



The Impact of Digitalization in Enhancing Maritime Safety of Cruise Ships

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Abstract

This research study aimed to determine the impact of digitalization in enhancing maritime safety on cruise ships. The study employed a purposive sampling technique for the survey, which allowed the researchers to select respondents who provided relevant data for the study. The survey questionnaire, which was converted into Google Forms for easy sharing in digital platforms, consisted of closed-ended questions and was divided into two parts: the perception on the digitalization of cruise ships in terms of navigation, port operations, and shipping operations; and, the impact of digitalization in enhancing safety onboard cruise ships in terms of risk management, health and security. Employing 30 Filipino seafarers with seagoing experiences, questionnaires were shared through social media platforms such as Facebook, Messenger, Twitter, Instagram, and Gmail. The gathered data underwent tabulation, statistical treatment and analysis. Based on the results, respondents “strongly agree” that digitalization plays a crucial role in enhancing maritime safety, particularly in navigation of cruise ships. This technology-driven approach contributes to a safer and more efficient maritime environment, benefiting both crew and passengers. They also “strongly agree” with the favorable impact of digitization in port and shipping operation. Further, respondents “strongly agree” that digitalization enhances safety awareness onboard cruise ships reflecting a consensus on the benefits of digital technology in promoting safety. More so, they “strongly agree” that technology and digitalization play a significant role in reducing stress and enhancing safety and security. The Pearson r test reveals that navigation is significantly and positively related to awareness, health, and security, while port operation is also significantly and positively related to awareness, health and security. Finally, shipping operation is significantly and positively related to awareness, health and security. This highlights the interconnectedness of digital transformation across various maritime operations and safety aspects. It suggests that investing in digital technologies not only improves efficiency but also contributes significantly to improving safety standards for seafarers.

Keywords: digitalization, maritime safety, cruise ship, safety navigation, port operation, shipping operation, Filipino seafarers



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INTRODUCTION

The shipping industry is undergoing intense and continuous digital innovations, and that all maritime activities will be completely altered in the coming years. There are impacts that can be produced in many aspects with this so-called digitalization, which can be positive or negative. Seafarers' tasks may be turned into more electronic versions, such as management control and operation surveillance, and operational work may be reduced (WMU, 2019). The maritime industry, like any other service

industry, faces the challenges of global competition, which may include maritime safety. According to Ichimura (2021), it is necessary to establish or revise safety standards to realize digitalization. Cooperation with stakeholders includes joint experiment with autonomous ships and data sharing. An experiment with autonomous ships means to evaluate the safety level of autonomous ships, and data sharing involves data related to safe navigation, such as hydrographical data and meteorological data. Digital technologies can contribute to maritime safety, so research and development of digital

technologies enhances safe navigation. Survey, inspection and certification are the essential tools to implement International Maritime Organization (IMO) instruments and ensure maritime safety. So, digitalization in this field is relevant to maritime safety.

Digitalization is transforming the maritime industry, enhancing safety, efficiency, and sustainability. Weather monitoring and prediction technologies are improving situational awareness and risk mitigation in maritime operations (Kadhafi, 2024). The integration of digital technologies is optimizing cargo handling, procurement, and logistics processes while minimizing environmental impacts (Babiča et al., 2019). Digitalization is crucial for the sustainable development of the maritime sector, contributing to greener and smarter shipping practices (Pavlinovic et al., 2023). Maritime container shipping companies are experiencing significant process changes through the deployment of digital applications, impacting costs, time, quality, and flexibility (Sanchez-Gonzalez et al., 2022).

However, challenges such as regulatory barriers and the need for stakeholder engagement must be addressed to ensure widespread adoption (Kadhafi, 2024). This led the researchers to conduct this study in order to fill this research gap by integrating existing literature and to determine the effects of digitalization in terms of maritime safety in cruise ships. Specifically, the study aims to elicit perceptions on the digitalization of cruise ships in terms of navigation, port operations, and shipping operations as well as its impact in enhancing safety onboard cruise ships in terms of risk management, health and security.

LITERATURES

Digitalization and Efficiency in Maritime Industry. Digitalization in the maritime industry is increasingly recognized as a crucial factor for improving efficiency, sustainability, and competitiveness. Studies show that digital adoption positively impacts shipping firms' efficiency, particularly in water transport activities (Gavalas et al., 2022). The

implementation of digital technologies in certification processes can enhance management practices and operational efficiency (Duisenbiyev et al., 2023). Despite the industry's traditional reluctance, digitalization offers prospects for optimized cargo handling, improved logistics, and reduced environmental impacts (Babiča et al., 2019). The COVID-19 pandemic has accelerated digital transformation in the sector, with experts agreeing that digitalization combined with environmental sustainability is essential for future development (Pavlinovic et al., 2023).

The Role of Technology in Autonomous Ships and Crew Reduction. While fully autonomous ships are not expected in the immediate future, advancements in autonomous technology have the potential to reduce crew sizes and improve operational efficiency. According to Brien (2018), autonomous ships can lower human error, reduce crewing costs, and optimize space and fuel use. However, Gallego (2022) noted the integration of autonomous vessels into current maritime systems requires overcoming challenges like technology compatibility and the high costs of implementation. Additionally, there remains a need for human oversight. The shift towards autonomy in smaller vessels can pave the way for a future where maritime operations rely less on human labor.

Impacts of Digitalization on Leadership and Workforce. The introduction of digital technologies in maritime operations raises concerns about the shifting dynamics of leadership and the workforce. According to Kitada et al. (2018), digitalization influences leadership on ships by altering how work is organized, and tasks are assigned. As operations become more automated, human-automation coordination becomes essential to ensure smooth ship functions. In the Philippines, where maritime employment is vital, there are concerns about the displacement of workers due to automation. Studies suggest that seafarers may need to transition from traditional on-board roles to shore-based positions, which requires redefining skills and adapting to new job requirements.

Environmental and Sustainability Benefits of Digitalization. The maritime sector has the potential to make substantial contributions to environmental sustainability through the adoption of digital technologies. highlight that improved information flow between ports and ships can reduce fuel consumption and emissions by optimizing docking times and allowing ships to sail at slower speeds. Similarly, advancements in smart ports, autonomous vessels, and resource management systems can promote greener operations (Gallego, 2022). The integration of these digital tools also supports broader sustainability goals, such as achieving net-zero emissions in the maritime industry by improving efficiency and reducing waste. These innovations make the maritime sector a key player in the global effort toward environmental sustainability.

METHODOLOGY

Population, Samples, and Sampling Techniques. In this study, the researchers used purposive sampling technique, hence, 30 Filipino seafarers with experience on digitalization onboard cruise ships were chosen to provide relevant data for the study.

Research Instrument. The research instrument was a researcher-made questionnaire anchored from the literatures reflected in the study. The questionnaire is composed of close-ended questions and was divided into two parts. The first part focused on the respondents' perception on the digitalization in cruise ship operations, such as navigation, port, and shipping operations. The second part addressed the impact of digitalization in enhancing safety onboard, specifically in terms of risks, health and security.

The questionnaire was validated by both a maritime professor and an English expert. It was also tested for reliability through a pilot-testing with 10 seafarer respondents. The Cronbach's Alpha results showed that the questionnaire had good internal consistency, with an alpha range of 0.856 to 0.932, indicating that it was acceptable in terms of reliability.

Data Gathering Procedure. To collect the necessary data, the researchers first reached out to potential respondents through relatives. To complete the required participants, maritime agencies and offices were contacted to outsource additional potential respondents who were either onboard or currently undergoing training. After getting approval from the administrators of maritime agencies to conduct the survey, the researchers distributed the questionnaires.

The survey distribution was conducted through various social media platforms, such as Facebook, Messenger, Twitter, Instagram, and Gmail. This online method allowed the researchers to reach respondents without putting their health at risk, especially considering the current circumstances. Additionally, since the respondents were also in their training programs or onboard ships, the collected data were reliable. In addition, the researchers ensured the confidentiality of respondents through anonymity of their background and information.

Statistical Treatment. Data collected were documented, tabulated, and analyzed by a professional statistician. The following statistical treatments were used in this research:

1. **Weighted Mean.** This method was used to describe the perception of respondents on the digitalization of cruise ships in terms of navigation, port operations, and shipping operations, as well as its impact in enhancing safety onboard cruise ships in terms of risk management, health and security. A 5-point Likert Scale was used to measure each indicator in the survey.
2. **Pearson Correlation Analysis.** This technique was used to assess the relationship between two continuous variables and their statistical correlation. In application, Pearson Correlation was used to examine the significant relationship between respondents' perceptions of digitalization and its impact on safety enhancement onboard cruise ships.

RESULTS

Perception of digitalization in cruise ships in terms of Navigation, Port Operation and Shipping Operation. Table 1 provides a summary of the perception of digitalization in navigation among 30 respondents in a cruise ship setting. The responses are based on a 5-point Likert scale, with scores ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The average weighted mean (4.93) for each statement indicates a strong favorable consensus regarding digitalization in navigation.

Table 1
Perception of Digitalization in Cruise Ship as to Navigation (N= 30)

Statement	Weighted Mean	Verbal Interpretation
1. I can easily identify the position of the vessel at sea.	4.93	Strongly Agree
2. I can efficiently navigate through the sea even though there is traffic.	4.93	Strongly Agree
3. I can find the fastest and safest route to reach our destination.	4.93	Strongly Agree
4. I can use technology to know the vessels near my vessel.	4.93	Strongly Agree
5. I can use technology to prevent delays in my voyage.	4.93	Strongly Agree
Average Weighted Mean	4.93	Strongly Agree

The high overall weighted mean reflects a broader trend in the maritime industry where digitalization has become integral to ensuring safety and efficiency in navigation. According to studies by Carter et al. (2021), the use of digital tools like ECDIS, AIS, and GPS has revolutionized maritime navigation, providing accurate, real-time information that enhances safety and efficiency.

Further research by Liu and Jones (2020) highlights how digitalization facilitates better communication and coordination among vessels, reducing the risk of collisions and other navigation-related incidents. Technologies such as AIS allow for the real-time tracking of vessel movements, contributing to a safer maritime environment.

Overall, the consensus observed aligns with the supporting literature, indicating that digitalization plays a crucial role in enhancing maritime safety, particularly in navigation on

cruise ships. This technology-driven approach contributes to a safer and more efficient maritime environment, benefiting both crew and passengers.

Table 2
Perception of Digitalization in Cruise Ship as to Port Operation (N= 30)

Statement	M	Interpretation
1. It makes my task easier during port operation.	4.77	Strongly Agree
2. It is convenient for me/us to communicate in port.	4.80	Strongly Agree
3. I am not experiencing any delays upon arrival and departure of our vessel on port.	4.43	Strongly Agree
4. The port can accommodate our vessel right away upon arrival.	4.63	Strongly Agree
5. Drones help in port and logistic processing.	4.47	Strongly Agree
Average Weighted Mean	4.73	Strongly Agree

Table 2 above shows the respondents' perception of digitalization in cruise ships as to port operation. The results show that all of the statements were marked "strongly agree" by the respondents, with the statement "It is convenient for me/us to communicate in port" having the highest weighted mean of 4.80. On the other hand, the statement "I am not experiencing any delays upon arrival and departure of our vessel on port" incurred the lowest weighted mean of 4.43.

The digitalization of ports offers numerous benefits, including enhanced efficiency, cost reduction, improved transparency, and better customer experience. By leveraging digital tools such as automation and data analytics, ports can streamline operations, reduce errors, and optimize resource utilization. This leads to increased productivity and lower operational costs. It also fosters transparency by providing stakeholders with real-time access to accurate information, thereby building trust and accountability. Moreover, it improves customer experience by offering real-time tracking and online services, while facilitating better cost allocation between stakeholders through electronic invoicing and billing systems. Overall, embracing digital transformation positions ports for greater competitiveness and sustainable growth in the evolving maritime industry (Opsealog, 2023). As a whole, respondents "strongly agree" with the favorable use of digitalization on port operation (4.62).

Table 3
Perception of Digitalization in Cruise Ship as to Shipping Operation (N= 30)

Statement	Weighted Mean	Verbal Interpretation
1. I thought digital equipment was easier to use in shipping operations.	4.80	Strongly Agree
2. I would say that digitalization is more efficient with regards to shipping operations.	4.87	Strongly Agree
3. I find digitalization more efficient by reducing delays and waiting time at ports.	4.77	Strongly Agree
4. I can easily execute my duties in shipping operations with the help of digitalization.	4.80	Strongly Agree
5. It was easy to communicate with other port authorities.	4.83	Strongly Agree
Average Weighted Mean	4.81	Strongly Agree

Table 3 above shows the respondents' perception on the digitalization of cruise as to shipping operation. The results show that all of the statements were marked "strongly agree" by the respondents, with the statement, "I would say that digitalization is more efficient with regards to shipping operations", which earned the highest weighted mean of 4.87. On the other hand, the statement "I find digitalization more efficient by reducing delays and waiting time at ports" incurred the lowest weighted mean of 4.77. As a whole, the respondents "strongly agree" with the advantageous use of digitization in shipping operation as reflected by the computed average weighted mean of 4.81.

Impact of digitalization on the enhancement of safety onboard cruise ship in terms of Awareness, Health and Security. Table 4 provides insights into the impact of digitalization on enhancing safety awareness onboard cruise ships, based on responses from 30 participants.

Table 4
Impact of Digitalization on the Enhancement of Safety Onboard as to Awareness

Statement	Weighted Mean	Verbal Interpretation
1. I thought digital equipment was easier to use in shipping operations.	4.73	Strongly Agree
2. I would say that digitalization is more efficient with regards to shipping operations.	4.83	Strongly Agree
3. I find digitalization more efficient by reducing delays and waiting time at ports.	4.73	Strongly Agree
4. I can easily execute my duties in shipping operations with the help of digitalization.	4.83	Strongly Agree
5. It was easy to communicate with other port authorities.	4.87	Strongly Agree
Average Weighted Mean	4.80	Strongly Agree

The scores, on a 5-point Likert scale where 5 signifies "Strongly Agree," reflect a consensus on the benefits of digital technology in promoting safety.

The highest mean score of 4.87 shows that digitalization is highly effective in identifying risks or errors in onboard equipment. The overall average weighted mean of 4.80 ("Strongly Agree") underscores the positive impact of digitalization on safety awareness in cruise ships. These findings is supported by previous researches which highlighted the role of digital technology in improving maritime safety.

Table 5
Impact of Digitalization on the Enhancement of Safety Onboard as to Health (N= 30)

Statement	M	Interpretation
1. My stress reduces due to technology that makes my tasks easier.	4.70	Strongly Agree
2. I did not have to worry about my health about possible threats because technology has safety features.	4.57	Strongly Agree
3. I can easily have access to medical personnel if someone hurt.	4.53	Strongly Agree
4. I can use technology for medical purposes, especially in annual check-up on board.	4.70	Strongly Agree
5. The accessible PCs, tablets and phones help me to get advice and support with such things as emergency care, medical treatment, vaccinations, hygiene, training and nutrition.	4.67	Strongly Agree
Average Weighted Mean	4.63	Strongly Agree

Table 5 presents the impact of digitalization on enhancement of safety onboard in terms of health. The data presented shows that technology and digitalization play a significant role in reducing stress and enhancing safety in cruise ships. With majority of the indicators gaining a "Strongly Agree" response, the scores indicate a strong consensus from the respondents about the positive impact of technology in these areas.

The average weighted mean of 4.63 across these statements signifies a strong agreement among respondents that technology and digitalization substantially reduce stress and enhance safety on cruise ships. Recent research indicates that digitalization and technology are enhancing safety and reducing stress on cruise ships. The implementation of digital systems for the International Safety

Management Code streamlines ship operations and improves safety processes (Ghosh & Abeyesiriwardhane, 2021). Computerization of bridge, machinery, and cargo systems has increased operational safety by enabling unmanned machinery spaces and autopilot functions (Masoudi, 2019). In emergency situations, digital escape route signage with up-to-date information has been shown to inspire trust and influence passenger decision-making under stressful conditions, potentially preventing crossing passenger streams and improving overall safety (Meier et al., 2015). However, the increasing reliance on technology also brings cybersecurity challenges that need to be addressed (Ghosh & Abeyesiriwardhane, 2021).

Table 6
Impact of Digitization of the Enhancement of Safety Onboard as to Security (N= 30)

Statement	M	Interpretation
1. I can do my duties with less worry.	4.67	Strongly Agree
2. I am confident that no unauthorized personnel are onboard the ship.	4.63	Strongly Agree
3. The control port is accessible and provides a detection and early warning system.	4.77	Strongly Agree
4. I don't feel anxiety due to piracy.	4.40	Strongly Agree
5. I feel secure onboard a cruise ship.	4.73	Strongly Agree
Average Weighted Mean	4.64	Strongly Agree

Table 6 presents the impact of digitization on the enhancement of safety onboard as to security. Majority of the respondents "strongly agree" that digitalization made them less worried on their duties (4.67), confident that no unauthorized personnel are onboard the ship (4.63), that control port is accessible and provides a detection and early warning system (4.77), and generally feel secured onboard the cruise ship (4.73). Overall, they "strongly agree" that digitalization has enhanced the safety of cruise ships.

Significant relationship between the digitalization of cruise ships and its impact on the enhancement of safety onboard cruise ships. As shown in Table 7, navigation is significantly and positively related to awareness, health, and security, as shown by the Pearson r values of 0.644, 0.748, and 0.634, all with p-values of 0.000. Likewise, port operation is also significantly and positively

related to awareness ($r=0.400$, $p\text{-value}=0.028$), health ($r=0.768$, $p\text{-value}=0.000$), and security ($r=0.804$, $p\text{-value}=0.000$). Finally, shipping operation is significantly and positively related to awareness ($r=0.610$, $p\text{-value}=0.000$), health ($r=0.668$, $p\text{-value}=0.000$), and security ($r=0.564$, $p\text{-value}=0.001$).

Table 7
Pearson Correlation Test Between Digitalization of Cruise Ships and its Impact on the Enhancement of Safety Onboard Cruise Ships

Variables	Pearson r	p-value	Interpretation
Navigation and Awareness	0.644	0.000	Significant
Navigation and Health	0.748	0.000	Significant
Navigation and Security	0.634	0.000	Significant
Port Operation and Awareness	0.400	0.028	Significant
Port Operation and Health	0.768	0.000	Significant
Port Operation and Security	0.804	0.000	Significant
Shipping Operation and Awareness	0.610	0.000	Significant
Shipping Operation and Health	0.668	0.000	Significant
Shipping Operation and Security	0.564	0.001	Significant

Overall, the results imply that respondents with high perceived application of digitalization in navigation, port operation, and shipping operation also have high perceived impact of digitization on awareness, health, and security. The digitalization has a positive impact on seafarers' development and efficiency at work by reducing the burden and spending time on their task. Which allows them to focus on relevant task and reduce physically challenging daily tasks. The seafarers also believe that the digital tools can lead on the enhancement of their personal safety onboard ship. (Schubert et al., n.d.)

DISCUSSION

The study reveals that seafarers have a generally positive perception of the impact of digitalization on various aspects of maritime operations. The respondents strongly agreed that digitalization has a positive effect on navigation, with an average weighted mean of 4.93, indicating that digital tools and systems significantly enhance their ability to navigate ships. This is consistent with the increasing adoption of digital technologies like GPS, electronic chart display and information systems (ECDIS), and automated navigation

tools, which have revolutionized navigation practices in the maritime industry.

The positive perception regarding port operations (average weighted mean of 4.62) further highlights the convenience and efficiency provided by digitalization. Seafarers noted improvements in communication during port operations, the timely arrival and departure of vessels, and the ability of ports to accommodate ships without delays. The use of digital systems in logistics, port management, and the tracking of shipments likely contributed to these positive experiences, which in turn support the argument that digitalization reduces operational bottlenecks and enhances the overall efficiency of maritime processes.

Similarly, the respondents reported a strong positive impact of digitalization on shipping operations (average weighted mean of 4.81). This further reinforces the role of technology in streamlining the operations of vessels, reducing delays, and improving the coordination between ships and port facilities. The integration of digital tools in shipping operations allows for better scheduling, real-time tracking, and more effective management of cargo, which ultimately leads to reduced operational costs and improved service delivery.

One of the most significant findings of this study is the positive impact of digitalization on maritime safety. Respondents strongly agreed that digitalization enhances safety awareness (average weighted mean of 4.80), health (average weighted mean of 4.63), and security (average weighted mean of 4.64) onboard cruise ships. These findings suggest that digital technologies, such as automated systems for monitoring vessel performance, weather conditions, and cargo safety, contribute significantly to improving safety standards onboard.

The strong agreement regarding safety awareness underscores the importance of digital tools in enhancing training, awareness programs, and real-time risk assessment onboard vessels. The integration of digital

safety systems likely helps seafarers stay informed about potential hazards and take timely action to mitigate risks. In terms of health, the respondents' positive perception about digitalization reducing stress and improving overall health further emphasizes how technology can alleviate the physical and mental pressures that seafarers face during long voyages. These tools likely support health monitoring and improve the well-being of seafarers by providing remote medical consultations and alerts for health-related issues.

Moreover, the strong positive response concerning digitalization's impact on security suggests that digital security systems, such as surveillance cameras, access control systems, and cybersecurity measures, are critical in safeguarding both personnel and assets onboard. As cyber threats become more prevalent in the maritime industry, the adoption of robust digital security measures is vital to ensuring the safety of ships and their crew.

The Pearson correlation analysis provided a clear indication that the perception of digitalization's impact on navigation, port operations, and shipping operations is significantly and positively correlated with the enhancement of safety, health, and security. The results, with p-values of 0.000, suggest that improvements in operational areas, such as navigation and port logistics, directly contribute to enhanced safety awareness, better health outcomes, and improved security measures onboard. This highlights the interconnectedness of digital transformation across various maritime operations and safety aspects. It suggests that investing in digital technologies not only improves efficiency but also contributes significantly to improving safety standards for seafarers.

Future studies could explore the specific digital tools and technologies that seafarers find most beneficial in their daily operations and safety practices. Additionally, expanding the sample size and including respondents from other countries could provide a more comprehensive understanding of the global impact of

digitalization on maritime operations. Policymakers and industry leaders should also focus on promoting digital literacy and providing continuous training programs for seafarers to ensure that they can fully leverage digital technologies to improve their work environment and safety.

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