

# Interrogating the global application of e-certification of seafarers

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## Abstract

**Purpose** – Amidst the ongoing digital transformation in the maritime industry, this study aims to interrogate the application of electronic certification (e-certification) to seafarers globally.

**Design/methodology/approach** – Data and methodological triangulation were used in the study. This included a scoping review to analyze the components of effective e-certificates; document analysis to evaluate the nature and functions of the international legal framework of seafarers' e-certification and thematic and statistical analyses of responses from survey questionnaires and interviews to examine the merits, demerits and challenges to global implementation of seafarers' e-certification. A modified Unified Theory of Acceptance and Use of Technology (UTAUT) model was used to determine the stakeholders' usage behavior regarding seafarers' e-certification.

**Findings** – The results revealed several merits associated with the implementation of seafarers' e-certificates, outweighing the presence of certain drawbacks. It also identified various challenges to global application along with potential solutions. Despite the strong industry support for the entire replacement of seafarers' traditional printed certificates with e-certificates, the study concludes that the coexistence of both formats will persist until crucial challenges are effectively addressed. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended, along with the relevant International Maritime Organization (IMO) guidelines, functions as the international legal framework for the effective global application of electronic certification for seafarers.

**Originality/value** – The study addresses a significant aspect of the contemporary digital transformation of seafarers' certification under the STCW Convention, 1978, as amended.

**Keywords** Electronic certification, E-certification, Digitalization, Seafarers, Digital certificates, Maritime industry

**Paper type** Research paper

## 1. Introduction

Technological advancements have been at the forefront of the global digitalization trend. This includes the use of emerging technologies in the certification process. Traditionally,

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*Ethical consideration:* Before data collection, the research instruments used were approved by the World Maritime University's Research Ethics Committee (REC-23-044(M) and REC-23-044II(M)). Informed consent was obtained from all individual participants involved in the study.



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printed certificates have been widely used as official documents attesting to facts. They are usually written and printed using special paper (Mayowa, Adedayo, Olamide, Awokola, & Sodipo, 2021) or security paper (Agung, Nugroho, & Hendriyanto, 2022). However, in consonance with the continuing global digital transformation, they are gradually being replaced by electronic certificates or e-certificates. For instance, some jurisdictions have been implementing e-certificates for e-government certification services (Wu, Shan, Wang, Shieh, & Chang, 2001), academic certification (Chen-Wilson, Blowers, Gravell, & Argles, 2009), land registration (Haryowardani, 2022; Syarif, 2021), medical certification (Li, Li, & Yang, 2022) and birth registration (Smulian, Ananth, Hanley, Knuppel, Donlen, & Kruse, 2001), among others. The term “electronic certificate” or “e-certificate” denotes different meanings across different fields. One popular definitional view is of the e-certificate as a digital form of a traditional paper-based certificate (Chen-Wilson *et al.*, 2009).

The shipping industry, responsible for the transport of 80% of global trade by volume (United Nations Conference on Trade and Development (UNCTAD), 2022), is likewise undergoing a digital transformation, e.g. in e-certificate implementation evident in ship certification (Cosgrave, 2018) and seafarer certification (Danish Maritime Authority (DMA), 2021). Accordingly, guidelines on the use of e-certification in the shipping industry were issued by the International Maritime Organization (IMO) (2013, 2014, 2016, 2023a). The IMO is a specialized agency of the United Nations tasked with ensuring the safety and security of shipping and preventing marine and atmospheric pollution caused by ships (IMO, 2019a). This work includes oversight of the certification of a substantial workforce of around two million seafarers manning over 50,000 merchant vessels engaged in international trade (International Chamber of Shipping (ICS), 2022).

Considering the harsh environmental conditions and risks of work at sea, the certification of seafarers is key to ensuring safe voyages of people, goods and vessels. Through the IMO's International Convention on Standards of Training, Certification and Watchkeeping (STCW) 1978, as amended, the minimum requirements for seafarer education, training, certification and watchkeeping were established and require the IMO Member States to implement them. It includes an obligation to ensure that all seafarers serving on board seagoing ships are duly certificated to guarantee that they are qualified and fit for their duties (IMO, 2017, 2019b). The STCW Convention defines a “certificate” as “*a valid document, by whatever name it may be known, issued by or under the authority of the Administration or recognized by the Administration authorizing the holder to serve as stated in this document or as authorized by national regulations*”. Further, Regulation I/2 paragraph 11 states that “*...any certificate required by the Convention must be kept available in its original form on board the ship...*” (IMO, 2017).

The use of e-certificates is argued to be beneficial in terms of fraud prevention and reduction of bureaucratic inefficiency and corruption (Mubarak, Zauhar, & Suryadi and Setyowati, 2022), convenience (Cosgrave, 2018; Herbert, Kowalewski, Schnitzler, & Lassak, 2022) and security and validity with prompt verification (DMA, 2021). However, it is hindered technically primarily by security issues relating to data or information integrity, confidentiality and availability if viewed as digital data (Cosgrave, 2018). Nevertheless, there are contemporary technologies used for e-certification, such as the blockchain technology (Alruwaili, 2020) and digital signature (Cosgrave, 2018), which help alleviate some of these challenges.

Although the maritime industry adopted the use of e-certification for seafarers more than a decade ago, global readiness to transition from the use of traditionally printed certificates to e-certificates is still in doubt, particularly in terms of stakeholders' acceptance and use of the e-certification system. This may be associated with trust in technology, the degree of which

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may be manifested in an individual's behavior (Mcknight, Carter, & Clay, 2009). In seeking to understand such behaviors and their underpinning rationales, several theories and models may be used to, for example, examine the acceptance ability of stakeholders to adopt new technologies. They include (1) Theory of Reasoned Action (TRA); (2) Technology Acceptance Model (TAM); (3) Motivational Model (MM); (4); Theory of Planned Behavior (TPB); (5) Combined TAM and TPB (C-TAM-TPB); (6) Model of PC Utilization (MPCU); (7) Innovation Diffusion Theory (IDT) and (8) Social Cognitive Theory (SCT) (Momani, 2020; Venkatesh, Morris, Davis, & Davis, 2003).

These eight prominent models and theories and their extensions relative to individual acceptance were reviewed by Venkatesh *et al.* (2003). They subsequently formulated a unified model called the Unified Theory of Acceptance and Use of Technology (UTAUT), which suggests that the actual use of technology is determined by behavioral intention. Performance expectancy, effort expectancy, social influence and facilitating conditions are four essential factors that have a direct impact on how likely people are to adopt the new technology. Such factors are moderated by age, gender, experience and voluntariness of use (Venkatesh *et al.*, 2003). The model defines the following core determinants of intention and usage of technology, as follows:

- (1) *Performance expectancy* – “the degree to which an individual believes that using the system will help him or her to attain gains in job performance”;
- (2) *Effort expectancy* – “the degree of ease associated with the use of the system”;
- (3) *Social influence* – “the degree to which an individual perceives that important others believe he or she should use the new system” and
- (4) *Facilitating conditions* – “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system”.

Given the comprehensiveness of UTAUT model, the researchers viewed it as the most suitable theory for this study. The theory has been widely used in examining the acceptability of new technologies (see Table A1 in the supplementary materials). However, there was no literature found regarding its application to the e-certification of seafarers.

As indicated earlier, e-certification is not a recent innovation. The practical utilization of this concept has been documented across various domains. However, in terms of its application to seafarers, only a few Member States have communicated the use of e-certificates for seafarers to IMO, despite the existence of IMO guidelines since 2013. They include Denmark (DMA, 2021), Panama (Panama Maritime Authority, 2020), the HM Government of Gibraltar (2022) and the Philippines (Maritime Industry Authority (MARINA), 2022).

There is a dearth in the literature of discussions regarding the global application of e-certification to seafarers. As such, this study evaluates its global application, guided by the following research questions (RQ):

- RQ1. What makes an effective e-certificate?
- RQ2. What is the nature of the international legal framework on e-certification for seafarers, and how does it work?
- RQ3. What are the merits and demerits of e-certification for seafarers?
- RQ4. What are the challenges assuming that e-certification for seafarers will be implemented globally?

## 2. Research methodology

The study applied a mixed-methods design, specifically data and methodological triangulation, to answer the research questions, where both qualitative and quantitative data were collected and analyzed.

The study was composed of two (2) stages. The first stage applied a qualitative approach through a scoping review of existing literature following [Arksey and O'Malley's \(2005\)](#) framework to analyze the concept of an effective e-certificate (RQ1). The literature search was conducted in the Google Scholar database using the pre-identified keywords "electronic certificate," "e-certificate" and "digital certificate." The criteria for inclusion were peer-reviewed journal articles related to e-certification, written in English language and published from 2009 onwards. Those publications that did not fall within the criteria were not considered in the study. The search resulted in an initial total of 128 journal articles. After a surface review to determine whether the articles pertain to e-certification, 97 articles were excluded for further analysis, leaving 31 articles. The abstracts of the 31 articles were reviewed to further check the articles' contents. Only 11 articles were found to be suitable for the study. The contents of the 11 articles were reviewed comprehensively. The extracted information about e-certification was then synthesized and presented as a mind map (see results section). Thereafter, document analysis was conducted using IMO legal documents retrieved from the IMO digital document repository, IMODocs, to examine the nature and operational functioning of the international legal framework on e-certification for seafarers (RQ2).

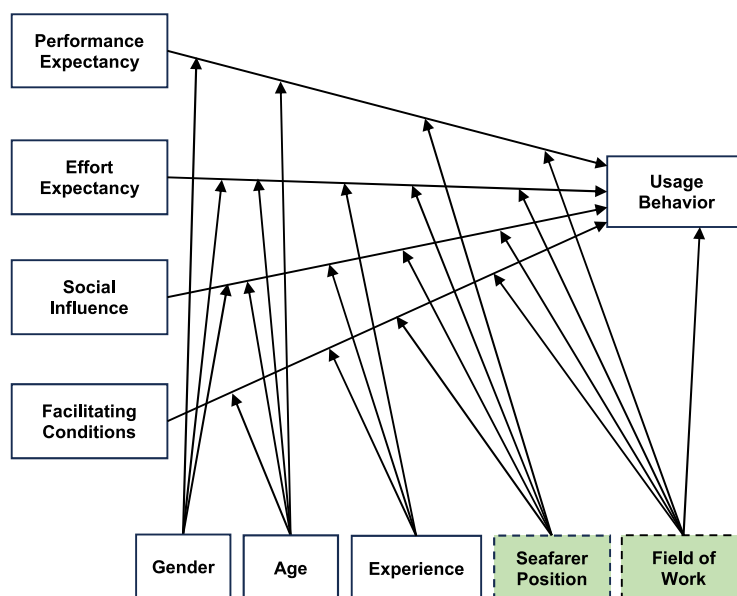
Using the results of the first stage and taking into consideration the modified UTAUT model, research instruments were developed – semi-structured interview questions and survey questionnaires for Maritime Administrations (MARAD), shipping companies/manning agencies and seafarers. These instruments were then used in the second stage, where both qualitative and quantitative data were collected to analyze the merits and demerits of e-certification for seafarers (RQ3) and the potential challenges to full global implementation of seafarers' e-certification (RQ4).

The survey questionnaires were composed of three open questions and six-point Likert scale statements to elicit a degree of agreement/disagreement based on the key constructs of the UTAUT model. Descriptive and inferential statistical analyses were applied to the quantitative data from the survey questionnaires using IBM SPSS Version 29.0.1.0 (171), while thematic analysis was used for the interview data and the qualitative data from the survey questionnaires using NVivo (Release 1.7.1) software.

As mentioned, the UTAUT model was modified by the researchers as illustrated in [Figure 1](#) to ensure its suitability for the study. Specifically, the constructs "behavioral intention" and "voluntariness of use" from the original UTAUT model were excluded since the application of e-certification is not dependent on seafarers' or other stakeholders' intention or voluntariness of use, but rather on the State's choice to implement the e-certification for seafarers. Additional moderators to the key constructs were tested, including a "seafarer position" category (either cadet/trainee, support level, operational level or management level) and a "field of work" category (either seafarers, MARAD or shipping companies/shipping agencies).

A set of null hypotheses was formulated based on the UTAUT model as follows:

- H1.* Performance expectancy has no significant relationship with usage behavior.
- H2.* Effort expectancy has no significant relationship with usage behavior.
- H3.* Social influence has no significant relationship with usage behavior.
- H4.* Facilitating conditions have no significant relationship with usage behavior.



**Note(s):** “Experience” and “Seafarer Position” were tested only for seafarers

**Source(s):** The authors

**Figure 1.**  
Modified  
UTAUT model

*H5.* The field of work has no significant relationship with usage behavior and

*H6.* The distribution of performance expectancy, effort expectancy, social influence, facilitating conditions and usage behavior are the same across the categories of demographic variables (gender, age, experience, position category and field of work).

The usage behavior in this study pertains to the way seafarers, MARADs and shipping companies/manning agencies respond to the utilization of e-certificates by seafarers, considering seafarers as holders, the MARAD as issuers or verifiers and shipping companies/manning agencies as receivers and verifiers.

### 3. Results and findings

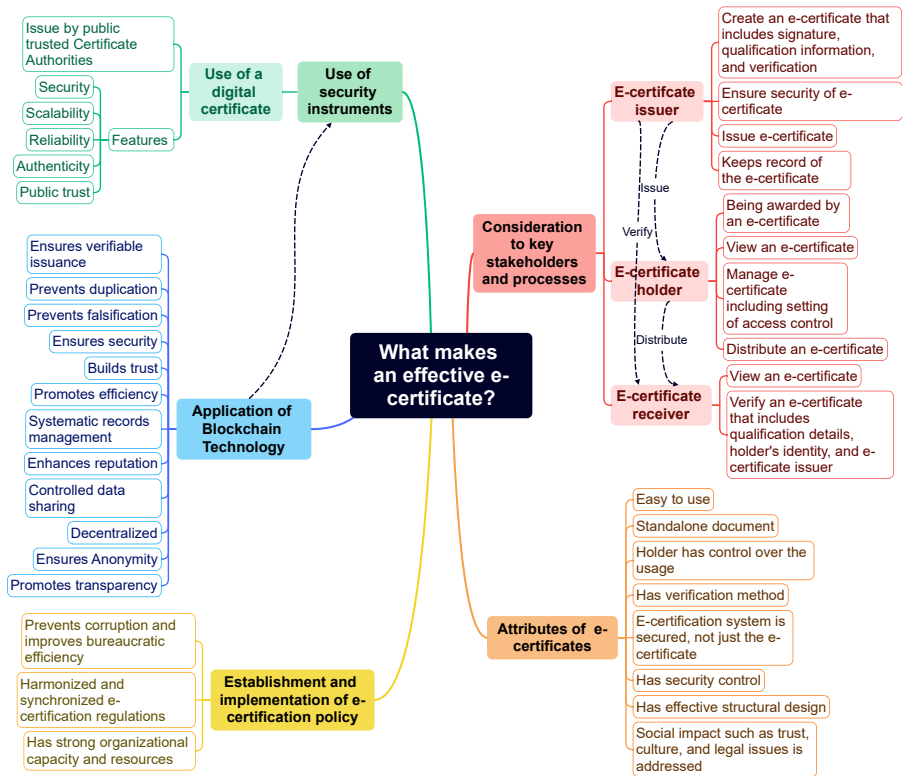
#### 3.1 Scoping review

As presented in Figure 2, the results show that the following components should be taken into consideration to ensure the effectiveness of e-certification: (1) use of security instruments; (2) use of blockchain technology; (3) consideration of key stakeholders and processes; (4) establishment and implementation of e-certification policy and (5) attributes of e-certificates.

#### 3.2 Document analysis

The researchers charted the development of IMO regulations and guidelines on the use of electronic certificates of seafarers, as presented in Figure 3.

IMO guidelines were initially issued in 2013 (IMO, 2013), with subsequent amendments in 2014 (IMO, 2014) and 2016 (IMO, 2016). In 2018, Member States proposed to the IMO a unified interpretation of STCW Convention Regulation I/2 paragraph 11, seeking clarification on



**Figure 2.**  
Components of an  
effective E-certificate

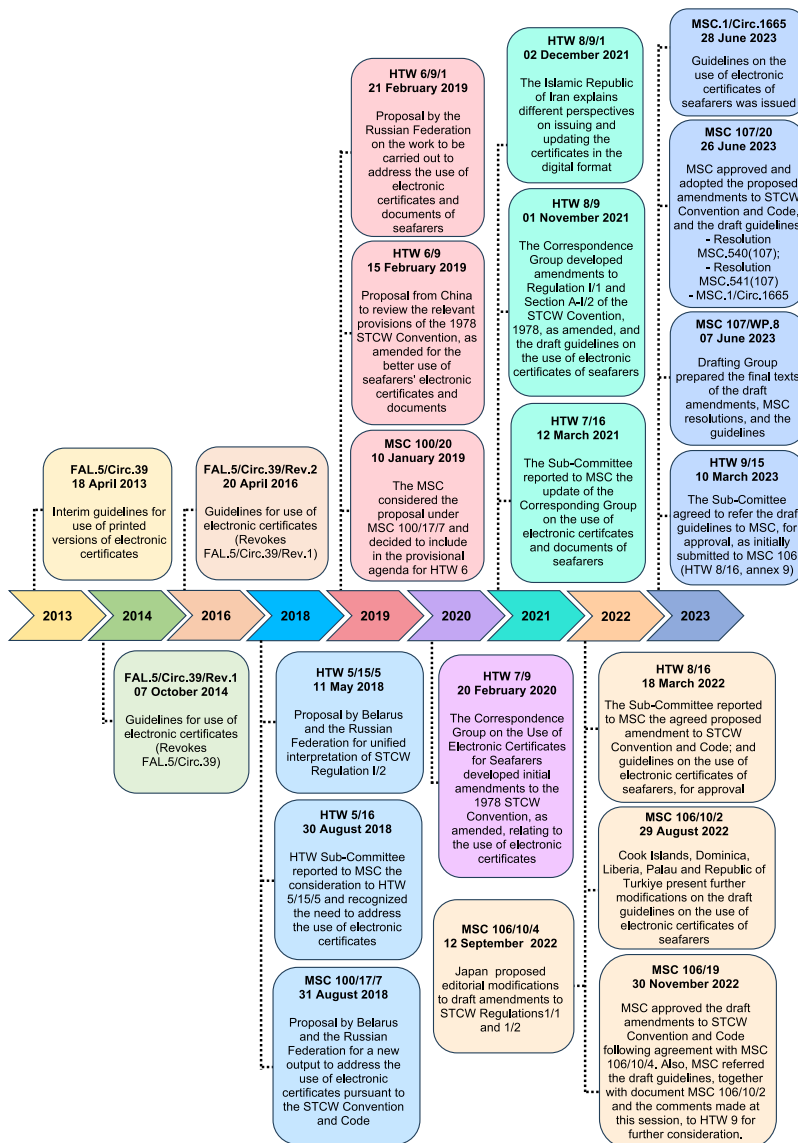
**Source(s):** The authors

whether “original form” could apply to paper or electronic certificates (IMO, 2018). Acknowledging the proposal’s merits, the IMO, until June 2023, worked on amendments to the STCW Convention, leading to the unanimous adoption of draft amendments and guidelines on electronic certificates by the Maritime Safety Committee during its 107th session, with representation from 107 Parties to the STCW Convention, 1978, as amended (IMO, 2023b).

### 3.3 Survey questionnaires and semi-structured interviews

The demographic profile of the survey questionnaires’ respondents was collected (see Table A2 in the supplementary materials). Of 286 respondents, 38 were from the MARAD, representing 13 countries, 23 were from shipping companies/manning agencies and 225 were seafarers with 18 nationalities. Before conducting data analysis, the responses were comprehensively screened based on respondents’ demographic information to establish the authenticity of the dataset.

On the other hand, there were eight participants in the interview, representing a variety of roles in the maritime industry with a wide range of knowledge, experience, and expertise extending from seafaring, crewing management, maritime administration in different contexts (leading seafarer supply, top flags of registration, leading administrations in the implementation of e-certification) and seafarers’ unionization. All of the interviews were



Source(s): The authors

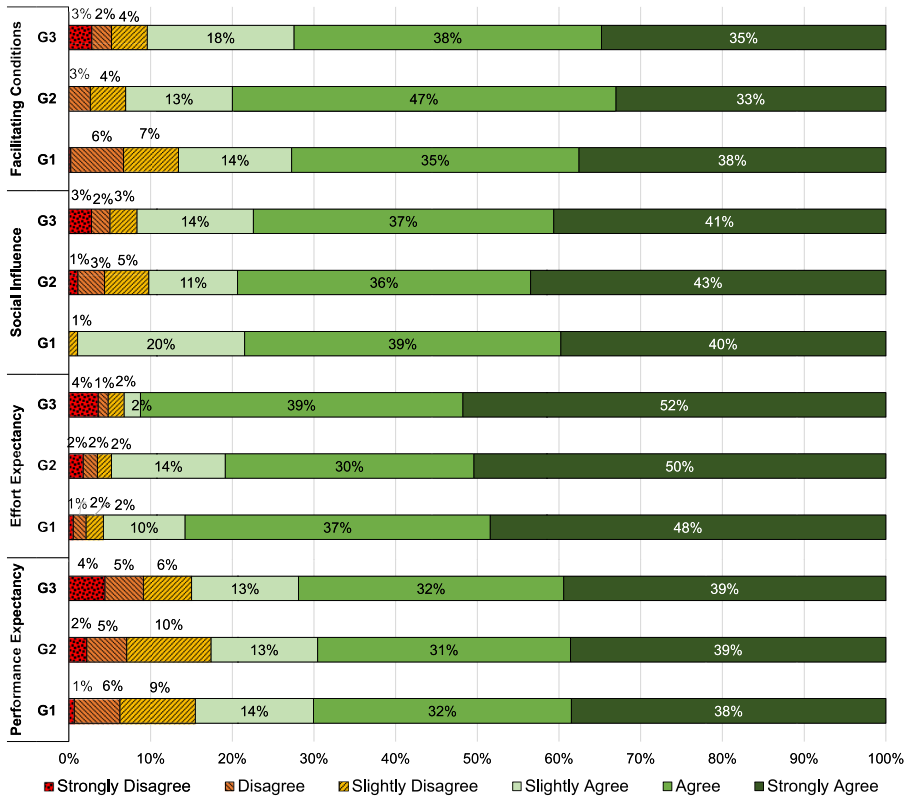
Figure 3. Development of regulations and guidelines on the use of electronic certificates of seafarers

individually conducted online using Zoom Video Conferencing and Microsoft Teams, except for one where a written response was received.

3.3.1 *Merits and demerits of e-certification for seafarers.* The responses of the three key stakeholders to the Likert scale questionnaires showed that more than 80% across all groups had positive perceptions of acceptance and use of technology, as illustrated in Figure 4.

Separately, the qualitative data from an open question asking about the participants' thoughts on the replacement of traditional printed certificates was converted into

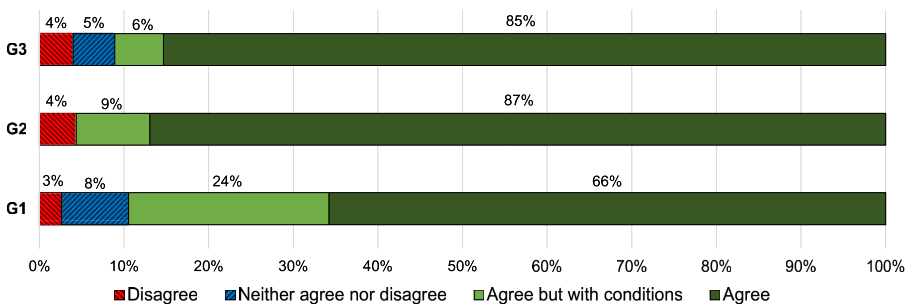




**Figure 4.** Stakeholders' level of agreement/disagreement on acceptance and use of technology

**Note(s):** G1 = MARAD, G2 = Shipping Companies/Manning Agencies, G3 = Seafarers  
**Source(s):** The authors

quantitative values using a four-point Likert scale to determine the usage behavior of the participants. As presented in Figure 5, the majority of the respondents agreed with the total



**Figure 5.** Stakeholders' thoughts on entire replacement of traditional printed certificates with e-certificates

**Note(s):** G1 = MARAD, G2 = Shipping Companies/Manning Agencies, G3 = Seafarers  
**Source(s):** The authors



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replacement of printed certificates, while 24, 9 and 6% from MARAD, shipping companies/ manning agencies and seafarers, respectively, agreed but with some conditions. Conditions include ensuring data privacy protection, lesser processing time and burden on seafarers, acceptance of e-certificates by the international community, ease of access to data, international standardization, protection against security breaches and breaking the technological barriers to the use of e-certification systems. Additionally, 8% of MARAD and 5% of seafarers neither agreed nor disagreed, while 3–4% of the stakeholders disagreed with the replacement.

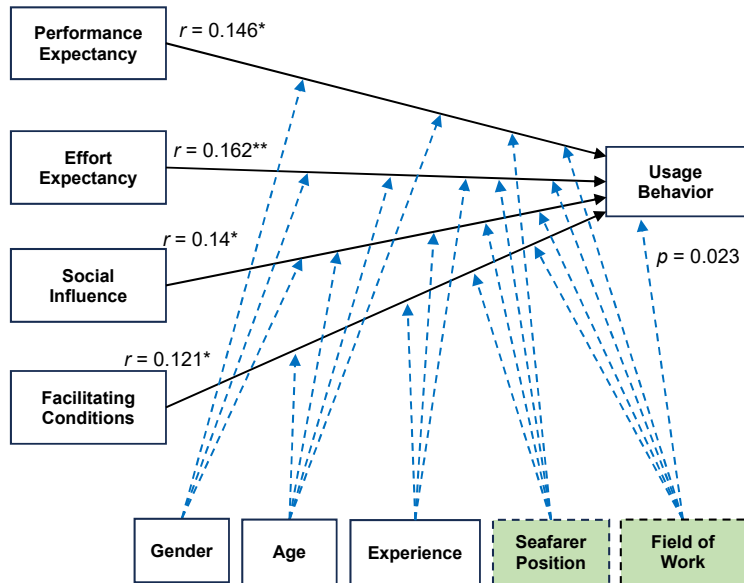
Hypotheses tests were conducted after assessing the internal consistency (reliability) of each questionnaire's set of items using Cronbach's alpha and the skewness of the data and subsequently removing the data that would not provide reliable statistical results. For **H1–H5**, using Spearman's correlation coefficient tests, it was shown that the usage behavior of the key stakeholders regarding e-certification has a statistically positive but very weakly significant relationship with performance expectancy ( $r = 0.146$ ,  $p$ -value  $<0.05$ ), effort expectancy ( $r = 0.162$ ,  $p$ -value  $<0.05$ ), social influence ( $r = 0.14$ ,  $p$ -value  $<0.05$ ), facilitating conditions ( $r = 0.121$ ,  $p$ -value  $<0.05$ ) and field of work ( $r = 0.125$ ,  $p$ -value  $<0.05$ ). As such, **H1–H5** are all rejected. It should be noted that, as in similar analyses, the correlation does not provide conclusive evidence regarding the causal relationship between these variables.

Further, using the independent-samples Kruskal–Wallis test, the results revealed that the null hypotheses under **H6** are to be retained across all tests except between the Usage Behavior and the Field of Work ( $H(2) = 7.583$ ,  $p$ -value = 0.023) at the 0.05 significance level. A post hoc test was conducted on the rejected null hypothesis (statistical significance between Usage Behavior and Field of Work). The pairwise comparison showed that the MARAD and the seafarers have statistical differences in terms of usage behavior. In contrast, the tests showed that the age and gender of individuals in the three key stakeholder categories as well as the position category and experience of seafarers, have no statistical significance regarding their mediating influence on the relationship between performance expectancy, effort expectancy, social influence and facilitating conditions (on the one hand) and usage behavior (on the other hand). This outcome is shown by the broken blue arrows in [Figure 6](#).

The study analyzed the extent of the merits and demerits of seafarers' e-certification by combining both quantitative and qualitative data from the three survey questionnaires and the eight semi-structured interviews. Specifically, merits and demerits were identified through thematic analysis of interview and survey responses using MS Excel (Version 16.77) and NVivo (Release 1.7.1). Responses were sometimes assigned to one or more codes depending on their context. The frequencies of comments and responses for each coded merit and demerit were thereafter tabulated and represented in a graph, as shown in [Figure 7](#). For instance, a total of 365 combined responses consider that e-certification has better accessibility, while 69 combined responses convey that e-certificates are difficult to access. On the other hand, 345 combined responses highlight the convenience of using e-certification for seafarers, while 45 responses convey opposition. [Figure 7](#) illustrates the extent of the merits and demerits of using e-certificates for seafarers and, at the same time, reveals the prominent aspects of seafarers' e-certification, which include accessibility, convenience, verification, time, security and data privacy.

In summary, while these prominent aspects of seafarers' e-certification provide greater merits, they likewise embody some degree of demerit. Nevertheless, the drawbacks associated with e-certification are overshadowed by the benefits it offers. Moreover, the study revealed other merits of using the e-certificates of seafarers, including fewer printed documents to carry onboard the ship, paperless transactions, efficiency for the industry, better management and control of seafarers' documentation, reliability, better means of compliance with international regulations, simplicity, transparency and reduced bureaucracy.

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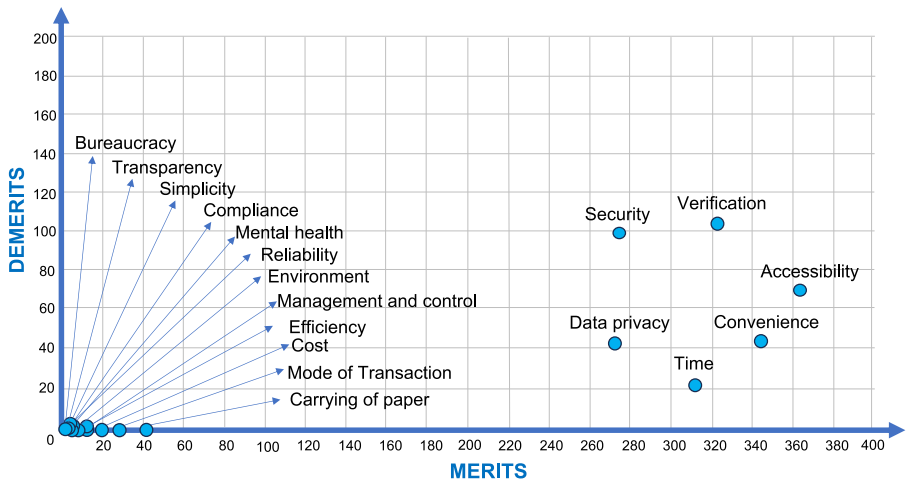
**Figure 6.**  
Summary result of hypotheses

**Note(s):**

\*Correlation is significant at the 0.05 level (2-tailed).

\*\*Correlation is significant at the 0.01 level (2-tailed).

**Source(s):** The authors



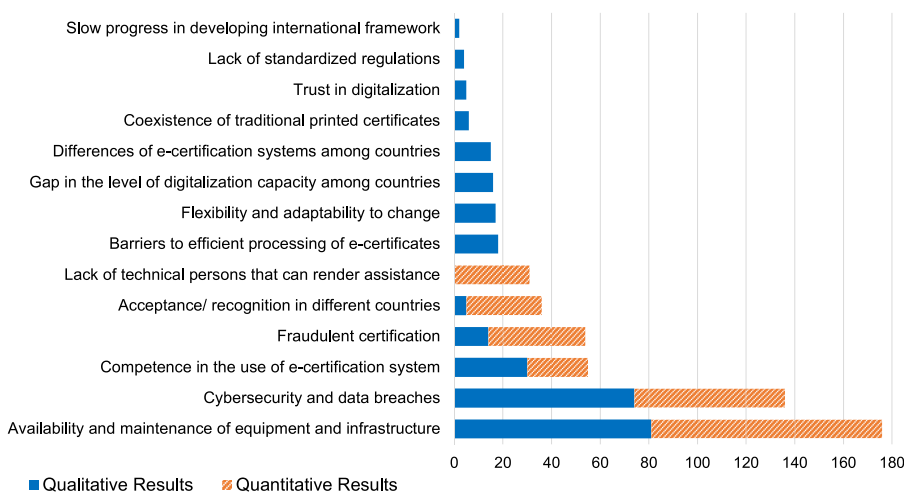
**Figure 7.**  
Combined results of merits and demerits of e-certification of seafarers

**Source(s):** The authors

3.3.2 *Challenges to global implementation of e-certification of seafarers.* Figure 8 presents the challenges to seafarers' e-certification based on the combined qualitative and quantitative data from the interviews and survey questionnaires. Specifically, the result was drawn from the combined frequency of comments from the thematic analysis of the interviews and the open-question from the surveys (qualitative results) and the number of responses from the Likert scale disagreeing with the statements about the facilitating conditions and performance expectancy (quantitative results).

3.3.3 *Total replacement of traditional printed certificates.* All participants in the interview supported the total replacement of traditional certificates with e-certificates. They highlighted the efficiency and ease of accessibility, storage and management of e-certificates. They were also of the view that full implementation of the e-certification system for seafarers is timely in the current era of digitalization.

3.3.4 *Other emerging themes from the semi-structured interviews.* Three overarching themes emerged from the inductive thematic analysis of responses from the semi-structured interviews. The first relates to best practices in e-certificate implementation, which include a high-level focus on security measures, the use of blockchain technology, the establishment of measures on equipment and infrastructure readiness, data privacy protection, data sharing mechanisms and the exchange of best practices. A second theme relates to the keys to the success of the global application of e-certificates to seafarers. These include the accessibility of e-certification systems by all MARAD, allowing data sharing to verify seafarers' certificates as required by the STCW Convention, clear and harmonized IMO regulations and guidelines for the standardization of e-certification systems, sufficient digitalization resources and implementation capacity of all Parties to the STCW Convention, building trust and having a maritime industry-agreed e-certification model with enabled data-sharing consent. Lastly, other suggestions for the effective implementation of e-certification for seafarers included looking at e-certification as data rather than something in a presentable file format, the MARAD of the certificate-issuing country as the originator of this data, extending the implementation of e-certificates to seafarers' training and integrating seafarers' certificates into one e-certificate.



Source(s): The authors

**Figure 8.** Combined results of challenges to the global implementation of E-certification of seafarers

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#### 4. Data analysis and discussion

This section presents the analysis and discussion of the study with the end view of interrogating the global application of e-certification to seafarers.

##### 4.1 Components of an effective e-certificate

To ensure the effectiveness of an e-certificate in general, it is necessary to look into not only the e-certificate itself but also the whole e-certification system and its stakeholders. The effective implementation of e-certification requires harmonized and synchronized policies, an effective legal framework with associated regulations, strong organizational capacity and resources (Mubarak *et al.*, 2022), in-place security measures (Agustin, Aini, Khoirunisa, & Nabila, 2020; Belaa, 2022; Ghani, Salman, Khudhair, & Aljobouri, 2022) and effective structural design (Li, Guo, Zhang, Wang, Sun, & Bie, 2019), allowing the effective management and control of records, multiple ways of verification, accessibility and ease of use of the system (Chen-Wilson *et al.*, 2009). Further, social acceptance of the technology is also essential and comes through education, training, awareness campaigns and trust-building (Chen-Wilson & Argles, 2010).

As for the application of e-certificates to seafarers, all the aforementioned components for the effective implementation of e-certificates are likewise present in the IMO guidelines on the use of e-certificates of seafarers (IMO, 2023a). The guidelines stipulate that the MARAD should establish appropriate procedures to guarantee that the requirements, capacities and expectations of all relevant stakeholders are duly considered before and during the implementation and utilization of e-certificates. It also provides requirements for security assurance, verification, data format, physical location, data privacy and e-certificate features. Furthermore, it highlights the acceptance of e-certificates by all port state control officers and relevant stakeholders.

##### 4.2 Nature and functions of an international legal framework on e-certification of seafarers

IMO Member States play an essential role in the development and implementation of e-certification for seafarers. For instance, Belarus and the Russian Federation made the first move towards the unified interpretation of the STCW Convention, 1978, as amended, relating to e-certification. Member States, Intergovernmental Organizations (IGOs) and International Non-Governmental Organizations (INGOs) with consultative status to IMO shape the contents of the amendments to the STCW Convention and Code as well as the contents of IMO guidelines, through submission of proposals to IMO and by participating in the Correspondence Group, HTW Sub-Committee and MSC sessions. On the other hand, the HTW Sub-Committee and the MSC act as facilitators toward the completion of action items proposed and agreed upon by the Member States.

The progress toward the approval of amendments to the STCW Convention and the non-mandatory guidelines is generally slow. It can be inferred from Figure 3 that it took five years to finally adopt such amendments and guidelines on the use of e-certificates of seafarers. One factor that affects such progress is the annual interval of HTW Sub-Committee and MSC sessions.

The international legal framework for e-certification of seafarers, established through approved and adopted amendments to the STCW Convention, mandates the use of certificates by all Parties to the Convention in either paper or electronic form. The 2023 amendment defines “original form” under Regulation I/1 paragraph 1 to encompass both paper and electronic certificates with specific requirements for maintaining the accessibility of minimum required data when using an electronic form (IMO, 2023c). Additionally, the associated guidelines (IMO, 2023a) provide a reference for the Parties to the Convention and other stakeholders in implementing e-certification.

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#### 4.3 Merits and demerits of e-certification for seafarers

There are varying views about the merits and demerits of e-certification for seafarers. While there are some demerits to using e-certificates when it comes to accessibility, convenience, time, verification, security and data privacy, they are all outweighed by their merits. These findings are supported by various pieces of literature about the implementation of e-certification across different fields of industry.

The ease of accessing and verifying e-certificates has been highlighted in various studies (Chen-Wilson *et al.*, 2009; Cosgrave, 2018; Herbert *et al.*, 2022; Wu *et al.*, 2001). However, the reliance on internet connections (Cosgrave, 2018; Wu *et al.*, 2001) has been identified as a drawback of e-certification. To address this issue, a suggested solution involves MARAD developing an application allowing seafarers to securely save and retrieve their certificates offline (Behforouzi *et al.*, 2022), a measure already implemented in one of the MARADs, as confirmed by an interview participant.

The research indicates that while e-certificates offer convenience, they pose a challenge for some seafarers due to the requirement of digital literacy. This aligns with another study, which highlighted the difficulty and contention surrounding the use of e-certificates, particularly for individuals lacking proficiency in computer literacy and familiarity with electronic devices (Chen-Wilson *et al.*, 2009). Recommendations include adapting e-certification systems to accommodate those without IT skills. Conversely, there is a suggestion for standardizing digital competences for all seafarers (Hopcraft, 2021), acknowledging the global trends in digitalization.

Various studies corroborate the findings of this study regarding the administration of e-certificates in the maritime industry. E-certificates have been shown to streamline processes and ensure accurate data (Cosgrave, 2018). Another study found that implementing digital certification in Oman reduced the administrative burden of seafarers (Behforouzi *et al.*, 2022), a view supported by DMA (2021). Additionally, digitalization accelerates data retrieval and minimizes errors (Behforouzi *et al.*, 2022).

To address data privacy concerns, a robust certification design with features of seafarers' consent for data sharing with shipping companies is recommended. The IMO guidelines on electronic certificates of seafarers require the inclusion of an electronic signature for verifying identity and data integrity, a feature applied by the HM Government of Gibraltar (2022). Digital signatures have garnered strong support for preventing document falsification (Gillis, Lutkevich, & Brunskill, 2023; Mubarak *et al.*, 2022).

However, the degree of security achieved in e-certification is debatable, paralleling the findings by Cosgrave (2018). The study suggests that an excessive number of system users and managers can compromise such systems, emphasizing the need for robust cybersecurity measures, which is consistent with other studies (Agustin *et al.*, 2020; Ghani *et al.*, 2022). It was found that utilizing blockchain technology can enhance security and document management. In addition, making a certificate electronic enhances its protection against fraud and security breaches, echoing the findings of Mubarak *et al.* (2022).

E-certificates, being digital (Ghani *et al.*, 2022), mitigate the need for seafarers to carry printed certificates, reducing the risk of loss. Further, implementing e-certificates for seafarers reduces processing and traveling costs and stress on individuals. It also enhances the management and control of seafarers' data, which aligns with the IMO's aim for efficient documentation management (IMO, 2023a). Meanwhile, the environmental benefits of e-certificates, such as being paperless and transport-free, were also highlighted during interviews. However, an argument can be made about the potential environmental strain emanating from digital carbon emissions and power usage due to technological progress (Sharma & Dash, 2022). Solutions such as cooler data center locations, green electricity, efficient data management and responsible technology usage for global sustainability are suggested (Sharma & Dash, 2022).

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Through the application of the UTAUT model in examining the usage behavior of key stakeholders – MARAD, seafarers and shipping companies/manning agencies, it was found that at this stage in the evolution of e-certification as applied to seafarers, performance expectancy, effort expectancy, social influence and facilitating conditions have a weak relationship with usage behavior in seafarers' e-certification, deviating from the expectations of the UTAUT model, meaning that those determinants minimally influence stakeholder behavior. Further, the age and gender of the three key stakeholder groups and the experience and position category of seafarers do not affect their usage behavior and its determinants, contradicting the earlier findings of Venkatesh *et al.* (2003) in the specific case of seafarer e-certification. Notably, the study revealed that the stakeholders' field of work significantly moderates their usage behavior, distinguishing it from other variables.

#### *4.4 Challenges to the global implementation of e-certification to seafarers*

The global implementation of e-certification for seafarers faces several challenges. The demerits of using e-certificates found in the study contribute to these challenges, including cybersecurity risks and user competence. In addition, other challenges include infrastructure and equipment limitations, fraudulent certification, international acceptance or recognition issues, lack of technical support, processing inefficiencies, flexibility and adaptability to change, digitalization disparities among countries, coexistence of traditional certificates, trust in digitalization and slow international standardization progress.

The challenge to technological equipment and infrastructure when implementing e-certificates is not unique. Mubarak *et al.* (2022) highlighted this barrier, asserting the need for sufficient funds to strengthen institutional resources. Separately, the challenge of possible non-acceptance or non-recognition of e-certificates by Port State Control officers in different countries can be associated with trust in technology (Mcknight *et al.*, 2009) and policy implementation effectiveness (Mubarak *et al.*, 2022) at a global level.

Moreover, as has been confirmed by the International Telecommunication Union (ITU), (2017) and UNCTAD (2021), there exist substantial differences in digitalization levels across countries. Data from ITU showed that some African and Asian countries have a low Information and Communication Technology (ICT) Development Index (IDI), an index that covers the presence of ICT infrastructure, its utilization and the digital skills level of the population (ITU, 2017). To facilitate seafarer e-certification at a global level, nations with low digital indexes require enhanced ICT capabilities, strong national commitment (Akiwumi, 2022) and international cooperation and technology transfer (UNCTAD, 2022).

### **5. Research limitations and future research**

This study focused solely on the global application of e-certification for seafarers. It may have overlooked specific jurisdictional challenges in e-certificate implementation. As such, there may be other challenges that were not revealed in the research. Additionally, as shown in Table A2, the sample size of seafarers was skewed heavily toward the Philippines, comprising 84% of the 225 participants. While it is acknowledged that the Philippines is a very important jurisdiction for seafarer supply (providing about 25% of global supply (Galam, 2022)), future research could consider a larger sample size with increased global representation of seafarers. Future studies can also focus on digitalization strategies in seafarers' e-certification and on assessing whether the adoption of e-certification represents a lasting shift in maritime documentation practices. Moreover, while this study applied a modified UTAUT model to understand the usage behavior of seafarers, MARAD and shipping companies/manning agencies towards the e-certification of seafarers, future research could apply the original UTAUT model proposed by Venkatesh *et al.* (2003), where different statistical methods are used.



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## 6. Conclusions

This research study investigated the global application of e-certificates of seafarers utilizing a mixed-method approach to data triangulation and methodological triangulation.

The study concludes that e-certificates for seafarers offer significant advantages, including improved accessibility, convenience, real-time verification and enhanced efficiency, with increased data privacy and cybersecurity protection through mechanisms like blockchain technology or digital signatures. While a weak positive correlation suggests limited certainty in stakeholders' usage behavior patterns and its key constructs, there are no statistically significant differences across the three stakeholders' age and gender and the seafarers' length of experience and position category. However, unlike other variables, the study notes that stakeholders' usage behavior on the use of e-certificates is moderated by their field of work.

Further, while the study acknowledges the widespread advantages of using e-certificates for seafarers, it also highlights challenges hindering their global application. Addressing these challenges is deemed crucial for the successful global implementation of e-certification. The integration of the best practices shared by the participants already implementing seafarers' e-certification systems in their respective jurisdictions, coupled with their perspectives on global implementation, may offer viable solutions to overcome these challenges.

Although there is strong support from the maritime industry for the entire replacement of seafarers' traditionally printed certificates with e-certificates, its global implementation will not be possible until such time that all Parties to the STCW Convention: (1) trust the integrity and reliability of digital systems; (2) recognize the advantages of implementing e-certificates for seafarers and (3) have adequate digitalization capacity (skills and infrastructure) to facilitate the use and acceptance of e-certificates for seafarers. It is anticipated that conventional printed certificates and e-certificates of seafarers will coexist while the global maritime community effectively addresses the hindrances identified in this study. Moreover, national commitment and international cooperation will be crucial in a scenario where e-certificates exist across the board. The STCW Convention, 1978, as amended, along with corresponding IMO guidelines, will remain key instruments in the international legal framework for implementing seafarers' e-certification.

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### Appendix

The supplementary material for this article can be found online.

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