

From Skills to Performance: Exploring Crew Competence in Ship Maintenance Efficiency at Dar es salaam Port

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Abstract: *The efficiency of ship maintenance operations depends not only on technological systems and infrastructure but also on the competence of personnel responsible for maintaining vessel performance and safety. This study explored how crew competence influenced ship maintenance efficiency at Dar es Salaam Port. Specifically, the study examined stakeholders' experiences regarding the competencies required for efficient ship maintenance and explored the perceived influence of crew competence on maintenance efficiency. A qualitative research approach with a case study design was adopted. Data were collected from 19 purposively selected stakeholders, including marine engineers, ship maintenance supervisors, technical managers, port operations officers, ship captains, safety officers, and representatives from shipping and ship repair organizations through semi-structured interviews. Thematic analysis was used to identify key patterns and themes from the collected data. The findings revealed that technical skills and maintenance knowledge, practical experience and problem-solving abilities, and safety awareness and compliance with maintenance procedures were critical competencies influencing maintenance effectiveness. The study further found that crew competence contributed to reducing equipment failures and operational downtime, improving operational reliability and vessel availability, and enhancing the timeliness of maintenance activities. However, stakeholders indicated that the benefits of crew competence were also influenced by supporting factors such as availability of spare parts, technological changes, maintenance resources, and organizational support. The study contributed empirical insights into the role of maritime workforce competence in improving ship maintenance performance within the Tanzanian port context. The findings highlighted that competent maintenance crews were essential for sustaining reliable vessel operations and supporting efficient maritime services at Dar es Salaam Port.*

Keywords— Crew Competence, Ship Maintenance Efficiency, Maritime Operations, Vessel Reliability, Technical Skills, Problem-Solving Agility, Safety Compliance

1. INTRODUCTION

The efficiency of ship maintenance operations depends largely on the competence of the crews responsible for inspection, repair, and routine maintenance activities. Competent crews possess the technical knowledge, practical skills, and safety awareness necessary to maintain vessel reliability, reduce operational downtime, and support efficient port operations. As maritime transport continues to expand, enhancing crew competence has become an important priority for improving maintenance performance and ensuring the sustainability of port services. This study explored how crew competence influences ship maintenance efficiency at Dar es Salaam Port.

Maritime transport is the foundation of international trade, carrying more than 80% of global merchandise by volume and supporting economic development worldwide [1]. The efficiency of ports depends largely on reliable ship maintenance, which enhances vessel safety, minimizes equipment failures, and reduces operational downtime [2, 3]. Effective maintenance requires not only advanced technologies but also competent crews with adequate technical skills, practical experience, and safety awareness [4]. As the maritime industry adopts increasingly sophisticated technologies, crew competence has become a critical factor in improving maintenance quality and operational performance [5].

The increasing adoption of automation, digital maintenance systems, and smart shipping technologies has transformed maintenance practices in the maritime industry [3]. These developments require maintenance personnel to possess updated technical knowledge, problem-solving abilities, and the capacity to operate advanced equipment effectively [4]. Continuous training and competency development enable maintenance crews to adapt to technological changes and improve maintenance performance [5]. Consequently, crew competence has become an essential factor in enhancing maintenance efficiency, operational safety, and vessel reliability within modern maritime operations [4].

Many African ports have invested in infrastructure modernization to improve operational efficiency and strengthen regional trade competitiveness [6]. Despite these investments, maintenance performance in many ports continues to be constrained by shortages of skilled personnel and inadequate technical training [7]. Limited competency development opportunities also reduce workforce productivity and contribute to maintenance delays, equipment failures, and increased operational costs [8]. These challenges demonstrate the importance of strengthening crew competence alongside technological advancement across African ports [6].

Dar es Salaam Port is Tanzania's largest seaport and serves as the country's principal gateway for domestic and regional trade [9]. Recent modernization initiatives have

improved port infrastructure, cargo handling capacity, and operational performance [10]. However, maintaining efficient ship maintenance operations remains essential as maintenance technologies continue to evolve and vessel traffic increases [11]. Competent maintenance crews therefore play an important role in ensuring reliable vessel performance, minimizing operational disruptions, and improving maintenance efficiency within the port [11].

While previous studies have established the general relationship between crew competence and ship reliability, and have examined Dar es Salaam Port in terms of turnaround time, labour gang productivity, and equipment efficiency, there is limited journal literature that specifically isolates and measures how different dimensions of crew competence influence ship maintenance efficiency at Dar es Salaam Port. Most studies focus on port infrastructure, throughput, or overall productivity, leaving the human competence to maintenance efficiency link underexplored in this specific local context.

Despite recent infrastructural modernization at Dar es Salaam Port to accommodate rising vessel traffic, maintaining optimal ship maintenance efficiency remains an ongoing challenge due to an underlying gap in understanding how the "human element" specifically crew competence manifests in localized port operations. While international frameworks establish baseline certifications, there is a critical shortage of qualitative insights into how stakeholders experience these competency requirements on the ground, and how the crew's practical skills, problem-solving abilities, and technical expertise are perceived to directly influence the speed and quality of maintenance outcomes. Without exploring these lived experiences and stakeholder perceptions, ship owners and port authorities lack the contextual, depth-oriented understanding needed to address maintenance inefficiencies, resulting in equipment vulnerabilities, extended repair periods, and costly vessel turnaround delays that ultimately bottleneck regional trade.

The study aimed to explore how crew competence influenced ship maintenance efficiency at Dar es Salaam Port. Specifically, the study explored stakeholders' experiences regarding the competencies required for efficient ship maintenance at Dar es Salaam Port and examined stakeholders' perceptions of how crew competence influenced the efficiency of ship maintenance operations at the port.

The study is expected to contribute to knowledge and practice in maritime maintenance by providing insights into the role of crew competence in improving ship maintenance efficiency. Specifically, the study contributed in the following ways:

- Provided insights into stakeholders' experiences regarding the technical, practical, and safety competencies required for effective ship maintenance operations.
- Highlighted the role of crew competence in reducing equipment failures, minimizing operational downtime, and improving vessel performance.

- Expanded knowledge on maritime workforce capabilities by demonstrating how practical experience and problem-solving abilities influence maintenance effectiveness.
- Contributed evidence from the Tanzanian maritime context by addressing limited understanding of crew competence within ship maintenance operations at Dar es Salaam Port.
- Provided a foundation for improving maritime maintenance practices through emphasis on competency development, safety compliance, and operational efficiency.

2. RELATED LITERATURES

2.1 Stakeholders' Experiences on Competencies Required for Efficient Ship Maintenance

In Europe and America, efficient ship maintenance has increasingly been linked to crew competence, particularly technical skills, safety awareness, and the ability to manage advanced vessel technologies. The adoption of automation and digital maintenance systems has increased the need for skilled personnel who can interpret technical information and make effective maintenance decisions [1, 12]. Continuous training and competency development have therefore become important strategies for improving maritime reliability and operational performance [5].

In Asia, maritime stakeholders have emphasized the importance of technical knowledge, practical experience, teamwork, and communication skills in achieving effective ship maintenance. Studies indicate that maintenance efficiency depends on crews' ability to operate modern marine systems, apply safety procedures, and adapt to technological changes within shipping operations [13, 14]. Competency development has consequently been prioritized to enhance vessel reliability and reduce maintenance-related risks [15].

In Africa, ship maintenance operations continue to face challenges related to shortages of skilled personnel, limited specialized training, and inadequate opportunities for technical capacity development. These competency gaps affect the ability of maritime organizations to manage modern vessel systems and maintain efficient operations [16, 17]. Strengthening maritime education and workforce development has been identified as essential for improving maintenance performance in African ports [18].

In Tanzania, Dar es Salaam Port requires competent maintenance crews capable of supporting vessel safety, reliability, and operational continuity. However, existing studies have mainly focused on port efficiency, infrastructure, and logistics performance, with limited attention to stakeholders' experiences regarding the competencies required for efficient ship maintenance [11, 19]. This creates a knowledge gap concerning how technical skills, practical

experience, and adaptive capabilities influence ship maintenance efficiency at Dar es Salaam Port. Therefore, exploring stakeholders' experiences provides important insights into the competencies needed to improve ship maintenance operations in Tanzania.

2.2 Perceived Influence of Crew Competence on Ship Maintenance Efficiency

Europe and America, stakeholders emphasize that efficient ship maintenance relies on advanced technical proficiency, strong safety culture, and digital competency [20]. European seafarers and supervisors stress the need for continuous certification and simulation-based training to handle automated maintenance systems [21]. In America, stakeholders associate competence with the ability to interpret condition-monitoring data and make quick decisions during complex repairs [22]. They also highlight teamwork, communication, and regulatory compliance as essential competencies for maintenance efficiency [23].

In Asia, stakeholders view structured maritime education combined with onboard mentoring as critical for developing maintenance competencies [24]. Experiences of Filipino, Indian and Chinese crew show that hands-on fault diagnosis and practical experience are valued more than theoretical knowledge [25]. Asian shipping companies emphasize discipline, resilience, and multilingual communication as competencies that improve maintenance coordination [26]. Senior-to-junior knowledge transfer is also perceived as vital for sustaining maintenance quality and reliability [27].

In Africa, stakeholders report persistent competency gaps linked to skills shortages and limited access to modern training facilities [28]. Port stakeholders in South Africa and Nigeria perceive inadequate technical training and limited exposure to new equipment as major barriers to efficient maintenance [29]. Maintenance delays are often associated with weak problem-solving skills and insufficient safety awareness among junior crew [30]. Consequently, many African stakeholders rely heavily on on-the-job learning and informal apprenticeship to build competence [31].

In Tanzania, studies at Dar es Salaam Port indicate a mismatch between formal training and actual maintenance demands [32]. Supervisors perceive that many crew members depend on improvisation and informal learning due to aging machinery and spare parts constraints [33]. Stakeholders also highlight gaps in safety awareness and adherence to standard procedures as areas needing targeted intervention [34]. With recent port modernization, there is growing demand for competencies in digital systems and automated equipment [35].

While studies from Europe, America and Asia focus on technology-driven competencies and African literature emphasizes training constraints, there is limited qualitative evidence from Tanzania on how stakeholders themselves experience and define the competencies required for efficient ship maintenance at Dar es Salaam Port.

3. METHODOLOGY

This study adopted a qualitative exploratory research design to gain in-depth understanding of stakeholders' experiences and perceptions on crew competence and ship maintenance efficiency at Dar es Salaam Port. The target participants were key stakeholders directly involved in ship maintenance activities, including ship maintenance crew (engineers, technicians, and ratings), port authority officials, shipping company representatives, and regulatory or training institution personnel. A purposive sampling technique was used to select a total sample size of 19 participants. This sample size was justified on the basis of data saturation principle typical in qualitative research, where the focus is on rich, detailed insights rather than statistical generalization, and it provided adequate representation across diverse stakeholder groups [36]. Data were collected through semi-structured in-depth interviews, which were audio-recorded with consent and transcribed verbatim. Thematic analysis was subsequently applied to identify emerging patterns and themes from the collected data. To ensure the trustworthiness of the findings, the study observed the principles of credibility, dependability, confirmability, and transferability, and ethical standards were maintained through obtaining informed consent, assuring confidentiality and anonymity, and securing permission from the relevant authorities before data collection.

4. RESULTS AND DISCUSSION

This section presents and discusses the findings on stakeholders' experiences of crew competence in ship maintenance efficiency at Dar es Salaam Port. The findings are organized according to the study objectives and presented thematically using evidence from participants' experiences. Selected quotations are used to illustrate the findings, which are discussed alongside relevant empirical literature to demonstrate how they compare with existing knowledge on crew competence and ship maintenance efficiency.

4.1 Stakeholders' Experiences on Competencies Required for Efficient Ship Maintenance

Stakeholders' experiences revealed that efficient ship maintenance at Dar es Salaam Port required a combination of technical skills and maintenance knowledge, practical experience and problem-solving abilities, as well as safety awareness and compliance with maintenance procedures. Participants highlighted these three core competency areas as essential for effective performance in the port's dynamic operational environment.

4.1.1 Technical skills and maintenance knowledge

The findings as presented in Figure 1 indicated generally mixed levels of technical competence regarding ship maintenance among stakeholders at Dar es Salaam Port. Out of the 19 participants, 9 participants ($n = 9$, 47.4%)

demonstrated high technical competence, 7 participants (n = 7, 36.8%) showed moderate competence, while 3 participants (n = 3, 15.8%) exhibited low technical competence. These results suggested that while there was a notable core of highly skilled personnel, a significant proportion of the workforce still grappled with the advanced technical demands of modern maritime operations, reflecting an uneven distribution of expertise across the port.

Respondents who exhibited high technical competence emphasized that deep maintenance knowledge and technical proficiency were essential for both vessel reliability and the mitigation of costly downtime. These findings were consistent with studies from Europe and North America, where the adoption of automation and digital maintenance systems has been shown to necessitate skilled personnel who can interpret complex technical information and make effective maintenance decisions [1].

A 42-year-old senior maintenance engineer explained in detail:

"...the ability to interpret digital sensor data and translate it into precise mechanical actions is not just a job requirement; it is the absolute difference between a vessel returning to sea on time and sitting idle for days due to misdiagnosed electrical faults. When you have the right technical grasp of these modern systems, you save the port millions in potential losses that would otherwise occur from extended downtime..."

Similarly, a 38-year-old lead technical instructor elaborated:

"...mastery of modern diagnostics is the backbone of our operation. Without deep technical knowledge, our teams are essentially guessing at the root causes of failure rather than performing targeted, efficient repairs. The high-competence technicians we have are able to navigate these sophisticated systems, but that level of expertise needs to be the standard, not the exception, if we are to remain competitive as a regional hub..."

These views aligned with Asian studies, which highlighted that maintenance efficiency depended heavily on the crews' ability to operate modern marine systems, apply safety procedures, and adapt to rapid technological changes [13, 14]. The responses suggested that where personnel had exposure to advanced training and continuous competency development, the technical capacity to maintain complex maritime infrastructure was notably higher.

Among the 7 respondents (n = 7, 36.8%) who demonstrated moderate competence, participants indicated a familiarity with standard procedures but struggled when faced with

complex, non-routine technical challenges. A 39-year-old maintenance supervisor explained:

"...most of our crew can handle the standard, repetitive maintenance tasks we see every day. However, when we encounter issues with the newer automated equipment that require deeper diagnostic analysis, we start to see some hesitation and uncertainty. We are at a stage where we know enough to keep things moving, but not enough to optimize the complex repairs that the new port systems require..."

A 45-year-old technician added:

"...I have been doing this for years, and I am comfortable with the equipment I know well. But these new digital systems and automated tools are a different story. I have moderate knowledge, but I often feel that my training has not kept up with the rapid technological upgrades we are seeing at the port. We are trying to adapt, but it is a slow process for many of us..."

These perceptions were consistent with African literature, which has shown that maintenance operations across the continent frequently face challenges related to shortages of skilled personnel and limited opportunities for specialized technical capacity development [16]. The findings suggested that while these personnel possessed foundational skills, the lack of targeted training on emerging technologies served as a barrier to achieving higher operational efficiency. The 3 respondents (n = 3, 15.8%) who exhibited low competence argued that they were often overwhelmed by the pace of technological change and lacked the necessary background training to effectively manage modern vessel systems. A 35-year-old junior maintenance assistant explained:

"...to be honest, I often feel out of my depth when I am tasked with anything beyond basic cleaning or standard mechanical checks. The diagnostic software and the new electronic systems are so complex that I struggle to understand the manuals, let alone perform the actual repairs. It feels like the technology has outpaced the skills that many of us were originally taught..."

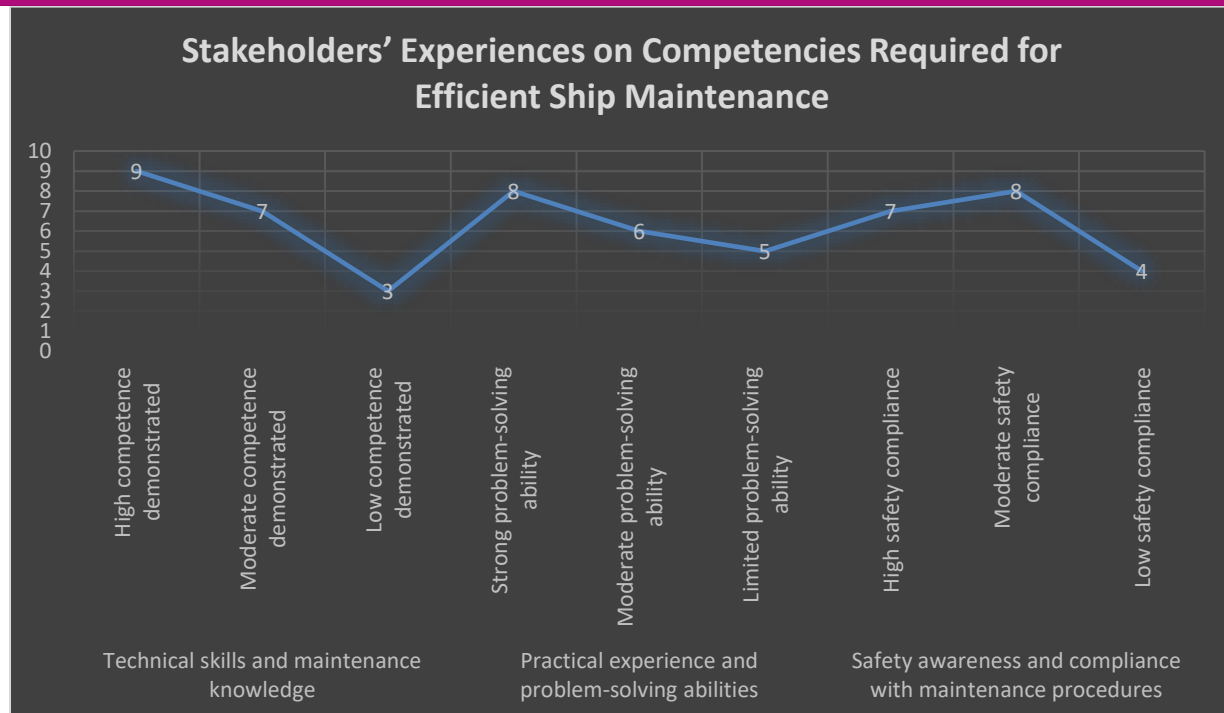


Figure 1: Showing the Stakeholders' Experiences on Competencies

Similarly, a 40-year-old general maintenance worker stated:

"...when we are dealing with high-tech equipment failures, I usually have to wait for the more experienced senior technicians to guide me through every step. I lack the formal training in these newer systems, and without that foundation, I find it very difficult to contribute meaningfully to the more complex maintenance tasks required today..."

These findings aligned with Tanzanian studies, which indicated that existing research at Dar es Salaam Port has mainly focused on port infrastructure and logistics performance, with limited attention to the technical competency requirements of maintenance crews, creating a knowledge gap regarding how these skills influence efficiency [11, 19].

When compared with existing literature, the findings suggested that while developed regions demonstrated strong technical proficiency due to structured competency development and integration of digital maintenance frameworks, the situation at Dar es Salaam Port remained mixed. Although a significant proportion of stakeholders exhibited high technical skills, a considerable share demonstrated moderate or low competence, indicating that maintenance efficiency was still constrained by limited access to specialized training and the gap between legacy knowledge and modern operational demands. This implied that strengthening maritime education, investing in targeted technical training, and prioritizing workforce development

would be essential in bridging the competence-performance divide and sustaining long-term maintenance efficiency at the port.

4.1.2 Practical experience and problem-solving abilities

The findings presented in Figure 1 indicated varying stakeholder experiences regarding the practical experience and problem-solving abilities demonstrated by ship maintenance crews at Dar es Salaam Port. Out of the 19 stakeholders interviewed, 8 participants (n = 8, 42.1%) perceived that maintenance personnel demonstrated strong problem-solving abilities, 6 participants (n = 6, 31.6%) indicated that crews exhibited moderate problem-solving abilities, while 5 participants (n = 5, 26.3%) believed that maintenance personnel demonstrated limited problem-solving abilities. These findings suggested that although many maintenance crews were capable of diagnosing and resolving maintenance problems efficiently, a considerable proportion still experienced challenges when dealing with complex equipment failures that required advanced practical experience and analytical skills. Participants explained that practical experience complemented technical knowledge by enabling maintenance personnel to respond effectively to unexpected equipment malfunctions, make timely maintenance decisions, and minimize disruptions to vessel operations.

Respondents who perceived strong problem-solving abilities explained that experienced maintenance personnel had developed the confidence and practical expertise required

to identify equipment faults quickly and implement effective corrective measures. They stated that years of working with different vessel systems had enabled these personnel to recognize recurring maintenance problems and apply appropriate solutions with minimal supervision. A 51-year-old marine engineer explained:

"...practical experience is something that cannot simply be learned from textbooks. After working on different vessels for many years, you begin to recognize equipment problems almost immediately. Sometimes you can identify a fault simply by listening to the sound of an engine or observing changes in vibration and temperature. This experience enables us to make quick decisions before minor faults become major breakdowns. It also helps us to guide younger engineers whenever they encounter maintenance challenges that they have never experienced before..."

Similarly, a 48-year-old ship maintenance supervisor stated:

"...the best maintenance personnel are those who combine technical knowledge with practical experience. They do not panic when unexpected failures occur because they have encountered similar situations before. Instead, they analyze the problem carefully, identify the root cause, and implement lasting solutions rather than temporary repairs. Their experience allows maintenance work to be completed more efficiently and minimizes unnecessary downtime for vessels..."

These findings agreed with studies conducted in Europe and America, which reported that experienced maintenance personnel were more capable of making sound maintenance decisions, responding effectively to equipment failures, and maintaining operational reliability because they possessed practical skills developed through continuous exposure to ship operations [1, 12]. The findings further suggested that practical experience strengthened the ability of maintenance crews to apply technical knowledge in real operational environments, thereby improving the quality and efficiency of ship maintenance activities.

Among the 6 respondents (n = 6, 31.6%) who reported moderate problem-solving abilities, participants explained that many maintenance personnel possessed sufficient experience to perform routine maintenance but occasionally required support from senior colleagues when confronted with unfamiliar or technically complex equipment failures. They noted that while these personnel demonstrated willingness to learn and adapt, limited exposure to advanced maintenance situations sometimes reduced their confidence during fault diagnosis. A 43-year-old technical manager explained:

"...many of our maintenance personnel are capable of handling routine servicing without any difficulty because they have performed these activities repeatedly. However,

whenever they encounter unusual machinery faults or newly introduced technologies, they often consult senior engineers before deciding on the most appropriate maintenance approach. This shows that they possess basic competence but still require additional practical exposure to strengthen their problem-solving capabilities..."

Another 40-year-old safety officer added:

"...problem-solving ability improves gradually with experience. New technicians usually understand maintenance procedures very well, but they sometimes hesitate when equipment behaves differently from what they expected. As they continue working and gain exposure to different maintenance situations, they become more confident and capable of making independent maintenance decisions..."

These observations were consistent with findings from Asia, where effective ship maintenance was found to depend heavily on continuous practical learning, workplace mentoring, and regular exposure to complex maintenance activities [14]. Studies further indicated that maritime organizations achieved better maintenance performance when experienced personnel transferred practical knowledge to junior crew members through mentoring and collaborative maintenance practices [15]. The similarity between these findings and the experiences shared by participants suggested that practical experience remained an important complement to formal technical training.

The remaining 5 respondents (n = 5, 26.3%) perceived that maintenance personnel demonstrated limited problem-solving abilities. Participants explained that some crew members experienced difficulties identifying the root causes of equipment failures, particularly when dealing with sophisticated marine systems or unexpected mechanical faults. They indicated that limited practical exposure sometimes resulted in repeated maintenance attempts, delayed repairs, and increased dependence on external technical specialists. A 47-year-old representative from a shipping agency explained:

"...some technicians understand the maintenance procedures theoretically, but when a complicated fault occurs, they struggle to determine exactly what caused the problem. Instead of identifying the root cause immediately, they may replace several components before finding the actual fault. This prolongs maintenance time and increases operational costs because the vessel remains unavailable for longer than expected..."

Likewise, a 45-year-old port operations officer remarked:

"...whenever maintenance personnel lack sufficient practical experience, they become overly dependent on senior engineers for guidance. Although teamwork is important, excessive dependence delays decision-making because every

major maintenance issue has to wait for experienced personnel before action can be taken. This affects maintenance schedules and sometimes delays vessel departures..."

These findings corresponded with studies conducted in Africa, which reported that limited practical experience among maintenance personnel contributed to weak problem-solving capacity, delayed repairs, and reduced maintenance efficiency [17]. Similar studies also indicated that strengthening workplace learning, practical training, and mentorship programs significantly improved maintenance decision-making and operational performance within African maritime organizations [18]. These findings reinforced the importance of practical experience as a critical component of workforce competence.

The findings also reflected the Tanzanian maritime context, where stakeholders emphasized that practical experience had become increasingly important due to the modernization of port facilities and the growing complexity of ship maintenance operations. Previous studies reported that improvements in maintenance efficiency required not only investment in infrastructure but also continuous development of practical competencies among maintenance personnel [11]. The present study extended these findings by demonstrating that stakeholders considered practical experience and problem-solving abilities to be indispensable for effective maintenance planning, fault diagnosis, and timely repair of ship equipment at Dar es Salaam Port.

When compared with the existing literature, the findings suggested that stakeholders at Dar es Salaam Port shared experiences similar to those reported in Europe and America, Asia, and Africa, where practical experience was consistently regarded as an essential factor influencing maintenance performance. Although the largest proportion of participants perceived maintenance crews to possess strong problem-solving abilities, a considerable number still reported moderate and limited capabilities, indicating that disparities in practical experience remained among maintenance personnel. These findings implied that strengthening workplace mentoring, continuous practical training, and experiential learning opportunities would enhance problem-solving capacity and ultimately improve the efficiency of ship maintenance operations at Dar es Salaam Port.

4.1.3 Safety awareness and compliance with maintenance procedures

The findings as presented in Figure 1 indicated varying stakeholders' experiences regarding safety awareness and compliance with maintenance procedures among ship

maintenance crews at Dar es Salaam Port. Out of the 19 stakeholders who participated in the study, 7 respondents (n = 7, 36.8%) perceived that maintenance crews demonstrated high safety compliance, 8 respondents (n = 8, 42.1%) indicated that crews demonstrated moderate safety compliance, while 4 respondents (n = 4, 21.1%) believed that maintenance personnel demonstrated low safety compliance. These findings suggested that although safety awareness was generally evident among maintenance crews, differences in adherence to established maintenance procedures continued to influence the safety and efficiency of ship maintenance operations.

The respondents who perceived high safety compliance explained that experienced maintenance personnel consistently followed standard operating procedures, used appropriate personal protective equipment, and adhered to established safety protocols before, during, and after maintenance activities. They emphasized that strict compliance with maintenance procedures minimized workplace accidents, prevented equipment damage, and ensured that maintenance activities were completed safely and efficiently. These findings were consistent with studies conducted in Europe and America, which reported that safety awareness, procedural compliance, and continuous competency development were essential for improving maintenance quality, operational reliability, and overall maritime safety [5, 12].

A Safety and Quality Assurance Officer explained in detail:

"...ship maintenance involves working with heavy machinery, high-pressure systems, electrical equipment, and hazardous materials, which means safety cannot be treated as an option. From what I have observed, experienced maintenance crews consistently follow inspection procedures, isolate equipment before beginning repairs, wear the required protective equipment, and verify that maintenance activities meet safety standards before vessels are returned to service. This level of discipline has greatly reduced workplace incidents and has also improved the quality of maintenance because technicians work more confidently when safety procedures are properly followed..."

Similarly, a Marine Engineer elaborated:

"...the most competent maintenance personnel are those who never ignore safety procedures regardless of how urgent the maintenance task may be. Before carrying out repairs, they ensure that every risk has been identified, all safety precautions have been implemented, and communication among team members is clear. This approach not only protects workers but also prevents costly mistakes that may occur when maintenance is performed under unsafe conditions. In my experience, crews that consistently comply with maintenance procedures usually produce more reliable maintenance outcomes than those who try to complete repairs quickly without following established safety requirements..."

These experiences were comparable with findings reported in Asia, where stakeholders emphasized that safety awareness, compliance with maintenance procedures, and disciplined work practices were fundamental for improving maintenance efficiency and reducing operational risks. Studies further indicated that continuous safety training and adherence to standardized maintenance procedures contributed significantly to vessel reliability and operational performance [15].

Among the 8 respondents (n = 8, 42.1%) who perceived moderate safety compliance, participants explained that although maintenance personnel generally understood established safety procedures, compliance occasionally varied depending on workload, operational pressure, and the complexity of maintenance tasks. They noted that safety standards were usually observed during routine maintenance activities but could sometimes receive less attention when urgent repairs were required within limited timeframes. A Port Operations Manager stated:

"...most maintenance teams understand the importance of following safety procedures because they have received basic safety training and know the consequences of unsafe practices. However, during emergency repairs or periods of heavy vessel traffic, some technicians become more focused on restoring equipment quickly than on following every procedural requirement. Although such situations are not common, they demonstrate the importance of continuously reinforcing safety culture through regular supervision and refresher training..."

These findings were similar to those reported in Africa, where studies found that maintenance personnel generally recognized the importance of safety compliance but experienced challenges in maintaining consistent adherence to safety procedures because of operational demands, limited refresher training, and resource constraints. Improving safety culture and continuous professional development was therefore considered essential for strengthening maintenance performance across African ports [16, 18].

The 4 respondents (n = 4, 21.1%) who perceived low safety compliance argued that some maintenance personnel occasionally overlooked established procedures, particularly during routine maintenance or urgent repair situations. Participants explained that such practices increased the likelihood of workplace accidents, equipment damage, and repeated maintenance activities, thereby reducing overall maintenance efficiency.

A Dockyard Supervisor explained:

"...there are occasions when some technicians become overconfident because they have handled similar maintenance tasks many times before. Instead of carefully following every safety procedure, they sometimes skip important inspection steps or fail to use all the required protective equipment in order to save time. While this may appear to speed up the maintenance process, it actually

increases the risk of accidents and may result in additional repairs if mistakes occur. We constantly remind our teams that efficiency should never come at the expense of safety because safe maintenance is ultimately more reliable and cost-effective..."

These findings complemented studies conducted in Tanzania, which suggested that previous research had concentrated mainly on port infrastructure, logistics performance, and operational efficiency while providing limited evidence regarding stakeholders' experiences of safety awareness and compliance during ship maintenance activities. Consequently, little empirical information existed on how adherence to maintenance procedures influenced maintenance efficiency from the perspectives of personnel directly involved in ship maintenance operations at Dar es Salaam Port [11, 19].

When compared with existing literature, the findings suggested that safety awareness and compliance with maintenance procedures were widely recognized as important determinants of efficient ship maintenance. Similar to studies conducted in Europe, America, Asia, and Africa, stakeholders at Dar es Salaam Port perceived that consistent adherence to safety procedures improved maintenance quality, reduced workplace risks, and enhanced operational reliability. However, unlike previous Tanzanian studies that focused primarily on infrastructure development and port performance, the present findings demonstrated that stakeholders regarded safety compliance as a critical human factor influencing ship maintenance efficiency. These findings imply that strengthening safety culture, regular refresher training, and continuous supervision would further improve maintenance performance and contribute to safer and more efficient ship maintenance operations at Dar es Salaam Port.

4.2 Perceived Influence of Crew Competence on Ship Maintenance Efficiency

The study evaluated the perceived influence of crew competence on ship maintenance efficiency, specifically examining the reduction of equipment failures and operational downtime, the improvement of operational reliability and vessel availability, and the timeliness of maintenance activities. Participants reflected on these sub-indicators to articulate how the expertise and technical readiness of the maintenance crew directly shaped the port's operational outcomes. By analyzing these perceptions, the study aimed to establish a clear link between human capital proficiency and the overall effectiveness of ship maintenance processes at the port.

4.2.1 Reduction of equipment failures and operational downtime

The influence of crew competence on reducing equipment failures and operational downtime appeared to be strongly associated with the technical capabilities, practical experience, and decision-making abilities of maintenance personnel at Dar es Salaam Port. The findings as presented in Figure 2 showed that out of the 19 stakeholders interviewed, 7 participants (n = 7, 36.8%) perceived that crew competence had resulted in a strong reduction in equipment failures and operational downtime, 8 participants (n = 8, 42.1%) reported a moderate reduction, while 4 participants (n = 4, 21.1%) indicated a minimal reduction. This distribution suggested that although stakeholders generally recognized the contribution of competent crews in improving maintenance outcomes, the extent to which competence reduced equipment failures was influenced by additional factors such as availability of spare parts, condition of vessel machinery, maintenance planning systems, and access to modern diagnostic technologies.

Respondents who perceived a strong reduction in equipment failures and operational downtime emphasized that competent maintenance crews were able to identify faults at early stages, conduct preventive maintenance effectively, and apply appropriate corrective measures before problems escalated into major failures. Participants explained that experienced personnel were not only involved in repairing damaged equipment but also played a preventive role by monitoring machinery performance and detecting abnormal conditions. These findings were consistent with literature from Europe and America, where crew competence had been identified as a critical factor in improving vessel reliability through effective fault diagnosis, preventive maintenance practices, and timely technical decision-making [20, 21]. A 54-year-old chief marine engineer explained in detail:

“...from my experience working with different vessels, I have observed that most serious equipment failures do not happen without warning. There are usually signs such as unusual vibration, abnormal temperature, or reduced performance before the equipment completely breaks down. A competent engineer is able to recognize these warning signs early and take corrective action before the problem becomes serious. When maintenance personnel have strong technical knowledge and practical experience, equipment remains reliable for a longer period and vessels spend less time waiting for repairs...”

Similarly, a 50-year-old maintenance manager stated:

“...crew competence has a direct relationship with the number of equipment failures we experience. When maintenance personnel understand the systems they are

working on, they follow proper procedures, conduct inspections carefully, and identify problems before they affect operations. The difference between a short maintenance interruption and a long operational delay often depends on whether the person handling the problem has enough skills and experience to make the correct decision quickly...”

These experiences supported previous studies which showed that maritime personnel with strong technical and analytical abilities were better positioned to manage complex vessel systems and reduce operational disruptions. Competence in interpreting equipment information, applying maintenance procedures, and responding quickly to technical challenges had been associated with improved vessel performance and reduced downtime [22]. The findings also reflected the importance of teamwork, communication, and regulatory compliance in ensuring that maintenance activities were completed effectively and safely [23].

Among the 8 respondents (n = 8, 42.1%) who perceived a moderate reduction in equipment failures and operational downtime, participants acknowledged that competent crews contributed positively to maintenance efficiency but explained that crew competence alone could not completely eliminate equipment failures. They indicated that operational conditions such as aging vessels, delayed availability of spare parts, and limited access to specialized technical support sometimes reduced the ability of maintenance personnel to restore equipment quickly. A 45-year-old ship operations officer explained:

“...competent maintenance teams definitely help in reducing failures because they understand the machinery and know how to respond when problems occur. However, there are situations where even experienced engineers face challenges because the problem is beyond their control. For example, when spare parts are unavailable or when equipment has reached the end of its useful life, the skills of the crew alone cannot solve everything. Competence helps to manage the situation, but it must be supported by other resources...”

A 43-year-old marine technician added:

“...we have experienced situations where the maintenance team understood the problem but required additional support because modern equipment is becoming more complicated. Some faults require specialized knowledge from manufacturers or advanced diagnostic tools. Therefore, improving crew competence reduces many failures, but organizations must also invest in technology, training, and maintenance resources...”

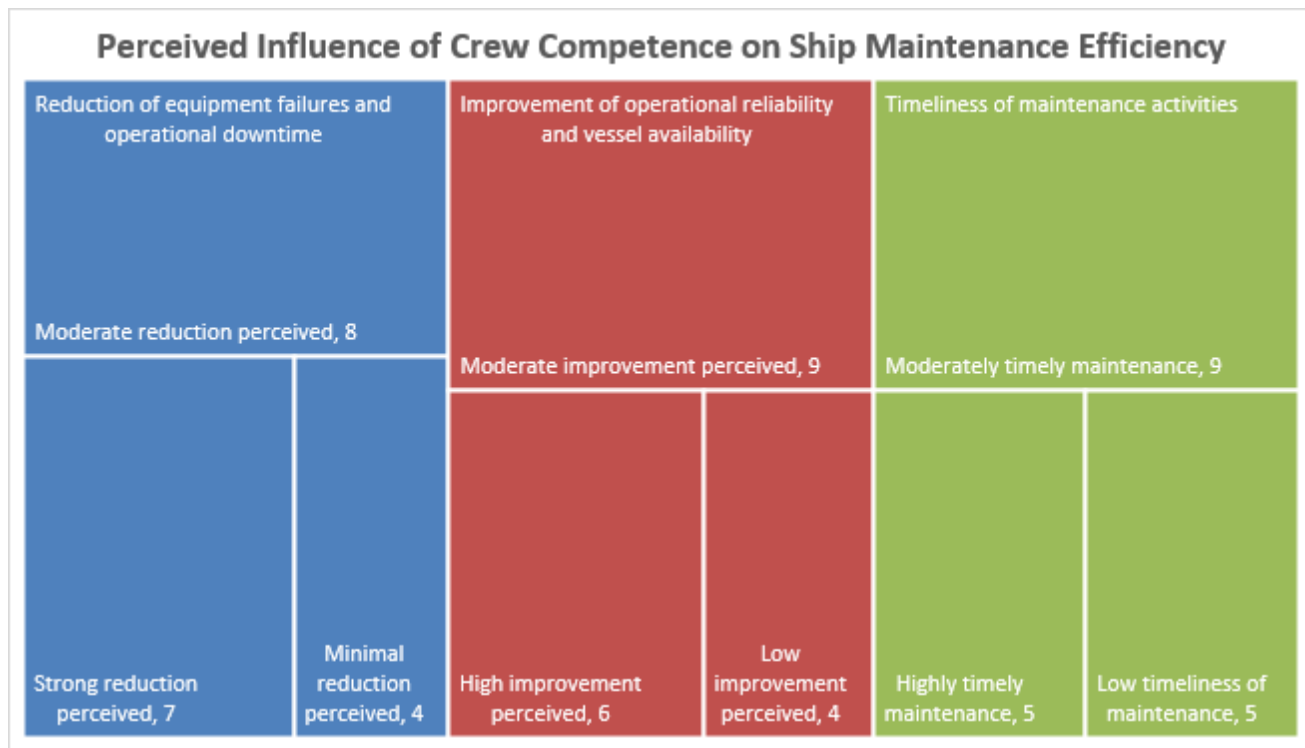


Figure 2: Perceived influence of crew competence on ship maintenance efficiency

These perceptions aligned with Asian studies, which had shown that although crew competence was essential for maintenance efficiency, its effectiveness depended on continuous training, organizational support, and access to appropriate technologies. Maritime organizations that invested in structured competency development, onboard mentoring, and knowledge transfer were more successful in improving maintenance reliability and reducing operational risks [24, 26]. The findings further supported the argument that senior-to-junior knowledge transfer was important in strengthening maintenance capabilities and sustaining operational reliability [27].

The 4 respondents (n = 4, 21.1%) who perceived a minimal reduction in equipment failures and operational downtime argued that crew competence alone was insufficient to significantly influence maintenance outcomes when other operational challenges existed. Participants explained that some equipment failures were associated with aging machinery, limited modernization, inadequate maintenance resources, and delays in obtaining technical support. They emphasized that even highly skilled personnel could experience difficulties when working under conditions characterized by resource limitations.

A 48-year-old shipping company representative explained:

"...sometimes people assume that equipment failure means the maintenance team lacks skills, but this is not always the case. Some vessels operate with old systems that naturally

experience frequent problems. Even experienced engineers cannot completely prevent failures when machinery has exceeded its expected lifespan or when replacement parts are difficult to obtain. Competence helps us respond better, but it does not remove all operational challenges..."

Similarly, a 47-year-old port technical officer noted:

"...there are situations where the maintenance team has the knowledge and experience needed, but downtime continues because of factors outside their control. Waiting for imported components or external technical support can delay repairs for several days. Therefore, improving crew competence is important, but it should go together with better maintenance planning and stronger operational support systems..."

These findings reflected challenges reported in African maritime contexts, where maintenance efficiency was often affected by both workforce competence and limitations in technical resources. Previous studies had indicated that skills shortages, inadequate training opportunities, and limited exposure to modern maintenance technologies contributed to equipment failures and prolonged operational downtime in African maritime organizations [28, 29]. Other studies further showed that weak problem-solving capacity and insufficient technical exposure among maintenance personnel increased the likelihood of repeated failures and delayed repairs [30].

In Tanzania, the findings reflected existing concerns regarding the relationship between workforce competence and maritime operational efficiency. Studies conducted within the Tanzanian maritime sector had indicated that maintenance personnel required continuous competency development to cope with increasing vessel complexity and modernization of port operations [32]. Furthermore, challenges related to aging equipment, spare parts availability, and changing technological requirements had created additional demands for skilled maintenance personnel capable of managing modern ship systems [33]. The increasing adoption of automated and digital maintenance technologies had also created a need for crews with stronger technical competencies and digital skills [35].

When situated within broader scholarly discussions, the findings suggested that stakeholders at Dar es Salaam Port generally perceived crew competence as an important contributor to reducing equipment failures and operational downtime. Similar to evidence from Europe and America, Asia, and Africa, participants recognized that technical knowledge, practical experience, and effective problem-solving abilities enabled maintenance crews to identify faults early and restore vessel operations more efficiently. However, the findings also demonstrated that competence operated alongside other supporting factors, including availability of resources, technological capacity, and organizational support. This implied that improving crew competence through continuous training, practical exposure, and knowledge-sharing mechanisms would be essential, but such efforts would need to be complemented by investments in maintenance infrastructure and operational support systems to achieve sustainable improvements in ship maintenance efficiency at Dar es Salaam Port.

4.2.2 Improvement of operational reliability and vessel availability

The study assessed the perceived influence of crew competence on the improvement of operational reliability and vessel availability at Dar es Salaam Port. The findings as per figure 2, indicated that out of the 19 participants, 6 participants (n = 6, 31.6%) perceived a high improvement in reliability and availability attributed to crew competence, 9 participants (n = 9, 47.4%) observed a moderate improvement, while 4 participants (n = 4, 21.1%) identified only low improvement. This distribution suggested that while the majority of stakeholders acknowledged the positive correlation between a skilled workforce and vessel performance, there remained a tempered expectation regarding how much human expertise alone could compensate for other operational variables, reflecting a realistic assessment of the port's complex environment.

Respondents who perceived a high improvement in operational reliability emphasized that a highly competent crew was the primary factor in ensuring that vessels remained ready and reliable for continuous operation. These findings were consistent with global literature, particularly in Asia,

where stakeholders have maintained that maintenance efficiency and vessel availability depend heavily on the crew's ability to operate modern marine systems and adapt to technological changes [13, 14].

A 43-year-old shipping operations lead explained in detail:

"...when the crew understands the vessel from top to bottom, the reliability of that ship goes up significantly. High competence means we spend less time wondering if a system will fail and more time relying on the ship to be ready for its next voyage. The teams that really know their craft are the ones who make the difference between a ship that is available on time, every time, and one that is constantly sidelined for unpredictable technical hitches..."

Similarly, a 46-year-old port services coordinator noted:

"...reliability is the cornerstone of our service, and it is driven by the people on the ground. When our technicians are highly skilled, they manage to keep the vessels in a state of 'ready-to-operate' for longer periods. I have seen that high competence leads directly to better vessel availability, because the crew manages to keep the systems performing at their peak, minimizing the gaps where the ship is essentially sitting idle..."

These views aligned with studies from Europe and America, which have identified that competence when linked to continuous certification and simulation-based training is a critical driver for maintaining vessel availability and overall operational performance [21]. The responses suggested that where personnel possessed deep technical mastery, the ability to sustain consistent vessel performance was noticeably higher.

Among the 9 respondents (n = 9, 47.4%) who perceived a moderate improvement, participants indicated that competence was a valuable asset but one that operated within the constraints of the port's wider ecosystem. A 39-year-old maintenance engineer explained:

"...competence definitely improves how we handle the ship, and it helps keep things running, but it is a moderate improvement at best because we are always fighting against factors like aging infrastructure and logistical bottlenecks. Skilled workers can make an old ship run better, but they cannot make it perform like a brand-new vessel. So, we see the benefits of our skills, but there is a ceiling to how much we can improve reliability given our current resources..."

A 42-year-old terminal supervisor added:

"...I see the improvement, but it is not as high as it could be if we had better support. A competent crew makes the vessel more reliable, yes, but we are also limited by how quickly we can get the right parts or how often we have to work around

power fluctuations at the port. My staff are skilled, and they bring moderate improvements to the table every day, but their impact is partially constrained by the environment they work in...

These perceptions were consistent with African literature, which has shown that maintenance stakeholders often face persistent competency gaps and limited access to modern training, making it difficult to achieve the levels of vessel reliability seen in more advanced maritime hubs [28]. The findings suggested that for this group, the link between competence and reliability was clear but functioned as one of several competing factors.

The 4 respondents (n = 4, 21.1%) who reported low improvement argued that factors such as procurement delays and vessel age were far more influential on reliability than crew competence. A 35-year-old technician stated:

"...I don't think crew skill is the biggest factor when it comes to vessel availability. If a ship has major engine issues that have been ignored for years or if we don't have the spare parts to fix it, no amount of skill can make that vessel 'reliable' on a schedule. The improvements we see are low because we are often just applying temporary patches to machines that need major overhauls..."

Similarly, a 32-year-old administrative officer stated:

"...from an administrative perspective, the vessel availability metrics are mostly determined by shipping schedules and port congestion, not just by how well the crew maintains the ship. While I value the crew's effort, I see a very low impact on the overall availability of the vessels because the larger port logistics often dictate when a ship is ready or not..."

These findings aligned with Tanzanian studies, which indicated that supervisors at Dar es Salaam Port often perceive that crews rely on improvisation and informal learning to compensate for aging machinery and spare parts constraints [32, 33].

When compared with existing literature, the findings suggested that while developed regions leveraged high competence to achieve elite levels of vessel reliability, the experience at Dar es Salaam Port remained heavily influenced by a combination of human skill and structural port limitations. Although stakeholders generally recognized the positive contribution of competence, the majority viewed its impact as moderate, suggesting that while investing in human capital is vital, simultaneous improvements in infrastructure and supply chain reliability are equally necessary to drive higher vessel availability.

4.2.3 Timeliness of maintenance activities

The efficiency of maintenance scheduling and completion was perceived to be influenced by the competence

level of ship maintenance crews at Dar es Salaam Port. The findings as presented in Figure 2 showed that out of the 19 stakeholders interviewed, 5 participants (n = 5, 26.3%) perceived that maintenance activities were completed with high timeliness, 9 participants (n = 9, 47.4%) reported moderately timely maintenance, while 5 participants (n = 5, 26.3%) indicated low timeliness of maintenance activities. This distribution suggested that although crew competence contributed to improving the speed and effectiveness of maintenance operations, variations existed in the ability of maintenance teams to complete activities within planned schedules. Stakeholders explained that competent crews were generally able to diagnose faults quickly, organize repair procedures effectively, and minimize unnecessary delays, while challenges such as spare parts shortages, equipment complexity, and coordination issues sometimes affected the timely completion of maintenance tasks.

Respondents who perceived highly timely maintenance activities emphasized that competent maintenance personnel were able to complete repair and servicing activities within expected timeframes because they possessed adequate technical knowledge, practical experience, and familiarity with vessel systems. Participants explained that experienced crews reduced delays by identifying problems accurately, preparing appropriate tools and materials before starting maintenance, and coordinating effectively among different technical teams. These findings were consistent with literature from Europe and America, where crew competence had been associated with efficient maintenance planning, faster fault identification, and improved decision-making during complex repair activities [21].

A 53-year-old marine engineer explained in detail:

"...the time required to complete maintenance depends greatly on the knowledge and experience of the people performing the work. When a technician understands the system properly, they do not waste time testing unnecessary components or repeating the same procedures. They quickly identify the source of the problem, prepare the correct solution, and restore the equipment within the shortest possible time. Experienced engineers also know how to organize their teams so that different activities can be performed simultaneously without compromising safety..."

Similarly, a 47-year-old maintenance supervisor stated:

"...competent crews help us maintain proper schedules because they understand the importance of completing maintenance activities on time. A delay in one maintenance activity can affect the entire vessel operation, including departure schedules and cargo handling plans. Skilled personnel normally anticipate possible challenges, prepare in advance, and complete most maintenance tasks according to the planned timeline..."

These experiences supported previous studies which indicated that competent maritime personnel improved maintenance efficiency through better planning, effective coordination, and rapid responses to technical problems. The ability of crews to interpret equipment conditions and make timely decisions was identified as an important factor in reducing maintenance delays and improving operational performance [22]. In addition, effective communication and teamwork among maritime personnel were found to support faster maintenance execution and improve reliability in vessel operations [23].

Among the 9 respondents (n = 9, 47.4%) who perceived moderately timely maintenance, participants acknowledged that maintenance crews generally completed their tasks within acceptable periods but explained that some delays remained common due to operational constraints. They indicated that although competent personnel improved maintenance speed, factors such as approval procedures, availability of spare parts, workload pressure, and coordination with external service providers sometimes affected completion times.

A 45-year-old technical manager explained:

"...our maintenance teams have improved significantly in terms of completing tasks on time, especially when dealing with routine maintenance activities. However, not every maintenance activity follows the same timeline because some repairs require additional procedures, approval from management, or waiting for specific components. In such situations, even a highly skilled technician may have to wait before completing the work..."

A 41-year-old ship repair specialist added:

"...experience helps technicians work faster because they know what steps to follow, but maintenance is not only about the person doing the repair. Sometimes the delay comes from outside factors such as procurement processes, availability of spare parts, or the need to consult equipment manufacturers. Therefore, competence improves timeliness, but it works together with other supporting systems..."

These views were consistent with Asian studies, which had shown that maintenance timeliness depended on both individual competencies and organizational support mechanisms. Maritime organizations that invested in structured training, onboard mentoring, and knowledge-sharing systems were more capable of improving maintenance coordination and reducing delays [24, 26]. Furthermore, effective transfer of technical knowledge between experienced and junior crew members had been recognized as an important strategy for improving maintenance efficiency and ensuring continuity of operational knowledge [27].

The 5 respondents (n = 5, 26.3%) who perceived low timeliness of maintenance activities explained that maintenance delays were sometimes associated with inadequate technical competencies, weak coordination, and

difficulties in diagnosing complex equipment problems. Participants argued that when maintenance personnel lacked sufficient experience, additional time was required to identify faults, determine appropriate repair approaches, and complete maintenance activities. They further indicated that delayed maintenance affected vessel schedules, increased operational costs, and reduced equipment availability.

A 49-year-old shipping company representative explained:

"...some maintenance delays occur because the team spends too much time trying to understand the actual problem. When personnel have limited experience with certain equipment, they may perform several inspections before identifying the correct cause of failure. This extends the repair period and affects vessel availability. More experienced technicians usually solve such problems faster because they have dealt with similar situations before..."

Similarly, a 46-year-old port operations officer noted:

"...timely maintenance requires both competence and good coordination. In some cases, the problem is not only technical knowledge but also communication between different departments. When information is not shared quickly, or when responsibilities are unclear, maintenance activities take longer than expected. This eventually affects vessel operations..."

These findings reflected challenges reported in African maritime contexts, where limited technical training, shortages of skilled personnel, and weak maintenance systems had contributed to delays in completing ship maintenance activities. Studies indicated that inadequate competency development and limited exposure to modern maintenance practices affected the ability of maritime organizations to respond quickly to technical problems [28, 29]. Other research further showed that weak problem-solving abilities and insufficient practical experience among maintenance personnel contributed to prolonged repair periods and reduced operational efficiency [31].

Within Tanzania, the findings reflected existing concerns regarding the ability of maritime organizations to maintain efficient operations under changing technological and operational conditions. Previous studies had indicated that Dar es Salaam Port required continuous improvement of workforce competencies to support timely maintenance activities, particularly due to increasing vessel traffic, modernization initiatives, and the growing complexity of marine equipment [32]. Other studies highlighted that maintenance efficiency was affected by challenges related to equipment conditions, technical capacity, and adaptation to emerging technologies [33]. The increasing adoption of automated and digital maintenance systems had further increased the demand for personnel capable of performing timely and accurate maintenance interventions [35].

When situated within broader scholarly discussions, the findings suggested that stakeholders at Dar es Salaam Port

generally perceived crew competence as an important contributor to improving the timeliness of ship maintenance activities. Similar to findings from Europe and America, Asia, and Africa, participants recognized that technical knowledge, practical experience, and effective coordination enabled maintenance crews to complete tasks more efficiently. However, the findings also demonstrated that maintenance timeliness was influenced by factors beyond individual competence, including availability of resources, organizational coordination, and technical support systems. This implied that strengthening crew competencies through continuous training, practical exposure, and improved knowledge-sharing mechanisms would be essential for enhancing maintenance responsiveness and ensuring efficient vessel operations at Dar es Salaam Port.

5. CONCLUSION AND RECOMMENDATIONS

The findings demonstrated that crew competence played a significant role in influencing ship maintenance efficiency at Dar es Salaam Port. Stakeholders consistently perceived that technical skills and maintenance knowledge, practical experience and problem-solving abilities, and safety awareness together formed the foundation for effective maintenance operations. Participants indicated that competent maintenance personnel were better equipped to diagnose equipment faults accurately, apply appropriate maintenance procedures, comply with safety standards, and respond effectively to operational challenges. Although variations in competency levels were reported, the experiences of stakeholders showed that strengthening crew competence remained essential for sustaining high-quality ship maintenance. The findings further revealed that competent crews contributed to reducing equipment failures and operational downtime, improving operational reliability and vessel availability, and enhancing the timeliness of maintenance activities. Stakeholders acknowledged that the benefits of crew competence were influenced by other operational factors, including the condition of ship equipment, availability of spare parts, maintenance resources, and organizational support. The study therefore highlighted that efficient ship maintenance depended not only on technological and physical resources but also on the knowledge, practical experience, and professional capabilities of maintenance personnel responsible for keeping vessels safe, reliable, and operational.

Based on the findings of the study, the following recommendations were proposed to enhance crew competence and improve ship maintenance efficiency at Dar es Salaam Port:

- Strengthen continuous technical training to equip maintenance crews with updated knowledge on modern vessel technologies, digital systems, and advanced maintenance practices.
- Promote practical learning and mentorship programs by encouraging knowledge transfer between

experienced engineers and junior maintenance personnel.

- Enhance safety compliance mechanisms through regular safety training, monitoring, and reinforcement of standard maintenance procedures.
- Improve maintenance support systems by ensuring timely availability of spare parts, diagnostic tools, and other resources required for efficient maintenance operations.
- Develop competency-based workforce development strategies that align crew skills with changing maritime technologies and operational requirements.

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7. REFERENCES

- [1] M. Grech, T. Horberry, and T. Koester, *Human factors in the maritime domain*. CRC press, 2008.
- [2] S. C. Mallam, S. Nazir, and A. Sharma, "The human element in future Maritime Operations—perceived impact of autonomous shipping," *Ergonomics*, vol. 63, no. 3, pp. 334-345, 2020.
- [3] S. C. Mallam, S. Nazir, and S. K. Renganayagalu, "Rethinking maritime education, training, and operations in the digital era: Applications for emerging immersive technologies," *Journal of Marine Science and Engineering*, vol. 7, no. 12, p. 428, 2019.
- [4] L. S. Lopes, J. L. Nabais, C. Pinto, V. Caldeirinha, and T. Pinho, "Essential Competencies in Maritime and Port Logistics: A Study on the Current Needs of the Sector," *Sustainability*, vol. 17, no. 6, p. 2378, 2025.
- [5] E. Demirel, "Maritime education and training in the digital era," *Universal Journal of Educational Research*, 2020.
- [6] G. Kahyarara and D. Simon, "Maritime transport in Africa: challenges, opportunities, and an agenda for future research," in *Proc. UNCTAD Ad Hoc Expert Meeting*, 2018, pp. 1-49.
- [7] M. Conti, M. Zilvetti, and R. Kotter, "Challenges and Opportunities for UK Seaports Toward Future Sustainability: The UK's North East Smart Ports Testbed Case Study," *Handbook of sustainability science in the future: policies, technologies and education by 2050*, pp. 805-844, 2023.
- [8] G. Acheampong, O. K. Aggrey, A. K. Y. Djan, A. S. Hansen, and M. Pinkie Segodi, "Digital transitions at the port: human capital, technology adoption and operational efficiency among independent truckers,"

- Innovation & Management Review*, vol. 22, no. 3, pp. 146-161, 2025.
- [9] J. Mwambipile and C. Ryoba, "The Influence of Lean Management Practices on Port Logistics Performance in Tanzania: A Case of Dar es Salaam Port," *Journal of Industrial Engineering & Management Research*, vol. 6, no. 5, pp. 195-206, 2025.
- [10] W. E. Msechu, M. Mashoke, and S. Kahangwa, "Assessing Port Service Quality on Customer Satisfaction: A Study of Dar Es Salaam Seaport, Tanzania," *Journal of Industrial Engineering & Management Research*, vol. 6, no. 5, pp. 97-108, 2025.
- [11] E. V. Mabinga and B. Mwalukasa, "The Effect Of Port Operations On Port Performance: A Case Study Of Dar Es Salaam Port," *Asian Journal of Management, Entrepreneurship and Social Science*, vol. 4, no. 04, pp. 1435-1447, 2024.
- [12] P. Perrotin, S. Sadou, D. Hairion, and A. Beugnard, "Detecting human vulnerability in socio-technical systems: a naval case study," in *Proceedings of the 23rd ACM/IEEE International Conference on Model Driven Engineering Languages and Systems: Companion Proceedings*, 2020, pp. 1-8.
- [13] O. Melnyk, O. Onishchenko, I. Mykhailova, A. Zaiets, and O. Kotenko, "Safety management in maritime transport within the framework of current challenges, trends, risks and settlement strategies," in *Systems, Decision and Control in Energy VI: Volume I: Energy Informatics and Transport*: Springer, 2024, pp. 459-475.
- [14] A. Galieriková, "The human factor and maritime safety," *Transportation research procedia*, vol. 40, pp. 1319-1326, 2019.
- [15] M. Belabyad, C. Kontovas, R. Pyne, and C.-H. Chang, "Skills and competencies for operating maritime autonomous surface ships (MASS): a systematic review and bibliometric analysis," *Maritime Policy & Management*, vol. 53, no. 1, pp. 1-26, 2026.
- [16] L. Rahayu, T. Busscher, T. Tillema, and J. Woltjer, "Maritime transport governance challenges in the Global South," *Marine Policy*, vol. 163, p. 106147, 2024.
- [17] L. D. Caesar, "Emerging dynamics of training, recruiting and retaining a sustainable maritime workforce: a skill resilience framework," *Sustainability*, vol. 16, no. 1, p. 239, 2023.
- [18] S. O. Anikwe, L. C. Unachukwu, and F. N. Onah, "Human capacity development and sustainable growth in the blue economy: Opportunities, challenges, and strategies for Nigeria," *African Banking and Finance Review Journal*, vol. 15, no. 15, 2024.
- [19] B. Sun and R. Kauzen, "The impact of port infrastructure and economic growth in Tanzania: Adopting a structural equation modeling approach," *Sage Open*, vol. 13, no. 1, p. 21582440221145894, 2023.
- [20] C. Kandemir and M. Celik, "Identifying training requirements to enhance basic skills for maintenance 4.0 in marine engineering through engine room simulator," in *13th International Conference on Engine Room Simulators*, 2017, pp. 20-21.
- [21] A. Oksavik et al., "Future skills and competence needs," 2021.
- [22] B. Laksmana, A. Supriatna, P. Dwijayanti, I. Trianda, and O. Avriani, *MARITIME HUMAN RESOURCE MANAGEMENT-OPTIMIZING SEAFARER PERFORMANCE WITHIN THE STCW FRAMEWORK: Leadership, Talent Development, and Crew Welfare Strategies for Sustainable Maritime Operations*. Tren Digital Publishing, 2026.
- [23] P. Baum-Talmor and M. Kitada, "Industry 4.0 in shipping: Implications to seafarers' skills and training," *Transportation research interdisciplinary perspectives*, vol. 13, p. 100542, 2022.
- [24] A. S. Alamoush and A. I. Ölçer, "Automated and remote engineering, maintenance, and repair in Maritime Autonomous Surface Ships (MASS)," *Journal of Shipping and Trade*, vol. 10, no. 1, p. 20, 2025.
- [25] A. C. Kuzu, "Analysis of seafarers' non-technical skills: cause-and-effect relationships," *Cognition, Technology & Work*, pp. 1-13, 2026.
- [26] Ç. Karatug, Y. Arslanoğlu, and C. G. Soares, "Review of maintenance strategies for ship machinery systems," *Journal of Marine Engineering & Technology*, vol. 22, no. 5, pp. 233-247, 2023.
- [27] R. M. Fernández Otero, G. A. Bayliss-Brown, and M. Papathanassiou, "Ocean literacy and knowledge transfer synergies in support of a sustainable blue economy," *Frontiers in Marine Science*, vol. 6, p. 646, 2019.
- [28] K. Adeyemi, S. Rahman, and M. Abdulrahman, "Do Human Resources Management (HRM) Practices Impact on Seaport Competitiveness?," in *1st Australian International Conference on Industrial Engineering and Operations Management*, 2022: IEOM Society.
- [29] D. Kuteyi and H. Winkler, "Logistics challenges in sub-Saharan Africa and opportunities for digitalization," *Sustainability*, vol. 14, no. 4, p. 2399, 2022.
- [30] S. E. Mthembu and M. G. Chasomeris, "An assessment of the capacity and the performance of marine services in South Africa's ports," *Journal of Transport and Supply Chain Management*, vol. 17, p. 879, 2023.
- [31] T. Potgieter, "Oceans economy, blue economy, and security: notes on the South African potential and developments," *Journal of the Indian Ocean Region*, vol. 14, no. 1, pp. 49-70, 2018.

- [32] S. Ng'ora, A. B. S. Mwakalobo, and F. Lwesya, "Managerial skills for micro, small and medium-sized enterprises (MSMEs)," *Management Dynamics in the Knowledge Economy*, vol. 10, no. 4, pp. 343-359, 2022.
- [33] M. M. Kunambi and H. Zheng, "Enhancing green ports in Dar es Salaam Port: facility optimization for emission reduction through Mamdani and Sugeno Fuzzy inference systems," *Frontiers in Environmental Engineering*, vol. 3, p. 1374622, 2024.
- [34] L. P. Binamungu, S. Maro, G. Justo, and J. Ndanguzi, "The dynamics of strengthening the skills to develop safety-critical systems in Tanzania," *Computer Science Education*, vol. 36, no. 2, pp. 255-277, 2026.
- [35] N. A. Tengecha, X. Zhang, M. J. Mwendapole, and T. N. Chusi, "East Africa Waterway Transport, Coastal Ports Growth, Opportunity and Challenges," *International Journal of Humanities and Social Science Invention (IJHSSI)*, vol. 11, no. 2, pp. 01-11, 2022.
- [36] J. W. Creswell and C. N. Poth, *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications, 2016.