marine automated systems must be highly trained and continuously developed.[34] Abidin and Ismail[35] indicate the importance of such operators to also have the maritime background. Meeting the minimum training requirements is not enough. To achieve this, Maritime Education and Training (MET) institutions of learning must acquire high-quality simulators that are required to

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27 OJ Rodseth 'From Concept to Reality: Unmanned Merchant Ship Research in Norway' (2017) *Proceedings of Underwater Technology (UT), IEEE*, Busan, Korea; IMO op cit note 26; Abidin & Ismail op cit note 3.

28 MarketsandMarkets. Autonomous Ships Market by Autonomy (Fully Autonomous, Remote Operations, Partial Automation), Ship Type (Commercial, Defense), End-Use (Linefit, Retrofit), Solution (Systems, Software, Structures), Propulsion and Region (North America, Europe, APAC and the Rest of the World' – Forecast to 2030' (2021) *Autonomous Ships Market* (available from: <https://www.marketsandmarkets.com/Market-Reports/autonomous-ships-market-267183224.html?gclid=EAIaIQobChMI4qqF44-b7wIVEL_tCh0LdQtNEAAYASAAEgK45_D_BwE>).

29 Ibid.

30 Caralli et al. op cit note 15.

31 Ghaderi op cit note 9.

32 MarketsandMarkets op cit note 28.

33 SC Mallam, D Nazir & A Sharma 'The Human Element in Future Maritime Operations – Perceived Impact of Autonomous Shipping' (2020) 63(3) *Ergonomics* 334–345.

34 M Kim, TH Joung, B Jeong & HS Park 'Autonomous Shipping and its Impact on Regulations, Technologies, and Industries (2020) 4(2) *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 17–25; Editorial Team 'New Training Standards for Autonomous Shipping to be Developed' *Safety4Sea Singapore Forum* 19 February 2021 (available from: <https://safety4sea.com/new-training-standards-for-autonomous-shipping-to-be-developed/>).

35 Abidin & Ismail op cit note 3.

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re-create real-life situations depicting the operations of autonomous vessels.

Caution should always be exercised to avert accidents that could occur due to an overdependence on automated systems.[36] Consequently, the United Kingdom (UK) joined MASSPeople, the MASS International Training Standards Working Group, looking at developing training standards for people operating autonomous vessels to ensure that these vessels are safe.[37] This is with the understanding that the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) is inadequate to address the MASS operations. To this effect, the UK, working with the IMO, reaffirmed its commitment to innovation in the shipping industry.

Kim et al.[38] conclude that autonomous ships will require seafarers and operators highly skilled in technology and IT systems. The new remote and autonomous operations will transfer more jobs to the land, opening opportunities for more people to find onshore maritime careers attractive, while enhancing the quality of life for seafarers, preventing accidents and affording them more time to spend with their families. This opportunity is not only for the young seafarers. It is worth noting that Lee et al.[39] found that, while older workers experience a lack of technology skills, they are generally open to learning and developing their technological skills. This will ensure that the maritime operations are conducted by skilled young and old seafarers.

Rodseth[40] highlighted that fully unmanned vessels will be designed differently due to no crew onboard. Crewless vessels translate into lower operational costs. Rodseth opined that with these developments, there are likely to be more smaller ships coming into operation. Inland waterway shipping and coastal shipping may become serious competitors to the long-distance truck transport.[41] This affords the seafarers with an opportunity to work domestically and within the high-tech shipping environment.

The changing role of the seafarer

According to the STCW, shipboard tasks are classified by function and three levels of responsibility, namely management, operations and support. The seven functions are navigation; cargo handling and stowage; controlling the operation of a ship and the care of persons on board; marine engineering; maintenance and repair; electrical, electronics and control engineering; and radio communications.

Ljung[42] stresses the importance of the continual professional development of seafarers to enable them to work effectively with the IT systems that are brought about by automation and computerisation and the administrative requirements brought about by new regulations and safety systems within the shipping industry. According to Cahoon and Haugstetter,[43] other than understanding new technologies, seafarers must know how to interact with technology. It that way, they may be able to utilise technology developments for their own advantage.

Ljung posits that safety on board is likely to increase as a result of more crew members mastering technology, computer programmes and IT systems.[44] More capacity and competence could be built by means of professional development, resulting in crew members being able to repair technical errors and computer problems. Acquiring such skills and competences would save costs for the employer, create operational efficiency onboard vessels and broaden the seafarer skills.

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36 MarketsandMarkets op cit note 28.
37 Safety4sea op cit note 34.
38 Kim et al. op cit note 34.
39 Lee et al. op cit note 7.
40 Rodseth op cit note 27.
41 Ibid.
42 Ljung op cit note 12.
43 Cahoon & Haugstetter op cit note 14.
44 Ljung op cit note 12.

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The crew members should view the increased administrative work as part of the job enrichment process and not as extra work. Other than safety and crew participation, Ljung is convinced that greater knowledge, not the least in cognitive skills, is of increasing importance in the workplace and that crew members need to constantly update their knowledge through continual professional development aimed at addressing the changing nature of their work.[45]

Today's vessels are technologically developed, with high levels of automation, environmentally friendly with energy efficient capabilities and require limited human intervention.[46] These developments have led to less maintenance required at sea, with major work done onshore by outsourced maintenance companies.

Only minor work has to be performed on board by crew members as part of their housekeeping schedule.[47] Manual charts have been replaced by electronic charts and, rather than being manned, the bridge is now monitored. The previous role of cargo officers having to plan cargo movements when in port is now being done on land by ship or cargo planners.[48] Roles such as radio officer and carpenter no longer exist, while jobs like electrical technician and administration officer, which were previously not in existence, are now available.[49] This is indicative of some of the changes and adjustments that seafarers are required to undertake in order to remain relevant to their employers.

Bagoulla and Guillotreau[50] are of the opinion that the global seafarers' labour market now relies more on the quality of seafarers than the number of available seafarers. This reliance is indicative of shipping companies streamlining their resources by seeking to achieve more efficiency with fewer workers. The planned automation of certain jobs functions also creates competition of employment amongst the seafarers. Kitada and Baum-Talmor[51] warn seafarers of the need to become digitally inclined through skills adjustment and advancement.

As autonomous shipping rapidly moves closer to real-world implementation, it is critical to understand the future roles of humans in autonomous maritime operations.[52] This is with the understanding that with automation, the most affected stakeholder will be the seafarer. Kitada and Baum-Talmor[53] caution that the majority of management practices tend to be focused more on the effects of organisations than on the physical environment and neglect human and social environment for sustainability purposes. They highlight the importance of the human element in particular seafarers and their career prospects in helping the maritime industry's socioeconomic sustainability.

In conclusion, it is evident from the literature that the shipping environment continues to face challenges that require the industry, including seafarers, to plan and adjust to continue providing a service to the global economy. The global changes brought by technology developments may be seen as likely to replace the seafarers, however, the 2021 BIMCO ICS Seafarer Workforce Report study points to a shortage of seafarers, while, on the contrary, there are seafarers who are battling to find employment.

To better understand the issues that impact and result in the battle to find employment, it becomes critical that seafarers are granted an opportunity to identify and highlight the challenges that they face when searching for employment.

The maritime employers are also critical, highlighting factors that they consider when hiring seafarers, while maritime training institutions are better placed

45 Ibid.
46 Kitada & Baum-Talmor op cit note 16.
47 Cahoon & Haugstetter op cit note 14.
48 Ibid.
49 Kitada & Baum-Talmor op cit note 16.
50 C Bagoulla & P Guillotreau 'Shortage and Labour Productivity on the Global Seafaring Market' in P Chaumette (ed.) *Seafarers: An International Labour Market in Perspective* (Gomylex: Université de Nantes 2016) 15–27.
51 Kitada & Baum-Talmor op cit note 16.
52 Mallam et al. op cit note 33.
53 Kitada & Baum-Talmor op cit note 16.

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to assist in responding to the changes. As a result, this paper deals with the challenges that are faced by seafarers in finding employment. It also highlights the management factors that maritime employers consider when recruiting seafarers. In conclusion, the paper deals with how maritime training institutions should be responding to the challenges and changes impacting on the role of the seafarer.

II RESEARCH METHODOLOGY, DATA COLLECTION AND ANALYSIS

This study employed both the quantitative and qualitative research approaches. In adopting quantitative research, data that is used to quantify opinions is measurable and allows the researcher to formulate facts. By using quantitative research methods, objectivity is maximised.[54]

The data collection method that was adopted in this study was the administering of questionnaires to South African seafarers to obtain their perspectives on the challenges they face regarding placement. The questionnaire was sent out to 395 South African seafarers and a total of 324 responded to the survey, resulting in 82% response rate. Seafarers were the most appropriate subjects, as they have first-hand experience of the challenges experienced in finding placement. The collected data was analysed utilising the SPSS software.

The researcher adopted a qualitative research approach using interviews as data sources because interviews are one of the most commonly used data collection methods.[55]

Maritime employers were interviewed to determine why it is difficult to place South African seafarers, how technology impacts the role of the seafarer and how this changing role should be managed, and how it can identify the managerial decision-making factors associated with seafarer development and placement. Maritime employers are best placed to provide insights into what they consider when placing a seafarer and could indicate issues they might encounter in placing South African seafarers. Non-probability sampling was employed until no new information came to light (saturation).

Representatives of MET institutions were also interviewed to determine how technology impacts the role of the seafarer and how this changing role should be managed. The rationale for conducting these interviews was the understanding that, as training providers, they could provide insights into technology trends and curricula that affect seafarers' work, including their current capacity challenges, to respond to the identified challenges and issues. The collected data was analysed following a thematic process.

By adopting a mixed methods research approach, the researcher was attempting to evaluate the current setup of the South African maritime industry to establish what could be the challenges that are experienced by seafarers and what policy intervention and management framework could be implemented to position the country as one of the preferred maritime labour supplying nations.

Mukumbang, Kabango and Eastwood[56] are in support of integrating both quantitative and qualitative research methods, and assert that this method is used for policy evaluation and intervention, along with the exploration of multifaceted, complex and broad issues. Conversely, the researcher may strategically decide whether to give quantitative or qualitative research methods an equal status, or whether one of the two methods may become dominant while the other becomes privileged.[57]

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[54] MR Harwell, MR 'Research Design in Qualitative/Quantitative/Mixed Methods' in CF Conrad and RC Serlin (eds) *The SAGE Handbook for Research in Education: Pursuing Ideas as the Keystone of Exemplary Inquiry.* (Thousand Oaks: SAGE Publications 2011); R Kumar, *Research Methodology: A Step-by-step Guide for Beginners* (London: Sage Publications 2011).

[55] R Janghorban, RL Roudsari & A Taghipour 'Skype Interviewing: The New Generation of Online Synchronous Interviews in Qualitative Research' (2014) 9(1) *International Journal of Qualitative Studies on Health and Well-being* 24152.

[56] FC Mukumbang, EM Kabongo & JG Eastwood 'Examining the application of retroductive theorizing in realist-informed studies' (2021) 20 *International Journal of Qualitative Methods.*

[57] RB Johnson, MW McGowan & LA Turner 'Grounded Theory in Practice: Is it Inherently a Mixed Method?' (2010) 17(2) *Research in the Schools.*

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III FINDINGS AND RESULTS

To explore the structure of the data and reduce the 23 survey questions to a small number of underlying latent variables, factor analysis with Promax rotation was applied. A Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.706 and a significant Bartlett's test indicated that successful factor extraction had occurred. Six factors, accounting for 46.09% of the variance in the data, were extracted. Rotation converged in seven iterations. During the process, two questions were dropped because they did not sufficiently load onto any factor.

The factors extracted and the factor loadings for each item are summarised in Table 1. It is also evident from the table that construct validity, including convergent and divergent validity, was attained.

Table 1: Structure of the Data: Factors and Factor Loadings

Description	Factor					
	1	2	3	4	5	6
1 Some of the recruitment and crewing agencies charge applicants a fee to find employment for them.	0.661					
7 The shipping companies are unreasonable when requiring experience but do not allow new graduates to build experience.	0.636					
2 Some of the applicants fall prey to online scams offering recruitment and crewing services.	0.634					
3 The absence of a centralised recruitment system makes it difficult to find employment.	0.560					
9 New graduates are not able to find employment, as they lack the technical skills required by shipping companies for their day-to-day vessel operations.	0.489					
8 It is difficult to get a job if you do not have a reference (family member, friend or mentor).	0.455					
14 Cadetship does not provide the specific skills required by potential employers.		0.774				
12 Cadetship programmes do not provide the experience required to find employment.		0.681				
13 South Africa's training vessel (MV Agulhas) did not provide the learners with the required/recognised experience to find employment.		0.623				
15 There is a lack of job opportunities within the maritime industry, making it difficult for new graduates to find placement.			0.496			
11 Training institutions do not have the capabilities to prepare new graduates to find placement amid the continual technological changes onboard vessels.			0.475			
17 The long waiting period to become a cadet discourages potential seafarers from actively seeking employment.			0.465			
6 Shipping companies are reluctant to employ female workers.			0.384			
18 Non-exposure to working with people of other nationalities adversely affects one's chances of finding employment.			0.346			

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Description	Factor					
	1	2	3	4	5	6
4 Shipping companies are not receptive to employing applicants with chronic health challenges.				0.840		
5 Shipping companies are reluctant to employ physically challenged applicants onboard vessels.				0.759		
23 New graduates are not prepared to accept jobs that pay less than their reservation wages.					0.750	
22 New applicants have unrealistic salary expectations that shipping companies are not prepared to meet.					0.721	
16 New graduates prefer to work on coastal trading vessels rather than long-haul merchant vessels as they want to be closer to their families.					0.408	
21 Lack of dual-purpose training (a mix of deck and engineering/ generalist) contributes to difficulty finding employment.						0.895
20 Traditional training (specialising in deck or engineering) limits one's chances of finding employment.						0.546

Reliability of the composite scores

Single composite measures for each factor were formed by calculating the average agreement scores across the items included in the factor. The reliability of these composite scores were measured using Cronbach's alpha coefficient. A value of at least 0.7 is generally accepted as indicating good reliability for a scale. This is summarised in Table 2.

Table 2: Summary Results of Factor Analysis on the 23 Items

Factor	Construct	Items included	Variance extracted (%)	Cronbach's alpha
1	Placement	1–3; 7–9	17.9	0.743
2	Cadetship	12 – 14	8.5	0.746
3	Access to employment	6, 11, 15, 17, 18	6.6	0.615
4	Health-related issues	4–5	5.3	0.802
5	Conditions of employment	16, 22, 23	4.5	0.632
6	Type of training	20, 21	3.2	0.721

While two of the reliability measures were below the generally accepted minimum requirement, they were adversely affected by the small number of items included in the composite measure and can be considered adequate. The remaining constructs show adequate reliability.

Analysis was conducted on these six composite variables that describe the types of challenges experienced by seafarers. Results from a one-sample t-test to determine whether there is significant agreement or disagreement that these challenges exist (Table 3) show that there is significant agreement that challenges exist around

https://doi.org/10.47348/SAJMET/2023/i1a7

placement, access to employment, health-related issues and conditions of employment. On the other hand, there is a significant disagreement that there are challenges around cadetship and the type of training received.

Table 3: Analysis of the Six types of Challenges

Construct	N	Mean (SD)	T	df	p-value
Placement (PL)	325	3.8 (0.738)	19.748	324	<0.001*
Cadetship (C)	325	2.8 (0.979)	-3.192	324	0.002*
Access to employment (AE)	325	3.6 (0.726)	15.473	324	<0.001*
Health-related issues (HI)	325	4.0 (0.898)	20.547	324	<0.001*
Conditions of employment (CE)	325	3.2 (0.903)	3.459	324	0.001*
Type of training (TT)	325	2.9 (0.988)	-2.050	324	0.041*

* Indicates significance at the 95% level

Challenges experienced by seafarers regarding placement

Following the factor loading analysis, the challenges that are experienced by seafarers regarding placement can be classified under the themes: type of training; cadetship; access to employment; conditions of employment; placement; and health-related issues.

Figure 1: Seafarers' Challenges in Finding Placement
Source: Author

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Type of training

The standards for training seafarers are globally accepted as outlined in the STCW Convention. South Africa follows a traditional MET delivery whereby the graduate qualifies as either an Officer of Marine Engineering or Officer of Deck and Navigation. The challenge of placement does not appear to be related to the system of training (ie dual-purpose or specialisation) that the seafarer received. Both dual-purpose and traditional seafarer training are beneficial to the seafarer and the shipping company. With the advent of advanced ship technology, automation, reduced crew size and cost containment, shipping companies may, in the future, prefer to employ seafarers with dual skills.

Cadetship

Cadetship ensures that seafarers acquire the practical skills and competency necessary to work on seagoing vessels and an opportunity to work under supervision while acquiring the necessary skills. Maritime countries need a well-structured cadetship programme supported by industry with a fully equipped and well-funded training vessel. In managing cadetship, it is important that the challenges experienced by cadets are identified and addressed and long-lasting solutions are found for the betterment of the programme.

The unfunded training vessel, MV Agulhas, has added value to the maritime industry in South Africa, although it has drained the South African Marine Safety Authority's (SAMSA) financial resources. This lack of financial assistance to maintain the training vessel is in line with Nguyen et al.'s[58] findings that shipping companies have reduced their commitment to training. As Ghosh and Bowles,[59] the direct and associated costs of running a training vessel are high and SAMSA cannot continue funding the training vessel alone. With the limited berths available for a cadetship, numerous seafarers lose interest in the maritime industry and there is a dire need for more training vessels to complement the MV Agulhas.

Access to employment

The shipping industry has not been able to create sufficient jobs and cadetship opportunities for South Africa's recently graduated seafarers. Despite the interest shown by women in shipping, they constitute only a small percentage of the workforce and encounter numerous obstacles to working onboard vessels. The doubling of the number of women seafarers between 2016 and 2021, as indicated by the BIMCO/ICS Seafarer Workforce Report of 2021, is an indication of progress, however limited.

There is no clear indication that shipping companies are reluctant to employ women seafarers, however, crewing managers and employers interviewed in this study highlighted some of the operational risks and conditions of work that must be considered before deciding on placement. These considerations may also be viewed as discriminatory towards female seafarers, as they are likely to reduce their chances of placement. South Africa's two MET institutions are currently not fully capacitated to prepare seafarers to develop the technical skills that are required onboard vessels because of the limited funding they receive.

Considering the multiracial crewing systems, the ability to communicate in English is one of the most critical elements that influence placement onboard vessels. The language requirement does not impede South African seafarers, as they are mostly instructed in English from their foundational schooling through to their tertiary education years.

Conditions of employment

The young and inexperienced seafarers are mostly affected by the placement challenge. This may be a result of having not been tested in the marketplace and having no point of reference or previous relationship with an employer. In seeking placement, they generally do not have a set reservation wage, which, if not met, would persuade them to not accept the job. They have

[58] TT Nguyen, H Ghaderi, L Caesar & S Cahoon 'Current Challenges in the Recruitment and Retention of Seafarers: An Industry Perspective from Vietnam (2014) 30(2) *The Asian Journal of Shipping and Logistics* 217–242.

[59] S Ghosh & M Bowles 'Management of Berths at Sea for Seafarer Students' (2013) 5(1) *Australian Journal of Maritime & Ocean Affairs* 11–21.

https://doi.org/10.47348/SAJMET/2023/i1a7

an understanding that salaries are defined by shipping companies' ability to pay and the seafarers' experience, competence and qualifications. As a result of interaction with peers, they have an idea of what certain job grades are paid.

Based on the foregoing discussion, the salary expectations held by new graduates are generally not unrealistic. New graduates seem to be most interested in gaining experience and ranking so that they may improve their earnings. In doing so, they are open to being placed on any vessel irrespective of whether it sails in coastal or international waters. It can be concluded that the graduates do not experience placement challenges as a result of unrealistic salary expectations and only seek job opportunities on coastal trading ships.

Following entry into force of the Maritime Labour Convention, 2006 (MLC 2006), shipping companies engaged and reached agreements with trade unions and labour federations such as the International Transport Workers' Federation (ITF) on salaries and wages. Maritime administrations have the responsibility to enforce compliance with the Labour Convention.

Placement

The difficulty and time taken to secure placement can lead to desperation and job seekers becoming victims of job scams, including agreeing to pay unscrupulous crewing agencies, in contravention of the MLC 2006. The absence of a centralised recruitment system is a possible contributor to placement challenges, as this allows online scammers to take advantage of seafarers. Shipping companies may be viewed as unreasonable in requiring experience while not facilitating cadetship or assisting to capacitate the training institutions with the required capacities, for example, simulators. The shipping companies play a significant role in assisting both the seafarer and the training institutions to acquire the necessary capabilities.

Without experience, some seafarers struggle to find a placement and are lost to the maritime industry when they seek employment in other sectors. Shipping companies need to contribute to the cadetship programme by offering placements.

Ghosh and Bowles[60] posit that shipping companies are reluctant to employ cadets, as they will have to spend valuable resources on training and ensuring their certification. However, the active participation of shipping companies in building training capacity will ensure that the seafarers of the future are competent. Networking in person or on social media platforms is an important skill that every seafarer should develop. Without networking, it is difficult for a seafarer to acquire a placement.

Health-related issues

Because of the requirements for safe manning, operations and navigation, as well as the physical demands of working onboard vessels, shipping companies seems to be reluctant to employ physically challenged seafarers and those on chronic medication. This may be attributed to the physically challenging setup on board vessels, whereby seafarers are expected to move around, including in constricted spaces, requiring physical movements which may not be easy for some.

The perspective on training institutions

The changing role of the seafarer requires that training institutions also respond to the demands brought by international shipping. Maritime and offshore oil and gas graduates were found to lack some of the expected competencies,[61] including soft skills and industry experience.

To respond adequately, training institutions must understand how the business of shipping is evolving and what such changes mean to the type of training

[60] Ibid.
[61] Acomi & Acomi op cit note 5.

https://doi.org/10.47348/SAJMET/2023/i1a7

they should deliver to the industry.[62] This is critical considering the changing role of the seafarer in line with the technological developments including digitalisation.[63] This also require that such institutions identify the challenges they experience in ensuring that they deliver quality training that meet the needs of the shipping industry.[64]

Emad et al.[65] caution against just focusing on the development of technology and forgetting about getting the seafarers ready for the future maritime landscape. Preparing for the changing role and technologies impacting on the seafarer, require training institutions to establish if they have the necessary resources such as simulators[66] to deliver on their mandate, as well as identifying the various role players who are key in ensuring a well-managed seafarer development programme. This requires that the training institutions adjust themselves to meet the changes.[67] As opined by Abidin and Ismail,[68] maritime training institutions must understand that the delivery of quality courses, exams and assessments is critical to the future of the seafarers.

The perspective on maritime employers

Employers advertise their job opportunities by various means and platforms, and follow processes that include amongst others, looking for referrals, insourcing and using recruitment agencies.[69] By identifying qualifications and perceived or actual characteristics that they can correlate with job performance, employers may not be sure of the graduate's capabilities.[70]

Nevertheless, they must make the hiring decisions. In seeking job opportunities, the seafarer goes through the process of searching for opportunities that exist in the market. It is during this period that they can establish the requirements that maritime employers are looking for in filling the positions that they have.

Understanding the requirements of maritime employers provides an avenue for the seafarers to gauge their competencies against the job adverts and ensure that they devise their own developmental plans to prepare them for these kinds of opportunities. This process provides an opportunity to understand how seafaring job adverts have changed in line with the future of seafarer work and how seafarers can prepare themselves to still be relevant.

The maritime employers are also best positioned to identify the factors that are associated with seafarer development and placement. With the continual technological changes within the industry, maritime employers are best positioned to indicate how such changes are impacting the role of the seafarer. By means of their adverts, they are able to indirectly influence the teaching, skills, knowledge and abilities that must be taught to help develop seafarers.

Engaging with maritime employers also helps to understand whether there are specific challenges with regard to recruiting South African seafarers and how this can be addressed. It is through this process that maritime training institutions can also learn about the factors that impact on the placement of seafarers, thereby developing their curriculum to address the

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62 ME Manuel 'Vocational and Academic Approaches to Maritime Education and Training (MET): Trends, Challenges and Opportunities' (2017) 16(3) *WMU Journal of Maritime Affairs* 473–483.

63 Abidin & Ismail op cit note 3.

64 Ghosh & Bowles op cit note 59.

65 Emad et al. op cit note 4.

66 A Vagale, OL Osen, A Brandsæter, C Hovden, HT Kristiansen & RT Bye 'On the Use of Maritime Training Simulators with Humans in the Loop for Understanding and Evaluating Algorithms for Autonomous Vessels' in *Proceedings of the 4th International Conference on Maritime Autonomous Surface Ships (ICMASS)* 4–6 April 2022 Singapore City, Singapore 6–7.

67 Cahoon & Haugstetter op cit note 14; Manuel op cit note 62; KM Aboul-Dahab 'The Readiness of the Maritime Education for the Autonomous Shipping Operations' (2021) 18 *Arab Academy for Science, Technology and Maritime Transport*.

68 Abidin & Ismail op cit note 3.

69 N Ruparel, A Dhir, A Tandon, P Kaur & JU Islam 'The Influence of Online Professional Social Media in Human Resource Management: A Systematic Literature Review (2020) 63 *Technology in Society* 101335.

70 P Moleke *Finding Work: Employment Experiences of South African Graduates* (Cape Town: Human Sciences Research Council Press 2006).

https://doi.org/10.47348/SAJMET/2023/i1a7

challenges and exploit the identified opportunities that can be addressed by way of training. This can be addressed by a collaborative effort between the maritime training institutions and the maritime employers.[71]

While higher education provides a competitive advantage for graduates in the labour market, there are other factors influencing the economic outcomes. Moleke[72] highlights factors such as geographic area, gender, race, institution of learning and occupation as some of the factors that play a role in the economics of the labour market. It is therefore critical that such factors are explored if they are contributing to the challenges of placement as experienced by South African seafarers, and whether the same factors are considered as part of the managerial placement decisions by maritime employers.

Technology effects on the seafarer

In the past, technology was confined to the engine room on a vessel. This has changed with the extension of technology into navigation, communication and the handling of cargo. Today's navigation bridge is fitted with integrated systems and it has now become the ship's operation centre. Technology continues to be the driving force in revolutionising numerous industries, including shipping, and is used to improve the efficiency and effectiveness of business processes and operations. Technology has significantly improved the speed, safety and stability of seagoing vessels.

Work activities that in the past required strong manual labour have now been automated. By means of a combination of electrical, electronic and mechanical engineering capabilities, today's vessels are sophisticated efficient, and fitted with modern navigational and engineering equipment that has changed how the seafarers undertake their jobs.

In the past, seafarers needed to focus on paper navigational charts. These have been replaced by technologies such as ECDIS and radios have been replaced by the Global Maritime Distress Safety System (GMDSS), making the work of the seafarer much easier. There is indication from literature and several of the respondents that various technologies have been rolled out in the past, and seafarers have adapted to these quite smoothly. The ease of adaptation is a result of highly trained seafarers.

However, the challenge is to persuade seafarers to show an interest in the new technologies that are being rolled out and learn about them. The seafarers' fundamental work has not changed but is being enhanced by technology. Continuous learning and quality training are fundamental requirements to prepare seafarers to remain abreast of technological changes.

With the changes in technologies, seafarers must ensure that they do not forget their seamanship. They need to work on their ability to learn and focus on improving their technical skills and psychological well-being, as these will make it easier for them to adapt to the continual changes.

Technology has been in the shipping industry for many years, and seafarers have always managed to adapt to the changes. The changing role of the seafarer requires seafarers to adopt a positive attitude to technology and familiarise themselves with the technologies that are implemented.

Managerial decision-making factors associated with seafarer development and placement

Crewing agents and employers consider various factors in the management process of placing seafarers. These factors are explained in the ensuing subsections.

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[71] M Mourshed, D Farrell & D Barton 'Education to Employment: Designing a System that Works' *McKinsey Center for Government* 1 January 2013.

[72] Moleke op cit note 70.

https://doi.org/10.47348/SAJMET/2023/i1a7

Job requirements

Crewing agents carefully consider the job requirements as advertised. This process indicates the job content and the experience, qualifications, knowledge, skills and competencies that are required, the type of vessel that the successful applicant will be working on, and the certifications required to work on that particular vessel. This consideration is a normal recruitment process.

Applicant profiling

The crewing agents also assess the applicant's profile to determine the applicant–position fit. This includes an assessment of the elements described hereunder.

- **Compatibility and alignment** (with the job and the company). Is the applicant a perfect fit for the job and the company that is recruiting?
- **Experience** (on the specific ship type and in the present rank). Does the applicant have the required minimum experience specific to the vessel?
- **Management capabilities, leadership style and conduct.** Does the applicant have management and leadership experience?
- **History.** What was the applicant's conduct in the past?
- **Soft skills** (communication abilities, teamwork, and collaboration capabilities). What inter-personal relationships does the applicant have?
- **Health, age, training, statutory requirements met.** Does the applicant meet the health, training and mandatory requirements?

System of training

One of the managerial considerations is the type of training that the applicant has received. Depending on the requirements of the vessel, it may sometimes be necessary to determine if the applicant underwent traditional training, that is, deck or engineering specialist or dual-purpose training.

This kind of decision may be based on the safety level of the vessel's requirements, and on cost and operational efficiency. Although it is accepted that the system of training does not disadvantage the seafarer, crewing agents must sometimes consider this factor, especially when shipping companies are trying to minimise their costs by adopting a reduced number of crew members. It must be pointed out that both systems of training have pros and cons in producing either specialist or generalist seafarers.

Travel requirements

With vessels expected to call in at different ports on their journeys, seafarers must have the necessary travel documentation that will allow for ease of access to the various countries they visit. The seafarer's country of origin should establish sound diplomatic relationships with its counterparts to ensure that its passport holders can transition through the ports with ease and ensure seamless crew changes. With the onset of Covid-19, travel restrictions have become more of a challenge, requiring more systematic considerations of the continually changing environment.

Ability to learn

Crewing agents are also interested in assessing the applicant's ability to learn. This assessment seeks to determine the seafarer's interest and attitude towards lifelong learning. A seafarer may be offered a job that they do not fully suit, with the understanding that they will adapt and learn on the job as soon as possible.

Accepting that an employee can learn is a developmental and progressive view that employers adopt that creates a mutually beneficial relationship. It is therefore necessary for the applicants to demonstrate their competence and qualification in the interviewing stage and, if they are unable to prove their experience, demonstrate their willingness to learn. Providing an opportunity to an inexperienced seafarer is also likely to promote employee loyalty. Caesar, Cahoon and Fei[73] advised that a psychological contract can be devised by way of succession planning, which will lead to loyalty.

[73] Caesar et al. op cit note 11.

https://doi.org/10.47348/SAJMET/2023/i1a7

Flexibility and adaptability

In some instances, the seafarer might be expected to work on a longer contract than originally anticipated due to unforeseen circumstances. The vessel owner may wish to have that flexibility with the crew. However, this flexibility might be used to exploit the seafarers and be in breach of the MLC, 2006. Crewing agents and shipping companies may also take advantage of the flexibility and at times the desperation of cadets by exploiting their situation to assist them in securing placement.[74]

Flexibility might also be related to the teamwork that is expected on board the vessel, especially during challenging times, such as the current Covid-19 pandemic. Cadets should also be assessed on their ability to work in a team. The seafarer has to be able to adapt their behaviour in line with the challenges that are presented; this includes being open-minded and always looking for opportunities to help solve and avert challenges.

Tolerance and sensitivity

Seafaring, like shipping, is international. Shipping crews comprise numerous nationalities and people of different races, genders, cultures and religions. Numerous vessels are crewed by a mix of seafarers who are confined together over a long period at sea. Successful seafarers are those who can do away with stereotypes, and view others professionally and humanely. They will not judge the orientation of others but rather allow others the space to be themselves, while respecting their professional presence.

Seamanship

This refers to the art, competence and knowledge of operating a vessel. It is not what the seafarer will do when encountering challenges but rather how to avoid and mitigate the risks. Seafarers must have a plan on how to manage a particular challenge if it were to occur but also mitigate and avoid such challenges. This will save time and resources for the organisation.

Managerial decision-making factors associated with seafarer development and placement

In managing the placement of seafarers, crewing managers and employers are interested in finding the best fit for the position. The person–position fit is in areas such as qualifications, skills, knowledge and attitudes.

It is important that the recruiter completely understands the type of ship on which the successful person will work, and any requirements for special certifications and permits. In conducting this process, there is a need to profile the applicant in detail, considering issues such as compatibility and alignment with the job and company, experience and management capabilities, soft skills and fitness.

Whether an applicant has gone through the traditional type of specialist training (deck or engine) or dual-purpose training (a mix of deck and engine), is also a consideration, especially when shipping companies are looking at operational efficiency and cost savings. However, this is done equally considering the safe manning level requirements of the vessel

With vessels calling in at different ports globally, seafarers must have the necessary travel documents to enable them to access ports and airports with ease during crew changes. This consideration is particularly important during the Covid-19 pandemic, considering the restrictions that are put in place from time to time. This calls for countries such as South Africa to have strong diplomatic relations and build authenticity into the travel documents to facilitate the free and easy movement of its seafarers.

How applicants approach the possibility and opportunity to work with new colleagues in different working environments, and tackle new challenges, influences the decision when making a placement. The willingness to assist others to learn is one of the hallmarks of a true seafarer. With the nature of work onboard vessels, whereby decisions are to be made promptly, while considering the safety of property and

[74] M Zhao & MS Amante 'Chinese and Filipino Seafarers: A Race to the Top or the Bottom?' (2005) 39(3) *Modern Asian Studies* 535–557.

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life, all onboard work as a team and need to be flexible and adaptable to ever-changing situations. This may include having to work longer contracts for reasons beyond the control of the shipowner.

Considering the multinationalism of crews on board, proficient communication in English is an important element that gives a seafarer an advantage in landing a job opportunity. To facilitate ease of work on a seagoing vessel, employers and crewing agents consider communication in English to be one of the deciding factors in placing a seafarer.

Discrimination is frowned upon globally in shipping. With the mix of nationalities on board and in ports, comprising of different races, genders, cultures and religions, seafarers are required to be tolerant and sensitive to these differences. There is an acceptance that there is unity in diversity. Crewing managers and shipping companies do consider diversity in placing seafarers. The ability to fit in with other nationalities and genders is an important factor that crewing managers are concerned about.

Identifying and mitigating risks are critical skills that all seafarers require. Although crewing managers are interested in the competence of a seafarer to deal with issues that might arise in operating a vessel, they are more concerned with the seafarer's ability to avoid and mitigate any possible risks, as prevention is better than cure. Seafarers must demonstrate their ability to adapt, avoid and mitigate against risks in conducting their daily operational activities.

Considerations on seafarer training and education

Shipping technology developments are ongoing and improve the efficiency and effectiveness of the shipping industry. With technology, the speed, safety and stability of vessels have increased significantly. These changes are also impacting the normal shipping business operations and procedures, as well as the role of the seafarer. Previous manual work such as the use of paper navigational charts has been replaced by technologies such as ECDIS.

Seafarers must take a positive approach to the introduction of technologies and learn and adapt accordingly. Future seafarers will require pragmatic competencies comprising Science, Technology, Engineering and Math (STEM), which will allow them the agility to deal with the continuous digital changes. However, it is important to also note that the core of the seafarer's work will continue, that is, technical and seamanship. The role of training institutions continues to be important in developing seafarers' skills.

Simulator and computer-based training are two of the available training options that may be investigated to the benefit of seafarers. With the current challenges of accessing the latest technologies, training institutions should use simulators as an alternative to traditional practical training. However, these are expensive to purchase and operate.[75] Although simulators are not the perfect solution, they do offer an opportunity to progress the process of learning and development, thereby supporting the traditional onboard training. To access these, financial assistance is required from stakeholders in the maritime industry.

Technology will not replace seafarers but will assist and facilitate the work that is currently being undertaken by seafarers. Technology is developed by humans and it is humans who will have to identify and evaluate technology's workability. Embracing the change will assist seafarers to learn and become part of the new seafarer profession going forward.

Training institutions must be able to prepare seafarers for their changing role by adopting innovative technologies and psychologically preparing the seafarers to adapt and learn new skills. Technology will usher in new opportunities for seafarers who have embraced the change and can participate in managing and controlling the system onboard or virtually from the ship. Seafarers must use various platforms, such as mobile phones, to practice using the new technology. This can be done anywhere in the world.

[75] Ghosh & Bowles op cit note 59.

https://doi.org/10.47348/SAJMET/2023/i1a7

In addition to the technological considerations that must be incorporated in seafarer training, it is equally important to consider other training aspects such as:

- *Human Element* – it is critical that seafarers are prepared on how to deal with the frustrations and stresses that they encounter in their daily operations. This also includes how to deal with and avoid matters such as harassment on board vessels and supporting those who may be experiencing such harassment. The Covid-19 pandemic has taught humans about the importance of good mental spirit, considering the isolation and other stresses that seafarers have to deal with.
- *General Management* – it is critical that with movement from sea to land, seafarers interact among themselves, including with those who are not seafarers. Learning about management principles assists with ensuring a smooth transition between land and sea. It is also critical as ships must also be managed and operated like any business organisation. General management should also include management reporting, financial reporting, risk management and strategy.
- *Interpersonal Development* – considering that ships are mostly crewed by seafarers from a mix of nationalities, seafarer training must also consider incorporating business communication, interpersonal skills including networking

In considering the above, it becomes important that MET institutions assist seafarers by equipping them with specific competencies, including the skills and attitudes necessary to navigate the shipping industry.

Table 4: Skills and Attitudes to Develop

Skills and Attitudes	
Adaptability	Leadership
Accommodative	Honesty
Communication	Mental health
Compliance	Mobility
Computer literacy	Monitoring
Continuous learning	Motivation
Cooperation	Negotiation
Critical thinking	Networking
Cross-cultural communication	Organising
Cybersecurity	Persistence
Diligence	Planning
Digital	Proactive
Discipline	Problem solving
Dispute resolution techniques	Prudence
Diversification	Research
Diversity	Resilience
Emotional intelligence	Role- and self-awareness
Empathy	Safety

https://doi.org/10.47348/SAJMET/2023/i1a7

Skills and Attitudes	
Ethical	Selfcare
Explorative	Self-development
Financial	Situational awareness
Information management	Soft skills
Innovation	Sustainability
Interpersonal	Systems controlling
Investigative	Teamwork
Judgement	Time consciousness

Source: Author

In order to address the skills shortage of maritime educators, it is critical that MET Institutions develop their own teaching capacity by encouraging both ex-seafarers and other non-maritime academics to develop an interest in MET. Additionally, other than traditional face-to-face classroom teaching, MET institutions must also explore other delivery methods, such as Augmented Reality (AR), e-learning, gaming, Virtual Reality (VR), simulations and webinars. Exploring these delivery methods will ensure that more students are able to access the training opportunities that are availed. Digital skills that comprise of the ability to analyse data and program systems is critical for the seafarer of tomorrow, who will need to be competent in controlling the systems that navigate the ship. This competency is additional to the current skill of having to physically navigate ships or undertake day-to-day ship engineering tasks.

While it is important for the seafarer to possess the technical skills that are important in undertaking the day-to-day operations on board vessels, there is a need to also ensure that the skills, knowledge and attitudes of the future seafarer must take cognisance of today's realities and what is expected into the future. Such competencies must be developed and maintained, taking into consideration the requirements of good seamanship and compliance factors related to environment, safety and legal. This becomes critical considering that new fuels are being developed and utilised on board vessels, as the maritime industry seeks to reduce greenhouse gas emissions. The seafarers must possess the skills and competencies required to ensure that these fuels are safely handled on board vessels.

With climate change and the 4IR being contemporary subjects, the seafarer of tomorrow must ensure that they can adapt and make a meaningful contribution into the future. This requires an open and proactive mindset and attitude, yearning to continuously learn. While the seafarer must be able to work independently, working in teams is an essential element that improves compliance and effectiveness. The team and the individual seafarer must know that they can depend on each other during the challenging operations on board the vessel. This requires that mentoring programmes and networking opportunities be made available to the seafarers.

Working on board vessels requires seafarers to be competent with regard to diversity, considering the internationality and mix of crews. This also relates to the issues of welfare that may emanate from possible poor working conditions, including being in a confined space, namely a vessel. The seafarers must be taught the skills necessary to ensure that they can navigate matters of diversity, harassment, bullying and racism, and are able to access and maintain good sound mental health.

What is evident is the need to ensure that seafarers are equipped with a positive psychological mindset that enables them to navigate the challenges experienced in their profession. This requires being aware of self and the environment and having the courage to deal with the issues being encountered with discipline and emotional intelligence.

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Limitations of this study

Considering the historical challenges experienced by South Africans, this research did not consider participants' demographics, as it was more concerned with receiving input without linking it to a participant's background. Future research may establish whether the challenges faced by South African seafarers differ based on their demographics or not.

This research did not assess the resources and capabilities of the MET institutions in preparing seafarers to transition to the new technology. It may be beneficial to establish a capacity needs analysis of the MET institutions, in line with the skills and competencies that maritime employers require.

IV CONCLUSION

Like other industries, shipping is exposed to many challenges, in line with the globalised environment. One of the major challenges that shipping is not able to avoid is the changes brought about by technology. Seafarers are therefore required to adapt to the changes and recognise that there is a need to respond to their changing roles.

Whereas the BIMCO/ICS Workforce Report points to a shortage of seafarers, it is evident that seafarers continue to experience challenges in acquiring placement. To understand the challenges, maritime employers and training institutions are best placed to contribute insights into how to respond to the changing role of the seafarer. Such responses can be informed by understanding placement decision-making factors by maritime employers and considering the effects and other aspects of training and education.

By so doing, new skills and competencies necessary for seafarers to adapt to the changing environment can be developed with the contribution of both the seafarers and the maritime employers. MET institutions must position themselves as apex institutions, build own capacity and develop the required skills and competencies needed in the maritime environment.

Responding to the changing role of the seafarer requires a strong collaboration by various stakeholders, including the seafarers.

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Challenges in International Convention on the Standards of Training, Certification and Watchkeeping Compliance: A case study of the South African Maritime Education and Training System

Yamkela Nhleko[†]

ABSTRACT

Maritime education and training (MET) has been instrumental in the development of seafarers in South Africa and internationally. As a result, different MET systems are used to not only produce eligible maritime professionals but to ensure that they comply with the requirements of the International Convention on the Standards of Training, Certification and Watchkeeping (STCW) 1978, as amended in Manila. Some of the challenges in MET prove not to be exclusive but common to some maritime countries. As such, this study aims to explore South Africa's unique approach to MET rather than the conventional approach of having higher education institutions dedicated specifically to maritime education and maritime training. This has created the need to analyse how the current MET system delivers training in compliance with the minimum standards of the convention. This paper therefore analyses how the STCW Convention and Code is embedded in the MET system in South Africa, and identifies the existing challenges in meeting the requirements of the convention, as well as identifying opportunities for improvement. The identification of challenges and opportunities is investigated by means of desktop research, reviewing existing literature, a document analyses on the academic and technical (vocational) framework, and a review of existing practice and benchmarking this against international practice standards (STCW). This paper proposes a framework that could contribute to the improvement of the current MET system in line with the requirements of the STCW 1978 as amended.[1]

Keywords: STCW compliance, Maritime Education and Training (MET), STCW Convention and Code

† ESD Coordinator, EThekwini Maritime Cluster

[1] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW) 1978 (2017). International Maritime Organization, London, UK.

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I INTRODUCTION AND BACKGROUND

The STCW Convention and Code

The international nature of the shipping industry is inarguable. This propelled the need for the industry to be regulated both at national and international level (Alderton & Winchester, 2002).[2] Like every industry, a skilled workforce, seafarers in this instance, form an integral part in the functionality of the industry and, as such, the human element has proved to be a subject of paramount importance for effective and efficient operations. Mohammed[3] emphasised the notion that it is crucial to have a shared definition of the competencies needed to manage the vessels when there is a global crew, in addition to the different social, cultural, and religious diversities. Therefore, an international instrument proving to be quite pertinent towards defining training and certification standards that synchronise the competences of both seafarers and instructors is crucial. MET on an international scale, specifically for seafarer training, is regulated by the International Maritime Organization's (IMO) STCW 1978 as amended. According to Mohammed:[4]

> *This identifies the STCW Convention and its associated Code as a unique supranational legal document and regulatory framework that defines and frames the competency of seafarers at a global platform by setting the minimum standards.*

As such, member states have the responsibility of implementing and enforcing STCW 1978 as amended. In South Africa, the South African Maritime Safety Authority (SAMSA) is the mandated maritime administration, while the South African International Maritime Institute (SAIMI) is tasked with the 'advocacy and the promotion of South Africa's maritime sector, the coordination of education, skills, training, research and development, as well as to serve as the knowledge hub on maritime matters'.[5]

MET in South Africa

To better understand the dynamics of the South African context, it is important to first provide a background of the nature of MET in the country. Maritime education begins at a basic education level, with some secondary schools offering maritime studies or maritime economics. The learners who are able to branch into other technical marine and maritime-related careers after secondary school are those who took physical sciences and mathematics subjects while at school. For the theoretical maritime subjects, higher education institutions (HEIs) have different requirements from undergraduate to postgraduate level.

SAMSA is responsible for implementing and regulating the STCW Convention and Code. Bonnin and Woods (2002)[6] highlighted the fact that, although SAMSA is the recognised maritime administrator for the country, the Transport Education Training Authority (TETA) is recognised as the sector education and training authority (SETA). This stems from the legislative mandates of TETA provided by South African Skills Development Act 1998 (SDA) as amended, South African Qualifications Authority Act 58 of 1995 and the National Qualifications Framework (NQF) Act 67

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2 Cited in TI Mohammed 'The Critical Role of Government and Key Industry Players for Sustainable Development of Maritime Education and Training Institutions: The Case of Institutional Development in Kenya' in A Pazaver, ME Manuel, J Bolmsten, M Kitada and I Bartuseviciene (eds) *Proceedings of the International Maritime Lecturers' Association. Seas of transition: setting a course for the future* (Malmö: World Maritime University 2021) 90–102 DOI: 10.21677/imla2021.09.

3 TI Mohammed 'All Hands on Deck: Addressing Key Challenges in Kenya's MET System in Compliance with The STCW Convention and Code for Sustainable Blue Economy Growth' *Proceedings of the 1st TUM Multidisciplinary Conference and Innovation Week* Mombasa, Mombasa April 2019 3–5.

4 Ibid at 2.

5 South African International Maritime Institute (SAIMI) 'Background' *SAMI* (2019) (available from: <https://saimi.co.za/article/background/>).

6 Cited in PM Kuhlase 'The importance of maritime education and training within the secondary education system in South Africa' (Master's dissertation, World Maritime University, Malmo 2020) (available from: <https://commons.wmu.se/cgi/viewcontent.cgi?article=2449&context=all_dissertation>).

https://doi.org/10.47348/SAJMET/2023/i1a8

of 2008.[7] The SDA paved the way for the establishment of 21 SETAs across the different sectors of the economy. As such, TETA was established so that the skills development issues of companies within the transport sector could be addressed, which led to the entity providing accreditation for some courses.[8] As such, TETA's responsibilities in the transport sector include rail, aircrafts, road passenger, maritime and aerospace, among others. Accordingly, the two certifying bodies, SAMSA and TETA, developed a memorandum of understanding (MoU) to collaborate in the certification of seafarer training in the country by way of a joint certification and approval processes.[9]. The purpose of the SAMSA/TETA MoU was to promote a coherent and effective quality assurance system for education and training in the maritime industry, and to clarify the manner in which SAMSA and the TETA Education and Training Quality Assurance (ETQA) unit would cooperate with each other, coordinate their functions and promote consistency in their respective quality assurance policies and procedures. Hence Bonnin et al.[10] described the South African MET system as one that is rather complex.

The training and development of seafarers in South Africa must comply with the STCW standards and fit within the NQF. However, maritime education is not limited to that of seafarer vocational education but different maritime HEIs offer maritime-related courses that are based more on the academic system. According to Manuel (2017),[11] 'training is more focused on using practical skills, whereas academic education deals more with developing the in-depth analytical and critical thinking skills of students'. This paper uses seafarers' practical training as the contextual basis. 'The current curriculum and learning programmes are also translated into the South African Qualifications Authority (SAQA) format and registered on the NQF.'[12]

The MET approach adopted in South Africa (in contrast to some of its African counterparts, such as Ghana, Egypt and Nigeria, among others) does not include an independent maritime university. Instead, the country has technical schools and HEIs that offer maritime-related courses.[13] Training institutions, such as the South African Maritime Training Academy (SAMTRA), offer maritime programmes up to the diploma level. The qualifications offered by these institutions are a combination of theory and practical training, which incorporates the requirements for STCW. For instance, the Durban University of Technology (DUT) offers a three-year National Diploma in Maritime Studies, where there is a requisite theoretical knowledge programme for two years and then 12 months of experiential learning in order to deem the qualification complete.[14] The design of the curriculum in these institutions depicts the nature of MET defined by Basak (2017):[15] 'MET is a combination of education of knowledge of the defined theoretical subject and training skills for a number of practical short duration courses, in training institutions'. However, the maritime HEIs mostly provide long-duration courses, with a minimum of

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7 Transport Education Training Authority (TETA) 'Mandates' *TETA* 2023 (available from : <https://www.teta.org.za/index.php/home/about-us/mandate>).

8 M Dube, V Lushaba & N Gumbi 'A qualitative investigation into challenges faced by transport sector small micro and medium enterprises in accessing skills development' *Southern African Transport Conference* July 5–7 July 2021 Pretoria, South Africa (available from: <https://repository.up.ac.za/bitstream/handle/2263/82391/2C_04.pdf?sequence=1&isAllowed=y>).

9 Kuhlase op cit note 6.

10 D Bonnin, T Lane, S Ruggunan & G Wood 'Training and Development in the Maritime Industry: The Case of South Africa (2004) 7(1) Human Resource Development International 7–22 (available from: <https://www.tandfonline.com/doi/abs/10.1080/1367886021000029449).

11 Y Nhleko 'Integrating a sustainability curriculum within maritime education: case study of a South African university' (Masters dissertation, World Maritime University, Malmo 2022) (available from: <https://commons.wmu.se/cgi/viewcontent.cgi?article=3079&context=all_dissertations>) at 7.

12 Kuhlase op cit note 6.

13 Nhleko op cit note 11.

14 Durban University of Technology (DUT) 'Maritime Studies' *Faculty of Applied Sciences* (2023) (available from: <https://www.dut.ac.za/faculty/applied_sciences/maritime_studies/>).

15 SK Basak 'A Framework on the Factors Affecting to Implement Maritime Education and Training System in Educational Institutions: A Review of the Literature' (2017) 194 Procedia Engineering 345–350 (available from: <https://www.sciencedirect.com/science/article/pii/S1877705817333064>) at 345.

https://doi.org/10.47348/SAJMET/2023/i1a8

three years to complete the qualification. Additional STCW training is then offered as short courses that are provided by various SAMSA-accredited independent training institutions. This is reflected in Table 1. As of 2021, the University of KwaZulu-Natal began offering a Post Graduate Diploma in Maritime Studies in the Unit of Maritime Law and Maritime Studies.[16]

However, Zimmerman[17] found that although South Africa produces sufficient graduates with maritime-related degrees, they lack the specific skills needed by the sector, which are mostly technical and professional maritime abilities, indicating the need to prioritise the critical skills for the industry.

Table 1: The Maritime Courses Offered by South African Institutions

Institution	Programme/structures
Cape Peninsula University of Technology (CPUT)	Marine Engineer/Seafarer
Durban University of Technology (DUT)	Degree/Diploma in Nautical Sciences
False Bay TVET College	Short courses/vocational
Maritime, Ports, Transport and Logistics – University of Stellenbosch	Short courses in ports and terminals, maritime and shipping, transport and logistics
Nelson Mandel Metropolitan University	Degree/Postgraduate Diploma
South African Maritime School and Transport College	Various courses/diplomas
STC-SA; SAMTRA; SA Naval College	Various courses and naval officers
Transnet Maritime School of Excellence	Port related courses
University of KwaZulu-Natal, Unit for Maritime Studies	Postgraduate Diploma in Maritime Studies, Master of Maritime Law, Master of Commerce Maritime Studies
SSTG Maritime Training Academy	STCW and STCW-F approved Maritime Training Courses
Others are minor course providers listed by SAMSA, TETA	Minor/Short courses, certificates and diplomas

Source: Modified from Dyer[18]

[16] University of KwaZulu-Natal (UKZN) 'Postgraduate Diploma in Maritime Studies' *Unit of Law and Maritime Studies* (2021) (available from: <https://maritime.ukzn.ac.za/programmes/postgraduate-diploma-in-maritime-studies/>).

[17] D Zimmerman 'South African Maritime Skills Supply and Demand' (2022) 1(1) *South African Journal of Maritime Education and Training* 63–70.

[18] JA Dyer 'The Impact of Climate Change on the Future of Pacific Maritime Supply Chains, Seaports and Shipping: How Stakeholders Can Adapt' (PhD thesis, University of Tasmania 2019).

https://doi.org/10.47348/SAJMET/2023/i1a8

II CHALLENGES

In 2019, South Africa was among the over 80 countries that faced a possible delisting from the list of parties to the STCW Convention by the Maritime Safety Committee, dubbed as the 'Whitelist', because of quality management systems and regulations-related reasons.[19] However, in 2022, the country was able to retain its Whitelist status, inferring compliance with STCW.[20] Although South Africa has its recognition on the IMO Whitelist, the country is still prone to challenges in implementation with regard to the synchronisation of the MET–STCW requirements.

Sufficient training

The STCW Convention clearly advocates for the amalgamation of theoretical knowledge with on-the-job training, promoting experiential learning. The findings of a comparative study done by Ruggunan et al.,[21] (2014) which aimed to review the human resources development strategies for seafarers in South Africa and Australia, indicated issues such as:

- On the part of South African seafarers, they claimed that reforming legislation that supports the industry, having the political will and providing more practical training on vessels for cadets would greatly enhance maritime training in South Africa.
- School-based instruction now dominates, even in many parts of the on-the-job training programmes. This leads to difficulties that frequently arise in acquiring and transitioning knowledge to workplace.
- The combination of school-based instruction and unstructured and unsupervised on-the-job training produces unsatisfactory results. Many mariners never get the chance or the proper learning environment to become verifiably competent.
- Too high a workload on the seafarer as a result of constantly updated conventions and codes. There is a lot to do, and there is a lot of paperwork and procedures to follow. The resultant increase in the workload of crewmembers leaves little room for mariners to engage in and supervise the training of apprentices on board ships. Rather than reducing the workload at sea, regulations are making it more challenging.

Qualified trainers/instructors

The STCW clearly states in Regulations I/6 (Training and assessment) and I/8 (Quality standards) the requirements for the qualification of instructors and assessors in maritime education and training institutions (METIs) (IMO, 2017).[22] The Convention and Code encourages the MET instructors and assessors to continually improve their teaching skills in order to keep up with the ever-changing trends within the industry. Vujičić et al.[23] assert that the instructors need to be adequately qualified for the specific type as well as the level of training and assessment. The authors put forward that (2017), the recommendatory Part B of the STCW Code in Sections B-I/6 and B-I/8 provide practical recommendations for Member States states on how to adhere to the requirements outlined in the mandatory Part A. Thereby serving as a guide for the kind of training required for qualifications at each level. In reference to the capacity of DUT and CPUT for training

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[19] South African Maritime Safety Authority (SAMSA) 'Possible Delisting of South Africa From IMO's STCW 'Whitelist' a Major Concern' *The 10th Province* 02 May 2019 (available from: <https://blog.samsa.org.za/2019/05/02/possible-delisting-of-south-africa-from-imos-stcw-whitelist-a-major-concern-samsa/>).

[20] South African Maritime Safety Authority (SAMSA) 'South Africa Proudly Retains its IMO 'Whitelist' Status for Continued International Validity of Seafarers' Certificates' *The 10th Province* 17 November 2022 (available from: <https://blog.samsa.org.za/tag/1978-stcw-convention/>).

[21] S Ruggunan, S Ghosh & M Bowles 'Reviewing Human Resources Development Strategies of Merchant Navy Seafarers in South Africa and Australia' *15th Annual General Assembly International Association of Maritime Universities* Australian Maritime College, University of Tasmania, 27-30 October 2104 152–162.

[22] International Maritime Organization (IMO) *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW) 1978* (London: International Maritime Organization 2017).

[23] S Vujičić, N Hasanspahić, A Gundić & L Maglić 'Analysis of Factors Influencing the Effectiveness of MET Instructors' (2022) 21(4) *WMU Journal of Maritime Affairs* 549–570 (available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9112274/>).

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officers, Ruggunan et al.[24] stated that 'these institutions are faced with severe human resource constraints in the training of cadets, and produce a combined total of 240 cadets a year'. This indicates that for METIs to acquire human talent with the appropriate qualifications and experience is still an enormous challenge, not only in South Africa but globally. The lack of knowledgeable instructors and assessors surely has an impact on the quality and the continuous supply of skilled seafarers by these METIs because the trainer's job is to impart the necessary skills to the trainee seafarers. Chawla[25] further emphasised the fact that, more significant than any gadgets, simulations or instructional aids present in a college, is the quality of the instructor.

This challenge is also stressed by Zimmerman.[26] The author makes the argument that tertiary institutions are experiencing difficulty in attracting and retaining lecturers who have adequate levels of knowledge and experience, together with students who enter these institutions and struggle with science, technology, engineering and mathematics (STEM) subjects. This exacerbates the mismatch between the demand and supply of maritime skills in the country. This is also highlighted in the Seafarer Workforce Report 2021 by BIMCO/International Chamber of Shipping (ICS) that the industry needs to 'significantly increase training and recruitment levels if it is to avoid a serious shortage in the total supply of officers by 2026'.[27] Zimmerman discusses the threat posed by this challenge and posits that 'these issues exacerbate the disconnect between the fast-paced, and increasingly technical, global maritime sector and the courses being offered in South Africa'.[28]

Vujičić et al. proposed a conceptual model (see Figure 1) regarding what makes a competent MET instructor, focusing on the characteristics, professional development and performance. The model emphasises the need for a balance between the practical (sea-going) and theoretical aspects of maritime training, while taking into account the STCW requirements and recommended IMO courses.[29]

Misalignment between STCW and the NQF requirements

Ruggunan et al.[30] stated that another challenge in South Africa is the lack of alignment between the country's NQF and the implementation of STCW. The accreditation framework for national skills and the standards of the maritime industry must be met. As such, implementing STCW in parallel to the NQF can have conflicting requirements on METIs and involved stakeholders. The author provides the example that, in the certification of officers, the NQF supports the recognition of prior learning (RPL). SAQA[31] defines RPL as:

> *a process through which non-formal learning and informal learning are measured, mediated for recognition across different contexts, and certified against the requirements for credit, access, inclusion or advancement in the formal education and training system, or workplace.*

This way of granting certification of officers has no station in STCW specifications which raises questions on the relevance of both requirements. Manuel and Baumler[32] state that the maritime industry

[24] Ruggunan et al. op cit note 21 at 3.
[25] P Chawla 'Standardizing Maritime Education Across Nationalities' *The Maritime Executive* 11 November 2015 (available from: <https://maritime-executive.com/editorials/standardizing-maritime-education-across-nationalities>).
[26] Zimmerman op cit note 17.
[27] International Chamber of Shipping (ICS) 'New BIMCO/ICS Seafarer Workforce Report Warns of Serious Potential Officer Shortage' ICS 28 July 2021 (available from: <https://www.ics-shipping.org/press-release/new-bimco-ics-seafarer-workforce-report-warns-of-serious-potential-officer-shortage/>).
[28] Zimmerman op cit note 17 at 63.
[29] Vujičić et al. op cit note 23.
[30] Ruggunan et al. op cit note 21.
[31] South African Qualifications Authority (SAQA) 'Current Recognition of Prior Learning (RPL) Initiatives in South Africa' SAQA 2023 (available from: <https://www.saqa.org.za/current-recognition-of-prior-learning-rpl-initiatives-in-south-africa/>).
[32] Manuel, ME and Baumler, R 'The Evolution of Seafarer Education and Training in International Law' (2020) *Maritime Law in Motion* 471–494 (available from: <https://link.springer.com/chapter/10.1007/978-3-030-31749-2_22>) at 475.

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'remains one of the most globalized of contemporary industries—if not the most globalized'. Because of the global nature of the industry, and because seafaring is an international profession, STCW requirements are of more relevance in this instance, and the requirements of the STCW Convention and Code have given local regulatory frameworks little space for manoeuvring. Regulators demand the same safety requirements on board all ships, regardless of the nationality of the crew,[33] hence the relevance of STCW as the tool that has been established for the purposes of setting minimum training standards for seafarers that are common across nations.

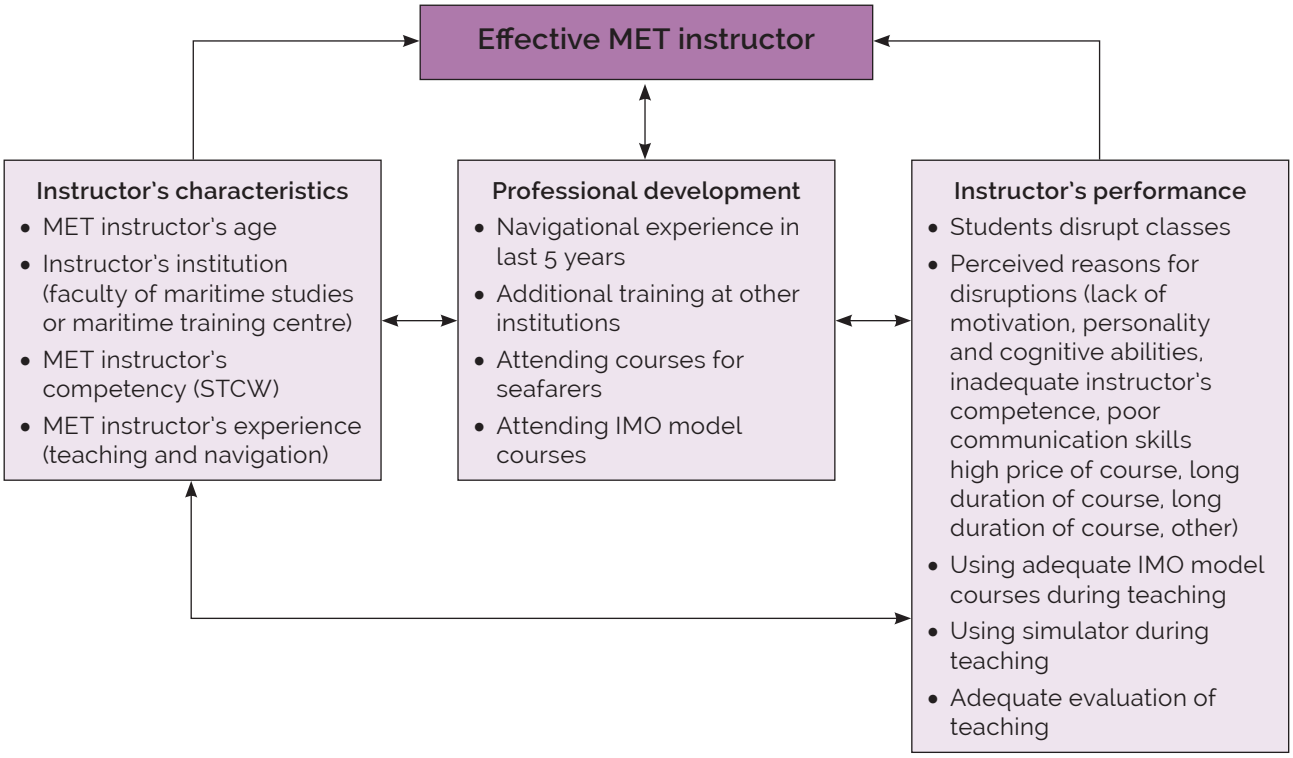

Figure 1: Conceptual Model for an Effective MET Instructor

Source: Vujičić et al.[34]

III METHODOLOGY

The aim of this study was to assess whether the South African MET system has challenges in complying with the requirements of the STCW Convention and Code, and a process to identify these challenges. Using a desktop research approach, this paper begins by looking at the South African MET system, in parallel to the global requirements for training seafarers in relation to STCW. This assisted the author to identify the gaps and challenges within the regulatory frameworks. The paper aims to answer the following questions:.

- Is the current South African MET system in accordance with the requirements of the STCW Convention?
- What are the existing gaps and challenges in optimizing the conformity of the MET system in meeting the minimum standards of the STCW Convention and Code?

[33] Chawla op cit note 25.
[34] Ibid.

https://doi.org/10.47348/SAJMET/2023/i1a8

- What change for continuous improvement could the relevant stakeholders implement towards STCW compliance?

These questions are addressed by means of a case study of the current South African MET model, by analysing the technical and academic regulatory environment, how it is currently implemented and how it benchmarks with the current minimal threshold for training standards. Online libraries were used for the relevant search, looking at key concepts, such as 'maritime education and training', 'higher education', 'STCW' and 'maritime higher education', among others. To assist in reducing the pool of articles, the timeline factor was applied to ensure that the majority of the material used was from the last five years. Any articles with more than a five-year timeline proved to be relevant to this study and likely to be true of the current state of affairs.

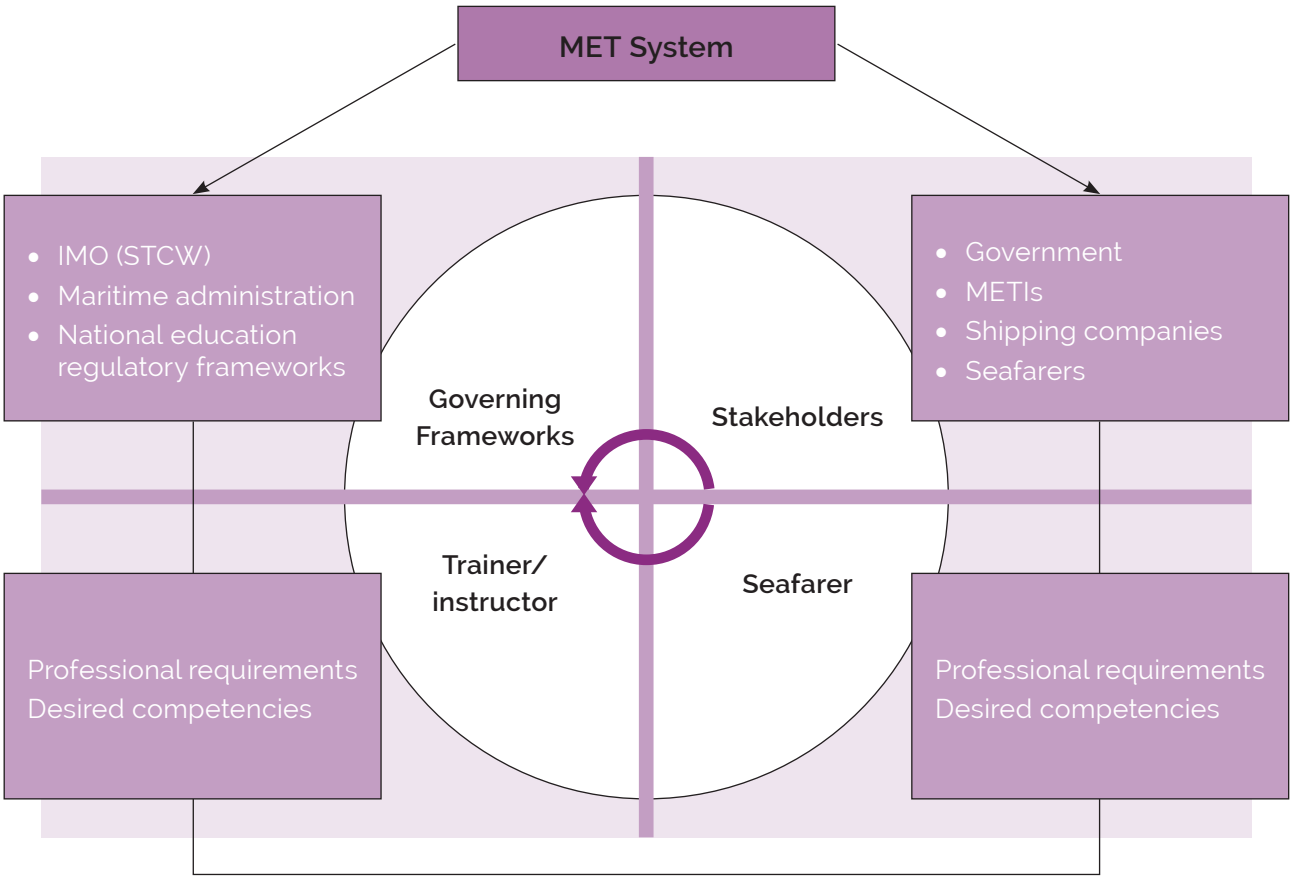

Figure 2: MET System Framework

Source: Author

IV FRAMEWORKS

MET system framework

The proposed framework (Figure 2) highlights the complexity of MET and the different factors that need to be considered in the development and management of MET. These factors must be clearly defined to achieve the desired MET outcomes to comply with the national educational policies and, on an international level, the requirements prescribed in the STCW. The interaction of all these stakeholders is imperative to ensure efficient learning and the synchronisation of the MET programme, while meeting the requirements of all stakeholders. While this may seem a rather complex

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task, it is achievable. The STCW Convention and Code recognises national regulatory frameworks or policies and, hence, sets minimum standards. In addition to these minimum standards, the national frameworks that regulate MET professional requirements, in alignment with the desired competencies in the industry, all have to interact to produce eligible maritime professionals. The challenges identified in this paper were sufficiency in training of seafarers, qualifications of instructors and the misalignment between STCW and national education regulatory frameworks. This indicates quite a few needed changes, such as standardising the requirements for the qualifications of instructors is a necessary step because this has a ripple effect on the quality of seafarers – the kind of training they receive.

Compliance framework

As a Member State of the IMO and a signatory to the STCW Convention and Code, South Africa is obligated to comply with the minimum requirements of STCW 1978, as amended. As such, the national education regulatory policies do not take first preference in this regard, and national policies must be designed in such a manner that they do not conflict with international requirements, and their implementation must be complementary. Consequently, 'giving effect to the provisions of STCW shall be achieved through restructuring of the requirements of national regulations regulating education and training' in the instance where there is a clash or a misalignment.[35] The author further suggests that, with regards to METIs complying and effectively implementing STCW, it is best to draw on best practices from other METIs that are well-established when considering factors that affect training delivery locally. This highlights the fact that, although STCW sets the minimum standards on an international level, countries or MET institutions must take into consideration local factors that may hinder effective implementation.

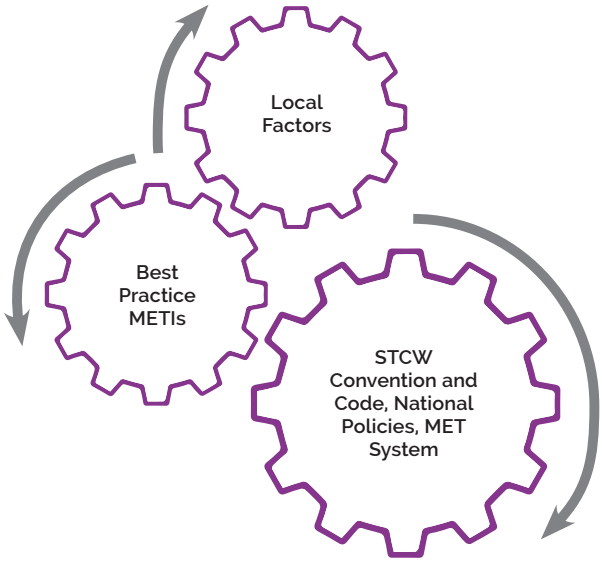

Figure 3: Compliance Framework

Source: Modified from Mohammed[36]

V CONCLUSION

South Africa has retained its listing on the Whitelist, inferring compliance with the STCW. There are still issues that can be improved for the country to maintain and improve upon the challenges associated with compliance and becoming a seafarer-supplying country. The country has done well in terms of attaining this standard without a dedicated MET university but should not overlook the possible opportunities associated with having such an institution, especially as one of the biggest maritime nations in the continent. Shipping remains and will continue to be the backbone of world trade. As such, the quality of seafarers produced is of vital importance in order to not only comply with regulatory frameworks but also attract the interest of major shipping companies in South African seafarers.

Therefore, this paper proposed looking at factors, such as ensuring that local frameworks align with international requirements, the quality of instructors

[35] Mohammed op cit note 3.
[36] Ibid.

https://doi.org/10.47348/SAJMET/2023/i1a8

in the South African METIs and the sufficiency of training that is received by cadets. For MET to be highly effective, it is vital to take into consideration all the aspects that make up and influence the MET system.

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Yamkela Nhleko

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