



JOURNAL OF COMPUTATIONAL INNOVATION AND ANALYTICS

<https://e-journal.uum.edu.my/index.php/jcia>

How to cite this article:

Mohd Radzi, S. H., Sappri, M. M., Zainol Abidin, M.Z. & Ahmad, P.A. (2025). Game-based pedagogy meets simulation: Using board games to model seaport operations in maritime education. *Journal of Computational Innovation and Analytics*, 4(2), 80-99. <https://doi.org/10.32890/jcia2025.4.2.6>

GAME-BASED PEDAGOGY MEETS SIMULATION: USING BOARD GAMES TO MODEL SEAPORT OPERATIONS IN MARITIME EDUCATION

**¹Shanizan Herman Mohd Radzi, ²Mazlan Mohd Sappri, ³Mohammad Zukuwwan
Zainol Abidin & ⁴Puteri Azwa Ahmad**

^{1,2,3}School of Quantitative Sciences,
Universiti Utara Malaysia, Malaysia

⁴Jabatan Teknologi Maklumat dan Komunikasi,
Politeknik Tuanku Syed Sirajuddin, Malaysia

⁴Corresponding author: puteriazwa@ptss.edu.my

ABSTRACT

Game-based learning has gained traction as an innovative educational initiative, particularly in fields requiring strategic decision-making and operational management. This study explores the effectiveness of a board game, *Port Management Game*, as a pedagogical tool for enhancing students' understanding of seaport management concepts. The primary objective of this study is to examine how board games can facilitate experiential learning, thus improving knowledge retention and supporting the development of critical decision-making skills among higher education students studying seaport management. A quasi-experimental research design involving a control and an experimental group was employed. The experimental group participated in board game sessions integrated into their coursework, while the control group underwent traditional lecture-based instruction. Data were collected through pre-tests and post-tests to assess students' learning outcomes. A split-plot ANOVA was conducted to determine the statistical significance of the differences in performance between the two groups. The findings revealed that students in the experimental group demonstrated a statistically significant improvement in their understanding of seaport management concepts compared to those in the control group. The results align with existing literature supporting the use of game-based learning as an effective pedagogical strategy in higher education. The significance of this study lies in its contribution to maritime education by validating the use of board games as an interactive learning medium and as a tool in enhancing students' understanding of lessons. The study also highlights the potential of board games to bridge theoretical knowledge with practical application, preparing students for real-world challenges in the maritime industry. Furthermore, the research underscores the suitability

of board games as a stepping stone toward apprenticeship training, as they provide a structured yet flexible environment for learning by doing.

Keywords: game-based learning, board games, maritime education, simulation

INTRODUCTION

The seaport industry plays a pivotal role in global trade and economic development, serving as the critical nexus for the transportation and management of goods across continents. Seaports are dynamic environments characterized by the interplay of numerous activities, including berth scheduling, cargo handling, resource allocation, and contingency planning (Ducruet, Berli, & El-Geneidy, 2022). Effective sea port management requires a combination of technical expertise, strategic decision-making, and operational efficiency (López & Martínez, 2021). Given the complexities involved, equipping university students with practical skills in this field is essential for preparing them to address the challenges of modern port operations.

Even though seaport management is crucial, conventional teaching methods frequently fall short in bridging the gap between theory and practice (Theories of Maritime Education and Training (MET) in Improving, 2020). Students in logistics and transportation studies sometimes find it difficult to see how abstract ideas translate into practical situations, hindering their comprehension of port management's complexities (Rahman, Chowdhury, & Karim, 2023). Their capacity to acquire the problem-solving and decision-making abilities that are essential for handling the intricacies of port operations is hampered by this gap. Furthermore, as López and Martínez (2021) point out, teaching seaport management necessitates a multidisciplinary approach that integrates knowledge from economics, technology, and logistics; a challenge that is sometimes disregarded in traditional curriculum.

The lack of practical learning tools in seaport management education has several adverse effects. Firstly, it causes students to grasp important ideas superficially, making them unprepared for the demands of real-world operations. Secondly, the development of crucial abilities like critical thinking, cooperation, and flexibility is hampered by the lack of opportunities for experiential learning (Jones & Baker, 2022). Moreover, disengaged learners, due to their dependence on traditional teaching methods, find it difficult to remember material and use it successfully in professional (workplace) settings (Taylor et al., 2023). Ineffective graduates who enter the industry are ill-prepared to manage the ever-changing demands of port operations, which raises operational risks and causes inefficiencies (Winarno et al., 2025). This affects supply chain efficiency and international trade while impeding innovation in new areas like sustainability and automation (López & Martínez, 2021; Zhang et al., 2024).

By creating meaningful learning experiences, game-based learning (GBL) has become a revolutionary strategy to close these educational gaps. GBL's capacity to foster cooperation, teamwork, and enhanced social skills among students is one of its main benefits (Fonseca et al., 2023). Games frequently require players to cooperate to accomplish shared objectives, promoting communication, conflict resolution, and cooperative problem-solving (Kapp et al., 2021). This collaborative environment mirrors the dynamics of professional settings, preparing students for real-world team-based challenges in seaport operations. Additionally, GBL enhances problem-solving skills by requiring players to analyze complex scenarios, develop strategies, adapt to changing circumstances, and propose solutions (Chen et al., 2023). Through repeated practice in a simulated yet realistic environment, students develop a structured approach to tackling problems, which is a critical skill in managing the multifaceted challenges of port operations (Perkovic et al., 2020).

Another significant benefit of GBL is its ability to improve students' confidence in decision-making. Games offer a secure environment where students may make choices, see the results, and grow from their errors without fear of consequences in the real world (Pan, Y., et al., 2021; Plass, Homer, & Kinzer, 2015). Students benefit from this iterative process by developing self-efficacy, a trait necessary for making wise decisions under pressure in work settings (Wilson & Grant, 2022). Additionally, game-based tools provide the perfect setting for practicing realistic occurrences and formulating alternative decisions. Games give students a realistic opportunity to put their theoretical knowledge into practice by modelling scenarios including emergency responses, resource allocation, and berth scheduling. This immersive experience fosters a deeper understanding of the complexities of seaport management while encouraging learners to adopt a proactive approach to problem-solving and innovation (Jones & Baker, 2022).

GBL also embodies the "learning by doing" principle, a pedagogical approach that enhances cognitive engagement and retention (Taylor et al., 2023). Students acquire topics more efficiently when they actively participate in game-based activities as opposed to passive learning strategies like books or lectures. Since students feel more involved and in control of their learning process, this method increases knowledge retention and cultivates intrinsic motivation (Chen et al., 2023). These advantages make GBL a potent instrument for giving students the competencies, self-assurance, and teamwork needed to succeed in this fast-paced industry, as it is incorporated into seaport management education.

Innovative teaching resources like board games have shown promise in addressing these issues. Board games facilitate the connection between theory and practice by giving students a simulated setting to interact with real-world situations. The fundamentals of game-based learning found in board games allow students to study independently in a relaxed, non-threatening setting (Plass, Homer, & Kinzer, 2015). These tools enable learners to interactively and engagingly develop critical skills, such as strategic planning, resource management, and decision-making (Taylor et al., 2023). In addition to helping students apply theoretical principles in a risk-free environment, board games' experiential aspect fosters leadership, teamwork, and communication skills (Jones & Baker, 2022). Furthermore, research has demonstrated that board games can improve cognitive engagement and motivation, which makes them a suitable teaching tool for logistics and marine education (Chen et al., 2023; Wilson & Grant, 2022).

This study explores the potential of board games as a learning tool in the context of seaport management. Modules including berth scheduling, cargo logistics, and emergency response management are all included in the game, which is meant to simulate important elements of port operations. In order to accomplish the goals, players must work through a series of planning, operational, and review stages while utilizing strategies like resource efficiency and spatial strategy. The game seeks to bridge the gap between academic theory and real-world applications by offering an interactive and captivating learning experience that will aid students in visualizing and internalizing the complexity of seaport management.

LITERATURE REVIEW

Board Games versus Digital Games

Board games have long been recognized as tools that simulate real-world processes and decision-making environments, providing an alternative yet equally engaging approach to computer-based simulations (Marcos & López-García, 2024; Board Games as a Research Method, 2024; Cushman-

Roisin, Rice, & Moldaver, 2000). Unlike digital games, which often depend on intricate algorithms and immersive graphics to replicate scenarios, board games rely on tangible elements such as cards, tokens, and boards. This tangibility fosters face-to-face interaction and creates an environment conducive to collaboration and critical reflection (Dahlin, Larsson, & Erlich, 2013). Unlike the virtual engagement seen in digital games, the tactile aspect of board games enables players to interact directly with game mechanics, promoting hands-on learning and communication.

Research has highlighted the strengths of board games in facilitating reflective and experiential learning. For example, Radzi et al. (2021) noted that, unlike digital games that could force players to make decisions more quickly due to real-time mechanisms, board games' intentional pacing frequently gives them enough time to think through their strategy and available options. Board games are perfect for encouraging cognitive engagement in educational settings because of their slower pace, allowing players to comprehend operational procedures and decision-making results fully. Furthermore, board games allow for the visualization of transparent operational processes, which enhances players' understanding of complex systems (Hayhow et al., 2019; Dahlin et al., 2013).

While digital games are often celebrated for their ability to replicate real-world scenarios through high processing power and sophisticated simulations, the constrained interaction options in digital environments can limit players' creativity and autonomy (Schneider, Blikstein, & Mackay, 2020). For example, digital games often restrict decision-making to predefined pathways, whereas board games encourage open-ended strategies and spontaneous problem-solving. Players in board games must negotiate, debate, and make decisions with others in real-time, fostering dynamic communication and interpersonal skills (Bagwan et al., 2021).

Moreover, board games provide a safe and low-pressure environment for experimentation. This feature of board games makes them especially beneficial for students who might feel overpowered by the technical or competitive difficulties of digital games, as Eterovic and Santos (2023) reported. Participants with different technical skill levels can interact with the learning content meaningfully due to its inclusive feature. Additionally, the portability and sustainability of board games offer practical advantages over digital games, which require specific technological infrastructure and are susceptible to obsolescence (Dahlin et al., 2023).

Board games have drawbacks despite their advantages. The physical components and manual operations can sometimes slow gameplay, making them less suited for replicating highly dynamic systems than digital games (Reng, Schoenau-Fog, & Kofoed, 2020). However, hybrid approaches that integrate tangible user interfaces with digital enhancements are emerging as promising solutions. Studies such as those by Schneider et al. (2022) demonstrate the potential of hybrid games to combine the strengths of both mediums, offering tactile engagement while leveraging the computational power of digital systems.

Ultimately, board games are not replacements for digital games but supplementary tools. The learning objectives, the subject matter, and the available resources all influence the decision between board games and computer simulations. Board games have special pedagogical benefits in the context of educational applications, especially in domains like logistics and seaport management, by encouraging group learning, critical thinking, and a thorough comprehension of procedures (Rahmat, Abdul Razak, Rashid, & Yajid, 2024).

Board Games in Sea Port Management

Integrating board games into sea port management education reflects a growing recognition of their pedagogical value in bridging theoretical knowledge and practical application (López & Martínez, 2021). Seaports are complex environments involving numerous interconnected activities, such as cargo handling, berth scheduling, and resource allocation. Teachers must enhance their pupils' problem-solving and decision-making abilities while providing them with a thorough knowledge of these complexities.

Board games, as tools for experiential learning, offer a simulated environment where students can explore these complexities in a structured yet engaging environment. By immersing players in scenarios that simulate real-world challenges, such as managing limited resources or responding to unforeseen disruptions, board games encourage strategic planning and adaptive thinking (Taylor, Nguyen, & Smith, 2023).. The potential workforce in the maritime and logistics sectors needs these operational effectiveness and responsiveness abilities.

Using board games in teaching seaport management aligns with the principles of game-based learning, which emphasize active participation and the construction of knowledge through problem-solving activities (Chen, Li, & Zhang, 2023). Students can, for example, try out various resource allocation strategies in the game, see the results of their choices, and modify their strategies in later rounds. This iterative learning process simulates real-world operations, where managers must continuously assess and improve their strategies to be effective and successful.

Numerous board games have been created especially for teaching logistics. Radzi et al. (2020) describe a board game that simulates port operations, focusing on tasks such as berth scheduling and cargo prioritization. The game incorporates elements of competition and collaboration, requiring players to balance individual goals with collective success. Another example is the "Shipping Empires" board game, which challenges players to optimize supply chain networks while navigating trade-offs between cost, speed, and environmental impact (Allate, 2021).

Board games have advantages for teaching marine port management beyond improving technical proficiency. According to studies, these games also help develop critical soft skills like leadership, cooperation, and communication. According to Hung, Young, and Lin (2022), the interactive nature of board games creates opportunities for players to practice negotiation, conflict resolution, and consensus-building skills that are invaluable in collaborative work environments. Moreover, the social interaction inherent in board games promotes a sense of community among learners, enhancing their engagement and motivation (Wilson & Grant, 2022).

Board games have educational benefits, but also useful features like scalability and accessibility. Board games are comparatively inexpensive and simple to use, unlike digital simulations, which can call for significant investments in hardware and software. They can be used in diverse educational settings, from classrooms to workshops, making them a versatile tool for maritime education (Jones & Baker, 2022).

However, how well board games are designed and implemented determines their usefulness in teaching sea port administration. The learning process may be oversimplified by poorly made games that do not adequately depict the intricacies of port operations, which could result in misunderstandings of actual situations (Zhang et al., 2024). Therefore, it is crucial to involve subject matter experts in the game development process to ensure the content is accurate and relevant. Additionally, integrating pre- and

post-game assessments can help educators evaluate the impact of the games on students' learning outcomes (Ober, 2023).

In conclusion, board games represent a valuable addition to the seaport management education. They overcome the drawbacks of conventional teaching techniques and equip students for the ever-changing demands of the maritime sector by offering an engaging and dynamic learning environment. As the field of game-based learning continues to evolve, further research is needed to explore the long-term impact of board games on students' knowledge retention, skill development, and professional readiness.

METHODOLOGY

For this study, a quasi-experimental research approach was selected. The main aim was to evaluate the effectiveness of learning board games using a non-equivalent control group design. The following subsections elaborate more on the methods employed in this study.

Participants of the Study

This study examined game-based learning as a medium for post-learning activities in maritime education. The participants consisted of 70 students, aged 20 to 25, enrolled in a Seaport Management course at a university in northern Malaysia. Among the participants, there were 50 females and 20 males. The research employed a pre-test and post-test design to evaluate the impact and effectiveness of different post-learning activities. To facilitate the study, the class was divided into two groups: a control group and an experimental group, each comprising 35 students. Group assignments were determined randomly using a computer-generated random number process. The control group was not exposed to any post-learning activities, while the experimental group engaged in a board game as their post-learning activity. All participants provided written consent to participate in the research; those who declined to sign the consent form were excluded from the study.

Instruments

Students' cognitive grasp of seaport management was assessed for this study using an Edu metric test with 15 multiple-choice questions. A group of subject-matter specialists from the university's test bank chose the questions to represent the subject of seaport administration best. The first learning objective—the capacity to comprehend and oversee many facets of seaport operations, such as vessel traffic, cargo handling, terminal management, logistics coordination, and strategic planning—was intended to be met by these questions. The specialists ensured the selection offered a thorough evaluation of the seaport management procedure, despite the test having only 15 questions.

The same set of questions was used for both the pre-test and post-test to evaluate the impact of the intervention. The questions were rearranged between the pre-test and post-test to reduce the testing effect and stop pupils from learning the answers by heart. This approach ensured that the test provided a valid and reliable measure of the students' learning outcomes.

Procedure

The study was conducted over 9 weeks during the first semester of 2013. All participants in the experimental and control groups received an overview of the study's protocols at the first session. After the briefing, both groups finished the pre-test, which evaluated their comprehension of seaport management principles.

The control group did not attend any further sessions during the second week and could engage in revision exercises independently. Meanwhile, the experimental group attended a session where they were introduced to the gameplay of *Penang Port: A Port Management Game*. Participants learned about the game's components and how it replicated realistic elements during this session of seaport operations, such as vessel traffic management, cargo handling, and logistics coordination.

From the second week onward, the experimental group engaged in weekly board game sessions that continued until the ninth week of the study. Before the experimental group began playing the game, they received comprehensive instructions on the rules and mechanics of the gameplay from two instructors who were experts in the domain. The instructors helped the participants set up the game and explained how the gameplay worked, including how turns advanced and how the game ended. The instructors were lecturers with experience in port and logistics management. The instructors were accessible to explain regulations and guarantee seamless gameplay sessions, but they avoided disclosing methods that might affect the game's outcome in order to preserve fairness. At the end of the ninth week, both groups—control and experimental—completed the post-test to evaluate the impact of the intervention. Participants who missed either the pre-test or the post-test were required to complete the missing test in the following week to ensure consistent data collection.

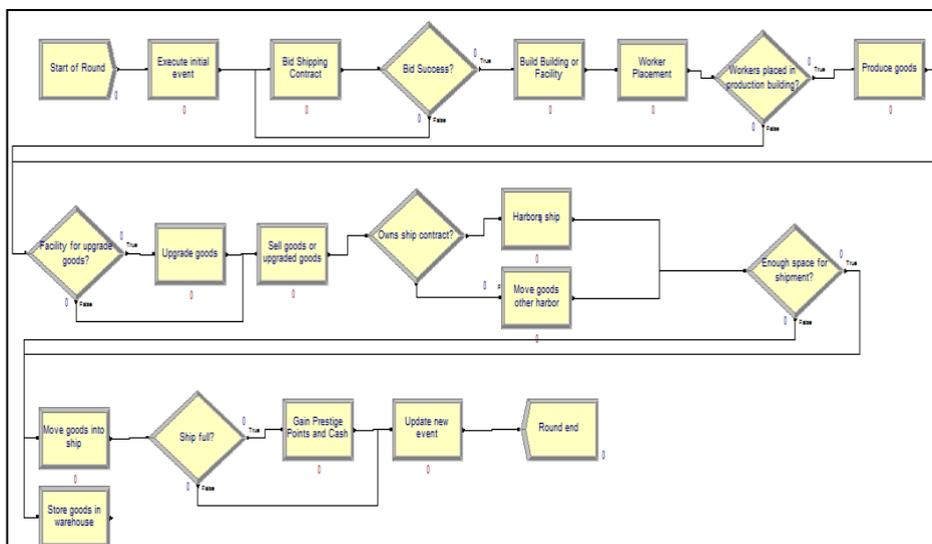
DEVELOPMENT OF THE SIMULATION BOARD GAME

Framework of the Simulation Board Game

Developing a simulation board game requires alignment with course content and domain expertise while ensuring an engaging and immersive experience for players. To create an effective learning tool, the game must reflect the operational flow of a comprehensive port management environment. The process flow identified was based on the core functions of port operations, including vessel traffic management, cargo handling, terminal logistics, and strategic planning. A simulation framework was developed to design the board game in a way that integrates these essential processes into the gameplay (see Figure 1). The framework represents key aspects of port management operations, allowing players to experience realistic scenarios within a controlled game environment.

Figure 1

Framework of the Simulation Board Game



Gameplay is defined as the set of challenges posed to the player and the corresponding actions they can take in response (Salen & Zimmerman, 2021). The game mechanics were carefully selected and mapped against relevant course content to ensure authenticity. Selecting suitable gaming mechanics is essential since they must accurately replicate actual port management procedures. The selected mechanics have effectively modelled key decision-making processes in port operations, such as berth scheduling, cargo allocation, resource optimization, and crisis management. The creation of the game's main board, berth and cargo cards, vessel and logistics tokens, and financial assets to symbolize port income and operating expenses came next. These physical components (Figure 2) serve as tangible user interfaces, enhancing player immersion and engagement (Ismail et al., 2022).

Figure 2

Penang Port: A Port Management Game Board Game



Based on the simulation framework in Figure 1, the board game incorporates fifteen key processes grouped into three main phases representing distinct stages of port management. These stages correspond to the player's turn structure in the game, namely the planning, operational, and review phases. Table 1 shows how these crucial stages and the tasks associated with port operations correspond, and Table 2 shows how the game fits in with the course's intended learning objectives.

Table 1

The Alignment of the Gameplay for the Board Game and the Task in Port Management with the Intended Learning Outcome

Player turn (main phase) with the intended learning outcome	Key processes in port management	Task in port management
Planning phase (Select the best shipping contracts based on the commodities the port manages.)	Evaluate available shipping contracts.	Strategic planning, contract bidding and negotiation
	Assess port capacity and operational feasibility.	Logistics coordination, infrastructure management

	Allocate berth slots for incoming vessels.	Berth allocation, scheduling
Operation phase (Effectively managed the port to fulfil the selected ship contracts acquired)	Dock and unload cargo from incoming ships	Terminal operations, cargo handling
	Store and categorize goods in designated warehouses	Inventory management, warehouse logistics
	Manage customs clearance and documentation.	Regulatory compliance, customs management
	Load outgoing shipments based on contract specifications	Cargo coordination, safety, and quality assurance
	Allocate labor and equipment for cargo movement	Workforce management, resource allocation
Refresh phase (To plan for the next step, extrapolate the operation's results from the prior activity.)	Evaluate port performance based on efficiency and revenue	Financial management, performance assessment
	Address operational disruptions and optimize workflow for the next cycle.	Risk management, contingency planning
	Update available contracts and prepare for the following shipping cycle.	Strategic forecasting, contract renewal

Table 2

The Alignment of the Intended Learning Outcome for A Port Management Course and the Activity in the Port Management Game that Players will Perform in Each Round

Intended learning outcomes	Activity in the game
Differentiate between different types of port services.	Selecting the type of port service to manage based on incoming shipping contracts.
Demonstrate port operations and logistics in maritime management.	Docking ships, unloading cargo, warehousing, and scheduling berths for different vessels.
Plan and allocate port resources efficiently to optimize operations.	Assigning berths, storage areas, and labor while ensuring smooth cargo flow within the port.
Justify strategic decisions in port management to optimize revenue and efficiency.	Deciding which shipping contracts to accept, prioritizing high-value shipments, and managing congestion.
Implement ethical considerations in port operations and regulatory compliance.	Following customs regulations, port tariffs, and safety protocols while handling cargo.
Evaluate the efficiency of port operations and overall logistics performance.	Reviewing port performance at the end of each round based on revenue earned, storage utilization, and contract fulfillment.

The game moves through several turns until a predetermined end condition is satisfied. Planning, operation, and evaluation are the three successive stages that make up each round. In order to ensure that players feel the difficulties of managing a port environment in a structured yet dynamic manner, these phases are streamlined from real-world port administration procedures. By striking a balance between skill and difficulty, the game is made to keep players interested and motivated to finish it. The game presents two main obstacles to accomplish this balance: rivalry from other players and dynamic in-game situations. As cargo volumes, vessel arrivals, and regulatory restrictions alter at every turn, players must strategically deploy their resources to adjust to shifting port demands.

Another layer of complexity arises from competitive interactions among players. Each participant competes to secure the most profitable contracts, optimize berth allocations, and manage cargo flows efficiently. Similar to actual port management situations, success hinges on strategic decision-making, risk assessment, and flexibility. Players receive financial gains and reputation points as rewards from the game, which encourage participation and reinforce their accomplishments (Morschheuser et al., 2018). As a result, players are encouraged to undertake more complex logistical challenges, ultimately striving to become the most successful port manager by the end of the game.

DESIGN OF THE PORT MANAGEMENT GAME

This study suggested using a simulation framework to create a board game for port management. An outline of the elements of the board game is given in this section.

The Main Board

The main board serves as the core interface through which players interact with various elements of port management. It integrates multiple strategic decision-making components that mirror real-life port operations, offering players an immersive experience of efficiently managing a port. The board is designed to facilitate gameplay flow, ensuring that players can engage with different aspects of port logistics while aligning with the learning outcomes of the game. Table 3 illustrates the key sections of the main board developed in the Port Management Game.

Table 3

Key sections of the main board for the Port Management Game.

Key section	Description
Construction area	The construction area represents the physical expansion and infrastructural development of the port. Players can invest in new berths, cargo storage facilities, warehouses, and cranes to enhance their port's efficiency. Expanding the port's infrastructure allows for increased capacity, enabling players to handle a larger volume of shipping contracts. This board segment simulates actual port development issues by emphasizing strategic planning, resource allocation, and investment decision-making.
Commodity demand and supply	Ports are vital in global trade, acting as hubs for import and export activities. The commodity demand and supply section reflects market fluctuations in various goods and commodities. Players must monitor demand trends and adjust their operational strategies accordingly. Players must use this area to make well-informed

	decisions about accepting shipments, assigning storage, and planning for efficient cargo movement.
Labor demand and workforce management	Efficient port management relies on an adequate and well-distributed workforce. The labor demand section represents the availability and distribution of workers. Players must ensure that they have enough manpower to fulfill port operations, particularly during peak demand periods. Workforce shortages may lead to operational delays, increased costs, and potential penalties. The game mechanics in this section emphasize the importance of human resource management in port logistics.
Shipping contracts and vessel management	Shipping contracts define the core revenue-generating activities of the port. Players must strategically bid for and fulfill contracts based on their port's capacity, available workforce, and infrastructure. Each contract specifies cargo type, volume, and time constraints. Efficiently managing shipping contracts ensures a steady revenue stream and enhances the port's reputation (which will be given as points in the game). This section mimics how decisions are made in the real world while deciding which profitable contracts to prioritize, while controlling port traffic and operational limitations.
Current and incoming events	The events section introduces dynamic challenges that players must navigate. Events can include weather disruptions, labor strikes, increased tariffs, equipment failures, flag discriminations or sudden surges in commodity demand. Players must modify their tactics due to these erratic factors, which emphasizes the necessity of risk assessment and backup plans in port management. Including real-world-inspired events adds complexity to gameplay, ensuring players remain engaged while learning to handle operational uncertainties.
Trading area and financial management	Port management extends beyond cargo handling to encompass financial strategies. The trading area allows players to engage in financial activities such as purchasing additional storage, negotiating shipping fees, and trading commodities based on market demand. In order to maintain operations, make enhancements, and increase profitability, players must effectively manage their financial resources. This section emphasizes the role of financial acumen in port management, encouraging players to balance revenue generation with operational costs.

The main board is the central component of the Port Management Game, integrating multiple aspects of port operations into a cohesive gameplay experience. It offers a structured yet dynamic environment where players can develop logistics, financial planning, risk management, and strategic decision-making skills. Through its carefully designed sections, the board ensures players gain practical insights into port management while enjoying an interactive and competitive game experience. By aligning with the intended learning outcomes, the game is an effective educational tool for students and professionals seeking to understand the complexities of port operations.

The Player Board

The player board serves as an essential component of the Port Management Board Game, reflecting the real-time status of individual ports throughout the play session. With this board, players can monitor and control many facets of their port operations, providing a strategic picture of their present situation and future planning. It records critical elements such as the types of commodities handled, which are abstractly represented by five different colors to distinguish between various commodity types, as well as their respective quantities. This visual representation simplifies resource management while maintaining the complexity of port logistics.

Additionally, the player board details the number of facilities currently available within a player's port. Facilities include storage areas, cargo handling equipment, maintenance docks, and administrative offices. These structures play a pivotal role in ensuring smooth operations, affecting the efficiency of loading and unloading activities, the speed at which goods are processed, and the ability to accommodate diverse shipping needs. Upgrading or expanding these facilities throughout the game allows players to enhance their efficiency and more effectively complete shipping agreements.

The port services offered by each player are also displayed on the player board. These services include cargo handling, maintenance, and other logistical functions that impact the efficiency and reputation of the port. The variety and quality of services influence the types of contracts a port can attract, requiring players to make strategic decisions about service investments to enhance their competitiveness. Offering superior port services facilitates better operations and ensures higher profitability and increased demand from shipping companies.

The number of berths available in a port is another crucial aspect monitored on the player board. Berths represent docking spaces for incoming vessels, dictating the port's capacity to handle multiple ships simultaneously. In order to avoid congestion, increase revenue creation, and improve vessel turnaround time, players must properly manage their berths. Expanding berth availability is essential for increasing port efficiency and simultaneously accommodating larger or multiple shipments.

The status of vessels within the port is another key element recorded on the player board. This includes information on vessels currently docked, those scheduled to arrive, and ships awaiting clearance to depart. Managing vessel flow efficiently is critical to ensuring seamless port operations, preventing delays, and maintaining strong relationships with shipping companies. In order to speed up the docking, loading, and departure processes, players must choose how best to spend resources.

Labor management is also a fundamental aspect tracked on the player board. In order to ensure effective port functionality and balance task allocation, players must strategically deploy personnel. If labor is mismanaged, bottlenecks may occur, leading to shipment delays and financial penalties. Managing the workforce accordingly can improve efficiency and service quality.

By integrating all these aspects, the player board functions as a dynamic tool for strategic decision-making. To improve performance, players must constantly assess the state of their port, foresee any operational difficulties, and make wise decisions. Because each player's board is visible, a competitive atmosphere is created, enabling players to track their opponents' development and modify their tactics accordingly. This simulation mirrors real-world port management, where transparency and data-driven decisions are crucial for success.

Furthermore, the game mechanics encourage players to balance short-term gains with long-term sustainability. For example, investing in high-quality facilities may reduce immediate profits but lead

to greater efficiency and higher returns in the long run. Similarly, prioritizing certain commodities over others may yield short-term advantages but could limit diversification and future growth opportunities. These tactical dilemmas, which require meticulous preparation and flexibility, increase player participation.

The player board's role extends beyond mere record-keeping; it actively influences gameplay decisions, fostering an immersive experience where players must think critically about port logistics, resource allocation, and competitive positioning. By accurately simulating the multifaceted nature of port management, the board game provides an educational and engaging platform for players to develop their understanding of real-world maritime operations while enjoying a challenging and dynamic gameplay experience.

Anatomy of Choice in the Port Management Game

Decision-making is crucial in port management, influencing how efficiently players operate their ports and maximize their resources. Players are given various options at specific points throughout the game, necessitating strategic planning and flexible reactions to shifting market conditions. Each decision impacts the player's ability to manage port infrastructure, labor allocation, commodity trading, and shipping contracts. This section outlines the anatomy of choice in the Port Management Game and how these choices shape gameplay progression.

In game design, the "anatomy of choice" refers to the structured framework that outlines how decisions are presented to players, the context surrounding these decisions, and the subsequent consequences that arise from them. This framework is crucial as it directly impacts player engagement, immersion, and the overall gaming experience. A well-designed choice architecture ensures that players are aware of the options available, understand the potential outcomes of their decisions, and can anticipate how these choices will influence future gameplay scenarios. Games may produce a more engaging and dynamic experience by offering players clear and meaningful choices, encouraging them to use critical and strategic thinking as they progress through the game.

Understanding the anatomy of choice is essential in the context of the Port Management Game. Players are continually faced with decisions that affect various aspects of port operations, such as infrastructure development, resource allocation, and contract negotiations. Each choice has immediate and long-term consequences, influencing the efficiency and profitability of their port. The game ensures that players stay interested and are prompted to consider their options thoroughly by carefully crafting these decision points. This method improves the gaming experience and offers instructional value by mimicking actual port management decision-making procedures. Table 4 shows the anatomy of choice for the Port Management Game.

Table 4

Anatomy of choice for the Port Management Game

Stage	Anatomy of Choice	Player activities in the Port Management Game
1	What happened before the player was given the choice?	Players analyze their current resources, including available berths, commodities in stock, active shipping contracts, labour force, and infrastructure. External factors such as demand fluctuations, port congestion, and incoming events also influence decision-making.
2	How is the possibility of choice conveyed to the player?	Players assess potential actions based on port capacity, market demands, and competitor strategies. They must decide whether to expand infrastructure, optimize resource allocation, or secure profitable contracts to enhance port efficiency.
3	How did the player make the choice?	Players select their actions during the planning and operation phases, choosing to invest in port upgrades, allocate labour effectively, or fulfil contracts by managing incoming and outgoing shipments.
4	What is the result of the choice? How will it affect future choices?	Choices influence future port operations, affecting revenue generation, reputation, and efficiency. A well-managed port with optimized logistics can attract more shipping contracts, while poor decisions may lead to congestion, delays, or financial losses.
5	How is the result of the choice conveyed to the player?	The impact of decisions is reflected in the player's port status, financial standing, and competitive positioning. Players receive immediate and long-term feedback through contract completions, event resolutions, and dynamic market changes.

By structuring decision-making in this way, the Port Management Game provides an immersive experience that simulates the complexities of real-world port operations. Players must continuously evaluate their strategies and adapt to evolving scenarios to maintain efficiency and profitability.

FINDINGS

Result for the homogeneity test.

The assumption of homogeneity of variance from the pre-test scores for both groups was tested and satisfied via Levene's test, $F(1,68) = .967$, $p = .329$. Therefore, it was concluded that the data were homogeneous.

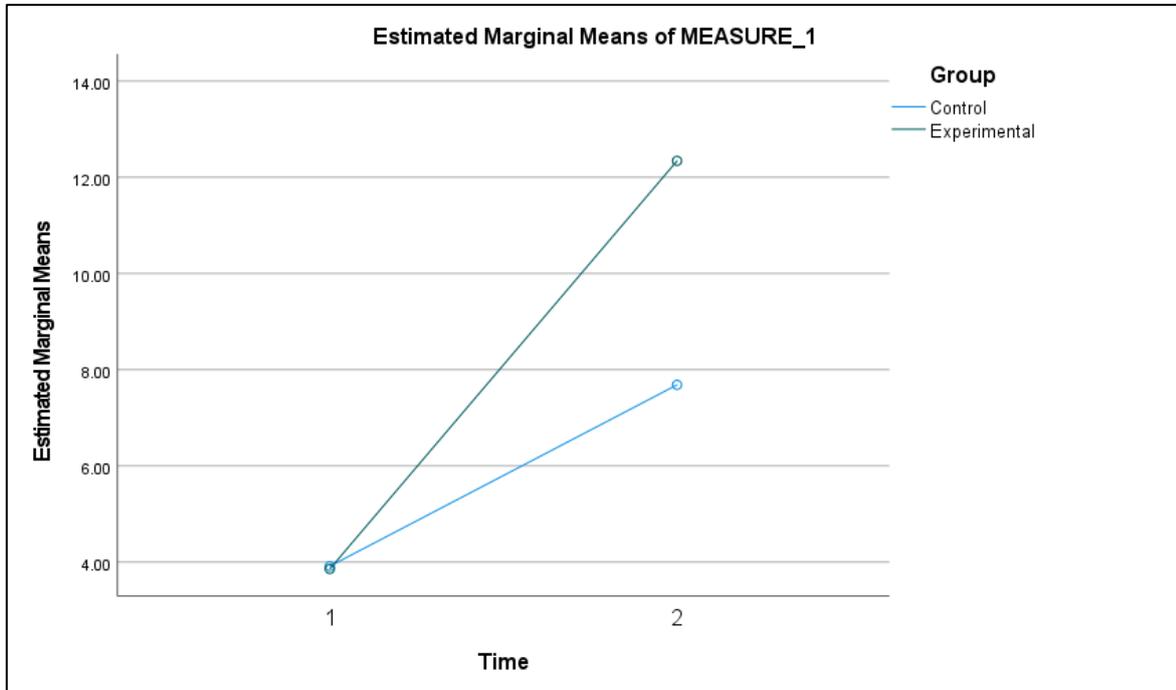
Comparison of performance for the overall score

The split-plot ANOVA (SPANOVA) was used to investigate whether a significant difference exists regarding the effect on performance in two different timeframes: during the pre-test and the post-test. Split-plot ANOVA tested whether groups change differently over time; either the control or experimental groups may change more rapidly or differently from pre-test to post-test. The alpha level

of 0.05 was applied ($\alpha = .05$). If the test is significant, then plotting the interaction will reveal the nature of the differential change. The split-plot ANOVA analysis for the sample is shown in Figure 3 and Table 5.

Figure 3

Split-plot ANOVA between the experimental group and the control group



Based on Figure 3, the control group shows very little difference in the test scores between the pre-test and post-test. The increment of the test scores is small compared to the experimental group (from $M = 3.914$, $SD = 1.121$ in the pre-test to $M = 7.686$, $SD = 2.665$ in the post-test). In contrast, the experimental group moved upwards substantially from the pre-test to the post-test (from $M = 3.857$, $SD = 1.287$ in the pre-test to $M = 12.343$, $SD = 1.814$ in the post-test).

Table 5

Split-plot ANOVA for the Pre-test Scores and Post-test Scores between the Control Group and the Experimental Group

Test of Within-Subject Effects					
	Sum of Squares	df	Mean Square	F	Sig.
Post-test	181.150	1	185.150	58.019	.000

Based on Table 5, the analysis results indicate a statistically significant effect of group differences on the dependent variable, $F(1,68) = 58.019$, $p = .000$. This suggests that the experimental condition had a meaningful impact on the participants' performance. The partial eta squared value of .460 demonstrates a moderate to high effect size, indicating that 46% of the variance in the outcome can be attributed to the group differences. Consequently, the findings suggest that the experimental group demonstrated

significant improvements compared to the control group, supporting the effectiveness of the board game intervention in the port management course.

DISCUSSION

The proposed board game, *Port Management Game*, was designed to simulate key aspects of seaport management, including port operations, resource allocation, and strategic decision-making. While the game simplifies real-world port management operations, it effectively integrates fundamental concepts essential for students to understand the complexities of operating a port. The board game's creation supports the learning objectives of the seaport management course by highlighting fundamental concepts such as port revenue management, berth distribution, cargo handling, and operational efficiency.

Although the game does not encompass the full intricacies of port governance, regulatory compliance, and advanced logistical frameworks, it maintains a balanced approach to providing an engaging and educational experience. The game mechanics encourage players to optimize port operations while responding to dynamic challenges such as congestion, resource shortages, and fluctuating trade demands. Since points are given for effective cargo handling, profitability, and reputation management, it is possible to evaluate players' performance throughout the game.

Three key characteristics of the *Port Management Game* reflect its effectiveness as a learning tool for seaport management. First, the game allows players to experience decision-making scenarios that balance sustainability, cost, and efficiency by highlighting the operational trade-offs inherent in port administration. Players gain an understanding of berth scheduling, cargo prioritization, and investment decisions by strategically managing their ports to maximize revenue and throughput. Secondly, the game incorporates competitive and cooperative elements, requiring players to adapt to market conditions while coordinating with trade partners and responding to unexpected disruptions. This aspect encourages critical thinking and fosters a more profound comprehension of logistical challenges in a dynamic seaport environment. Finally, the game facilitates experiential learning through hands-on activities where players can experiment with different management strategies, assess their outcomes, and refine their decision-making skills. By engaging in realistic simulations, players develop a practical understanding of port operations, reinforcing theoretical knowledge through interactive gameplay.

The results of the field testing for the *Port Management Game* align with existing literature (Az-zahroh et al., 2019; Cardinot & Fairfield, 2019; Sato & Haan, 2016; Wait & Frazer, 2018; Willet, Boltz, Greenhalgh, & Koehler, 2018) that support the effectiveness of game-based learning in enhancing student engagement and knowledge retention. Compared to the control group, statistical analysis revealed that the experimental group engaged in gameplay significantly improved their comprehension of port management concepts. The statistical significance of the interaction effect suggests that the board game has assisted in improving learning.

Furthermore, the *Port Management Game* may serve as a suitable platform for bridging academic learning with practical apprenticeship training. The game's emphasis on decision-making, strategic planning, and real-time problem-solving aligns well with the principles of learning by doing. Through immersive gameplay, students gain insights into operational decision-making processes, which can be further reinforced through practical training in real-world port environments. While this aspect can be discussed in greater depth in the conclusion, it is evident that the board game offers a structured and engaging way to prepare students for future roles in the seaport industry.

Overall, this study supports the implementation of the *Port Management Game* as an effective educational tool for higher education students studying seaport management. The findings suggest that integrating board games into the curriculum can enhance student comprehension, facilitate experiential learning, and provide a learning platform toward real-world apprenticeship opportunities in the port management sector.

CONCLUSION

Board games have emerged as a valuable tool in seaport management education, offering an interactive and engaging approach to understanding the complexities of port operations. Board games provide students with an experiential learning platform where they can hone their critical thinking, decision-making, and strategic planning abilities by mimicking real-world situations. These games enable players to try various approaches and strategies in a risk-free setting, bridging the gap between academic understanding and real-world application.

Board games have advantages for seaport management that go beyond conventional teaching techniques. They encourage active participation, teamwork, and problem-solving, which are essential competencies in the dynamic maritime industry. Players can explore the interdependencies between different stakeholders, such as port authorities, shipping companies, logistics providers, and regulatory bodies. This holistic understanding fosters a deep internalization of port management challenges, including cargo handling, vessel scheduling, and resource allocation.

Furthermore, board games can be tailored to reflect real-world challenges, including congestion, environmental regulations, and economic fluctuations. This adaptability makes them an effective pedagogical tool that can evolve alongside industry trends. Board games provide the benefit of simulated real-world contact over digital simulations, allowing players to discuss, negotiate, and make decisions in person while strengthening their social and communication skills.

Despite these advantages, integrating board games into seaport management education requires careful design and implementation. Educators and trainers must ensure that game mechanics align with learning objectives and that debriefing sessions provide opportunities for reflection and knowledge reinforcement. Furthermore, cooperation between industry professionals and game designers is necessary to produce meaningful and pertinent scenarios in board games that accurately depict the difficulties of port management.

In conclusion, board games represent an innovative and practical approach to seaport management training, fostering engagement, collaboration, and practical learning. As the maritime industry evolves, incorporating interactive educational tools such as board games can enhance competency development and prepare future professionals to conceptualize the complexities of port operations successfully. The long-term effects of board games on learning outcomes and their possible combination with digital resources to further improve educational efficacy can be investigated in future studies.

Acknowledgement

This research was supported by the Ministry of Higher Education (MoHE) of Malaysia through the Fundamental Research Grant Scheme (PRGS/1/2012/UUM/12496).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- Allate, S. (2021). Shipping Empires: A board game for supply chain optimization. *Journal of Logistics Education Research*, 14(3), 67–82.
- Az-zahroh, F., Effendi, R., & Septian, R. (2019). The effectiveness of game-based learning in enhancing student engagement and learning outcomes. *International Journal of Educational Technology in Higher Education*, 16(1), 1-15.
- Bagwan, S., Bias, E., Ahuja, K., & Bagde, R. (2021). Tactile interfaces in education: Enhancing learning through board games. *Journal of Educational Technology*, 19(4), 45–60.
- Board Games as a Research Method. (2024). In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (pp. 1–13). ACM Digital Library.
- Bycer, J. (2023). *The Clash of Choices in Game Design*. Medium. Retrieved from medium.com
- Cardinot, A., & Fairfield, J. A. (2019). Game-based learning to engage students with physics and astronomy using a board game. *International Journal of Game-Based Learning*, 9(1), 42–57.
- Chen, Y., Li, H., & Zhang, X. (2023). Gamified learning: Analyzing the impact of educational board games on logistics students. *Journal of Logistics Education Research*, 15(4), 101–115.
- Chou, Y. (2023). *Exploring the Art of Choice in Game Design Technique: Plant Picker vs. Poison Picker*. Retrieved from yukaichou.com
- Cushman-Roisin, B., Rice, R., & Moldaver, S. (2000). Board games as simulation tools: A comparative analysis. *Educational Simulations Quarterly*, 5(2), 15–32.
- Dahlin, T., Larsson, M., & Erlich, J. (2013). Reflective learning through board games: Lessons from maritime education. *Maritime Studies Review*, 10(1), 12–27.
- Ducruet, C., Berli, J., & El-Geneidy, A. (2022). Ports' criticality in international trade and global supply chains. *Nature Communications*, 13(1).
- Eterovic, M., & Santos, F. (2023). Enhancing student engagement through board games: A case study in logistics education. *International Journal of Game-Based Learning*, 15(2), 89–102.
- Fonseca, I., Caviades, M., & Chantré, J. (2023). Gamification and game-based learning as cooperative learning tools: A systematic review. *International Journal of Emerging Technologies in Learning*, 18(21), 4–23.
- Hayhow, S., Parn, E. A., Edwards, D. J., Hosseini, M. R., & Aigbavboa, C. (2019). Construct-it: A board game to enhance built environment students' understanding of the property life cycle. *Industry and Higher Education*, 33(3), 172–180.
- Hung, C., Young, D., & Lin, Y. (2022). Building soft skills through collaborative board games: Evidence from maritime education. *Educational Practices in Maritime Studies*, 18(3), 34–50.
- Ismail, A., Hassan, R., & Yusof, N. (2022). Enhancing immersive learning through tangible game interfaces: A case study in logistics education. *Educational Technology & Society*, 25(1), 112–125.
- Jones, A., & Baker, R. (2022). The role of gamification in maritime logistics education. *Journal of Educational Strategies in Logistics*, 14(3), 45–58.
- López, J., & Martínez, P. (2021). Seaport management: Challenges and educational strategies. *International Journal of Maritime Studies*, 18(2), 34–50.

- Marcos, S., & López-García, B. (2024). Boardcraft: Learning the art of strategic decision-making card by card. In *Proceedings of the 18th European Conference on Games Based Learning, ECGBL 2024* (pp. 1048–1057). Academic Conferences International.
- Morschheuser, B., Hamari, J., Maedche, A., & Werder, K. (2018). How games induce cooperation? A study on the relationship between game features and we-intentions in an augmented reality game. *Computers in Human Behavior*, 77, 169–183.
- Pan, Y., Tlili, A., Li, J., Jiang, F., Shi, G., Yu, S., & Yang, J. (2021). How to implement game-based learning in a smart classroom? A model based on a systematic literature review and Delphi method. *Educational Technology Research and Development*, 69(6), 2399–2426.
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist*, 50(4), 258–283.
- Perkovic, M., Harsh, R., & Vidmar, P. (2020). The use of integrated maritime simulation for education in real time. *WMU Journal of Maritime Affairs*, 19(2), 231–253.
- Radzi, S. H. M., Tan, W. H., & Yusoff, A. (2020). Evaluating the effects of a board game in cognition in learning shipping management for higher education. *International Journal of Modern Education*, 2(7), 180–201.
- Rahman, S., Chowdhury, A., & Karim, N. (2023). Bridging theory and practice in logistics education through simulation games. *Journal of Logistics and Supply Chain Education*, 12(1), 20–35.
- Rahmat, A. K., Abdul Razak, A. H., Rashid, M. F., & Yajid, A. A. (2024). Developing LogistiQuest: A Board Game for Logistics and Project Cargo Management Education. *International Journal of Latest Technology in Engineering, Management & Applied Science*, 8(6), 18–30.
- Reng, L., Schoenau-Fog, H., & Kofoed, L. B. (2020). Physical vs digital tabletop games: A comparative study. In *Proceedings of the 2020 DiGRA International Conference*. DiVA Portal.
- Salen, K., & Zimmerman, E. (2021). *Rules of play: Game design fundamentals*. MIT Press.
- Sato, T., & Haan, D. (2016). Educational benefits of board games in higher education: A systematic review. *Journal of Learning and Teaching*, 12(3), 85–97.
- Schneider, B., Blikstein, P., & Mackay, W. (2022). Hybrid board games in education: Combining tactile and digital interactions. *Educational Technology and Research Journal*, 25(3), 67–81.
- Taylor, L., Nguyen, P., & Smith, J. (2023). Enhancing decision-making skills through board game simulations: A study in port management education. *International Journal of Maritime Studies*, 20(1), 12–25.
- Theories of Maritime Education and Training (MET) in Improving. (2020). *Scientific Research Publishing (SCIRP)*. <https://www.scirp.org/journal/paperinformation?paperid=100303>
- Wait, K., & Frazer, R. (2018). The impact of serious games on student learning: A meta-analysis. *Journal of Interactive Learning Research*, 29(4), 523–548.
- Willett, R. M., Boltz, M. G., Greenhalgh, S. P., & Koehler, A. A. (2018). Exploring the effectiveness of simulation-based learning in logistics and supply chain education. *Journal of Applied Learning & Teaching*, 2(1), 34–50.
- Wilson, T., & Grant, E. (2022). Active learning in maritime education: A case for board games. *Education and Maritime Studies Journal*, 19(2), 56–71.
- Winarno, Riyanto, Barasa, L., Kuntadi, C., Gunawan, A., Malau, Herawati, S., Wibowo, T. A., & Simanjuntak, M. B. (2025). A qualitative analysis and systematic literature review on enhancing maritime vocational education. *Action Research Journal (ARJ)*, 2(1), 12–28.

Zhang, H., Xu, J., & Lee, C. (2024). Preparing the workforce for future port operations: Challenges in education and training. *Maritime Education Quarterly*, 23(1), 5–20.