HUMAN ANATOMY AWARENESS AND ENVIRONMENTAL SUSTAINABILITY IN MARITIME OCCUPATIONAL EDUCATION

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Abstract
The study examined human anatomy awareness and environmental sustainability in maritime occupational education. It was guided by the need to address increasing concerns about occupational injuries, human error, and environmental degradation associated with maritime operations. The study focused on the extent to which human anatomy knowledge influenced safe maritime practices, occupational health, human factors, and environmental sustainability in marine environments. It also explored the integration of anatomy awareness into maritime training systems, the challenges affecting its promotion, and its implications for maritime educational development. The study adopted a conceptual and analytical approach by reviewing relevant literature from both international and Nigerian perspectives. It revealed that human anatomy awareness played a significant role in improving safety behaviour, reducing occupational risks, and enhancing performance among maritime personnel. The paper also revealed that occupational health and human factors affected operational efficiency, while poor integration of health-related content in maritime curricula limited effective safety practice. Furthermore, the study established that environmental sustainability in maritime operations was closely linked to human behaviour, health awareness, and adherence to safety standards. The paper concluded that integrating human anatomy awareness into maritime occupational education was essential for improving safety culture, enhancing worker performance, and promoting environmental sustainability in marine environments. The paper suggested the strengthening of curriculum integration, continuous training, and improved safety culture in maritime institutions and workplaces.

Keywords: Human anatomy awareness, maritime education, occupational health and education, environmental sustainability, marine environment

Introduction

A persistent and growing concern in maritime occupational education is the increasing occurrence of preventable injuries, occupational fatigue, and health-related incidents among maritime workers, which are often linked to inadequate understanding of how the human body functions under demanding marine and offshore conditions. Maritime environments are characterized by continuous vessel motion, exposure to harsh weather conditions, confined working spaces, irregular work-rest cycles, and physically demanding operational tasks. These conditions place significant physiological and psychological stress on the human body. However, in many maritime training contexts, insufficient attention appears to be given to human anatomy awareness as a foundational component of occupational preparation. This raises a serious concern about whether maritime trainees are adequately equipped with the biological and physiological knowledge required to maintain health, safety, and efficiency in such high-risk environments.

Human anatomy awareness refers to the structured understanding of the human body and its major systems, including the musculoskeletal, cardiovascular, respiratory, nervous, and integumentary systems, as well as how these systems respond to occupational stressors such as fatigue, vibration, dehydration, and prolonged physical exertion. According to International Maritime Organization (2020), maritime safety culture is not only dependent on

technical competence but also on the physical readiness and health awareness of personnel working in complex marine environments. In the same direction, World Health Organization (2021) emphasizes that occupational health education enhances workers' ability to prevent injuries, recognize early signs of physical strain, and adopt safer work practices in hazardous environments.

In the Nigerian context, occupational health and safety scholars have also emphasized the importance of integrating human health awareness into technical and vocational education. Okoye and Okafor (2019) observed that many occupational accidents in physically demanding industries in Nigeria are associated with poor awareness of body mechanics and inadequate safety education. They argued that when workers understand basic human anatomical functions, they are more likely to adopt preventive behaviors that reduce workplace injuries. Similarly, Eze and Nwankwo (2020) highlighted that vocational education programs in Nigeria often emphasize technical skills at the expense of human physiological awareness, thereby limiting trainees' ability to manage occupational stress effectively.

Furthermore, maritime occupational education requires a clear understanding of how the human body responds to continuous motion, physical exertion, and environmental stressors. According to Eze and Nnadi (2021), workers in marine and coastal industries are frequently exposed to musculoskeletal strain, fatigue-related errors, and reduced cognitive alertness due to prolonged exposure to demanding working conditions. Without adequate knowledge of human anatomy, maritime trainees may not fully understand the causes of these conditions or adopt appropriate preventive strategies. This knowledge gap increases the risk of operational errors, accidents, and long-term health complications. Supporting this perspective, Adamu and Bello (2022) noted that human performance in occupational settings is directly linked to physical and physiological awareness, especially in environments that require sustained attention and physical coordination. In maritime operations, such as cargo handling, engine room maintenance, navigation watch-keeping, and emergency response drills, a lack of anatomy awareness may lead to improper body posture, overexertion, and delayed response to fatigue signals. These factors not only compromise individual health but also affect overall operational safety and efficiency. In addition, maritime occupational environments are associated with unique physiological challenges that influence human performance. According to Ugwu and Chukwu (2020), seafarers and marine workers often experience motion sickness, sleep disruption due to irregular watch schedules, and physical fatigue resulting from repetitive tasks. These conditions affect concentration, decision-making ability, and physical coordination. When maritime trainees are not adequately grounded in human anatomy awareness, they may struggle to understand how these physiological responses occur and how they can be managed effectively.

Therefore, beyond individual safety, human anatomy awareness also contributes to environmental sustainability in maritime operations. Physically fit and health-aware personnel are less likely to make errors that could result in environmental hazards such as oil spills, equipment malfunction, or navigational accidents. Nwosu and Okeke (2022) emphasized that occupational health education plays a vital role in reducing human-induced environmental risks, particularly in industries where human error can have large-scale ecological consequences. Therefore, integrating human anatomy awareness into maritime education supports both safety and environmental sustainability objectives. Notwithstanding, these benefits, there appears to be a gap in the emphasis placed on anatomy-related knowledge within some maritime training programs in Nigeria and beyond, where greater focus is often placed on technical navigation, engineering skills, and regulatory compliance. This imbalance may limit trainees' understanding of the relationship between human physiological conditions and safe maritime operations. As maritime activities continue to

expand and become more technologically advanced, there is a strong need to strengthen human anatomy awareness within maritime occupational education as part of a holistic training framework that integrates health, safety, and environmental sustainability.

Conceptualization

Human anatomy is a fundamental scientific concept that explains the internal and external structure of the human body and how its systems function in relation to survival, performance, and adaptation in different environments. In occupational contexts such as maritime operations, understanding human anatomy becomes particularly important because the human body is constantly exposed to physical stress, environmental pressure, and operational demands that can affect health and performance. Tortora and Derrickson (2018) define human anatomy as the scientific study of the structure of the human body and the relationships among its parts. Marieb and Hoehn (2019) further described it as the study of body structures such as cells, tissues, organs, and organ systems and how they interact to sustain life. Saladin (2020) viewed human anatomy as the branch of biology that focuses on the form and structure of organisms and how these structures support physiological function. In the Nigerian context, Eze and Nwankwo (2021) emphasized that human anatomy is essential in technical and vocational education because it enables learners to understand how physical workload, posture, and environmental exposure affect bodily health and efficiency.
In the context of this study, human anatomy refers to the structured knowledge of human body systems such as the musculoskeletal, cardiovascular, respiratory, and nervous systems, and how these systems respond to maritime occupational demands such as heavy lifting, vessel movement, fatigue, dehydration, and prolonged working hours. This understanding is critical because it enables maritime trainees to recognize early signs of physical stress, prevent injuries, and maintain operational effectiveness. Human anatomy therefore provides the biological foundation upon which safe maritime practices are built, making it an essential starting point for maritime education.

Maritime education is a specialized form of technical and vocational training designed to prepare individuals for professional roles in marine-related industries such as shipping, navigation, offshore engineering, port operations, and fisheries. It involves the acquisition of knowledge, skills, and competencies required to ensure safety, efficiency, and environmental responsibility in maritime environments. The International Maritime Organization (2021) defines maritime education as a structured training system that equips seafarers with technical, operational, and safety competencies necessary for safe maritime operations. Mallam and Inyang (2019) described maritime education as a formal instructional process that develops cognitive, practical, and behavioral skills required in marine occupations. Okorie and Ekanem (2020) explain it as a specialized area of vocational education that focuses on preparing learners for ocean-based and coastal industrial activities. In Nigeria, Nwosu and Okafor (2022) emphasized that maritime education plays a vital role in producing skilled manpower capable of ensuring safety, productivity, and sustainability in the maritime sector.

In this study, maritime education refers to the structured teaching and learning processes that prepare students for maritime careers by combining technical maritime knowledge with human physiological awareness, particularly human anatomy, to enhance safe working behavior and performance efficiency. Maritime education is therefore not limited to navigation or engineering skills but also includes understanding the human body and its limitations in demanding marine environments. This makes maritime education directly connected to occupational health, because effective training must ensure that workers are physically and mentally prepared for the demands of their occupation.

Occupational health is a multidisciplinary concept that focuses on the physical, mental, and social well-being of workers in relation to their working environment. It

emphasizes the prevention of workplace injuries, illnesses, and hazards while promoting safe and healthy working conditions. The World Health Organization (2021) defined occupational health as the highest attainable standard of physical, mental, and social well-being of workers in all occupations. The International Labour Organization (2020) described it as the prevention of work-related diseases and injuries through the improvement of working conditions and the promotion of workers' health. Alli (2008) explains occupational health as the science concerned with protecting workers from hazards and ensuring a safe working environment. In Nigeria, Okeke and Chukwu (2020) highlighted occupational health as the systematic effort to reduce workplace injuries and illnesses through education, safety measures, and improved environmental conditions. In this study, occupational health refers to the state of physical and mental well-being of maritime workers achieved through awareness, education, and preventive strategies that reduce injury risks and enhance productivity in marine occupational environments. In maritime settings, occupational health is strongly influenced by workers' understanding of human anatomy because knowledge of body systems helps individuals recognize fatigue, prevent overexertion, and respond appropriately to physical stress. Occupational health is therefore directly connected to environmental sustainability, as healthy workers are more likely to engage in safe practices that minimize environmental harm and operational accidents.

Environmental sustainability refers to the responsible management and conservation of natural resources to ensure that ecological systems remain functional and productive for present and future generations. It is particularly important in maritime operations because human activities at sea directly affect marine ecosystems through pollution, resource extraction, and transportation activities. The United Nations Environment Programme (2022) defined environmental sustainability as the practice of maintaining environmental quality while supporting human development and economic activities. Goodland (1995) described it as the maintenance of natural capital without causing irreversible ecological damage. Moldan, Janoušková, and Hák (2012) explained it as ensuring that human activities remain within the ecological carrying capacity of the environment. Akinbami and Adeyemi (2021) further related environmental sustainability to balancing industrial growth and environmental protection, particularly in developing countries such as Nigeria. In this study, environmental sustainability refers to maritime operational practices that minimize pollution, reduce environmental degradation, and ensure the long-term protection of marine ecosystems through safe human behavior and responsible decision-making. Environmental sustainability in maritime contexts depends largely on the health, awareness, and behavior of workers, meaning that occupational health and human anatomy awareness indirectly contribute to environmental protection. This makes environmental sustainability closely linked to the marine environment, where these activities take place.

The marine environment refers to the oceanic and coastal ecosystems that support biodiversity, economic activities, and global ecological balance. It includes seas, oceans, estuaries, and coastal zones where maritime activities such as shipping, fishing, offshore drilling, and transportation occur. The United Nations Educational, Scientific and Cultural Organization (2022) defined the marine environment as the interconnected ocean and coastal systems that support life and human livelihoods. Valiela (2006) described it as a complex ecological system influenced by physical, chemical, and biological processes. Kullenberg (2010) emphasized its importance in regulating global climate systems and supporting biodiversity. In Nigeria, Nwilo and Badejo (2018) highlighted the marine environment as a key economic and ecological zone that supports transportation, oil exploration, and fisheries activities. In this study, the marine environment refers to the ocean and coastal operational spaces where maritime occupational activities are carried out and where human actions directly influence ecological conditions. The marine environment is therefore shaped by the

level of human anatomy awareness, occupational health practices, and environmental sustainability behavior of maritime personnel. This shows a continuous and interdependent relationship among all the variables, where improved human understanding leads to safer occupational practices and ultimately contributes to the protection of the marine ecosystem.

Relationship between Human Anatomy Knowledge and Safe Maritime Practices

The relationship between human anatomy knowledge and safe maritime practices is an important dimension in maritime occupational education because the effectiveness of safety behaviour at sea is strongly influenced by how well personnel understand their own physical structure and physiological limits. Maritime operations are physically demanding and often involve activities such as cargo handling, engine room operations, deck maintenance, long-hour watch keeping, and emergency drills. These tasks expose workers to fatigue, musculoskeletal strain, dehydration, and reduced cognitive alertness, all of which can compromise safety if not properly understood and managed. The concern, therefore, is that inadequate human anatomy knowledge among maritime workers may contribute to unsafe practices, avoidable injuries, and operational errors that can escalate into serious maritime accidents.

Human anatomy knowledge refers to the understanding of how the body is structured and how its systems function under different levels of stress and environmental conditions. Tortora and Derrickson (2018) explained that human anatomy provides the structural foundation for understanding how body systems work together to support movement and survival. Marieb and Hoehn (2019) emphasized that knowledge of body systems such as muscles, bones, circulation, and respiration is essential for understanding physical performance and fatigue. Saladin (2020) further notes that anatomical knowledge is critical in explaining how structure determines function in living organisms. In occupational contexts, Eze and Nwankwo (2021) asserted that awareness of body mechanics helps workers adopt safer physical behaviours and reduce workplace injuries. In maritime settings, this knowledge becomes directly connected to safe practices because it enables workers to understand the limits of physical endurance and the biological effects of stressors such as vibration, motion, and prolonged exertion. According to the International Maritime Organization (2021), safe maritime operations depend not only on technical skills but also on the ability of personnel to manage fatigue and maintain physical readiness during operations. Mallam and Inyang (2019) also observe that maritime safety outcomes improve when training includes awareness of human limitations alongside technical competencies. This means that when maritime personnel understand how the musculoskeletal system responds to lifting heavy loads, they are more likely to adopt correct lifting techniques, reduce strain injuries, and avoid unsafe movements that could compromise safety on board.

Furthermore, human anatomy knowledge contributes to better decision-making during physically stressful maritime operations. For instance, understanding how the cardiovascular system responds to dehydration and heat stress helps workers recognize early warning signs such as dizziness, rapid heartbeat, and fatigue. World Health Organization (2021) emphasized that occupational health awareness improves workers' ability to identify early symptoms of physical distress and respond appropriately before conditions become severe. In maritime operations, such awareness is essential because delayed response to physical stress can result in accidents, equipment damage, or loss of life, especially in emergency situations at sea.

In addition, safe maritime practices such as adherence to safety protocols, proper use of personal protective equipment, and correct manual handling techniques are reinforced by anatomical awareness. Okeke and Chukwu (2020) noted that workers who understand how injuries occur in the human body are more likely to comply with safety measures and avoid risky behaviours in the workplace. This is particularly relevant in maritime environments

where slippery decks, moving machinery, and unstable platforms increase the risk of falls and injuries. Human anatomy knowledge therefore serves as a preventive tool that strengthens safety culture and reduces occupational hazards. From a broader perspective, the integration of human anatomy knowledge into maritime education also enhances operational efficiency and reduces human error. Eze and Nnadi (2021) explained that fatigue and poor physical condition are major contributors to errors in high-risk occupational environments. When maritime personnel understand how fatigue affects the nervous system and reaction time, they are more likely to take rest periods seriously and manage workload effectively. This understanding contributes to safer navigation, improved communication, and better coordination during operations, thereby reducing the likelihood of accidents at sea.

Hence, the relationship between human anatomy knowledge and safe maritime practices is both direct and significant. Human anatomy awareness enables maritime personnel to understand their physical limitations, recognize early signs of fatigue or injury, and adopt safer working behaviours. This knowledge strengthens compliance with safety procedures, reduces occupational risks, and improves overall operational performance. It also contributes indirectly to environmental protection because safer human practices reduce the likelihood of accidents that may harm the marine environment. Therefore, strengthening human anatomy knowledge within maritime occupational education is essential for improving safety outcomes and promoting sustainable maritime operations.

Human Factors, Health, and Occupational Performance in Maritime Settings

A major concern in maritime occupational education is the extent to which human factors and health conditions influence occupational performance and safety outcomes in maritime environments. Maritime operations are highly dependent on human involvement in navigation, engineering, cargo handling, communication, and emergency response. However, these tasks are often carried out under stressful and physically demanding conditions such as vessel motion, long working hours, isolation, fatigue, and exposure to harsh weather conditions. These factors can negatively affect human performance, increase the likelihood of errors, and contribute to accidents at sea. The challenge, therefore, is ensuring that maritime personnel are adequately prepared to manage human limitations while maintaining high levels of performance and safety. Human factors refer to the physical, psychological, and behavioural characteristics of individuals that influence their performance in work environments. Reason (1997) explained human factors as the study of how humans interact with systems, equipment, and environments, particularly in relation to safety and error prevention. Hancock and Szalma (2008) described human factors as the understanding of human capabilities and limitations in order to design safer and more efficient systems. Stanton et al. (2013) further defined human factors as the scientific discipline concerned with optimizing human well-being and system performance. In the Nigerian context, Eze and Nnadi (2021) emphasize that human factors such as fatigue, stress, and poor health significantly contribute to workplace errors and accidents in high-risk occupations, including maritime and industrial sectors.

In maritime settings, human factors are closely linked to occupational health because the physical and mental condition of workers directly affects their ability to perform tasks safely and efficiently. The World Health Organization (2021) explained that occupational health is essential for maintaining worker well-being and preventing performance decline caused by illness, fatigue, and environmental stressors. Similarly, the International Labour Organization (2020) highlighted that poor health conditions in workplaces lead to reduced productivity, increased accidents, and higher operational risks. In maritime environments, these risks are amplified due to continuous exposure to motion, vibration, noise, and irregular work schedules, all of which affect human alertness and physical stability. Occupational

performance in maritime settings refers to the ability of maritime personnel to effectively carry out assigned duties with accuracy, safety, and efficiency under varying environmental and operational conditions. According to Mallam and Inyang (2019), occupational performance in maritime industries depends on both technical competence and human reliability, including the ability to manage fatigue and stress. Okorie and Ekanem (2020) add that effective maritime performance is achieved when workers possess not only technical skills but also adequate health awareness and physical preparedness. When human factors such as fatigue, stress, and poor physical condition are not properly managed, performance tends to decline, leading to delayed reactions, poor judgment, and increased likelihood of accidents.

Furthermore, human factors significantly influence safety compliance and decision-making in maritime operations. Salas et al. (2010) noted that human error is a major contributor to accidents in complex operational environments, particularly when individuals are fatigued or under psychological stress. In maritime contexts, this may result in navigational mistakes, improper cargo handling, or failure to respond appropriately during emergencies. Eze and Nwankwo (2021) emphasized that awareness of human biological and physiological limits, including those explained through human anatomy knowledge, can improve safety behaviour and reduce error rates among workers in physically demanding environments. In addition, health conditions such as fatigue, dehydration, and musculoskeletal strain have direct implications for occupational performance in maritime settings. According to Reason (1997), fatigue reduced cognitive function, slows reaction time, and increases the probability of human error. In maritime operations, where quick decision-making is often required, such impairments can have serious consequences. World Health Organization (2021) further stressed that maintaining worker health is essential for sustaining productivity and safety in all occupational sectors, particularly in high-risk environments such as maritime industries.

Consequently, human factors and occupational health are central determinants of performance in maritime settings. When maritime personnel are physically and mentally healthy, they are more likely to perform tasks accurately, comply with safety procedures, and respond effectively to operational challenges. However, when human factors such as fatigue, stress, and poor health are not properly managed, occupational performance declines, increasing the risk of accidents and environmental hazards. Therefore, integrating human factors awareness and health education into maritime occupational training is essential for improving safety, efficiency, and sustainability in maritime operations.

Environmental Impacts of Maritime Activities and Sustainability Considerations

A growing global concern in maritime studies is the environmental impact of maritime activities and the urgent need for sustainability considerations in marine occupational practices. Maritime operations such as shipping, offshore drilling, fishing, port activities, and cargo transportation contribute significantly to economic development; however, they also generate environmental challenges including marine pollution, oil spills, greenhouse gas emissions, ballast water contamination, and destruction of marine biodiversity. These environmental consequences raise serious concerns about the sustainability of maritime operations, especially as human activities at sea continue to expand in scale and complexity. The central worry is that without adequate environmental awareness and sustainable practices, maritime activities may continue to degrade marine ecosystems and threaten global ecological balance. Environmental impact refers to the effects that human activities have on the natural environment, particularly in terms of pollution, resource depletion, and ecosystem disruption. According to the United Nations Environment Programme (2022), environmental impact involved any change to the environment caused by human activities that may be positive or negative, but often results in degradation when not

properly managed. Glasson, Therivel, and Chadwick (2013) defined environmental impact as the alteration of environmental conditions resulting from development projects and industrial activities. Canter (1996) describes it as the measurable change in environmental quality due to human actions, especially in air, water, and land systems. In the Nigerian context, Akinbami and Adeyemi (2021) explained environmental impact as the consequences of industrial and economic activities on ecosystems, particularly in sectors such as oil exploration and transportation, which are closely linked to maritime operations.

In this study, environmental impact refers to the changes and disturbances caused to the marine ecosystem as a result of maritime occupational activities such as shipping emissions, oil leakage, waste disposal, and coastal operations. These impacts affect water quality, marine biodiversity, and ecological balance, thereby creating a need for sustainable maritime practices that reduce environmental harm. Environmental sustainability, therefore, becomes a critical consideration in maritime operations, as it focuses on the responsible use of marine resources to ensure long-term ecological protection and environmental balance. Environmental sustainability is defined as the responsible management of natural resources in a way that meets present needs without compromising the ability of future generations to meet their own needs. The United Nations Environment Programme (2022) emphasized that sustainability involves maintaining environmental quality while supporting economic and social development. Goodland (1995) explained sustainability as the maintenance of natural capital without causing irreversible environmental damage. Moldan, Janoušková, and Hák (2012) further describe sustainability as ensuring that human activities remain within ecological carrying capacity limits. In Nigeria, Akinbami and Adeyemi (2021) highlighted the importance of integrating sustainability principles into industrial and transportation sectors to reduce environmental degradation and promote ecological balance.

In maritime contexts, sustainability considerations involve the adoption of practices that reduce pollution, prevent oil spills, manage waste effectively, and minimize greenhouse gas emissions from ships and offshore operations. International Maritime Organization (2020) emphasizes that sustainable shipping practices are essential for reducing the environmental footprint of global maritime trade. This includes the use of cleaner fuels, improved waste management systems, and adherence to environmental regulations designed to protect marine ecosystems. Additionally, maritime activities have direct implications for the marine environment, which serves as the operational space for shipping, fishing, and offshore exploration. The United Nations Educational, Scientific and Cultural Organization (2022) defined the marine environment as the interconnected oceanic and coastal systems that support biodiversity and human livelihoods. Valiela (2006) described it as a complex ecological system influenced by physical, chemical, and biological processes. Kullenberg (2010) emphasized its role in regulating global climate and supporting marine life. In Nigeria, Nwilo and Badejo (2018) highlighted the marine environment as a vital economic and ecological resource supporting transportation, fisheries, and oil production activities.

For this reason, maritime activities have significant environmental impacts that must be carefully managed through sustainability considerations. The relationship between maritime operations and the marine environment is highly interdependent, as human actions directly influence ecological conditions. Therefore, promoting environmental sustainability in maritime occupational practices is essential for reducing pollution, protecting biodiversity, and ensuring the long-term health of marine ecosystems.

Integrating Anatomy Awareness into Maritime Training and Education Systems

A critical concern in contemporary maritime occupational education is the extent to which human anatomy awareness is effectively integrated into maritime training and education systems to enhance safety, performance, and environmental responsibility. Maritime work environments are physically demanding and expose personnel to continuous

occupational stressors such as fatigue, vibration, heavy lifting, irregular sleep cycles, and motion-induced strain. Despite these realities, many maritime training curricula remain heavily focused on technical navigation, engineering operations, and regulatory compliance, with limited emphasis on the biological and physiological dimensions of human performance. This gap raises concern about whether maritime trainees are sufficiently equipped with human anatomy knowledge to support safe and efficient occupational behaviour at sea. Integration refers to the systematic incorporation of one component into a broader educational or operational framework in a way that ensures functional alignment and relevance. Tyler (1949) described curriculum integration as the organization of learning experiences that are consistent with educational objectives and learner needs. Taba (1962) explains integration as a curriculum development approach that ensures meaningful connections between content areas to improve learning effectiveness. Drake and Burns (2004) further defined integrated curriculum as an approach that connects different subject areas in a coherent manner to enhance understanding and application. In the Nigerian educational context, Udo and Akpan (2020) emphasized that effective curriculum integration improves learner competence by linking theoretical knowledge with practical occupational demands.

In this study, integration refers to the deliberate inclusion of human anatomy awareness within maritime education curricula, training modules, and instructional practices in order to help learners understand how the human body responds to maritime occupational demands and how this knowledge can be applied to improve safety and performance. This means that anatomy should not be taught as an isolated scientific subject but as an applied knowledge area directly connected to maritime tasks such as cargo handling, navigation watch-keeping, emergency response, and onboard maintenance operations. Human anatomy awareness provides the biological foundation necessary for understanding occupational health and safe working practices in maritime environments. Bruner (1960) emphasized that meaningful learning occurs when learners can relate new knowledge to practical experiences, suggesting that anatomy education becomes more effective when linked to real occupational situations. Dewey (1938) also argued that education should be experience-based, where learners connect theoretical knowledge to real-life applications. In maritime education, this implies that trainees should understand how musculoskeletal strain occurs during lifting operations, how fatigue affects cognitive alertness during navigation, and how respiratory and cardiovascular systems respond to environmental stressors at sea.

In addition, integrating anatomy awareness into maritime training systems enhances occupational health outcomes by improving workers' ability to identify early signs of physical stress and prevent injury. Salas et al. (2010) noted that training programs that incorporate human factors and health awareness significantly reduce error rates and improve safety performance in high-risk environments. Similarly, Hancock and Szalma (2008) emphasized that understanding human physical and cognitive limitations is essential for designing safer work systems and improving performance reliability. Moreover, integration of anatomy awareness contributes to environmental sustainability in maritime operations. When maritime personnel are physically healthy and aware of their bodily limitations, they are less likely to engage in unsafe practices that may lead to accidents such as oil spills, equipment damage, or navigational errors. These incidents often have direct negative impacts on marine ecosystems. Therefore, improving human anatomical understanding indirectly supports environmental protection by reducing human error in maritime operations. Hence, integrating anatomy awareness into maritime training and education systems is essential for bridging the gap between technical maritime skills and human physiological understanding. Such integration ensures that maritime personnel are not only technically competent but also physically aware and capable of managing occupational stress effectively. This holistic

approach strengthens safety culture, improves occupational performance, and supports environmental sustainability in maritime operations.

Challenges in Promoting Sustainability and Health Awareness in Maritime Occupations

The promotion of sustainability and health awareness in maritime occupations is essential for ensuring the safety, well-being, and productivity of maritime personnel, as well as the protection of the marine environment. However, despite growing international emphasis on occupational health, environmental sustainability, and maritime safety, several challenges continue to hinder the effective implementation of sustainability and health awareness programmes within the maritime sector (International Maritime Organization [IMO], 2021; United Nations Environment Programme [UNEP], 2023). These challenges affect the quality of maritime education, limit compliance with safety standards, and reduce the effectiveness of environmental conservation efforts. The major challenges include the following:

Limited Integration of Human Anatomy and Sustainability Education into Maritime Curricula: One of the major challenges is the inadequate integration of human anatomy, occupational health, and environmental sustainability into maritime education curricula. Most maritime training institutions emphasize technical competencies such as navigation, marine engineering, and cargo handling while giving less attention to health education and sustainability issues. This imbalance limits learners' understanding of the relationship between human health, occupational safety, and environmental protection (Eze & Nwankwo, 2021; Udo & Akpan, 2020; World Maritime University [WMU], 2022).

Inadequate Training Exposure: Many maritime personnel receive limited practical and theoretical training on occupational health, anatomy awareness, and sustainable environmental practices. The lack of adequate training opportunities reduces their ability to identify workplace hazards, respond appropriately to health-related risks, and adopt environmentally responsible practices during maritime operations (International Labour Organization [ILO], 2022; Mallam & Inyang, 2019).

Weak Safety Culture: A weak safety culture remains a significant obstacle to promoting health awareness in maritime occupations. In some maritime organizations, inadequate commitment to safety procedures, poor attitudes toward risk management, and non-compliance with established safety protocols encourage unsafe work practices. Such behaviours increase the likelihood of occupational accidents, injuries, and environmental pollution (Reason, 1997; Eze & Nnadi, 2021; Stanton, Salmon, Walker, & Jenkins, 2013).

Limited Continuous Professional Training: Continuous professional development is essential for maintaining competence and keeping maritime personnel informed about emerging occupational health and environmental issues. However, many workers receive only their initial certification without participating in regular refresher courses or specialized training programmes. This limits opportunities to update knowledge and adapt to evolving workplace challenges (ILO, 2022; IMO, 2021).

Inadequate Enforcement of Environmental and Occupational Health Regulations: Although international organizations have established comprehensive environmental and occupational health standards for the maritime industry, enforcement remains inconsistent in many operational settings. Weak regulatory monitoring and poor compliance mechanisms allow unsafe practices and environmental violations to persist, thereby undermining sustainability efforts (UNEP, 2023; ILO, 2020).

Low Awareness of Occupational Health and Environmental Sustainability: Some maritime personnel possess limited knowledge of the relationship between occupational health, human anatomy, workplace safety, and environmental sustainability. This low level of awareness often results in poor adherence to health and safety guidelines and reduces

commitment to sustainable operational practices (Okeke & Chukwu, 2020; World Health Organization [WHO], 2021).

Human, Technical, and Organizational Limitations: The effective promotion of sustainability and health awareness is often constrained by human errors, inadequate technological facilities, and weak organizational structures. These limitations reduce the capacity of maritime institutions and organizations to effectively implement health promotion and environmental sustainability programmes (Reason, 1997; Hancock & Szalma, 2008; Stanton et al., 2013).

Weak Institutional Support and Limited Capacity Building: Many maritime training institutions and organizations experience inadequate funding, insufficient instructional resources, and limited capacity-building initiatives. These institutional weaknesses hinder the effective delivery of sustainability education, occupational health programmes, and professional development activities (UNESCO, 2022; WMU, 2022).

Poor Compliance with Safety Standards: Failure to comply with established occupational safety standards remains a persistent challenge within the maritime sector. Poor compliance increases the risk of workplace injuries, fatigue-related incidents, occupational illnesses, and environmental accidents, thereby threatening both human life and marine ecosystems (ILO, 2020; Eze & Nnadi, 2021; Ugwu & Chukwu, 2020).

Weak Monitoring and Evaluation Mechanisms: Effective sustainability and health promotion require regular monitoring and evaluation of workplace practices. However, inadequate inspection systems, poor supervision, and weak evaluation mechanisms often make it difficult to assess compliance with occupational health and environmental standards, allowing existing deficiencies to remain unaddressed (UNEP, 2023; IMO, 2021). Hence, the promotion of sustainability and health awareness in maritime occupations is constrained by several interrelated challenges, including inadequate curriculum integration, insufficient training opportunities, weak safety culture, limited professional development, poor regulatory enforcement, low awareness, organizational limitations, weak institutional support, poor compliance with safety standards, and ineffective monitoring mechanisms. Addressing these challenges is essential for strengthening maritime education, enhancing occupational health and safety, and promoting environmentally sustainable maritime operations (Nwosu & Okafor, 2022; Goodland, 1995; Moldan, Janoušková, & Hák, 2012).

Implications for Maritime Educational Development

The findings and conceptual relationships discussed in this study have important implications for maritime educational development, particularly in strengthening the quality, relevance, and effectiveness of training programmes for maritime personnel. A key implication is the need to reposition maritime education beyond technical skill acquisition to include human anatomy awareness and occupational health education. This is important because maritime operations are not only technically driven but also highly dependent on human physical capacity and physiological stability. The International Maritime Organization (2023) emphasized that modern maritime training must adopt a holistic approach that integrates technical competence with human performance and safety awareness in order to reduce operational risks. Another implication is the need for curriculum restructuring in maritime training institutions to ensure that human anatomy and occupational health concepts are embedded within core maritime courses rather than treated as peripheral content. The World Maritime University (2022) noted that competency-based maritime education is most effective when it reflects real operational conditions, including human limitations and environmental stressors. This suggests that maritime curricula should be designed in a way that links human biological understanding with practical maritime tasks such as navigation, cargo handling, and emergency response.

Furthermore, the study implies that maritime educational development must prioritize capacity building for instructors and trainers. Educators need adequate knowledge of human factors, occupational health principles, and environmental sustainability to effectively deliver integrated maritime training. The United Nations Educational, Scientific and Cultural Organization (2022) highlighted that teacher capacity significantly influences the quality of curriculum implementation and learner outcomes in technical and vocational education systems. In addition, there is an implication for stronger collaboration between maritime institutions, regulatory bodies, and environmental agencies to ensure that training content aligns with international safety and sustainability standards. The United Nations Environment Programme (2023) stressed that interdisciplinary collaboration is essential for achieving sustainability goals in sectors that have significant environmental impacts such as maritime transport. Generally, the integration of human anatomy awareness into maritime education is essential for producing competent, health-conscious, and environmentally responsible maritime professionals.

Conclusion

This study concludes that human anatomy awareness plays a critical role in enhancing safe maritime practices, improving occupational performance, and supporting environmental sustainability in maritime occupational settings. The integration of human anatomical knowledge into maritime education helps learners understand how the human body responds to physical and environmental stressors such as fatigue, motion, vibration, and heavy workload, which are common in maritime operations. This understanding is essential for reducing occupational injuries, improving decision-making, and strengthening safety culture at sea. The study also concludes that human factors and occupational health significantly influence performance in maritime environments, where errors caused by fatigue or poor physical condition can lead to serious operational and environmental consequences. Furthermore, the environmental impacts of maritime activities highlight the importance of sustainable practices that protect marine ecosystems while maintaining operational efficiency. Overall, the study establishes that there is a strong interrelationship among human anatomy awareness, maritime education, occupational health, and environmental sustainability. Strengthening this relationship through improved training and curriculum integration will contribute to safer maritime operations and better protection of the marine environment.

The Way Forward

In order to improve maritime occupational education and ensure sustainable maritime operations, several strategic actions are necessary. First, maritime education institutions should integrate human anatomy awareness and occupational health modules into core maritime training programmes. This will ensure that trainees develop a strong understanding of human physical limitations and safety requirements alongside technical skills. Second, continuous professional development programmes should be introduced for maritime instructors and personnel to keep them updated on modern practices in human factors, occupational health, and environmental sustainability. This will improve the quality of instruction and enhance safety awareness among maritime workers. Third, regulatory agencies and maritime authorities should strengthen enforcement of safety and environmental standards to ensure compliance with international best practices. Regular monitoring and evaluation of maritime operations will help reduce unsafe practices and environmental risks.

Fourth, there should be increased collaboration between maritime institutions, health professionals, and environmental agencies to develop interdisciplinary training approaches that reflect real operational conditions at sea. Finally, awareness campaigns should be intensified to promote a strong safety culture among maritime workers, emphasizing the importance of human anatomy awareness, personal health management, and environmental

protection. Therefore, through these measures, maritime education can produce professionals who are not only technically competent but also health-conscious and environmentally responsible, thereby contributing to safer and more sustainable maritime operations.

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