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Exploring digital solutions in maritime transport - challenges in supply chain management on training vessels

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Abstract: During the analysis of procurement routines aboard Dar Młodzieży, a training vessel operated by Gdynia Maritime University (GMU), recurring inefficiencies were observed in inventory verification and order forecasting. For instance, in 2023, nearly 18 kg of dairy products were discarded due to expired stock that had not been properly tracked. Interviews with the vessel's kitchen and technical staff confirmed that such cases were not isolated but reflected systemic gaps in cross-departmental coordination.

This paper investigates the current state of onboard provisioning practices and explores the feasibility of digital intervention using a custom-built prototype platform: DYLLI SHIP. The prototype adapts digital workflows originally tested in the HoReCa sector [6], combining role-based approvals, mandatory stock updates prior to ordering, and integrated food waste tracking.

The proposed system was conceptually tested through user feedback sessions and visual interface walkthroughs, conducted with crew members and shore-based logistics officers. While not yet deployed onboard, preliminary reactions suggest that the tool could streamline inventory coordination and increase order accuracy, particularly in high-turnover training environments. Participants especially valued the waste tracking dashboard and structured communication panel as enhancements over current ad-hoc paper-based methods.

This research highlights the challenges of digital transformation in maritime education and proposes a replicable system architecture to improve transparency, reduce waste, and support data-informed supply chain management. DYLLI SHIP, while still a prototype, provides a starting point for further testing and operational validation within the maritime training sector [1,2,3,7].

Keywords: ICT tools, digital transformation, supply chain management, training vessels

1. Introduction

Digital transformation is increasingly recognized as a driver of efficiency, transparency, and sustainability across the maritime industry [1,2]. While commercial shipping has widely embraced digital solutions in navigation, maintenance, and logistics, maritime education institutions, particularly those operating training vessels - often lag in modernizing critical operational domains such as supply chain management (SCM) [9,10].

Gdynia Maritime University (GMU), established in 1920, is one of the largest and most prestigious maritime academies in Central and Eastern Europe [3].With more than 5,000 students and a legacy of training officers and maritime professionals, GMU operates the full-rigged sailing ship Dar Młodzieży as its flagship training vessel [3,11].This 110-meter ship, designed for ocean-going cadet voyages, is not only a symbol of Polish maritime heritage but also a floating campus requiring comprehensive logistical support [11].

Each voyage necessitates careful planning of food, technical equipment, and consumables. Yet the current procurement processes onboard Dar Młodzieży remain largely analog and fragmented [9]. Orders are typically generated using static Excel files, transmitted via email, and processed without synchronized access to inventory data [1]. This often leads to inaccurate forecasting, excessive or duplicate orders, and wastage

of food and materials [7,8]. Communication between the ship and shore-based procurement offices is hindered by limited connectivity, reliance on asynchronous exchanges, and the absence of a shared documentation platform [12].

2. Theoretical framework: digital supply chain management in maritime sector

2.1 ICT and Operational Realities in Maritime Supply Chains

In recent years, the maritime supply chain has undergone a visible transformation, largely driven by advancements in Information and Communication Technologies (ICT) [12]. Traditional logistics, often reliant on fragmented paperwork and manual oversight, are being replaced with systems that prioritize responsiveness, automation, and better access to data. However, implementing these tools on training vessels, ships that double as educational platforms and operational units, introduces a unique set of opportunities and challenges [10,3].

One of the most prominent technologies in this shift is the Internet of Things (IoT). Onboard sensors installed in storage units or galleys, for example, can track temperature, humidity, and stock levels in real time. On GMU's training vessel Dar Młodzieży, IoT-enabled monitoring was cited as a factor in reducing spoilage, particularly during long voyages with irregular access to fresh supplies [13,17].

Figure 1. Dar Młodzieży in Gdynia port.
Source: Gdynia Maritime University

Commissioned in 1982 as the successor to Dar Pomorza, Dar Młodzieży remains one of the most iconic tall ships in European maritime education. Operated year-round by Gdynia Maritime University (GMU), the sailing vessel accommodates over a hundred cadets per voyage, offering hands-on instruction in navigation, mechanics, and seamanship. According to Capt. Dariusz Jellonnek, Director of GMU's Shipowner and Internship Department, "Dar Młodzieży continues to be more than just a school at sea, it's where cadets transition from theory to practice through teamwork, watchkeeping, and exposure to dynamic sailing conditions."

Each summer, the vessel participates in international events such as The Tall Ship Races and high-profile port visits across Europe. During the 2025 season, students will sail to Le Havre, Bremerhaven, and Amsterdam, where Dar Młodzieży will represent Poland at the 750th anniversary of the Dutch capital. These long-standing engagements reflect the vessel's dual mission: to preserve Poland's maritime heritage and prepare future officers for service in the global fleet.

Yet technology is only one side of the equation. In many maritime institutions, inventory tracking still relies on paper logs or basic spreadsheets [9,4]. These documents are rarely updated in real time, and often stored separately by different departments, engineering, procurement, deck operations, leading to

version conflicts and limited institutional oversight [1].

Blockchain, cloud platforms, and AI offer potential solutions. Blockchain creates secure, time-stamped records for requisitions and deliveries that cannot be modified retroactively, which is especially valuable when procurement decisions must be traceable [14,16]. Cloud-based systems and analytics help forecast consumption and coordinate supply cycles more efficiently [1,2]. However, in practice, few systems offer reliable functionality in offline or low-bandwidth environments, still common at sea [13].

The hybrid nature of training vessels also complicates demand planning. Unlike commercial ships with fixed routes, voyages are tied to academic calendars that may change due to weather, exams, or vessel availability [11]. As one logistics coordinator at GMU noted, “Sometimes we plan for a 10-day Baltic loop and end up rerouting to the North Sea, the provisioning can’t keep up.”

These operational shifts often clash with physical realities. Limited storage forces difficult decisions about what to carry. During a recent audit, crew reported that shelf space in the engine room was being repurposed for galley storage, highlighting the absence of a unified allocation model. Officers typically rely on intuition or experience, rather than centralized, data-driven processes [3].

Compliance also remains a constant pressure. Missing gaskets or expired fire extinguishers can trigger penalties or jeopardize a vessel's certification status [18]. Despite this, many inventory tasks fall to cadets or junior officers still learning maritime logistics. While this supports hands-on education, it also introduces inconsistency, particularly when no digital procedures are in place [10].

Finally, digital twins and automated systems may offer a way forward. At GMU, early-stage simulations model the effect of different procurement strategies on waste and delivery time. These are not yet operational tools, but they reflect a broader shift in training, from memorizing protocols to actively managing them using digital tools. This operational complexity is further compounded by the lack of streamlined communication between shipboard personnel and shore-based procurement offices, a challenge that directly undermines even the most advanced digital systems.

2.2 Communication between ship and shore-based procurement offices

Smooth coordination between onboard personnel and land-based procurement offices remains one of the most persistent challenges in maritime education logistics [1,12]. Communication inefficiencies are not just occasional, they are systemic, especially during long voyages or when sailing in poorly connected regions.

Multinational crews and procurement teams often operate with varying degrees of English proficiency. Misunderstandings over technical terminology or supply codes are frequent, especially when order templates or internal documentation differ by department [10]. One officer noted that the same type of gloves was ordered twice, once under the Polish term "rękawice" and again as "safety gloves."

Training vessels frequently operate beyond stable internet coverage. Even short email exchanges may be delayed by hours or days, especially in remote sea zones [12,13]. Moreover, many ships still rely on standalone systems not integrated with institutional databases [1], forcing procurement officers to cross-check documents manually. GMU’s Horyzont II, a small polar research vessel used for student practice and scientific expeditions, has operated in these areas for over two decades, including missions to the Antarctic and annual voyages to Hornsund in the Svalbard archipelago.

Figure 2. Horyzont II navigating icy waters near Svalbard
Source: Gdynia Maritime University

The traditional maritime chain of command often discourages junior officers or cadets from initiating communication with shore-based staff [18]. A logistics coordinator at GMU noted: "Some crew hesitate to report missing items early, fearing it might be seen as their mistake."

Without shared platforms or standardized protocols, information remains locked within departmental silos [4]. Inventory logs, order histories, and supplier communications are often kept in separate folders or personal drives, which hinders transparency and slows down decision-making [1,9].

This fragmentation impacts not only daily operations but also compliance. During one audit, mismatched records between the onboard inventory and the university's procurement system led to a full review of kitchen supplies, an unnecessary delay that could have been avoided with a centralized database.

This case illustrates how fragmented systems, institutional hierarchy, and limited connectivity converge to hinder efficient maritime logistics - a challenge that digital integration alone cannot solve without organizational reform.

3. Methodology

This research adopts a qualitative case study approach to investigate supply chain procedures and logistical inefficiencies aboard training vessels operated by Gdynia Maritime University (GMU) [19,3]. The case study framework was chosen intentionally. It reflects the operational and organizational specificities of maritime education, where logistical processes must serve a dual purpose, supporting both training goals and vessel operations [4,19].

Primary data came from semi-structured interviews conducted with crew members and GMU's maritime operations staff. These conversations were held in either Polish or English, depending on participant preference, and were transcribed manually. The questions explored everyday procurement routines, typical points of failure, and how communication currently flows between ship and shore.

To cross-check interview responses, institutional documents were also reviewed. These included requisition forms, inventory logs, and purchase approval records. Informal observations during onboard visits added another dimension. They helped identify gaps between how procedures are described on paper and how they actually play out in real conditions. As one logistics officer put it: "Sometimes the paperwork says one thing, but what's really on the shelf tells a different story."

Together, this triangulated evidence base shaped the development of the DYLLI SHIP prototype, a

digital solution tailored to the recurring issues identified by both onboard personnel and land-based administrators.

2.3 Qualitative interviews and process mapping

The core of the study is based on a series of in-depth interviews conducted between January and March 2024 with key stakeholders at GMU [4,20]. These interviews were semi-structured and conducted in person and online, focusing on understanding the end-to-end supply process, the typical communication flow between ship and office, pain points in inventory management, and procedural bottlenecks in procurement [4,19].

Based on the qualitative data collected, the research team developed a business process map representing the current state of SCM operations on training vessels [4]. This map served as the foundation for identifying digital intervention points and process optimization opportunities [1,2].

2.4 Prototyping and digital design using DYLLI

After identifying the key inefficiencies in onboard supply workflows and ship-to-shore communication, the research team moved on to designing a prototype of a digital tool tailored specifically for training vessels. This early-stage model was created using Figma, a collaborative interface design platform often used to visualize and test user journeys before development begins [6].

The concept builds on DYLLI, a mobile application originally developed under the Innovation Incubator 4.0 programme for the HoReCa and wholesale sectors [6]. Adapting the system for maritime education required several contextual adjustments, including offline access, simplified user inputs, and alignment with documentation routines onboard ships.

The prototype consists of four primary modules [6]:

- a digital requisition form structured around shipboard workflows,
- a real-time status panel indicating the progress of orders and approvals,
- a messaging feature that facilitates communication between onboard personnel and shore-side teams,
- and an administrative interface for monitoring inventory and supply cycles across departments. These functions were presented as clickable screens and demonstrated to selected staff members at GMU.

During feedback sessions, several participants remarked that the layout was intuitive and addressed their existing pain points, particularly the absence of visibility into procurement workflows. One participant commented that the status panel “makes it easier to follow what’s going on, even if you’re not part of every conversation.”

Although the prototype has not yet been tested in live onboard conditions, it was reviewed in detail against real-world operational procedures from previous voyages. Based on the feedback received, the system has been revised to better reflect the documentation habits, communication styles, and functional priorities of maritime training crews. The next phase will involve structured usability testing in controlled training environments.

2.5 Document review and data sources

In parallel with interviews and field observations, the study involved a structured analysis of internal documentation provided by Gdynia Maritime University (GMU). These records helped validate qualitative insights and offered a broader understanding of how supply chain processes unfold in daily operations [4,20].

Document analysis remains a well-established method in qualitative research, particularly when exploring institutional practices that are often not verbalized during interviews [4,20]. It enables researchers to uncover routine patterns, administrative constraints, and procedural norms embedded in the organization’s internal workflows.

The materials reviewed covered a wide range of formats and sources. Among them were archived procurement orders, sample invoices, inventory spreadsheets prepared manually on board, and ship-to-shore

communication reports. The team also examined maintenance logs, inspection checklists, and standard documentation templates used during voyage preparations and onboard audits [4,6].

One noteworthy example involved a set of requisition forms where the recorded stock levels did not match the quantities listed in corresponding delivery receipts. While this mismatch was small, two cases of tinned vegetables, it signaled a recurring issue reported in several interviews. These kinds of inconsistencies were critical in identifying weak points in the paper-based process.

Materials related to DYLLI's original development were also reviewed. This included early-stage design drafts, internal evaluations, and feedback logs from previous pilots. Together, these documents enriched the interview data and anchored the system design in actual operational needs [20].

2.6 Limitations and scope

This study draws on detailed input from staff members at Gdynia Maritime University, offering insight into how procurement and inventory systems operate aboard a specific training vessel. However, as the analysis was limited to a single institution, the findings should not be generalized to all maritime universities or shipboard environments. No data were gathered from other training ships, international academies, or commercial vessels, which restricts the comparative scope of the research.

Another limitation lies in the development stage of the proposed solution. The DYLLI SHIP prototype, while positively received during stakeholder walkthroughs, remains a conceptual model. It has not been tested in live sailing conditions, nor has it been integrated with existing onboard infrastructure. The system's resilience under practical constraints, like satellite signal loss, multitasking during drills, or limited digital literacy among rotating crews, still needs to be validated.

3. Findings

The analysis revealed several recurring problems in how procurement and inventory are managed aboard Dar Młodzieży, the main training vessel operated by Gdynia Maritime University (GMU) [3,11]. These issues came up repeatedly in interviews with logistics staff and officers and were confirmed through the review of internal documentation and process observations [4,20].

Among the most common concerns were duplicate orders, lack of real-time inventory visibility, and long approval cycles. One crew member mentioned during an interview, "Sometimes we end up requesting items we already have on board, simply because the last update wasn't recorded in time."

This pattern was also visible in procurement archives. For example, canned vegetables and dry goods appeared multiple times in separate orders filed only a few days apart. In some cases, items were listed under different names by different departments, making duplication harder to detect.

The formal procedure at GMU involves a three-step requisition process, but in practice, this is often bypassed. Especially during training voyages, crew members reported placing orders directly via phone or email to speed up the process. These informal workarounds were not always documented, which complicated inventory tracking.

Insights from these findings directly influenced the design of the DYLLI SHIP prototype. The tool includes modules for logging order history, monitoring stock levels, and working offline during limited internet access. While still in the testing phase, the prototype reflects the specific operational challenges identified during the study.

2.7 Inventory mismanagement

Inconsistent tracking of onboard inventory emerged as one of the most pressing issues highlighted by both ship crew and GMU administrative staff [9]. Inventory records were typically kept in separate Excel spreadsheets, often managed individually by department heads. These files were rarely updated and almost never synchronized across departments [1]. As a result, discrepancies between documented stock and actual items onboard were not uncommon.

Each department seemed to operate with its own version of the truth. For instance, one officer recalled a situation where two departments ordered the same dry goods without realizing they already had surplus stored in different compartments. "We were literally unpacking boxes of things we already had," he

said.

A more serious case occurred during a port return in early 2024. Over 250 expired yogurt containers were found in the galley refrigerator. These products had been reordered unnecessarily due to both spreadsheet misplacement and the lack of any physical stock check before submitting the new order [7,8]. According to the galley staff, no one had opened the lower shelf of the refrigerator in several weeks. The space was small, dimly lit, and often used as temporary storage during drills.

This incident underscored the absence of a unified system for managing supplies. The current paper and Excel-based methods not only reduce accountability but also make it difficult to avoid waste or plan resupply effectively. Interviews with multiple crew members confirmed that inventory updates were usually made retroactively, if at all, and often depended on the initiative of individual cadets or junior officers.

2.8 Lack of real-time communication and order tracking

Communication between the ship and the university's procurement office relies almost entirely on email exchanges [1,12]. While convenient on land, this method proves inefficient at sea. Messages are often delayed due to poor satellite connectivity, and replies can take days, especially when the vessel operates beyond Europe's coastal networks [13]. In practice, once a supply request is sent, the crew receives no status updates, unless someone follows up by phone. And even then, the person on the other end might not have access to the same file or context.

During interviews, multiple officers reported situations where they weren't sure whether an order had been placed, processed, or rejected. "You send an email, and then you wait. Sometimes it feels like shouting into the void," one crewmember remarked.

There is currently no shared platform or central dashboard to track the progress of requests [14]. Each team, galley, engineering, deck, uses its own system of folders and checklists, usually saved locally or on USB sticks. These disconnected practices result in delayed approvals, duplicate orders, and frequent misunderstandings, particularly when crew rotation occurs mid-voyage [9].

This lack of coordinated tools is most problematic during longer trips, especially when the vessel faces unpredictable weather or schedule changes. In such conditions, the absence of real-time information can force officers to make decisions based on outdated assumptions, increasing the risk of shortages or overstocking [11].

2.9 Overordering and waste

Overordering is not just a budgeting issue, it's a symptom of deeper problems in how information flows onboard and onshore. Without a unified inventory system or up-to-date stock validation, crew members often place orders "just to be safe" [7,8]. It's not uncommon for different departments to request the same items within days of each other, simply because no one has a full picture of what's already been delivered [1].

During field visits, several officers admitted they rarely check stockrooms before submitting requests. "Sometimes we're halfway through the voyage when we realize we've got double the sugar and no coffee," joked one galley assistant. The issue isn't carelessness, it's the lack of a shared overview.

Mismatch between documents stored in separate Excel files also plays a role. If one department updates their sheet but forgets to share it, another may place a redundant order. These errors are especially frequent during crew handovers, when working files are passed on hastily or skipped altogether [9].

The result? Waste. Not just of money, but of food, chemicals, and packing materials. Spoiled dairy, expired cleaning agents, or broken bulk containers aren't rare. Disposal requires time, space, and sometimes regulatory documentation, especially when chemicals are involved [7,21]. For an institution promoting sustainable development goals, these inefficiencies represent both a financial and ethical concern.

2.10 Procedural bottlenecks and fragmented responsibility

Another recurring theme in the data was the unclear division of responsibilities. Procurement tasks are split among captains, superintendents, and university administrative staff, yet no standardized protocol links their actions into a cohesive system [18]. In practice, this means key decisions are often based on

personal initiative or informal conversations, rather than structured workflows [4].

Administrative staff reported spending a disproportionate amount of time on routine reconciliations, merging conflicting inventory lists, checking incomplete order forms, or confirming basic supply quantities. “Sometimes we receive three different files for the same delivery,” noted one office assistant. These tasks, while necessary, add up quickly and could be handled more efficiently with automation [12].

Another concern is the absence of audit trails. There's no unified documentation structure to track who approved what and when. When inspections or financial audits occur, staff must search through scattered folders, both digital and physical, to piece together a paper trail [9]. The lack of version control adds to the risk of error and procedural delays.

2.11 High Institutional Interest in Digital Solutions

Despite these procedural inefficiencies, one of the more encouraging findings was the level of institutional interest in change. Interviews with GMU’s Maritime Operations Department revealed strong support for digital transformation, not as a distant ideal, but as an urgent operational need [3,10].

Stakeholders responded positively to the proposed DYLLI SHIP prototype, particularly features that addressed their day-to-day frustrations: real-time inventory validation, transparent tracking of orders, centralized documentation, and internal messaging tools designed with maritime workflows in mind [6].

Some voiced concern over unstable satellite connections during longer voyages. But these were framed as logistical hurdles, not objections to digitalization itself [13]. As one senior officer remarked: “The system doesn't need to be online all the time, it just needs to work when we do.” Overall, both crew and staff viewed the digital platform to streamline work, reduce waste, and regain clarity in supply coordination [7,8].

3. System visualizations

In response to the issues surfaced during fieldwork, the research team developed a functional prototype of a digital supply platform called DYLLI SHIP. Built in Figma and grounded in the logic of the original DYLLI system, used previously in HoReCa and wholesale logistics, the prototype was redesigned specifically for maritime training vessels.

At its foundation, DYLLI SHIP is meant to improve communication between three groups: onboard staff, captains, and university procurement officers. Rather than reinvent procedures, the tool mirrors what users already do, but adds structure, memory, and traceability.

Several core modules were introduced to reflect this approach:

- Mandatory inventory validation before an order can be submitted, ensuring that requests are grounded in actual stock data.
- Real-time order tracking with visualized order progress and messaging threads.
- Centralized document modules that separate editable forms from final, locked reports for auditability.
- Role-based access and approval hierarchies, enabling clear accountability while maintaining operational flexibility.

The visual assets presented in this chapter are not merely illustrative but serve as evidence-based system design artefacts, rooted in qualitative findings and verified pain points. The figures that follow correspond directly with functional modules developed for the proposed digital transformation of the university’s training vessel procurement workflows.

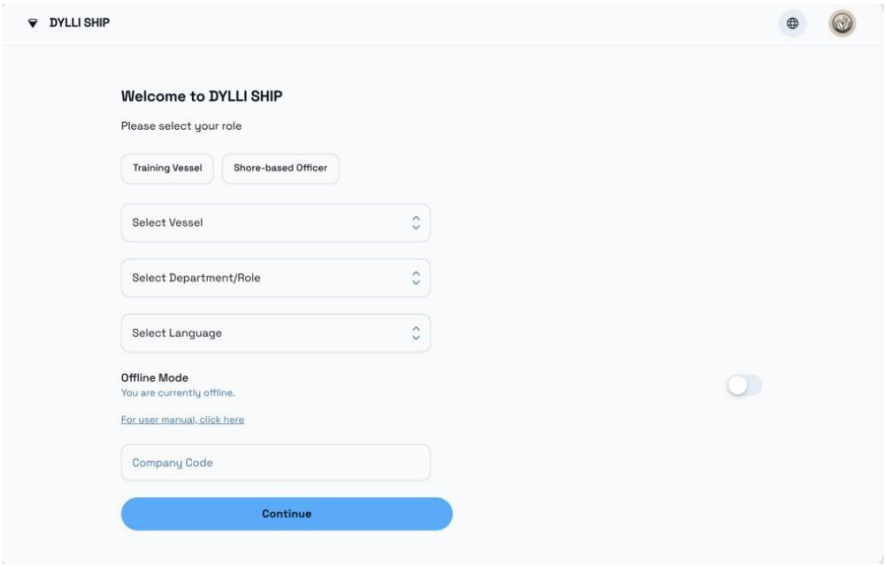

Figure 3. Role-Based Login Interface

Source: own elaboration.

The login interface of DYLLI SHIP is designed to accommodate two primary user groups involved in training vessel supply chains: shipboard personnel and shore-based officers. Upon selecting their role, users proceed to specify the vessel they are assigned to, their functional department or rank, and the preferred interface language. The inclusion of an offline mode toggle addresses connectivity limitations at sea, while the access to a digital user manual supports onboarding and usability. The minimal, responsive design ensures compatibility with varying screen sizes and maritime connectivity conditions.

This editable inventory table allows crew members to update real-time stock levels. Products are categorized, quantities can be edited, and expiry dates noted. Crucially, a “Save draft” option ensures input continuity in case of lost connectivity, while the “Send to Captain” action initiates the approval flow. Unlike many existing solutions, this system does not allow the crew to bypass this step, ensuring accountability and traceability.

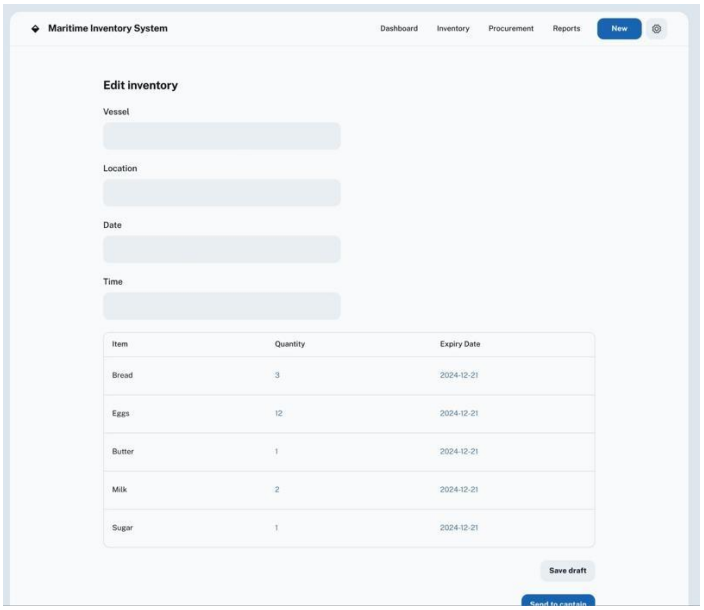

Figure 4. Inventory Update Panel (Shipboard User)

Source: own elaboration.

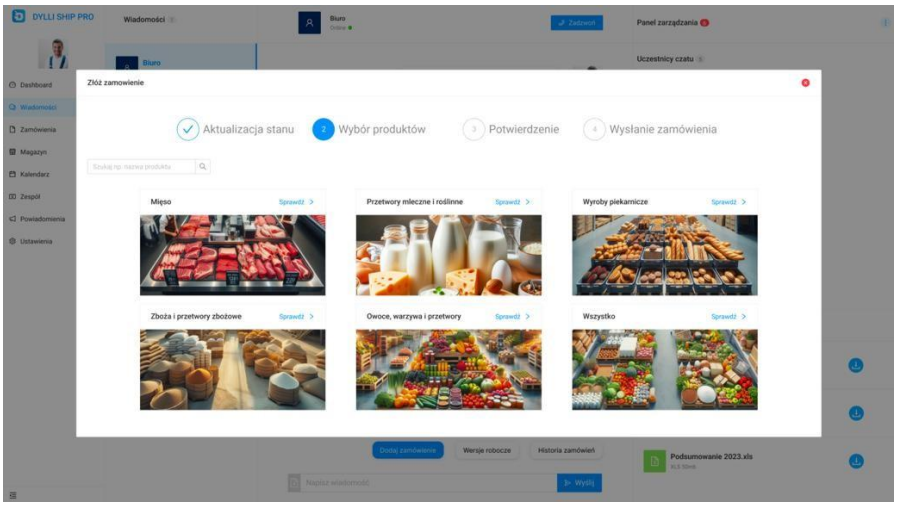

Figure 5. Order Creation Process with Visual Categories

Source: own elaboration.

This ordering interface introduces visual product categorization to minimize ambiguity. Users select from predefined categories (meat, dairy, bakery, vegetables, etc.), then choose specific products. This visual-first approach reduces cognitive load, especially for international crews with varying language skills. Notably, product search is embedded with inventory logic - a soft reminder appears if a similar product already exists in stock.

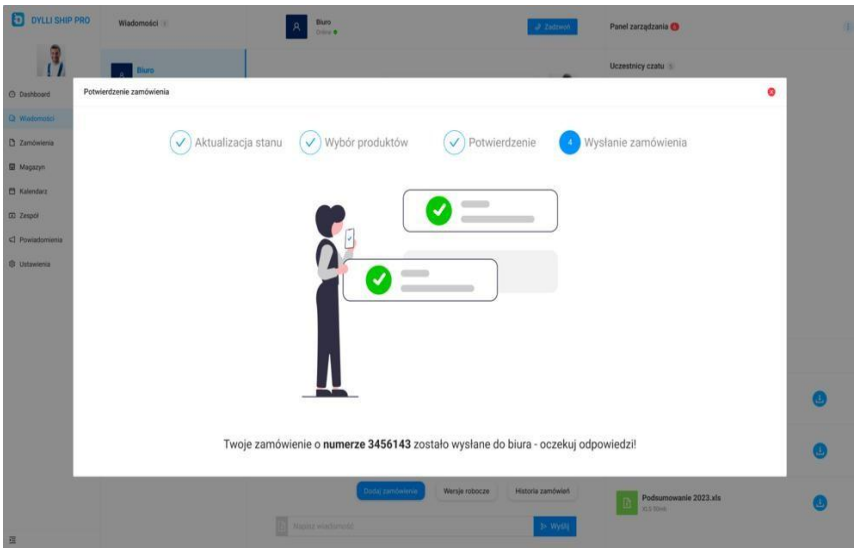

Figure 6. Order Confirmation Summary

Source: own elaboration.

The confirmation screen presents an animated summary of submitted orders. This stage functions both as user feedback and psychological closure, increasing trust in system responsiveness. The order ID is clearly visible for later tracking. This contrasts with previous Excel-based systems, where orders were often saved in separate local files and difficult to trace after submission.

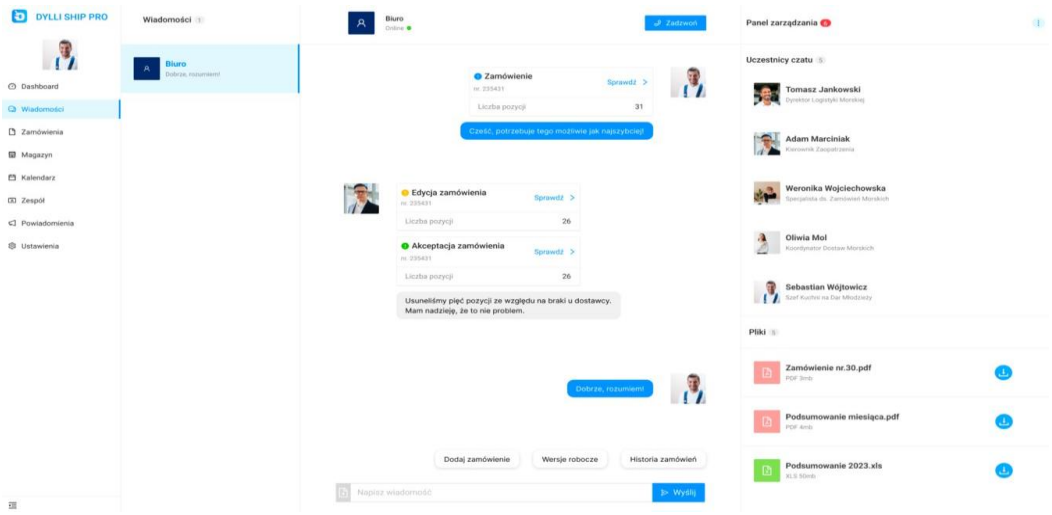

Figure 7. Shipboard-Office Communication Panel

Source: own elaboration.

This visualization presents the integrated communication interface developed within the DYLLI SHIP system to support structured, traceable interaction between onboard crew and shore-based maritime operations staff. The module was designed in direct response to challenges identified during interviews, particularly the lack of standardized communication protocols and fragmented correspondence related to order processing.

The panel enables synchronous and asynchronous dialogue that is contextually linked to specific procurement requests. Messages are organized in threads associated with individual orders, allowing for transparent editing, approval tracking, and comment-based clarification. The participant list - displayed in the management panel, ensures clear role identification, improving procedural accountability.

Critically, this communication space is not isolated from operational workflows. It incorporates direct access to order history, editable order drafts, supplier quotations, and automatically generated documentation (e.g., PDFs and spreadsheets). All attachments remain visible and accessible throughout the communication thread, eliminating issues related to version control and dispersed file storage.

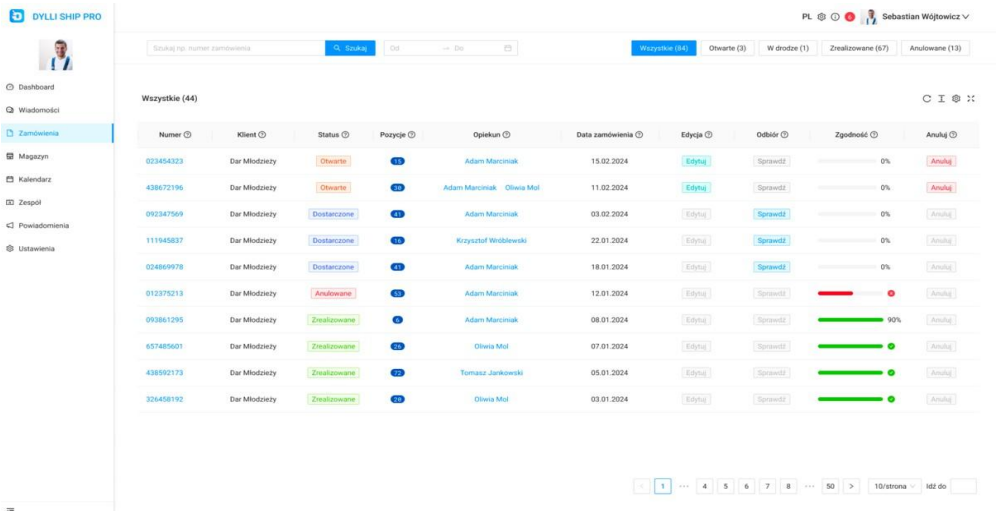

Figure 8. Procurement Dashboard (Office View)

Source: own elaboration.

By embedding document management, approval routing, and status notifications within a single interface, the module significantly enhances coordination efficiency. It mitigates the risk of miscommunication across departments and provides a scalable template for multi-role collaboration within

maritime educational logistics.

This screen allows procurement personnel to manage all incoming and processed orders. Filters for status, ship, and time range are integrated. Orders can be edited, cancelled, and exported to documentation. Notably, the system automatically generates matching PDF files (purchase order, invoice) for record-keeping - a step previously handled manually, leading to frequent discrepancies.

Figure 9. Sustainability Dashboard: Food Waste Monitoring

Source: own elaboration.

The screenshot illustrates a conceptual module within DYLLI SHIP designed for tracking food waste generated during a voyage. This dashboard presents aggregated data on discarded food, categorizing it by material type (e.g., food, paper, packaging) and linking it with key indicators such as the number of meals served or total voyage duration.

The upper section of the interface displays waste summary metrics, while the lower graph visualizes historical trends and waste projections over time. This functionality aims to support more sustainable and transparent food management on board training vessels, especially in contexts where overordering, poor inventory visibility, and inconsistent storage practices have previously led to unnecessary spoilage.

To make such a module operational, DYLLI SHIP assumes integration with smart kitchen infrastructure, such as food waste bins equipped with embedded scales and labeling systems. These devices, increasingly used in hospitality and cruise sectors, allow automatic quantification of discarded food at the point of disposal and enable detailed reporting on waste composition.

In the maritime educational context, implementing this component would require not only equipment acquisition but also kitchen workflow adjustments, including fixed-location storage, standardized labeling of ingredients, and routine training for galley staff. The primary objective of this module is not only to record waste but also to create behavioral feedback loops, whereby increased visibility of waste patterns leads to more conscious procurement and consumption practices.

The dashboard supports long-term monitoring of institutional sustainability goals and may be aligned with broader environmental compliance initiatives in the maritime sector. While the data shown is demonstrative, it reflects industry standards and benchmarks achieved in similar systems deployed in offshore and institutional environments.

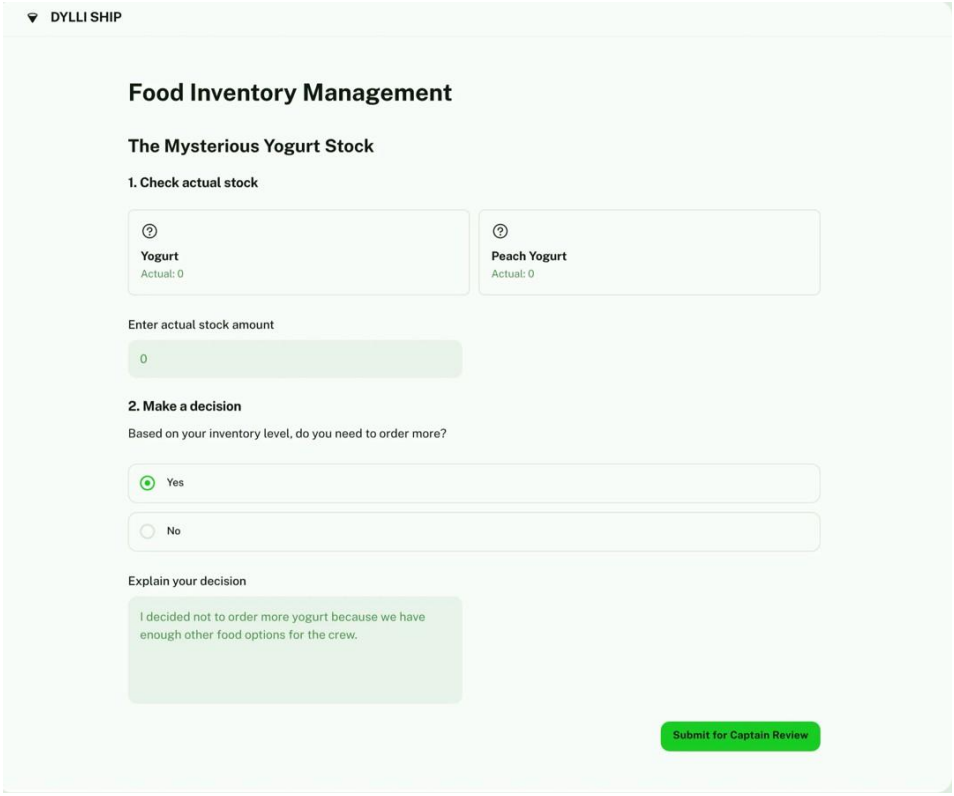

Figure 10. Microtraining Module: "The Mysterious Yogurt Stock"
Source: own elaboration.

This gamified simulation was developed to address a real-world anecdote from GMU crew, repeated over- ordering of yogurt due to lack of accurate stock tracking. The scenario walks the user through checking actual inventory, deciding on necessity, and receiving system feedback. It doubles as both an onboarding and awareness tool, reinforcing process logic before real operations.

3 Discussion

The DYLLI SHIP prototype, as presented in this study, builds upon the foundational design of the original DYLLI platform - an ICT tool first developed for the hospitality and wholesale sectors [6]. While the core functionalities such as digital ordering, inventory tracking, and communication remain central to both versions, the maritime adaptation introduces sector-specific features that address the unique constraints of shipboard operations [1,12].

The original DYLLI system was optimized for land-based environments with stable internet access, predictable delivery timelines, and professional inventory staff [6]. In contrast, training vessels such as Dar Młodzieży operate under conditions of intermittent connectivity, high personnel turnover, limited physical storage, and varied procurement cycles driven by voyage duration and weather [11]. These factors necessitated the development of offline functionalities, real-time crew-to-office communication modules, and simplified interfaces adaptable to a wide range of user competencies [10,13].

Furthermore, the inclusion of a smart food waste monitoring dashboard and structured order validation workflow represents an evolution beyond the HoReCa use case [7,8]. While food waste is an emerging priority in land-based sectors due to rising ESG reporting requirements, it is particularly critical in maritime contexts where space and disposal capacity are limited [2,27]. Here, the DYLLI SHIP design offers not only efficiency gains but also a platform for sustainable behavior change, informed by real-time data and supported by training features such as micro-simulations [10].

One of the less obvious but important distinctions of DYLLI SHIP lies in its educational design [3]. Unlike many commercial tools, this system wasn't developed solely for efficiency. It was shaped with training in mind. Integrated within the interface are microlearning prompts and real-time feedback loops, designed to reinforce supply chain logic for cadets and junior crew members [10,19].

In practice, this means that instead of simply filling out digital forms, users are prompted to reflect on stock levels, decision criteria, or timing, often with brief hints or process explanations built into the workflow. One of the instructors commented that "DYLLI doesn't just log the yogurt, it teaches you to think before ordering it."

This pedagogical layer didn't exist in the original DYLLI platform, which prioritized speed and logistics coordination in the HoReCa sector [6]. By contrast, the maritime adaptation treats the ordering process as a learning opportunity, not just a transaction.

4 Conclusions

This study shows that logistical operations aboard maritime training vessels remain deeply manual, despite their complexity and the growing availability of digital tools [1,9]. Inventory is still tracked in siloed spreadsheets. Communication between departments is fragmented. And costly mistakes, from food waste to missed approvals, are often the norm, not the exception.

Using a mix of qualitative research and low-fidelity prototyping, the DYLLI SHIP concept was developed to address these challenges in a direct, functional way [4,6]. The process wasn't about introducing another generic app. It focused on building something that matched the rhythm of life at sea, with its delays, multitasking, and need for offline access.

Three insights stand out from the project:

- Digital tools are only effective when paired with user training, accountability, and intuitive design [10]. A slick interface is useless if no one trusts it or understands why it's better than Excel.
- Breakdowns in communication and inventory visibility are not isolated bugs. They reflect deeper process flaws that require rethinking how procurement roles and approvals are structured [1,12].
- Sector-specific features matter. Offline functionality, compliance-ready reporting, and interfaces that work during a storm, not just in port, are critical to making tech usable at sea [13,3].

Looking ahead, DYLLI SHIP will move through several development phases [6]. Early mockups, shaped through user interviews and field observation, will form the base for controlled usability testing with onboard personnel. Short trial voyages will follow, allowing for data flow validation and behavior monitoring. With feedback from these early rounds, the system will be refined, enhanced, and finally prepared for a multi-month pilot deployment, complete with live support and embedded analytics [4,19]. This approach mirrors how things work in maritime education: test, adjust, repeat. The goal isn't just a smoother supply chain, it's a smarter one.

Future development phases will also explore integration with smart kitchen devices, external supplier databases, and regulatory compliance frameworks [7,8]. The long-term goal is to establish a scalable digital infrastructure that enhances maritime education, reduces waste, and aligns training vessels with the global transition toward sustainable, data-driven transport ecosystems [12].

This research contributes not only a proof of concept but also a methodological roadmap for how digital tools can be thoughtfully introduced in traditionally analog sectors, blending technology with pedagogy, and logistics with learning [10,15].

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