

Information behavior and digital competencies in maritime studies: a systematic literature review

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Received 7 November 2025
Revised 5 January 2026
Accepted 18 April 2026

Abstract

Purpose – By performing a systematic literature review from 2015 to 2025 on the information behavior and digital competencies of maritime students, the study aims to identify key thematic areas, research trends and gaps in maritime education and maritime digital information literacy. The review also emphasizes on the need for human-centered, competency-based educational models aligned with the framework of DigComp 2.2 and underscores the evolving role of academic libraries in supporting maritime students' digital literacy.

Design/methodology/approach – The study adopts a systematic literature review methodology, following the PRISMA guidelines. The review analyzes 46 peer-reviewed publications retrieved from international scientific databases between 2015 and 2025. Keywords were organized according to DigComp2.2 framework, and data were processed using open-source tools, such as Zotero, Biblioshiny and VOSviewer to enable both qualitative and bibliometric analysis.

Findings – The study revealed growing academic interest in maritime students' digital competencies and information behavior, particularly after 2020, driven by digital transformation and the COVID-19 pandemic. As a result, three key thematic areas emerged: maritime information literacy and behavior, digital competencies and education and the impact of emerging technologies on professional development. Also, the findings highlight the need for human-centered, competency-based educational models aligned with DigComp 2.2. framework.

Practical implications – Findings of this review suggest a growing need for maritime academic institutions to adapt their curricula to better integrate digital and maritime information literacy competencies, particularly those aligned with the DigComp 2.2 framework. Competency-based, human-centered approaches should be incorporated to prepare maritime students for evolving industry demands. Given the interdisciplinary nature of digital and maritime information literacy, collaboration between academic libraries and the maritime industry could serve as a strategic approach to bridge the gaps between theoretical instruction and practical digital competency development.

Originality/value – This review synthesizes scientific literature on maritime students' information behavior and digital competencies during 2015–2025. By aligning its analysis with DigComp 2.2 framework and focusing on maritime education sector it fills a gap in the literature and simultaneously it provides a foundation for future empirical studies, curriculum design and policy development.

Keywords Information behavior, Information literacy, Digital competencies, Maritime students, DigComp 2.2, Maritime education

Paper type Literature review

Introduction

The concept of information literacy and digital competencies has been thoroughly examined with a range of academic fields. These fields encompass, for instance, economics and business administration (Bauer, 2018; Zhang *et al.*, 2020; Amegashie and Ankamah, 2020; Naveed and Mahmood, 2022; Chaw and Tang, 2024), educational sciences (Guzmán-Simón *et al.*, 2017), library and information science (Okeji *et al.*, 2020; Alex-Nmecha and Ejitagh, 2023), humanities and social sciences (Korobili *et al.*, 2011; Pinto *et al.*, 2020; Vodă *et al.*, 2022;



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Reference Services Review
Vol. 54 No. 3, 2026
pp. 285-311
Emerald Publishing Limited
e-ISSN: 2054-1716
p-ISSN: 0090-7324
DOI 10.1108/RSR-11-2025-0095

Martzoukou *et al.*, 2022), medical and nursing sciences (Allari *et al.*, 2022; Marasinghe *et al.*, 2023; Martzoukou *et al.*, 2023), in addition to faculties focused on science and technology (Brindesi *et al.*, 2013; Freund, 2014; Gordon *et al.*, 2018, 2020; Zhao *et al.*, 2021). Although the integration of digital technologies and ICT tools is becoming increasingly essential in maritime education, the scholarly examination of information literacy and digital competence within this domain remains limited (Chlomoudis *et al.*, 2022). This highlights a growing need to better understand and support the development of such competencies among maritime students.

For the purposes of this review, “maritime education” is defined as the structured curriculum and training delivered in maritime academies, nautical colleges or university level departments, offering training in maritime and transport economics, management of shipping, logistics, supply chain management and human resource management. In the same context, the term “maritime students” refers specifically to individuals enrolled in formal maritime programs in the mentioned institutions.

The purpose of this study is to summarize and interpret the main outcomes of the literature review, focusing on the factors contributing to information needs, the obstacles encountered, the types of sources used and the digital competencies reported. Additionally, it provides a detailed analysis of the methodological profiles and thematic content of the reviewed studies, shedding light on the way scholarly discourse conceptualizes information practices in the maritime sector.

The post-pandemic period, marked by an abrupt transition to digital environments and a heightened need for remote learning, has intensified scholarly interest in the role of digital information literacy in maritime education. Within the frameworks proposed by organizations, such as Organization for Economic Co-operation and Development (OECD), Association of College and Research Libraries (ACRL) and the European Union (Ferrari, 2012; ACRL, 2016; OECD/International Transport Forum, 2018; Vuorikari *et al.*, 2022), recent studies increasingly emphasize the importance of familiarizing maritime students and professionals with information systems (Wulandari *et al.*, 2020; Sullivan *et al.*, 2021; Hopcraft, 2021; Scanlan *et al.*, 2022; INMARSAT, 2022; DNV, 2023), digital tools and the competencies necessary to navigate the demands of an evolving digital landscape (Khuraisah *et al.*, 2020; Simmons and McLean, 2020; Hopcraft, 2021; Cabaron, 2023, 2024; Hussein and Song, 2023).

The decision to align this study specifically with the DigComp 2.2 framework is grounded in its comprehensive, up-to-date and modular structure which offers a nuanced classification of digital competencies relevant across educational and professional contexts. In advance, DigComp 2.2 provides a broader, multidimensional lens compared to ACRL framework or OECD taxonomies, by incorporating not only information literacy but also digital communication, safety, content creation and problem-solving. Its wide acceptance across the European Union further supports the relevance for aligning educational strategies with international standards. Additionally, DigComp 2.2 adaptability allows context-specific implementation in technical disciplines such as maritime education, facilitating the development of tailored, competency-based learning approaches.

Aligned with the digital development, increasing emphasis has been placed on redefining the role of libraries and information services as key factors in promoting digital literacy in the maritime sector, particularly through structured information literacy programs (Bartusevičienė and Valionienė, 2020; Jiang *et al.*, 2021). This concern had started to emerge in academic discourse even before the COVID-19 outbreak (Padmashree and Sasikala, 2018; Reyes, 2019; Udayangani de Silva and Chandrawamsa, 2016; Constantinou and Fazal, 2020), along with the issue of students’ and future professionals’ digital competencies (Chen *et al.*, 2018; Nause *et al.*, 2019; Topal and Süner, 2020; Hopcraft, 2021).

This study argues that the digital transformation of the maritime sector requires a strategic rethinking of educational approaches and information literacy support, grounded in a human-centered, competency-based framework such as DigComp 2.2. By synthesizing existing research this literature review provides critical insights to inform future curriculum design,

library practices and policy development within maritime higher education. In this context, the study is guided by the following research questions:

- RQ1. What are the key thematic areas addressed in the literature on information behavior and digital competencies in maritime education between 2015 and 2025?
- RQ2. How are digital competencies, particularly those defined in the DigComp 2.2 framework addressed and operationalized in maritime academic contexts?
- RQ3. What gaps and future directions emerge from the existing literature concerning maritime students' digital literacy, information behavior and institutional support mechanisms?

Methodology of systematic literature review

The SLR conducted across international scientific databases on the information behavior and digital skills of students in maritime field revealed a relatively limited volume of research output. The findings suggest that scholarly interest has been primarily directed toward the development of information systems, with comparatively less emphasis placed on investigating the information needs and digital competencies of both students and professionals within the maritime sector.

To carry out this review of students' information needs and behaviors in the field of maritime education, a set of keywords was employed, following the protocol proposed by [Petticrew and Roberts \(2006\)](#) and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) methodology ([Petticrew and Roberts, 2006](#); [Liberati et al., 2009](#); [Moher et al., 2009](#); [Kitchenham et al., 2009](#); [Creswell and Plano Clark, 2017](#); [Lavranos et al., 2016](#); [Snyder, 2019](#); [Ramírez-Montoya and Lugo-Ocando, 2020](#); [Page et al., 2021](#); [Kolyvas and Kostagiolas, 2024](#)). Following the initial retrieval of results, the data were processed using qualitative analysis tools to extract meaningful conclusions from the selected publications, based on methodological steps outlined in the following sections.

Given the international scope and globalized context of the maritime field, literature search was conducted in English language. The process involved querying a range of multidisciplinary databases, including Scopus, PubMed, IEEE Xplore, ScienceDirect, JSTOR, MDPI, Emerald, Taylor and Francis, CORE (CONnecting REpositories) and DOAJ (Directory of Open Access Journals).

The search was restricted to the period between 2015 and 2025, to capture the most recent and up-to-date body of research. The decision to begin the search in 2015 was intentional, as this year marked the broader public dissemination of artificial intelligence tools relevant to information access and evaluation (e.g. the release from Google Brain Team, a machine learning system that allowed people treating search engines more like humans by asking complex questions, rather than typing specific strings of words and Facebook's Algorithm feed evolution that led to a shift from intentional seeking to passive information consumption by "pushing" information based on users' previous behavior) ([Abadi et al., 2016](#); [Bakshy et al., 2015](#)). These developments began to reshape how digital information is consumed, searched and interpreted, core aspects of both information behavior and digital literacy ([Clark, 2015](#); [Deng, 2018](#)). While other cut-off-points, such as the release of ACRL Framework for Information Literacy in 2015 could also serve as justification for the selected year, in this study is intended to capture the intersection between technological transformation, particularly AI integration and evolving conceptions of information literacy within educational contexts.

No further eligibility criteria were applied beyond the temporal restriction. Publications were not excluded based on document type or country of origin. Search terms were required to appear in the article's title, abstract or in the list of indexed keywords. The identified records were subsequently imported into Zotero, an open-source reference management tool to facilitate organizing the results and analyzing the retrieved literature.

Accordingly, the keywords used in literature search were organized into five thematic clusters, based on the DigComp 2.2 competence framework, adapted in our research topic. For each cluster, multiple keyword combinations were created using Boolean terms (e.g. “AND”, “OR”) to enhance the precision and recall of search results. Due to differences in databases architectures, indexing practices and search functionalities, keyword combinations were not executed as isolated or uniform queries whose results could be meaningfully compared across platforms. Instead, searches were conducted in parallel across databases and subsequently merged into a single corpus for deduplication and screening. As a result, while the total number of retrieved records is reported, it is not methodologically feasible to provide discrete result counts for each individual keyword combination. The keyword groupings in [Table 1](#) therefore represent conceptual search clusters rather than discrete, independently quantifiable queries. Their primary function was to ensure thematic coverage and alignment with the DigComp 2.2 framework, rather than to serve as individually countable search strings.

During the qualitative analysis the selection and exclusion criteria were applied, in accordance with the methodologies established by [Petticrew and Roberts \(2006\)](#) and [Kitchenham et al. \(2009\)](#). Furthermore, filters were employed to select the articles that satisfy the predetermined criteria or not. The articles that included were focusing explicitly on maritime students, maritime education or training programs, the addressed themes of information behavior, digital competencies, digital literacy or related constructs. Furthermore, the included articles were peer-reviewed journal articles, conference proceedings and other reputable institutional reports, written in English language and published between 2015 and 2025. These criteria were applied to ensure thematic relevance to the intersection of maritime education and digital competency frameworks within a contemporary technological context.

Besides duplicates, non-peer-reviewed sources and grey literature, several publications were excluded due to thematic misalignment. As far as the grey literature concerns, was initially included in the search strategy to ensure thematic comprehensiveness and avoid missing peer-reviewed or formally published materials that may be indexed within the repositories. For example, although the Transportation Research Board (TRB) Publications Index [\[1\]](#) hosts grey literature, it also contains structured reports and conference proceedings that are peer-reviewed or institutionally validated, that’s why we have selected broader initial searches, followed by rigorous filtering to ensure quality and relevance. Furthermore, studies that focused on maritime engineering, navigation systems or logistics technologies were

Table 1. Categorization by subject of keywords

Subject	Keywords
Maritime information literacy and information behavior	“information seeking” AND “maritime” “information literacy” AND “maritime” “information competence” AND “maritime” “information seeking behavior” AND “maritime” “academic information needs” AND “maritime”
Digital competencies AND maritime education	“digital competence” AND “maritime” “digital skills framework” AND “maritime” “higher education” AND “digital competence” AND “maritime”
Maritime information sources	“information sources” AND “maritime students”
AI AND maritime education	“artificial intelligence” AND “maritime information seeking”
Career development in maritime industry	“career development” AND “maritime university students”
Digital security AND maritime sector	“cybersecurity” AND “digital learning environments” AND “maritime”
Digital content creation AND maritime education	“digital content creation” AND “maritime education”
Social media AND maritime blogs	“social media” AND “maritime information”
Source(s): Authors’ own work	

excluded, if they did not address student learning, digital competencies or information practices. Likewise, numerous articles centered on maritime informatics, maritime health issues or port management systems lacked a man-centered or educational perspective and were therefore excluded. Notably, a significant number of excluded articles referred to ocean literacy, teaching English maritime terminology and gamification in educational contexts, themes outside the scope of the review. Additionally, in some cases articles were excluded because, although their abstracts were written in English, the full text was in another language, preventing a comprehensive assessment.

As far as the screening process, the initial screening was conducted at the title and abstract level using the criteria mentioned above. A second level full text review was then performed for potentially relevant articles. The decision about include/exclude was made by using the Zotero's tools. In advance, ambiguous cases were flagged and revised after the full corpus was assembled with judgement guided by alignment to DigComp 2.2 dimensions and maritime students focus.

The bibliometric analysis was conducted by using Biblioshiny, the web-based interface of Bibliometrix R package and VOSviewer. The dataset was exported from multiple scientific databases in BibTex (.bib) format using Zotero. After inserting the dataset in BibTex (.bib) format in Biblioshiny, we could visualize many features of the exported dataset, referring to the sources, the authors and the characteristics of the publications. For VOSviewer the BibTex file was converted into a VOS-compatible format using a built-in converting tool. All tools were used in accordance with their documentation and user manuals and consistent parameters (e.g. minimum keyword occurrence threshold was set to 2) were applied to ensure replicability.

Methodological challenges and limitations

The use of Google Scholar in conjunction with Publish or Perish (PoP) software revealed notable methodological limitations. Variability in keyword combinations triggered technical restrictions inherent to the platform, often producing inconsistent or duplicated search results. Additionally, many entries retrieved were non-peer-reviewed sources of grey literature, making it difficult to apply standard inclusion criteria. For these reasons, Google Scholar was ultimately excluded from the final search strategy in favor of scientific and academic maritime databases [2], such as the Maritime and Coastguard Agency (MCA) Publications [3], TRB and the Nautical Institute Publications [4].

Another significant challenge was the inconsistent distinction between the terms “information” and “informatics”. Most of the times digital competencies are equated with tool use (e.g. simulators, navigation systems), rather than critical digital literacy information search behaviors. This ambiguity was especially problematic in the maritime context where the term “maritime information” often referred to technical systems rather than informational practices. Although there were foundational theoretical distinctions, such as Shannon's (1948) information theory and Denning's (1985) definition of science of informatics, the distinctions tend to be obscured in the current technological context. To address this, the study adopted a clear conceptual boundary treating “information” as related to data transmission and behavior, and “informatics” as referring to technical infrastructures for information processing.

Another notable finding was the lack of sufficient literature directly addressing the core subject of this research. While many studies addressed technological and managerial aspects of maritime education (as discussed in the *Introduction* section), few focused directly on student-centered information behavior. This limitation constrained the comparative scope of the review required adaptation of search terms and inclusion criteria to capture relevant but scattered literature.

Finally, keyword variability across sources presented additional difficulties. Thematic overlap, inconsistent indexing and the use of broad or ambiguous descriptors complicated the retrieval process. To limit these difficulties, keywords were organized according to DigComp

2.2 framework, as we have noted in the previous section, enabling a more structured and targeted retrieval, aligned with literature review’s conceptual goals. In addition, since search strategy involved multiple overlapping Boolean queries executed across heterogeneous databases, exact attribution of retrieved records to individual keyword combinations was not retained, after merging and deduplication. To maintain methodological integrity, the study reports aggregate search results and documents the search logic rather than isolated query yields.

SLR results

The research process conducted in May–June 2025 yielded 989 results from Scopus database and 954 from all others, as shown in Figure 1 (Petticrew and Roberts, 2006; Moher et al., 2009; Page et al., 2021).

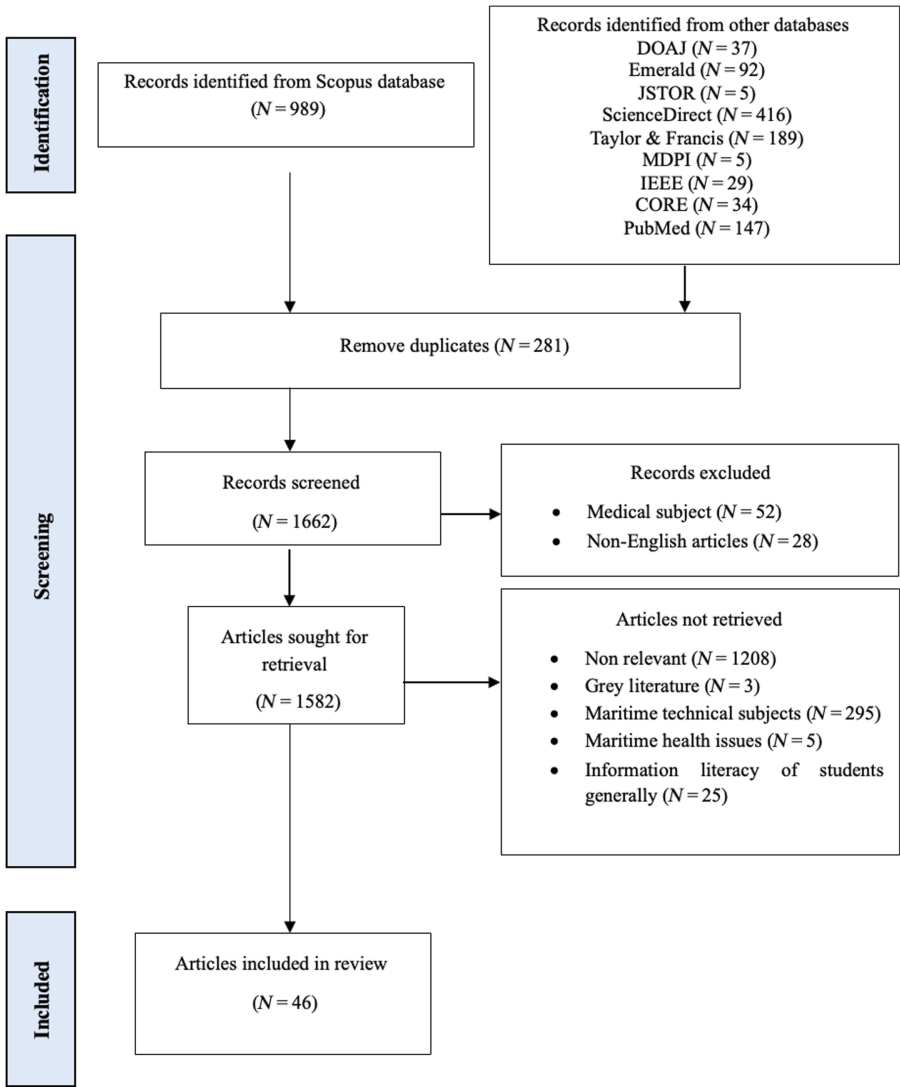


Figure 1. PRISMA flowchart. Source: Authors’ own work

A significant number of excluded studies were thematically unrelated to the research focus. Instead, they addressed topics such as ocean literacy, English language acquisition in maritime contexts and gamification in educational environments. After implementing the defined inclusion criteria (as seen in the previous section), 46 publications were deemed eligible for qualitative analysis. The temporal distribution of these studies, as illustrated in Figure 2, reveals a substantial increase in research activity beginning in 2020, accounting approximately 80.43% of the final corpus ($N = 37$). Notably, year 2023 showed a decline ($N = 2$), likely due to disruptions caused by COVID-19 pandemic.

An analysis of the geographical distribution for the publications in the selected sample in Table 2 reveals that the leading country is United States with five articles ($N = 5$), followed by United Kingdom, Turkey and Philippines, each with four publications ($N = 4$). Sweden, Singapore and Canada also demonstrate similar research activity, contributing three studies each ($N = 3$).

Further analysis of the sample reveals that out of 46 publications 31 (~67.39%) are peer-reviewed journal articles, while the remaining 15 (~32.61%) are conference proceedings, as shown in Table 3. Subject categories follow Scopus classification, and many studies are indexed under multiple categories within the fields of Social Sciences ($N = 27$), Engineering ($N = 20$) and Business, Management and Accounting ($N = 10$).

Regarding publication sources, Table 4 lists the main publishers represented in the reviewed dataset. These include academic publishers as well as the institutional and conference-related publishers. Elsevier emerges as the leading publisher ($N = 6$), followed by Emerald ($N = 5$), Routledge ($N = 4$) and the International Association of Maritime Universities (IAMU) publications ($N = 3$).

Table 5 identifies the most frequently recurring journals and conference proceedings among the 46 publications reviewed, indicating the prominence of specific publication venues within the thematic scope of the study. Among the selected journal articles, *Proceedings of the International Association of Maritime Universities Conference* holds the highest frequency ($N = 3$), followed by *Technology Analysis & Strategic Management* ($N = 2$), *TransNav* ($N = 2$) and *Library Philosophy and Practice (e-journal)* ($N = 2$). All remaining sources are represented by a single publication each.

The concentration of relevant publications within a limited number of sources aligns with the pattern described by Bradford's Law (1934, as cited in Budd, 1988) [5] as identified using the Biblioshiny [6] tool. Figure 3 demonstrates a publication pattern consistent with Bradford's Law, where a limited set of core journals, such as *IAMU Proceedings*, *Technology Analysis & Strategic Management* and *TransNav* concentrate most publications. The rest of the sources

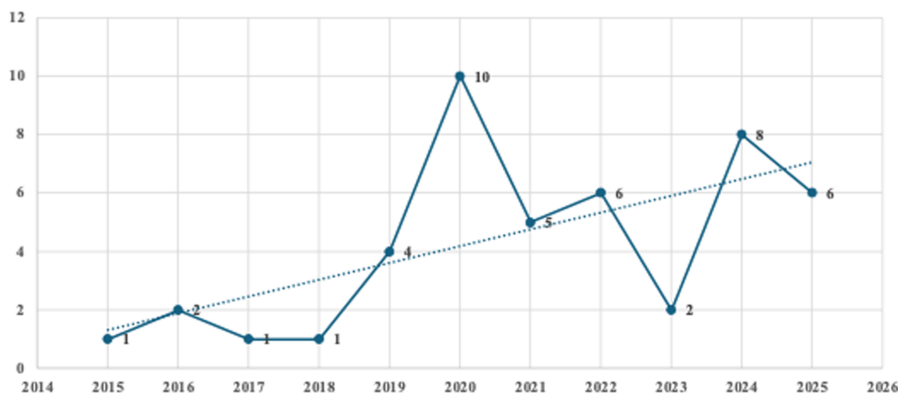


Figure 2. Publications per year. Source: Authors' own work

Table 2. Number of publications per country, based on dataset of 46 peer-reviewed articles

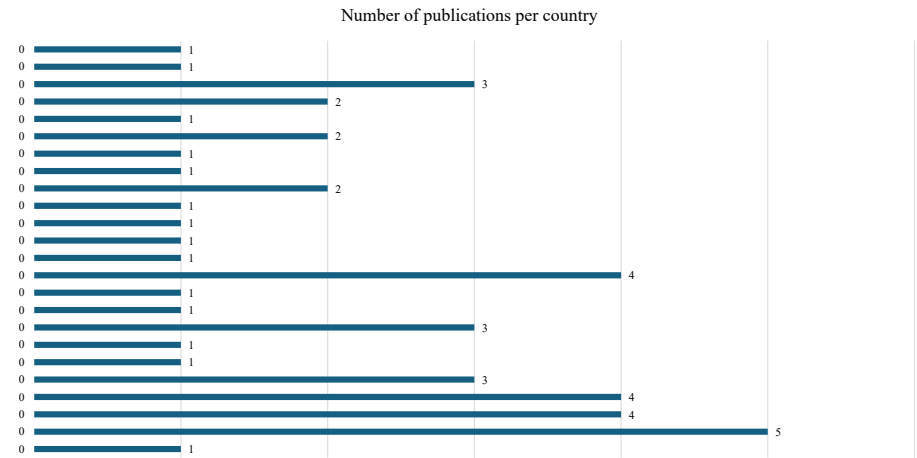


Table 3. Publication types and subject areas of included articles

Category	Sub-category	Frequency (N = 46)	Percentage (%)
<i>Publication Type</i>	<i>Article</i>	31	~67.39
	Conference Proceedings	15	~32.61
<i>Subject area</i> (Scopus classification)	Social Sciences	27	~31.76
	Engineering	20	~22.47
	Business, Management and Accounting	10	~11.76
	Decision Sciences	8	~8.99
	Computer Science	4	~4.49
	Environmental Science	4	~4.49
	Arts and Humanities	3	~3.37
Source(s): Authors' own work			

Table 4. Publishers and included publications

Publisher	Frequency	Percentage (%)
Elsevier	6	~13.04
Emerald	5	~10.87
Routledge	4	~8.7
IAMU	3	~6.52
Faculty of Navigation, Gdynia Maritime University	2	~4.35
Horizon Research Publishing	2	~4.35
IEEE	2	~4.35
SAGE	2	~4.35
Source(s): Authors' own work		

Table 5. Most frequently occurring journals and conference proceedings

Publication title	Frequency	Percentage (%)
<i>Proceedings of the International Association of Maritime Universities Conference</i>	3	~6.52
<i>Technology Analysis and Strategic Management</i>	2	~4.35
<i>TransNav</i>	2	~4.35
<i>Library Philosophy and Practice (e-journal)</i>	2	~4.35
Source(s): Authors' own work		

contribute fewer articles, more evenly distributed across the dataset. This distribution confirms the existence of a core-periphery structure in the scholarly landscape of maritime information literacy and digital skills.

Table 6 shows that the final dataset comprises 111 distinct authors. Among 46 publications, 11 (~23.91%) were authored by a single individual, while the remaining 35 (~76.09%) involved multiple authors. Bartusevičienė is the only author who appears twice as first author across the sample. Li X. and Yuen K.F. are each associated with three publications, and Valionienė and Fazal are among the few authors who appear more than twice in total, regardless of author position.

Citation analysis was used to assess the scholarly impact of the publications included in the final sample. Table 7 presents a ranked overview of the top-cited publications, based on

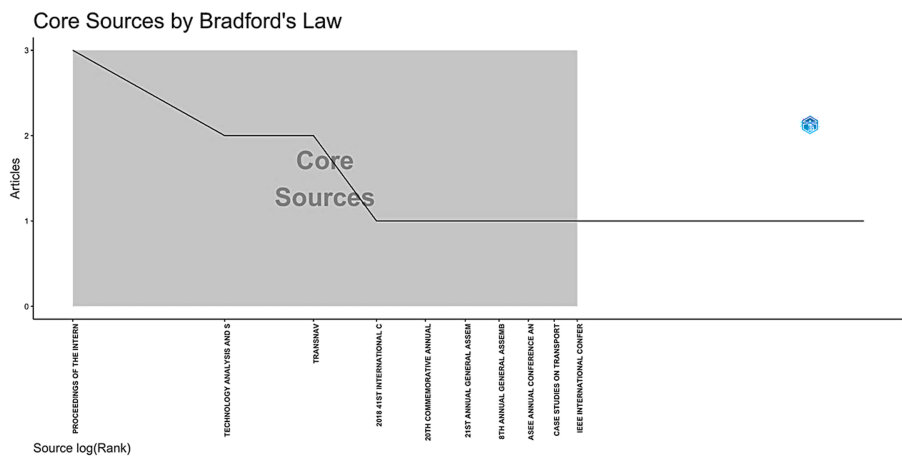


Figure 3. Core sources according to Bradford’s law, generated using Biblioshiny (“Core Sources by Bradford’s Law” function), based on dataset of 46 peer-reviewed articles

Table 6. Most prominent authors

Author(s)	Number of publications
Distinct authors	111
Single-authored publications	11
Multi-authored publications	35
First authors with the most appearances	Frequency
Bartusevičienė I	2
Authors with most appearances (regardless of author order)	Frequency
Li X.	3
Yuen, K.F.	3
Valionienė E.	2
Fazal S.	2
Source(s): Authors’ own work	

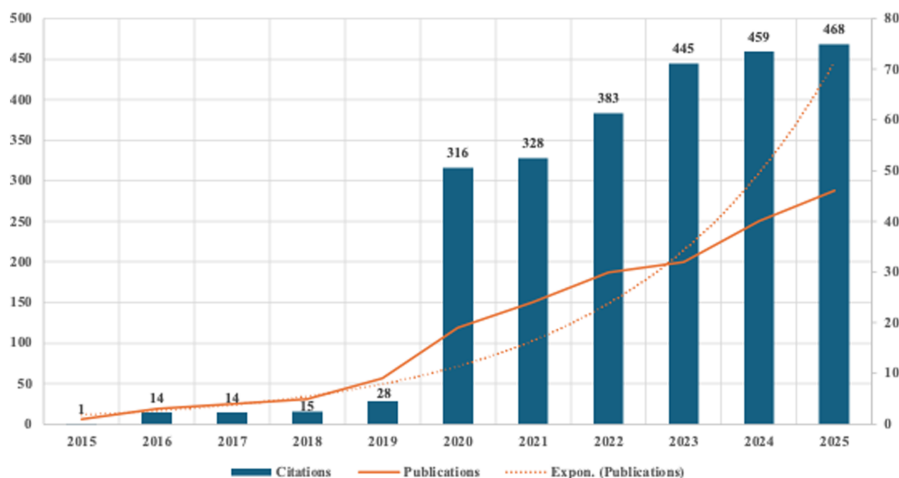
citation data retrieved from the databases. The most cited article was authored by [de la Peña Zarzuelo et al. \(2020\)](#) ($N = 199$), followed by [Lu et al. \(2023\)](#) ($N = 57$), [Baum-Talmor and Kitada \(2022\)](#) ($N = 31$) and [Esser et al. \(2020\)](#) ($N = 27$).

As illustrated in [Figure 4](#), there has been a notable increase in citation activity from 2020 onwards, which likely reflects the heightened research impact of publications influenced by the exceptional circumstances of the COVID-19 pandemic. Additionally, data revealed a gradual and steady rise in citations over time, indicating sustained scholarly interest and consistency within this specific field of research.

[Table 8](#) presents citation impacts statistics for the reviewed 46 articles in literature as generated using Biblioshiny’s “Average Citations Per Year” function. The table displays the number of articles published per year, their total “citable years” since publication, the average number of citations per article and the average number of citations per year. As shown in [Table 8](#) articles published in 2020 and 2023 have the highest citation averages, with 2020 publications receiving an average of 34.5 citations per article. While, 2023 articles have a slightly lower total citation count (~31), they demonstrate a higher average citation per year (~10.33), suggesting recent publications are gaining visibility faster. Conversely, articles from

Table 7. Most cited articles

Author(s)	Title	Journal/Source	Year	Citations
de la Peña Zarzuelo et al.	Industry 4.0 in the port and maritime industry: A literature review	<i>Journal of Industrial Information Integration</i>	2020	199
Lu et al.	Digital transformation as an enabler of sustainability innovation and performance – Information processing and innovation ambidexterity perspectives	<i>Technological Forecasting and Social Change</i>	2023	57
Baum-Talmor and Kitada	Industry 4.0 in shipping: Implications to seafarers' skills and training	<i>Transportation Research Interdisciplinary Perspectives</i>	2022	31
Esser et al.	The labour market for the port of the future. A case study for the port of Antwerp	<i>Case Studies on Transport Policy</i>	2020	27
Demirel, E.	Maritime education and training in the digital era	<i>Universal Journal of Educational Research</i>	2020	22
Smith et al.	Capturing expert knowledge to inform decision support technology for marine operations	<i>Journal of Marine Science and Engineering</i>	2020	13
Simmons and McLean	Understanding the paradigm shift in maritime education: The role of 4th Industrial Revolution technologies: an industry perspective	<i>Worldwide Hospitality and Tourism Themes</i>	2020	11
Koh et al.	Key knowledge domains for maritime shipping executives in the digital era: a knowledge-based view approach	<i>Technology Analysis and Strategic Management</i>	2024	10

Source(s): Authors' own work**Figure 4.** Cumulative publications and citations. Source: Authors' own work

earlier years such as 2016 and 2019 show significantly lower citation impact over time. These results suggest that scholarship in this field has gained momentum in recent years, both in volume and influence. The table includes articles in the dataset grouped by publication year, rather than a filtered selection of top-cited works.

Table 8. Average citations per article by year of publication

Year	Number of articles published (N)	Total citable years	Average citations per article	Average citations per year
2020	8	6	34.50	5.75
2023	2	3	31.00	10.33
2022	6	4	9.33	2.33
2019	2	7	5.00	0.71
2016	1	10	4.00	0.40

Source(s): Generated by Biblioshiny (“Average Citations Per Year” function). Based on dataset of 46 peer-reviewed articles

By reviewing the 283 indexed keywords identified in the selected publications of the dataset, it is noted that $N = 10$ of these keywords was mentioned more than twice, as illustrated in [Table 9](#). Keyword “students” ($N = 6$) ranked first, as anticipated, while the remaining keywords predominantly pertain to maritime education and digital transition, thereby highlighting the significant relationship between these concepts.

Subsequently, utilizing VOSviewer software, the relationships among keywords and their historical evolution were illustrated in [Figure 5](#). Particularly, it emphasizes on three primary domains where the keywords are based: maritime sector (e.g. “ships”, “shipping”, “maritime industry”), education (e.g. “students”, “education”, “curricula”) and digital skills alongside information literacy (e.g. “information literacy”, “e-learning”).

The clustering and robust associations between keywords “students”, “education” and “curricula” suggest that researchers globally are focused on the aspect of education and training in the maritime industry. Concurrently, keywords such as “information literacy” and “digital skills” are closely linked to the educational domain, underscore the significance of the digital transition and the incorporation of new technologies in maritime education. This trend has been increasingly apparent over the past two years (2023–2025).

An advanced keyword co-occurrence analysis conducted using Biblioshiny (“Trend Topic”) tool produced the thematic mapping displayed in [Figure 6](#), highlighting the dominant

Table 9. Keyword occurrences

Keywords	Frequency
Students	6
Maritime industry	5
Ships	5
Teaching	5
Curricula	4
Digital transformation	4
Information literacy	4
Personnel training	4
Education and training	3
Maritime students	4
Engineering education	3
Industry 4.0	3
Internet of things	3
Maritime education	3
Supply chains	3

Source(s): Authors’ own work

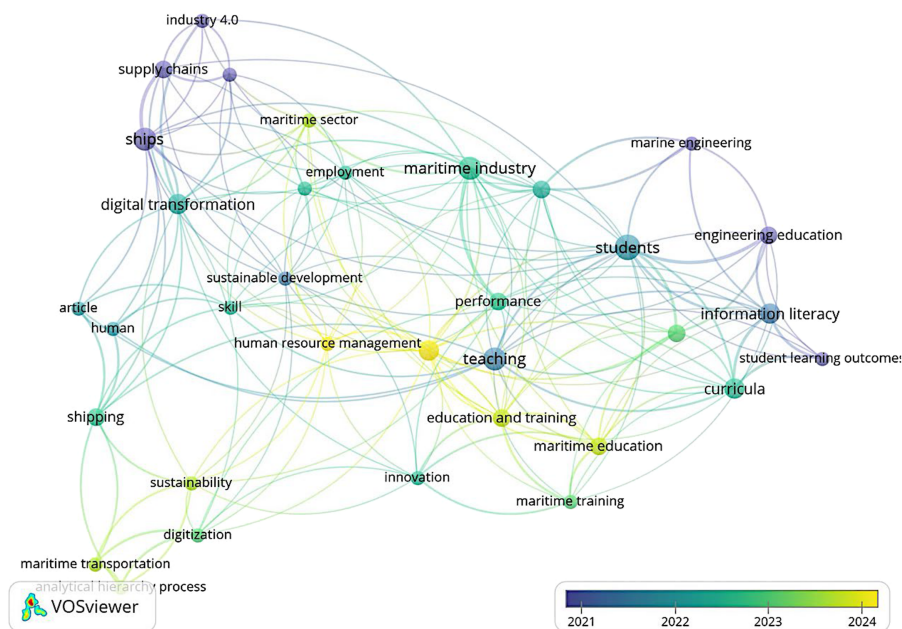


Figure 5. Historical evolution of indexed keywords generated using VOSviewer, based on co-occurrence analysis of indexed keywords (full counting method, minimum keyword occurrence: 2), using the dataset of 46 peer-reviewed articles

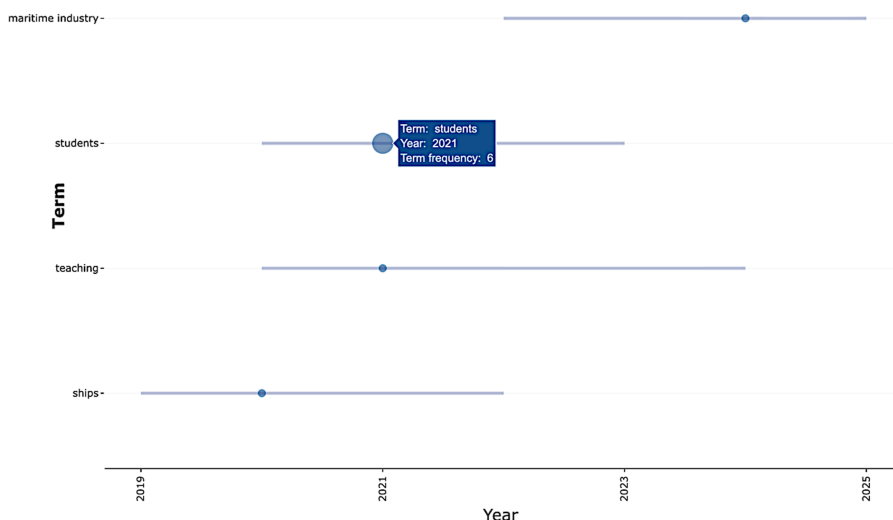


Figure 6. Thematic mapping of keywords generated by using Biblioshiny ("Trend Topics" function) (minimum word frequency: 2), based on dataset of 46 peer-reviewed articles

areas of research interest during 2015–2025. The keyword "students" was particularly prominent in 2021, a year that coincided with intensified focus on distance learning and digital adaptation prompted by the COVID-19 pandemic.

As a result of the keyword categorization process, distinct thematic clusters were identified, as visualized in [Figure 7](#) (“Thematic Map”). This figure classifies clusters of keywords based on two dimensions: *centrality* (how important a theme is to the overall field) and *density* (how well developed it is). The analysis revealed that keywords such as “students”, “maritime industry” and “teaching” fall within the category of “*Motor Themes*” which means that they are central and well-developed in the research area. In contrast, terms such as “marine engineering”, “analytical hierarchy process” and “maritime transportation” are classified as “*Emerging or Declining Themes*”, suggesting they are weak in both relevance and development. Notably, no keywords from the dataset were positioned within the “*Niche Themes*” or “*Basic Themes*”, indicating an absence of isolated or underdeveloped foundational topics in the current literature.

At the conclusion of the literature review, the findings were thematically grouped based on the conceptual dimensions informed by the search strategy ([Petticrew and Roberts, 2006](#); [Creswell and Plano Clark, 2017](#); [Snyder, 2019](#); [Ramírez-Montoya and Lugo-Ocando, 2020](#)). These groupings reflect the structure of the existing academic discourse and were organized into three primary categories:

- (1) *Information literacy and behavior*, which incorporates terms such as “information literacy”, “information behavior” and “maritime information sources”,
- (2) *Digital skills and education*, which includes keywords to “digital skills and maritime education”, “digital content creation” and the use of “social networks and blogs in maritime contexts”,
- (3) *New technologies and professional development*, which comprises studies on “artificial intelligence in maritime education”, “digital security” and “professional upskilling in maritime industry”.

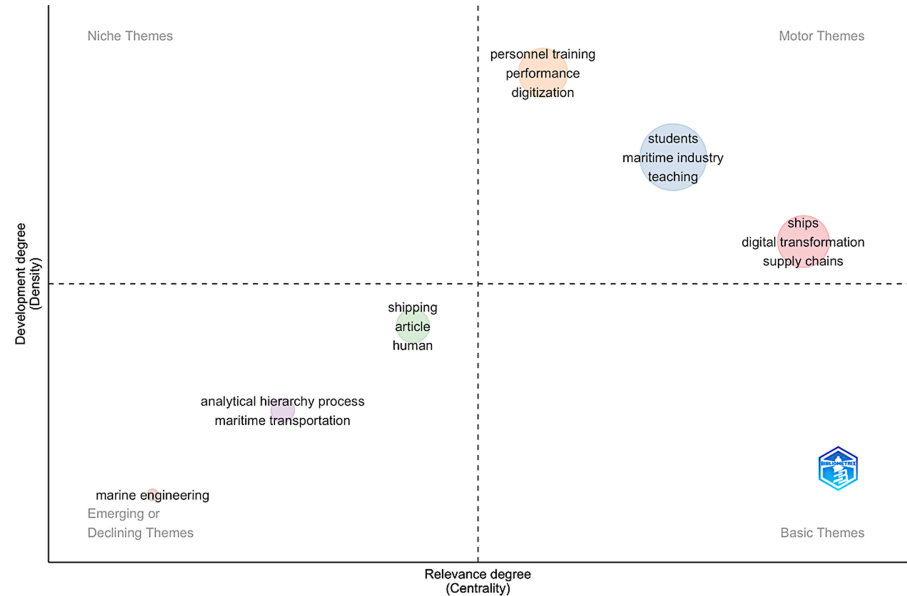


Figure 7. Thematic map of keywords clusters, generated using Biblioshiny (“Thematic Map” function), based on dataset of 46 peer-reviewed articles. The map displays centrality and density of topic clusters across the corpus

Table 10 classifies each reviewed article alphabetically and by thematic category, Information Literacy and Behavior (ILB), Digital Skills and Education (DSE) and New Technologies and Professional Development (NTPD), alongside with bibliographic details.

Discussion of SLR results

A key characteristic of maritime information is its heterogeneous nature by a wide range of sources that vary in type, scope and language. These sources must rapidly adapt to ongoing digital transformation ([Padmashree and Sasikala, 2018](#)). In this context, academic libraries and information services play a critical role in this adaptation process, particularly within maritime education institutions. As information intermediaries, these organizations must remain agile, updating and enhancing the quality of the resources they provide.

In an era marked of information overload and digital transformation, the proximity of such services to students becomes essential. Ensuring access to trustworthy and academically sound information is not a necessity but a responsibility ([Reyes, 2019](#)).

The SLR reflects the profound impact of technological advancement on maritime education. Digitization, automation and the rise of autonomous systems are not only transforming operational practices but also redefining the competencies required by maritime professionals ([Smith et al., 2020](#); [de la Peña Zarzuelo et al., 2020](#); [Demirel, 2020](#); [Bartusevičienė and Valionienė, 2021](#); [Pareliussen et al., 2022](#); [Ceylani et al., 2022](#); [Lu et al., 2023](#); [Owowo et al., 2024](#); [Weintrit, 2024](#); [Nguyen, 2024](#); [Li et al., 2024](#); [Šekularac-Ivošević, 2025](#); [Zhang and Yu, 2025](#); [Malau et al., 2025](#); [Belabyad et al., 2025](#)). As such, digital skills, including information literacy, cybersecurity, real-time analytics and digital content development emerge as essential for maintaining professional relevance and competitiveness of competency-based training ([Blakeley, 2017](#); [Owowo et al., 2024](#); [Koh et al., 2024](#)), advanced simulators and industry-academia collaboration, aiming to bridge the persistent gap between theoretical instruction and practical application ([Nause et al., 2019](#); [Cross and Tucker, 2020](#); [Demirel, 2020](#); [Esser et al., 2020](#); [Weintrit, 2024](#)).

Another important finding highlights the critical role of information behavior and the utilization of trustworthy sources in situations characterized by crisis and uncertainty like those encountered by humanity during the COVID-19 pandemic. During this period professionals demonstrated an increasing trust in alternative digital platforms and collaborative information sources ([Botnaryuk and Kalinina, 2021](#); [Gerakoudi-Ventouri, 2022](#); [Nguyen, 2024](#); [Koh et al., 2024](#)).

Moreover, research has underscored the inconsistencies between requirements of maritime sector and maritime educational establishments, stressing the necessity to modify analytical and contemporary programs in accordance with international standards (e.g. Standards of Training, Certification and Watchkeeping for Seafarers (STCW), DigComp 2.2) ([Bartusevičienė and Valionienė, 2020](#); [Esser et al., 2020](#); [Demirel, 2020](#); [Ceylani et al., 2022](#); [Szwed and Benton, 2022](#); [Weintrit, 2024](#); [Li et al., 2024](#); [Cabaron, 2024](#); [Zhang and Yu, 2025](#)). Additionally, social media is recognized as a significant source of information, serving not only educational objectives but also facilitating professional development ([Cross and Tucker, 2020](#); [Türkistanlı and Sevgili, 2024](#)). Besides, there is a strong emphasis on the critical role of training and trainers within maritime academic contexts ([Cabaron, 2024](#)).

The dataset also highlights an industry undergoing transformation wherein the cultivation of a digitally proficient workforce is deemed essential for both sustainability and competitiveness. Since the onset of the decade, research conducted [Abarquez et al. \(2015\)](#), [Udayangani de Silva and Chandrawamsa \(2016\)](#) and [Fazal \(2016\)](#) have concentrated on the information requirements and behaviors of students in maritime studies, particularly through the perspective of maritime information facilities. Their objective was to improve the utilization of the maritime information services available. Simultaneously, [Wulandari et al. \(2020\)](#) has examined maritime education by prioritizing the needs and competencies of students, underscoring the significance of utilizing information systems.

Table 10. Thematic classification of each article in the three primary categories: information literacy and behavior (ILB), digital skills and education (DSE), new technology and professional development (NTPD)

Author(s)	Title	Journal/Source	Primary themes
Abarquez <i>et al.</i> (2015)	Awareness of Maritime Students on the Sotero H. Laurel Learning Resource Center (SLRC) Club	<i>Asia Pacific Journal of Maritime Education</i>	ILB, DSE
Bartusevičienė and Valionienė (2020)	Meeting digitalization challenges to future specialists: Development of educational environment at lithuanian maritime academy to ensure effectiveness of studies in shipping and logistics information systems	<i>Transport Means–Proceedings of the International Conference</i>	DSE, NTPD
Bartusevičienė and Valionienė (2021)	An integrative approach for digitalization challenges of the future maritime specialists: A case study of the Lithuanian maritime academy	<i>TransNav</i>	DSE, NTPD
Baum-Talmor and Kitada (2022)	Industry 4.0 in shipping: Implications to seafarers’ skills and training	<i>Transportation Research Interdisciplinary Perspectives</i>	DSE, NTPD
Belabyad <i>et al.</i> (2025)	Skills and competencies for operating maritime autonomous surface ships (MASS): a systematic review and bibliometric analysis	<i>Maritime Policy & Management</i>	DSE, NTPD
Blakeley (2017)	The role of a professional society in promoting the success in the maritime industry	<i>Procedia Engineering</i>	NTPD
Botnaryuk and Kalinina (2021)	Impact of the internet of Things on the formation of a model for optimizing port terminal operations	<i>Journal of Physics: Conference Series</i>	DSE, NTPD
Cabaron (2024)	Exploring the impact of digital literacy on the self-efficacy of maritime education faculty	<i>International Journal of Advanced and Applied Sciences</i>	ILB, DSE
Ceylani <i>et al.</i> (2022)	A Ranking of Critical Competencies for Future Seafarers in the Scope of Digital Transformation	<i>Proceedings of the International Association of Maritime Universities Conference</i>	DSE, NTPD
Chlomoudis <i>et al.</i> (2022)	Information needs and information-seeking behaviour of maritime students: a systematic literature review using the PRISMA method	<i>Library Management</i>	ILB, DSE
Colar (2021)	Usage of Library Resources and Services of Maritime Academy of Asia and the Pacific (MAAP): Bases for Promotional Strategies	<i>Library Philosophy and Practice (e-journal)</i>	ILB
Constantinou and Fazal (2020)	Developing information literacy for the maritime curriculum: Strategy and pedagogy	<i>8th Annual General Assembly 2007 - (IAMU)</i>	ILB, DSE

(continued)

Table 10. Continued

Author(s)	Title	Journal/Source	Primary themes
Cross and Tucker (2020)	Technology and social media in the maritime classroom	<i>Proceedings - 16th Annual General Assembly and Conference of the IAMU AGA 2015</i>	DSE
de la Peña Zarzuelo <i>et al.</i> (2020)	Industry 4.0 in the port and maritime industry: A literature review	<i>Journal of Industrial Information Integration</i>	DSE, NTPD
Demirel (2020)	Maritime Education and Training in the Digital Era	<i>Universal Journal of Educational Research</i>	DSE, NTPD
Duin and Thoben (2019)	Future Scenarios of maritime Logistics and their Impact on Vocational Training	<i>Proceedings – 2019 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2019</i>	DSE, NTPD
Esser <i>et al.</i> (2020)	The labour market for the port of the future. A case study for the port of Antwerp	<i>Case Studies on Transport Policy</i>	DSE, NTPD
Fazal (2016)	Library Strategic Planning for Middle States Accreditation: A 10-Year Road to Success	<i>Journal of Library Administration</i>	ILB, DSE
Gerakoudi-Ventouri (2022)	Shipping managers' information behavior during a pandemic crisis	<i>Maritime Business Review</i>	ILB, NTPD
Li <i>et al.</i> (2024)	A study on digital literacy and influencing factors among Chinese seafarers	<i>Scientific Reports</i>	DSE, NTPD
Karahalios (2025)	Enhancing maritime education for digital sustainability	<i>International Journal of Innovation Science</i>	DSE, NTPD
Koh <i>et al.</i> (2024)	Key knowledge domains for maritime shipping executives in the digital era: a knowledge-based view approach	<i>Technology Analysis & Strategic Management</i>	NTPD
Li <i>et al.</i> (2023, 2024)	A ranking of critical competencies for shore-based maritime logistics executives in the digital era	<i>Technology Analysis & Strategic Management</i>	DSE, NTPD
Lu <i>et al.</i> (2023)	Digital transformation as an enabler of sustainability innovation and performance – Information processing and innovation ambidexterity perspectives	<i>Technological Forecasting and Social Change</i>	DSE, NTPD
Luce and McNie (2024)	Charting New Courses: Reimagining Information Literacy in Maritime Education and Training	<i>24th International Association IAMU 2024</i>	ILB, DSE
Malau <i>et al.</i> (2025)	Developing Competency-Based Maritime Education for the Digital Age	<i>Journal of Maritime Research</i>	DSE, NTPD
Miscevic <i>et al.</i> (2018)	Applications and software for teaching logistics and logistics management	<i>2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2018 – Proceedings</i>	DSE, NTPD

(continued)

Table 10. Continued

Author(s)	Title	Journal/Source	Primary themes
Nause et al. (2019)	International Maritime Management: Serving the seafarers of tomorrow and their educational needs	<i>(IMLA Conference) 2019</i>	DSE
Nguyen (2024)	Investigating Driving Factors of Digital Transformation in the Vietnam Shipping Companies: Applied for TOE Framework	<i>SAGE Open</i>	DSE, NTPD
Nordfeldt and Ljungklint (2021)	Marine student's information literacy skills- a case study of marine engineer's bachelor thesis at Chalmers University of Technology	<i>21st Annual General Assembly, IAMU AGA 2021 – Proceedings of the IAMU Conference</i>	ILB
Owowo et al. (2024)	Evaluation of the Impact of Industry 4.0 Technologies on Supply Chain Resilience in the Maritime Industry	<i>2024 IEEE 5th International Conference on Electro-Computing Technologies for Humanity (NIGERCON)</i>	NTPD
Pareliussen et al. (2022)	Professions, work and digitalization: Technology as means to connective professionalism	<i>Journal of Professions and Organization</i>	DSE, NTPD
Rajapakse and Emad (2019)	A review of technology, infrastructure and human competence of maritime stakeholders on the path towards autonomous short sea shipping	<i>20th Commemorative Annual General Assembly, AGA 2019 - Proceedings of IAMUC 2019</i>	DSE, NTPD
Reyes (2019)	Library Patrons' Satisfaction and Information Need Assessment of Maritime Students	<i>Library Philosophy and Practice (e-journal)</i>	ILB, DSE
Šekularac-Ivošević (2025)	Generic Core and Soft Skills for Maritime Industry 4.0: A Conceptual Framework	<i>Mechanisms and Machine Science</i>	DSE, NTPD
Simmons and McLean (2020)	Understanding the paradigm shift in maritime education: The role of 4th Industrial Revolution technologies: an industry perspective	<i>Worldwide Hospitality and Tourism Themes</i>	DSE, NTPD
Smith et al. (2020)	Capturing expert knowledge to inform decision support technology for marine operations	<i>Journal of Marine Science and Engineering</i>	DSE, NTPD
Subaveerapandiyan et al. (2024)	Marine information-seeking behaviours and AI chatbot impact on information discovery	<i>Information Discovery and Delivery</i>	ILB, DSE, NTPD
Szwed and Benton (2022)	Helping Accelerate the Global Maritime Professional Body of Knowledge up the S-Curve of Innovation	<i>Proceedings of the IAMUC, 2022</i>	ILB, DSE

(continued)

Table 10. Continued

Author(s)	Title	Journal/Source	Primary themes
Topal and Süner (2020)	Information searching and commitment strategies of maritime faculty students on the web	<i>Information Development</i>	ILB, DSE
Tsai and Janssen (2021)	Information Fluency Instruction as a Continuous Improvement Activity	<i>ASEE Annual Conference and Exposition, Conference Proceedings</i>	ILB, DSE
Türkistanlı and Sevgili (2024)	Social media presence and organisational attractiveness of ship owner and management companies	<i>International Journal of Shipping and Transport Logistics</i>	ILB, NTPD
Udayangani de Silva and Chandrawamsa (2016)	Information needs and information seeking behavior of students at higher educational institutes: With special reference to CINEC maritime campus	<i>Sociology and Anthropology</i>	ILB, DSE
Weintrit (2024)	Sustainable Reaction of the Maritime Education Sector to Marine Technology Development including Autonomous Surface Shipping	<i>TransNav</i>	DSE, NTPD
Wulandari <i>et al.</i> (2020)	Development of human resources quality through implementation of academic information systems for education and training participants at Maritime Higher Education (stip) Jakarta	<i>Journal of Digital Business Management</i>	ILB, DSE
Zhang and Yu (2025)	A review on the preparedness of Chinese maritime law education for emerging industry and technology trends: Sustainable net-zero shipping, maritime digitalization and application of artificial intelligence technologies	<i>Sustainable Futures</i>	DSE, NTPD
Source(s): Authors' own work			

Consequently, it is a necessity for an increasingly profound understanding of the information requirements of students engaged in maritime studies, driven by rapid advancements in technology. In this context, Constantinou and Fazal (2020), Tsai and Janssen (2021), Chlomoudis *et al.* (2022), Subaveerapandiyan *et al.* (2024) and Luce and McNie (2024), have made substantial contributions to the identification and documentation of students' information needs, the available information sources and the obstacles they are facing in accessing maritime information. In more recent studies Nguyen (2024), Li *et al.* (2024), Belabyad *et al.* (2025), Karahalios (2025), Šekularac-Ivošević (2025), Zhang and Yu (2025) and Malau *et al.* (2025), the researchers emphasize on the importance of connecting educational frameworks with maritime enterprises, as well as the beneficial impacts of students' digital competencies on the facilitation of digital transformation with maritime industries.

Ceylani *et al.* (2022) underscore the necessity of enhancing cognitive abilities, including critical thinking and problem-solving which are directly associated with dimensions one and

five of DigComp 2.2, relating to information literacy and problem solving respectively. Simultaneously, [Baum-Talmor and Kitada \(2022\)](#) indicates the significance of comprehending the interaction between humans and technology, a factor connected to the second dimension of the European DigComp 2.2 framework, which focuses on communication and collaboration. Equally, [Duin and Thoben \(2019\)](#) indicate the imperative for ongoing education and identity management within digital contexts, as outlined by the third dimension related to digital content creation, and the fourth dimension referring to security. Moreover, there are two specializations, such as those presented by [Zhang and Yu \(2025\)](#) who highlight the necessity of integrating education in maritime law with contemporary practices and skills, analyzing the situation of maritime academic institutions in China and illustrating the relevance of digital competencies nowadays in maritime sector.

Conclusions

This research provides a structured SLR concerning information seeking behavior and digital competencies of maritime students. The methodological approach was based on acknowledged academic tools and frameworks, resulting in detailed report of the extracted findings. The results reflect a shifting landscape in maritime education, shaped significantly by technological disruptions and the digital transformation of the maritime industry. The primary contribution of this review is the identification of a dual imperative across the literature: the necessity to equip future maritime professionals with adaptive skillsets and the critical need to ensure the strategic management of information resources. As a result, the immediate integration of AI tools and digital technologies into the curriculum becomes a necessity. The paradigms of Maritime 4.0 and Maritime 5.0 highlight the growing relevance of established digital literacy frameworks, such as DigComp 2.2. Crucially, the analysis reveals a significant research focus on digital literacy and the necessary competencies for a maritime professional operating a highly competitive and demanding environment, especially since 2020.

The review also, identified a lack of consistency in how digital and information literacy concepts are integrated across maritime education literature. While some studies highlight emerging digital competencies, many focus narrowly on operational technologies or general ICT training without aligning to comprehensive frameworks, such as DigComp2.2. This fact reveals a curriculum gap that, if remains unaddressed, may leave maritime students underprepared for the digital demands of maritime industry.

The literature review ultimately calls for a reconfiguration of educational methodologies, prioritizing human-centered technology-responsive educational models that address the emerging realities of the maritime domain. The findings lead to several concrete recommendations for both academic institutions and the maritime industry:

- (1) Curriculum integration: the primary intention of maritime education must be to acclimate students to digital technologies, especially artificial technology tools. Curricula must be redesigned to actively demonstrate how these tools facilitate problem-solving in online contexts and contribute to critical decision thinking.
- (2) Information services modernization: academic libraries and information services in maritime universities are urged to prioritize the enhancement and modernization of their service offerings. Concurrently, they must implement up-to-date information literacy programs specifically aimed at addressing maritime students' needs. This strategic action is vital for strengthening students' ability to manage information resources effectively. Notably, few of the reviewed articles explicitly referenced the role of academic libraries in digital competency development. This absence suggests a missed opportunity for collaboration, particularly as libraries are traditionally positioned to support information literacy instruction and access to digital resources.

- (3) Industry alignment: scholars recognize the necessity for upcoming maritime professionals to develop the essential competencies required to adapt to the digital transformation and the current requirements of the maritime industry. Since prominent maritime organizations and implementing specific training frameworks certified in accordance with ISO standards to identify needed skills, educational institutions must align their programs with these professional certification requirements.

Overall, while literature answers the three research questions, it also reveals increasing engagement with digital tools in maritime education, it lacks depth in examining the way students engage with information itself; how they seek, evaluate and apply digital maritime content in both academic and professional contexts. This review highlights the need for further research on how digital competencies and information behaviors are conceptualized, taught and assessed within maritime education.

While providing a comprehensive overview based on three primary pillars: (1) information literacy and behavior, (2) digital skills and education and (3) new technologies and professional development, this review suggests critical opportunities for future research. Another aspect for further research should focus on developing and validating robust measurement tools to quantitatively assess the actual digital competency levels of maritime students, beyond self-assessment to measure capabilities ashore and at sea. Furthermore, targeted cases studies are needed to evaluate the long-term effectiveness of educational models that integrate advanced technologies, particularly AI and established frameworks like DigComp 2.2, across maritime universities all over the world. Also, further research should conduct a detailed analysis to specifically identify the most critical digital competencies, enabling a precise mapping of the contemporary gap between current educational output and maritime industry's future demands.

Notes

1. Part of the US National Academies of Sciences, Engineering and Medicine, the TRB has the knowledge to solve complex transportation challenges with an index of more than 84,000 documents, articles and research papers on transportation in general and shipping in particular since 1922 (<https://pubsindex.trb.org/>).
2. Maritime databases with free access.
3. Provides access to publications and research related to maritime safety navigation and environmental protection under the auspices of the British government (<https://www.gov.uk/government/organisations/maritime-and-coastguard-agency/about/publication-scheme>).
4. Non-governmental organization that advises the international organization IMO with the aim of providing knowledge on best practices in the shipping industry, safety and education (<https://www.nautinst.org/shop-listing.html>).
5. Bibliometric method concerning dispersion, based on the assumption that the use of any collection of objects is not distributed evenly among those objects. In other words, some objects may be used quite frequently, others moderately and others not at all (Budd, 1988).
6. A bibliometric analysis tool that uses the open source programming language R and is implemented by K-Synth Srl, Academic spin-off, of the University of Naples Federico II (<https://www.bibliometrix.org/home/>).

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