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Concept of e-certification: interrogating its global application to seafarers

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WORLD MARITIME UNIVERSITY

DISSERTATION

CONCEPT OF E-CERTIFICATION:

INTERROGATING ITS GLOBAL APPLICATION TO SEAFARERS

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): .....

(Date): 25 September 2023 .....

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Abstract

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One of the contemporary issues in the maritime industry in terms of digitalization is the use of electronic certificates (e-certificates) of seafarers. This study examined the concept of e-certification and its global application to seafarers. Data triangulation and methodological triangulation were applied in the study. Specifically, a scoping review was conducted to analyze the components of effective e-certificates and a document analysis was employed to evaluate the nature and functions of the international legal framework of seafarers' e-certification. This comprised Stage 1 of the study, which informed the development of the research instruments (survey questionnaires and semi-structured interviews) for Stage 2. A mixed method approach was applied in the second stage, which included the analysis of qualitative and quantitative data. A descriptive and inferential statistical analysis was applied to the data collected from the survey questionnaires guided by a modified Unified Theory of Acceptance and Use of Technology (UTAUT) model. Further, a conversion of qualitative data into quantitative values (QQVs) was applied.

The results of the study showed that there are a number of merits in the implementation of seafarers' e-certificates, which outweighed the presence of certain drawbacks associated with it. Additionally, a number of challenges to the global application of seafarers' e-certificates were identified. Nevertheless, the analysis showed that these challenges can be addressed by integrating the best practices in the maritime industry relating to seafarers' e-certification and by applying the perspectives of maritime industry professionals who have extensive and practical experience in the implementation of the e-certification of seafarers. In addition, strong national commitment and international cooperation are needed to enhance the innovative capabilities of developing nations and facilitate technology transfer, thus addressing the gap in the level of digitalization between countries. The study concluded that, although there is strong support from the maritime industry toward the entire replacement of seafarers' traditional printed certificates with e-certificates, the coexistence of these two formats would still remain until such time that the crucial challenges are effectively addressed. The STCW Convention, in conjunction with the relevant IMO guidelines, functions as the international legal framework for the effective global application of electronic certification for seafarers.

KEYWORDS: Electronic certification, E-certification, Digitalization, Seafarers, E-certificates merits, E-certificates demerits, E-certification challenges, Digital certificates, Maritime industry

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List of Abbreviations

AI	Artificial Intelligence
BIMCO	The Baltic and International Maritime Council
CA	Certificate Authority
DMA	Danish Maritime Authority
EE	Effort Expectancy
FAL	Facilitation Committee
FC	Facilitating Conditions
HTW	Human Element, Training and Watchkeeping
IBM	International Business Machines Corporation
ICS	International Chamber of Shipping
ICT	Information and Communication Technology
IDI	ICT Development Index
IGO	Intergovernmental Organization
IMO	International Maritime Organization
INGO	International Non-Governmental Organization
ITU	International Telecommunication Union
MARAD	Maritime Administration
MARINA	Maritime Industry Authority
MSC	Maritime Safety Committee
PE	Performance Expectancy
QQV	Quantitative-Qualitative Values
RQ	Research Question
SI	Social Influence
SPSS	Statistical Package for the Social Sciences
STCW Convention	International Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended
UNCTAD	United Nations Conference on Trade and Development
UTAUT	Unified Theory of Acceptance and Use of Technology
WMU	World Maritime University

Chapter 1: Introduction

1.1 Background

Printed certificates have been widely used as official documents attesting a fact. However, in consonance with the continuing global digitalization trend, they are gradually being replaced by electronic certificates or e-certificates. For instance, some jurisdictions are now using e-certificates for e-government certification services (Wu et al., 2001); academic certification (Chen-Wilson et al., 2009); land registration (Syarief, 2021; Haryowardani, 2022), medical certification (Li et al., 2022), birth registration (Smulian et al., 2001), ship certification (Cosgrave, 2018; Song, 2021), and seafarers certification (DMA, 2021), among others.

Focusing on the shipping industry, the International Maritime Organization (IMO) which is a specialized agency of the United Nations responsible for the improvement of the safety and security of international shipping and the prevention of pollution from ships, also sheds light on the use of e-certification for seafarers by issuing corresponding guidelines (IMO, 2014).

Globally, the maritime industry employs a substantial workforce of around 2 million seafarers manning a fleet of over 50,000 merchant vessels engaged in international trade (ICS, 2022). To ensure that all seafarers serving on board seagoing ships are qualified and fit for their duties, the International Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW Convention) requires that seafarers must be duly certificated. The fulfillment of this requirement is an obligation of Parties to the STCW Convention where Article 1 (General obligation under the Convention) paragraph 2 states that "The Parties undertake to promulgate all laws, decrees, orders and regulations and take all other steps which may be necessary to give the Convention full and complete effect..." (IMO, 2017). As of 2020, there are 165 countries, representing 99.03% of world tonnage, that are Parties to the Convention (Manuel & Baumler, 2020).

Historically, the conventional method for documenting compliance with IMO regulations has involved the issuance of paper certificates that are signed by Governments or recognized organizations acting on their behalf (IMO, 2013). Since

the entry into force of the STCW Convention on 28 April 1984 (IMO, 2019a), a certificate has been issued to seafarers in accordance with the Convention. It was only in 2013 that the IMO issued guidelines for the use and acceptance of "printed versions of electronic certificates" (IMO, 2013). It was then revised in 2014 to facilitate the use and acceptance of "electronic certificates" (IMO, 2014). The said guidelines cover all documents issued by an Administration or its representatives to show compliance with IMO requirements and to describe crewing requirements, operation conditions, and ship equipment carriage requirements (IMO, 2016).

On the other hand, with reference to the STCW Convention, which mainly focuses on the competency of seafarers, a "certificate" is defined 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".* Furthermore, 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). In view of the ambiguous provisions in the STCW Convention about the application of e-certificates and challenges with the definition of "original form", proposals were received by the IMO calling for the development of amendments to the STCW Convention and Code regarding the use of electronic certificates (IMO, 2018; IMO, 2019b).

Consequently, an initial review of Circular Letters issued by the IMO pertaining to the use of e-certificates was conducted. At present, only a few Member States have communicated their acceptance and issuance of e-certificates. They include Germany (Circular Letter No. 3712), Sierra Leone (Circular Letter No. 3715), Malta (Circular Letter No. 3794), United Kingdom of Great Britain and Northern Ireland (Circular Letter No. 3812), France (Circular Letter No. 3821), and Portugal (Circular Letter No. 3822). In addition, the communications of the aforementioned Member States only pertain to the ship's certification and not to the seafarer's certification.

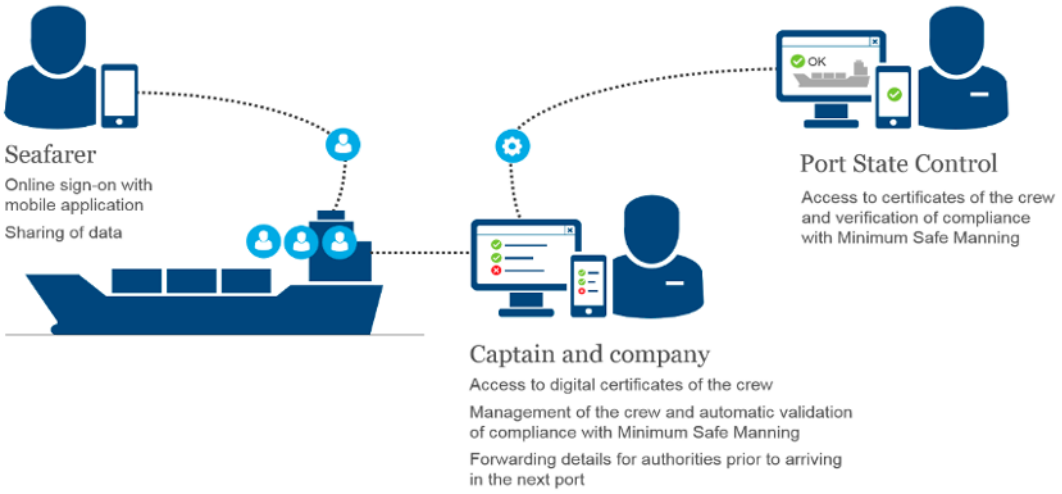
During the 107th session of the Maritime Safety Committee (MSC) held from May to June 2023, amendments to the STCW Convention regarding the use of electronic certificates and documents for seafarers were adopted. These amendments are anticipated to come into effect on January 1, 2025. Additionally, the IMO accepted the

corresponding guidelines, MSC.1/Circ.1665, regarding the utilization of electronic certificates for seafarers (IMO, 2023a).

One of the countries that initiated the introduction of digital certificates for seafarers is Denmark. With the digitalization of seafarers' certificates, the Danish Maritime Authority (DMA) anticipates the reduction of administrative burdens of all stakeholders within the maritime sector and the provision of a higher level of security and validity with prompt and automatic verification as its primary features. It also predicts that Port State Control will become smoother and more efficient (DMA, 2021). DMA illustrates its vision as shown in Figure 1.

Figure 1

Vision of E-certification by Danish Maritime Authority



Note. From *Digital certificates for seafarers*, by DMA, 2021 (https://dma.dk/seafarers-and-manning/discharge-book-and-certificates-/digital-certificates-for-seafarers).

1.2 Problem Statement

As outlined in Chapter 1.1, electronic certification is not a recent innovation. Its implementation has been in existence for a considerable period of time. The practical utilization of this technology has been documented across various domains,

encompassing the sector of shipping as well. However, the utilization of e-certification for seafarers has not been widely adopted up until the present day.

Although there are already some initiatives on the use of e-certificates in attesting the proficiency and competency of seafarers under the STCW Convention as illustrated by the DMA example, there is no existing study about its global application to seafarers. As such, this study intended to analyze the concept of e-certification and evaluate its global application to seafarers.

1.3 Research Aims and Objectives

The study aimed to interrogate the concept of e-certification and evaluate its global application to seafarers. To achieve this, the following objectives were proposed:

- To determine the attributes of an effective e-certificate;
- To analyze the nature of the international legal framework on e-certification for seafarers as well as its functionality;
- To analyze the merits and demerits of e-certification for seafarers; and
- To analyze the challenges to e-certification assuming it will be implemented in the global setting.

1.4 Research Questions

The following research questions were posed to achieve the study's aims and objectives:

1. What makes an effective e-certificate?
2. What is the nature of the international legal framework on e-certification for seafarers and how does it work?
3. What are the merits and demerits of e-certification for seafarers?
4. What are the challenges assuming that e-certification will be implemented globally?

1.5 Research Methodology and Methods

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

Heale & Forbes (2013) explain that triangulation in research uses more than one approach to researching a question in order to increase confidence in the findings through the confirmation of a proposition using two or more independent measures. Data triangulation makes use of several data sources in a study (Bans-Akutey & Tiimub, 2021) while methodological triangulation can be used to enhance the analysis and the interpretation of findings. As data are drawn from multiple sources, it broadens the researcher's insight into the different issues underlying the phenomena being studied (Bekhet & Zauszniewski, 2012).

Chapter 2: Review of Related Literature

This Chapter reviews the existing literature about e-certification including the contemporary technologies for e-certification, its application to seafarers, as well as the relevant theories that could be applied in understanding the concept of e-certification for seafarers. Additionally, it outlines the gaps in the existing literature about the application of e-certificates to seafarers which substantiates the problem statement of the study.

2.1 Certification and Its Nature

Certification is defined by the Oxford English Dictionary (n.d.) as a noun that refers to "the action or process of providing someone or something with an official document attesting to a status or level of achievement". In an academic setting, certification frequently refers to the granting of a certificate or other testimonial that formally acknowledges and records achievement in the evaluation of knowledge, skills and/or competencies, as the last stage in completing a qualification (Weiss et al., 2009; Singhal and Pavithr, 2015 as cited in Mayowa et al., 2021).

In the context of seafaring, considering the danger from the harsh environmental conditions and the nature of the work of seafarers, certification of seafarers, along with education and training, has been integral to ensuring safe voyages of people, goods, and vessels. Historically, the pertinent international legal documents established under the framework of the International Labour Organization (ILO) consisted of the Officers' Competency Certificates Convention, 1936 (No. 53), and the Certification of Able Seamen Convention, 1946 (No. 74). ILO Convention No. 53 was the inaugural endeavor within an international platform to establish regulations pertaining to the competence of seafarer officers. The Convention came into effect on March 29, 1939, and was ratified by 37 states, followed by 13 subsequent denunciations (Manuel & Baumler, 2020).

The growth of the shipping industry faced some challenges such as the impact of flags of convenience as well as a series of notable maritime accidents throughout the latter half of the twentieth century. These incidents placed significant worldwide

attention on the industry and its human element which further emphasized the necessity for an international legal framework that extends beyond the parameters set by the ILO. As a result, the STCW Convention was established in 1978. It sets minimum requirements for education, training, certification and watchkeeping for seafarers that State Parties are required to meet or surpass. The Convention is a legally binding treaty in the field of public international law, characterized by its technical, regulatory, and preventive nature. It currently serves as the principal global framework for the education and certification of seafarers. As of 2020, there are 165 Contracting States to the STCW Convention, which represent approximately 99.03% of the global tonnage (Manuel & Baumler, 2020).

In contemporary times, certification is often either in the form of a printed certificate or an electronic certificate. Printed certificates are usually written and printed using special paper (Mayowa et al., 2021) or security paper (Agung et al., 2022) while e-certificates are stored and can be retrieved digitally (Ghani et al., 2022).

2.2 Electronic Certification

The term “electronic certificate” or “e-certificate” denotes different meanings across different fields. Chen-Wilson et al. (2009) explained that in the realm of online marketing, this particular concept is commonly denoted as e-voucher and e-currency. Additionally, it is also recognized as an e-card and printable certificate template, as well as an access token in the context of system authentication.

In the context of seafaring, the innovation of certificates from printed paper-based certificates to e-certificates has likewise been adopted by the maritime industry since 2013 (IMO, 2013). Even while the development of amendments to the Convention relating to the use of e-certificates was still in progress, some Member States have been implementing the use of e-certificates for seafarers either in full implementation or piloting stage, such as Denmark (DMA, 2021), HM Government of Gibraltar (HM Government of Gibraltar, 2022), Panama (PMA, 2020), and the Philippines (MARINA, 2022).

IMO (2023b) defined electronic certificate (for seafarers) as *“a certificate issued in an electronic format established/approved by the Administration to ensure viewing*

compatibility for all intended verifiers". This is similar to Chen-Wilson et al.'s (2009) definition of "e-certificate of qualification" to which this dissertation is pertaining. They explained that it is a reward certificate that does not necessitate the use of physical paper, nor does it pertain to a digital signature or any alternative means of authentication. Nevertheless, an e-certificate of qualification involves authentication within its process. An example of this is the e-certificate being issued by HM Government of Gibraltar for its ships and seafarers which contain digital signatures and are signed by a trusted Certificate Authority (CA) (HM Government of Gibraltar, 2022). Table 1 further outlines the difference between an e-certificate of authentication and an e-certificate of qualification.

Table 1

E-certificate of Authentication and E-certificate of Qualification

Criteria	E-certificate of authentication[a]	E-certificate of Qualification of Seafarers[b]
Issuing Entity	Issued by a CA	Issued by or under the authority of the Administration or recognized by the Administration
Purpose	To authenticate the veracity of one's identity and possessions	To ensure that a seafarer holds an authentic and valid electronic certificate, so as to be considered and treated as holding an original certificate on board the ship
Usage	Typically applied to a particular environment or set of organizations	Authorizes the holder to serve on board the ship as stated in the certificate
Identity Verification	Identifies the individual external to the system	Identifies a seafarer who was issued a certificate by the Administration of the certificate-issuing country
Content Verification	Verifies materials that are external to the system. Typically, materials are paper-based in nature. The user is required to furnish all the necessary materials as evidence.	Verifies the qualification of seafarers. The Administration of the certificate-issuing country is required to provide various means of verification.
Trust	Anyone can be a CA, but it is essential to identify and select a trusted CA. This process may involve multiple layers of CAs.	Requires electronic signature, a unique tracking number, and other data to serve as a method of authentication of the issuer and contents of the electronic data.

Note. [a]Adapted from "Towards an secured e-Certificate System for use in e-Portfolios" by Chen-Wilson, L., Blowers, R., Gravell, A., and Argles, D., 2009, *International*

conference on Multimedia and Information and Communication Technologies in Education (m-ICTE 2009); and [b]Adapted from *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended* (2017 Edition), by IMO, 2017; *Guidelines on the use of electronic certificates of seafarers* (MSC.1/Circ.1665) by IMO, 2023.

In various literature, the electronic format of a certificate is called either an electronic certificate (Cosgrave, 2018; Mubarak et al., 2022; Somsuk & Thakong, 2020; Song, 2021) or a digital certificate (e.g. in DMA, 2021; Herbert et al., 2022). As such, this dissertation uses these terms interchangeably for seafarer's certificate.

2.3 Advantages and Disadvantages of E-certification

The emergence of e-certification provided a lot of advantages to different industries. According to Mubarak et al., (2022), e-certification can prevent data and information from being falsified; supports national security by protecting information that belongs to the government; maintains and ensures the authenticity of information dissemination; and guarantees security with quicker fraud detection. Additionally, the authors asserted that it can reduce bureaucratic inefficiency and avoid corruption by promoting transparency. Digital certificates can also be integrated into smartphone applications allowing for increased convenience for users as compared to paper certificates (Herbert et al., 2022).

In the shipping industry, e-certificates of ships can drive administrative processes faster while ensuring their regulated implementation and the completeness of data input (Cosgrave, 2018). However, Cosgrave (2018) also argued that e-certificates are primarily hindered technically by security issues relating to data or information integrity, confidentiality, and availability if they are viewed as digital data.

2.4 Contemporary Technologies for E-certification

Taking into consideration the nature of e-certification as well as its advantages and disadvantages, this sub-section discusses the latest technologies for e-certification that are available in the industry which includes the blockchain technology and the

digital signature possibilities.

2.4.1 Blockchain Technology

Blockchain technology is a distributed and unalterable ledger that enhances the process of documenting transactions and monitoring assets inside a corporate network (IBM, 2023). It is a sophisticated database technique that facilitates the transparent exchange of information within a network of businesses (Amazon Web Services, 2019). It was initially introduced by Satoshi Nakamoto as the underlying technology for the digital currency Bitcoin (Nakamoto, 2008). At present, it is used in a variety of other disciplines, including e-commerce, smart cities, health care, and the creation of digital certifications (Agustin et al., 2020). This is due to its strong technical features and logical structure. Among its features are decentralization, immutability, consensus, scalability, data validity, and security, as well as controlled privacy (Zheng et al., 2017; Makridakis & Christodoulou, 2019).

According to Makridakis and Christodoulou (2019), due to its decentralized nature and permanently unchangeable storage layer, blockchain has shown to be appealing for the certification and storage of various types of information, including employment qualifications, transactions, sensitive data or documents, as well as the verification of identities. Certification using blockchain technology can be used in academic certificates, passports, driver's licenses (Makridakis & Christodoulou, 2019), financial certification (Zhu & Wang, 2019); and even in ships and seafarers' competency certification (IMO, 2013).

Consequently, blockchain is utilized to ensure that the e-certificate is secure and cannot be readily falsified, copied, or even replaced by individuals without access privileges (Agustin et al., 2020). In terms of data sharing, it can share data in ways that can be verified without losing control over the information's ownership. This is contrary to the typical centralized data-sharing systems where data are consolidated and stored on a third-party platform, exposing them to serious security concerns and limited database storage space (Ghani et al., 2022). However, in terms of privacy, Beck et al. (2018) underlined that while blockchain user identification fosters accountability, it also poses privacy concerns. For instance, blockchain-based voting is founded on the idea that each vote may be traced back to the voter's identity,

making the promise of anonymous voting problematic or impossible. User authentication and accountability could possibly be enabled by pseudonyms, but privacy concerns may challenge the use of blockchain which may lead to institutional pressures that prohibit blockchain from reaching its full potential.

2.4.2 Digital Signature

A digital signature is a mathematical method for verifying the legitimacy and consistency of a digital message, document, or piece of software. It gives much more intrinsic security than a handwritten signature or stamped seal, yet it is the digital version of them. In digital communications, the issue of tampering and impersonation is what it aims to address (Gillis et al., 2023). Adobe (2023) describes a digital signature as an e-signature that is protected by a digital certificate and offers the highest level of identity assurance when working with digital documents. Meanwhile, Lim (2002) and Microsoft (2023) claimed that a digital signature is more commonly known as a *digital certificate*. The issuance of such digital certificates is commonly done by a CA, which is a purportedly dependable third-party organization. Microsoft (2023) further explained that a digital certificate is required for a digital signature because it issues a public key that can be used to validate the private key linked to a digital signature.

In terms of e-certification, Mubarak et al. (2022) found that the falsification of information by untrusted sources has declined after the adoption of digital signatures on every document. However, Lim (2002) emphasized that among the four functional components of typically paper-based handwritten signature elements, (integrity, non-repudiation, authenticity, and confidentiality), non-repudiation remains a barrier to using digital signatures. Non-repudiation refers to “the assurance that someone cannot deny the validity of something” (Cryptomathic, 2023). In terms of information security, non-repudiation is a legal and procedural concept that demonstrates the legitimacy of a data transfer or a message by providing indisputable proof of both integrity and authenticity (Chin, 2022). However, in the opinion of Czagan (2019), digital signatures are used to provide non-repudiation. Czagan also claims that security is broken when private keys are stolen and, therefore, suggests that private keys should be stored on smart cards to reduce the risk of the theft.

2.5 Theories and Models on Acceptance and Use of Technology

While the use of e-certificates brings some advantages as discussed in the previous section, the global readiness of the maritime industry on the transition from the use of traditionally printed certificates to e-certificates is still unknown, specifically in terms of stakeholders' acceptance and use of the e-certification system. This may be associated with trust in technology. In general, trust often influences behaviors, decisions, dispositions, institutions, and social networks (Kramer & Tyler, 1996 as cited in Rousseau et al., 1998). At an individual level, trust is defined by Rousseau et al., (1998) as the willingness of an individual to rely on another party based on the perceived qualities and attributes of the latter. Similarly, trust in technology is defined by McKnight et al. (2009) as the inclination to rely on a certain technological system or device in a given context, even when there is a potential for adverse outcomes. The authors explained that trust in technology can be exhibited in an individual's behavior.

In examining user behavior in terms of acceptance and use of technology, there are various theories and models that provide guidance. Venkatesh et al. (2003) and Momani (2020) outlined a number of prominent theories and models that can be applied in determining the acceptance ability of stakeholders to adopt new technologies which 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).

Table 2 presents a brief description of each model and theory. These models and theories draw from the fields of social psychology, social science, and information technology. While they have their own strengths, they also exhibit some weaknesses (Venkatesh et al., 2003; Momani, 2020).

Table 2

Prominent Theories/Models that can be Applied in Determining the Acceptance and Use of Technology

Theory	Developer and Year	Field of Development	Strengths	Weaknesses
Theory of Reasoned Action (TRA)	Ajzen and Fishbein, 1980	Social Psychology	• one of the most fundamental theories of human behavior and is designed to explain virtually any human behavior	• general • does not refer to other variables that affect behavioral intention like fear, threat, mood, or previous experience
Theory of Planned Behavior (TPB)	Ajzen, 1985	Social Psychology	• successfully applied to the understanding of individual acceptance and usage of many different technologies	• suggests that the behaviors are already planned and it does not refer to other variables that affect behavioral intention
Technology Acceptance Model (TAM)	Davis, 1986	Information Technology	• powerful model for technology applications • replaced TRA's attitude toward behavior with two technology acceptance measures: perceived usefulness and perceived ease of use • less general than TRA and TPB	• does not include the TRA's subjective norms • does not provide any feedback on some factors like integration, flexibility, completeness of information, and information currency • does not specify how expectancies are influencing the behavior
Combined TAM and TPB (C-TAM-TPB)	Taylor and Todd, 1995	Information Technology	• combines the TPB model from the social psychology field with TAM from the IT field in order achieve better use of TPB in technology acceptance	• TAM constructs are not fully reflected • factor of behaviors' planning is not stated • does not pay attention to fear or threat concerning use

Theory	Developer and Year	Field of Development	Strengths	Weaknesses
Model of PC Utilization (MPCU)	Triandis, 1979	Information Technology	• suitable to predict individual acceptance of many technologies • successful in understanding and explaining the usage behavior with a voluntary causative	• complexity factor has computer and technology usage and an indirect impact on perceived short-term consequences
Innovation Diffusion Theory (IDT)	Rogers, 1983	Social Science	• has the ability to study any kind of innovations • explains and predicts the rates of the adoption factors of innovation	• general • does not indicate how the attitude impacts on accepting or rejecting the decisions, or how innovation factors affect decisions
Motivational Theory (MM)	Deci and Ryan, 1985	Social Psychology	• has many applications on motivational studies, learning, and health care • can be applied for understanding new technology adoption and use	• still needs many factors to be adopted by it so as to become more suitable to study technology usage
Social Cognitive Theory (SCT)	Compeau & Higgins, 1995	Social Psychology	• one of the most powerful theories of human behavior • applied to determine the perceived usefulness, extrinsic motivation, outcome expectations, job-fit, and relative advantage	• self-efficacy and anxiety are nonsignificant in this theory

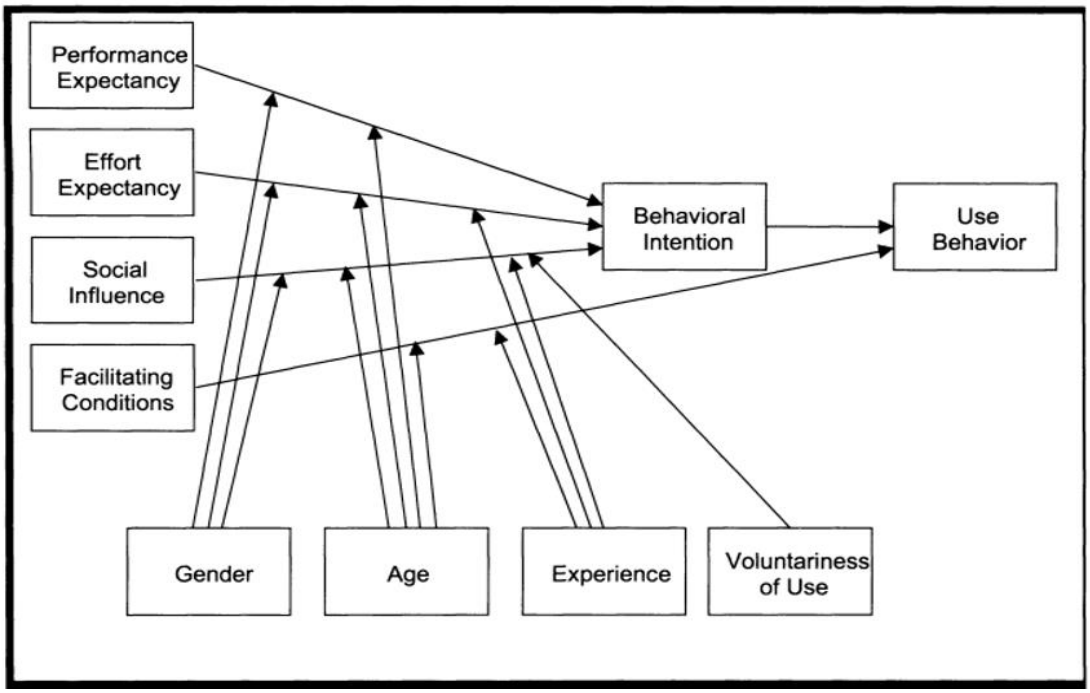
Note. Adapted from "The Unified Theory of Acceptance and Use of Technology" by Momani, A. M., 2020, *International Journal of Sociotechnology and Knowledge Development, 12*(3), 79–98 (https://doi.org/10.4018/ijskd.2020070105); and "User Acceptance of Information Technology: Toward a Unified View" by Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D., 2003, *MIS Quarterly, 27*(3), 425-478 (https://doi.org/10.2307/30036540).

2.6 Unified Theory of Acceptance and Use of Technology (UTAUT)

In view of numerous existing models and theories relating to the acceptance and use of technology, researchers are faced with the challenge of selecting from a wide array of models and theories and often must decide between selectively combining constructs from various models or favoring one particular model while largely disregarding the input from other alternatives (Venkatesh et al. 2003). As such, the eight existing prominent models and theories including their extensions relative to individual acceptance as outlined in Table 2 were reviewed by Venkatesh et al. (2003), who subsequently formulated a unified model called the Unified Theory of Acceptance and Use of Technology (UTAUT) as illustrated in Figure 2.

Figure 2

UTAUT Model



Note. From “User Acceptance of Information Technology: Toward a Unified View” by Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D., 2003, *MIS Quarterly, 27*(3), 425-478 (https://doi.org/10.2307/30036540).

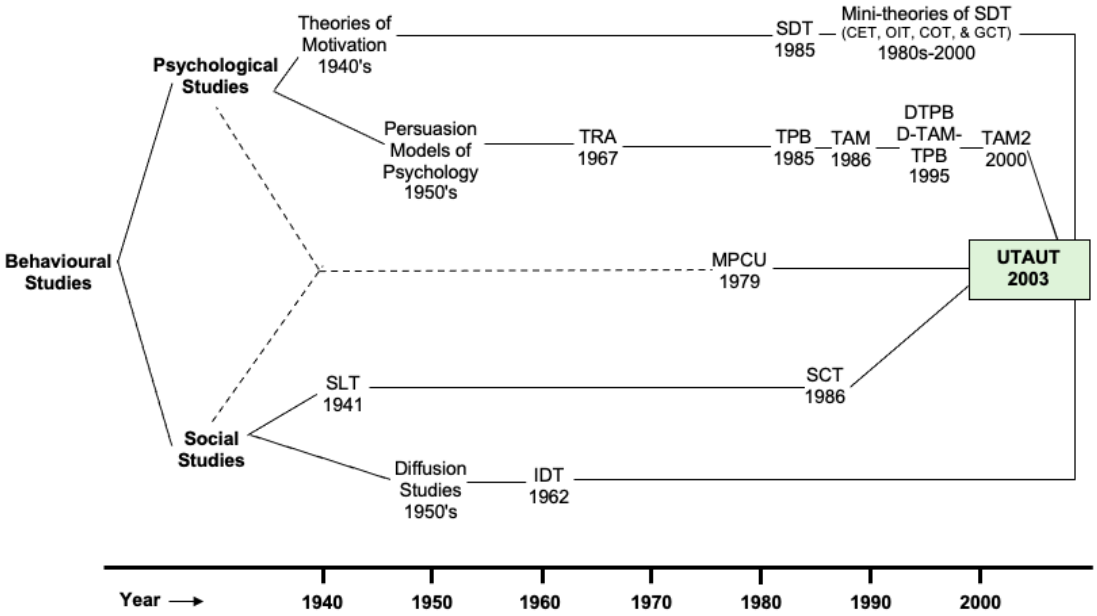
The UTAUT model suggests that the actual use of technology is determined by behavioral intention. Performance expectancy, effort expectancy, social influence, and facilitating conditions are four essential factors that have a direct impact on how likely people are to adopt the new technology. Such factors are moderated by age, gender, experience, and voluntariness of use (Venkatesh et al., 2003). The authors also claimed that this theory offers managers a helpful tool for determining the likelihood of success for the introduction of new technologies and aids them in understanding the factors that influence acceptance so they can proactively design interventions targeted at user populations that might be less likely to use or adopt new systems. The model defines the following core determinants of intention and usage of technology, as follows:

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

Figure 3 shows the development of the UTAUT model which encompasses the behavioral studies that are associated with psychological and social studies.

Figure 3

Development of UTAUT Model



Note. From "The Unified Theory of Acceptance and Use of Technology" by Momani, A. M., 2020, *International Journal of Sociotechnology and Knowledge Development, 12*(3), 79–98 (https://doi.org/10.4018/ijskd.2020070105).

In view of the comprehensiveness of UTAUT, the researcher viewed it as the most suitable theory for the study. UTAUT investigates how technology acceptance is influenced by factors which include performance expectancy, effort expectancy, social influence, and facilitating conditions. This theory has been widely used in examining the acceptability of new technologies such as e-learning systems (Abbad, 2021), e-books (Lawson-Body et al., 2018), Artificial Intelligence (AI) tools (Ventakesh, 2022), electronic document management systems (Ayaz & Yanartaş 2020), and e-government services (Kurfali et al., 2017; Puspitasari et al., 2019; Maznorbalia & Awalluddin, 2020). However, there was no literature found regarding its application to e-certification of seafarers.

2.7 Chapter Summary

It is established by the existing literature that e-certificates are being used in different fields such as the financial sector (Zhu & Wang, 2019), medical field (Li et al., 2022; Smulian et al., 2001), and maritime industry (Cosgrave, 2018; Song, 2021; DMA, 2021). Likewise, their advantages over the traditionally printed certificates as well as some drawbacks have been highlighted in this Chapter.

In terms of its application to seafarers, it was found that only a few Member States have communicated the use of e-certificates for seafarers to IMO despite the existence of IMO guidelines since 2013. It has been highlighted in the literature that the global application of e-certification to seafarers has not yet been studied. In view of this, this dissertation explores the concept of e-certification and interrogates its global application to seafarers by analyzing what makes an effective certificate; analyzing the international legal framework on e-certification for seafarers including its functionality; analyzing its merits and demerits, as well as the challenges assuming e-certification will be implemented globally, using the UTAUT model as a guide.

Chapter 3: Research Methodology and Methods

This chapter discusses the methodological framework applied to the study in order to interrogate the global application of e-certification to seafarers. Recalling the research gap identified, the study focuses on the objectives outlined in chapter one which cover the following areas:

- Attributes of an effective e-certificate;
- Nature of the international legal framework on e-certification for seafarers as well as its functionality;
- Merits and demerits of e-certification for seafarers; and
- Challenges to e-certification assuming it will be implemented in the global setting.

3.1 Methodological Approach and Rationale

To address the research objectives, the study employed a mixed-methods approach, specifically data triangulation and methodological triangulation which led to the compilation and analysis of both qualitative and quantitative data. Morse (1991) stated that the purpose of mixed method design is to acquire diverse but complementary data on the same topic in order to better comprehend the research issue. The purpose of this design is to combine differing strengths and nonoverlapping weaknesses of quantitative and qualitative approaches (Patton, 1990 as cited in Creswell & Plano Clark, 2007). Since the existing literature regarding the e-certification of seafarers is very limited, the researcher opted to utilize other data sources. Additionally, different methodological approaches were applied. Such approaches were adopted in order to acquire a deeper understanding of the issue.

According to Bekhet & Zauszniewski (2012), methodological triangulation is the use of more than one type of method to explore a phenomenon. Similarly, Morse (1991) and Denzin (2017) asserted it as the use of at least two methods, usually quantitative and qualitative. As Valencia (2022) explained, triangulation is a concept that was initially employed within the field of navigation, wherein numerous reference points

are utilized to get the precise coordinates of an unknown location. It has been proven to be useful in providing confirmation of findings, more extensive data, higher validity, and a better understanding of the phenomena being examined. While many researchers have employed this well-established technique, there are few published examples. On the other hand, data triangulation utilizes different sources of data in a study (Bans-Akutey & Tiimub, 2021). Data triangulation broadens the researcher's understanding of the underlying issues of the phenomenon being investigated (Bekhet & Zauszniewski, 2012).

The study is composed of two (2) stages. The first stage applied qualitative analysis through a scoping review of existing literature to address RQ1. In addition, document analysis was conducted using legal documents to answer RQ2. Thereafter, instruments were developed using the results of stage one - semi-structured interview questions and survey questionnaires. These instruments were then used in the second stage, where both qualitative and quantitative analyses were conducted to address RQ3 and RQ4.

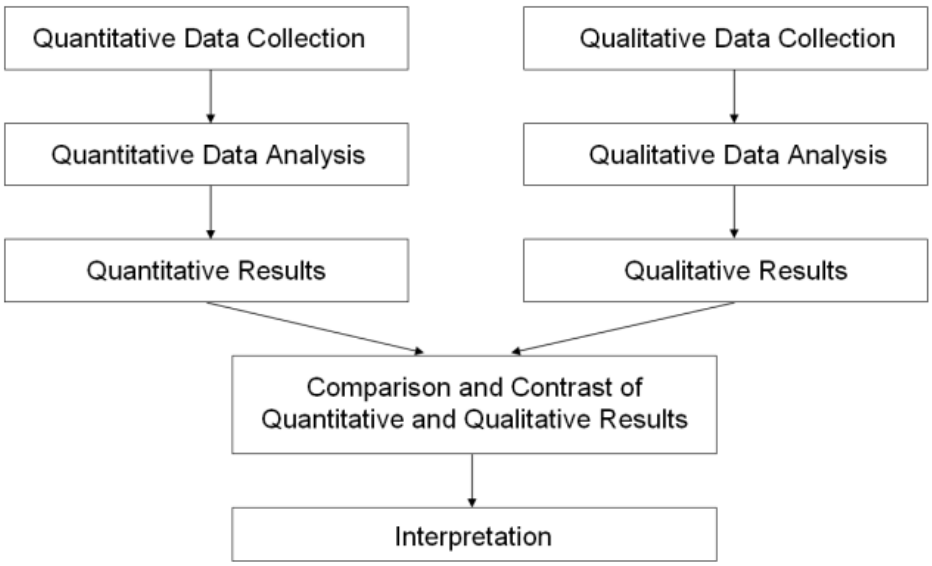
More specifically, in order to understand and analyze the concept of an effective e-certificate, a scoping review of existing literature was conducted. According to Arksey & O'Malley (2005), this method is used to map the concepts and sources of evidence underlying a research field. Likewise, Peters et al. (2021) explained that a scoping review is a type of evidence synthesis with the purpose of mapping and identifying relevant evidence that satisfies predetermined inclusion criteria pertaining to the concept, context, field, topic, or issue being investigated.

Subsequently, document analysis was employed to examine qualitatively the nature of the international legal framework on e-certification for seafarers as well as how it functions. Document analysis is a qualitative methodical process for assessing or evaluating both printed and electronic documents. It necessitates the examination and interpretation of data in order to derive meaning, acquire comprehension, and advance empirical knowledge (Corbin & Strauss, 2008). Documents can be used as a stand-alone data source for studies if it is the only necessary source required for interpretive paradigm-based investigations (Bowen, 2009).

As to the second stage of the study, since the availability of secondary data about seafarers' e-certification is very limited, the researcher developed instruments (survey questionnaires and semi-structured interview questions) to gather primary data from the relevant stakeholders - seafarers, shipping companies/manning agencies, and MARAD. This was done to identify and analyze the merits, demerits, as well as possible future challenges of the implementation of e-certification for seafarers. A convergence model of mixed methods triangulation design (Creswell & Plano Clark, 2007) as shown in Figure 4 was adopted in this stage of the research where the researcher collected and analyzed qualitative data from the interview and surveys separately. Subsequently, the quantitative data derived from surveys were also analyzed independently. The results were integrated and interpreted to answer the RQ3 and RQ4.

Figure 4

Convergence Model of the Triangulation Design of Mixed Methods

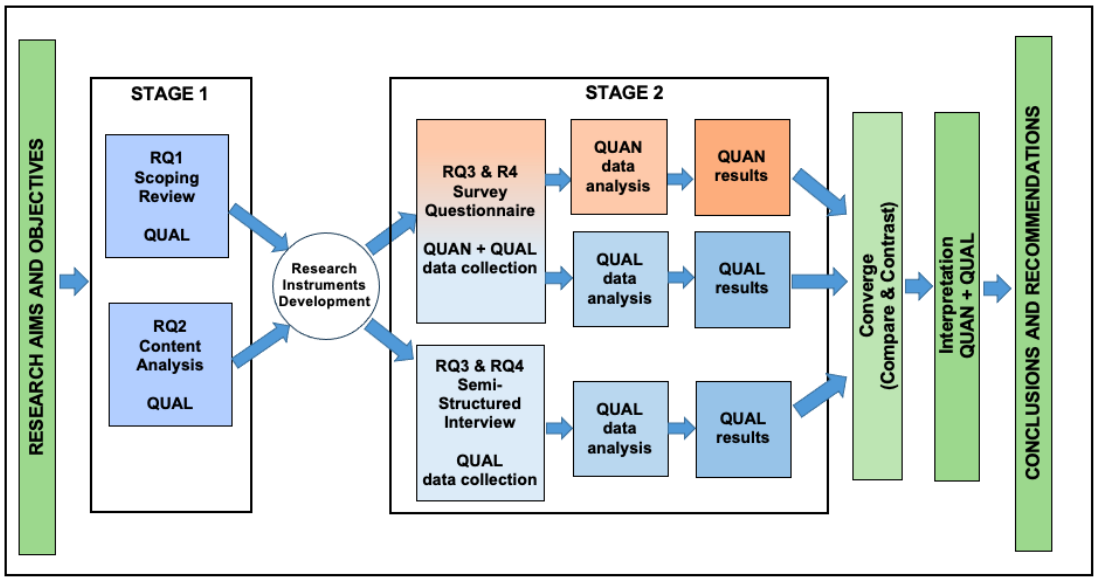


Note. From *Designing and conducting mixed methods research* by Creswell, J.W. & Plano Clark, V. L., 2007. Copyright 2007 by SAGE.

Figure 5 illustrates the overall methodological framework of the study as previously described.

Figure 5

General Methodological Framework of the Study

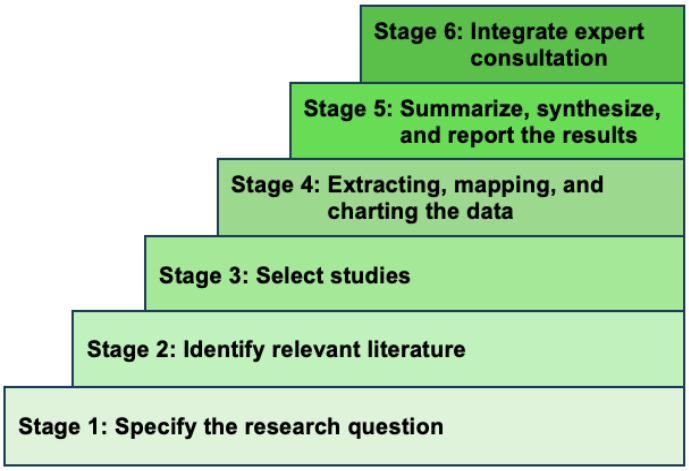


3.1.1 Scoping Review

This study adopted Arksey & O'Malley's (2005) framework for scoping review which consists of six (6) stages as illustrated in Figure 6.

Figure 6

Arksey & O'Malley Scoping Review Framework



Note. Adapted from "Scoping studies: Towards a Methodological Framework," by Arksey H. and O'Malley L., 2005, *Int J Soc Res Methodology.*

Stage 1: Specify the research question

Since the researcher intended to employ a scoping review method to answer RQ1, the identified research question for the first stage is “What makes an effective e-certificate?”.

Stage 2: Identify relevant literature

Guided by the research question, Google Scholar was used as the primary database for the literature searches. In addition, official websites were also utilized in gathering relevant literature regarding certificate attributes. The keywords used include “electronic certification”, “e-certificates”, “digital certificates”, and “e-certification application”.

Stage 3: Selecting studies

In order to select the most relevant and valid studies, inclusion and exclusion criteria, presented in Table 3, were established. The criteria were used to filter the literature search in the database as well as in reviewing and selecting the studies to be included for the next stage. In selecting studies, the article title and abstract were reviewed.

Table 3

Inclusion and Exclusion Criteria for Scoping Review

Category	Criteria
Inclusion	- published 2010 onwards - published in English Language - peer-reviewed journal articles or from official websites of established organizations - related to e-certification
Exclusion	- published earlier than 2010 - not published in English language - not peer-reviewed journal articles - not related to e-certification

Stage 4: Extracting, mapping, and charting the data

At this stage, all selected studies in the previous stage were reviewed comprehensively to extract their content relating to e-certification. All results were tabulated as a preparation for the next stage.

Stage 5: Summarize, synthesize and report the results

This stage pertains to the development of an analytical framework that encompasses the entirety of the literature and highlights key areas of focus within that material. The researcher summarized the data (see Appendix A) and developed a framework using a mind map to present the synthesized results of the scoping review which is presented in Chapter 4.1. Such results were used as inputs in the development of survey questionnaires and interview questions to further understand the attributes of an effective e-certificate.

Stage 6: Integrate expert consultation

This stage offers avenues for stakeholder engagement, enabling them to contribute supplementary references and offer perspectives that extend beyond the existing body of literature. This stage was done by conducting surveys and interviews with different stakeholders in the maritime industry. As such, the output of the last stage integrates the essential attributes of an e-certificate for seafarers.

3.1.2 Document Analysis

IMO documents such as circulars and meeting reports were used to analyze the nature of the international legal framework on e-certification for seafarers including its functionality. The authenticity, credibility, representativeness, and meaning of the selected documents are considered as four essential factors in selecting documents (Scott, 1990 as cited in Flick, 2009).

The researcher collected the relevant documents to answer RQ1 and RQ2. This includes IMO legal documents including documents relating to the e-certification of seafarers that were submitted by various Member States to IMO. In addition, existing literature about the attributes of an effective e-certificate was also utilized.

Using the authoritative database of IMODocs[1] increased the assurance that these factors were adequately met. All documents relating to the e-certification of seafarers were extracted and subsequently tabulated (see Appendix B). All information was then synthesized and presented chronologically (as presented in Chapter 4.2) to better understand the development of relevant rules and regulations which implies how the international legal framework functions.

3.1.3 Mixed Method

Data and methodological triangulation were utilized in addressing RQ3 and RQ4 of the research study. As previously mentioned, the results of the first stage of the study were utilized in the development of the survey questionnaires and semi-structured interview questions for the second stage of the study. The collected quantitative and qualitative data were then analyzed separately and subsequently converged through comparison and contrast of the results.

3.2 Instrumentation, Data Collection, and Analyses

Survey questionnaires, and semi-structured interviews were utilized in gathering primary data for the study.

3.2.1 Online Survey Questionnaires

Three specific online survey questionnaires were developed based on the results of the first stage of this study and taking into account the UTAUT model. These surveys carried the same aim of assessing the implementation merits, demerits, and possible future challenges to e-certification. The target participants were seafarers, individuals working for MARAD, and representatives of shipping companies/manning agencies. Since the target participants have different roles in e-certification, one survey was created for the MARAD (Appendix C); another was for the shipping companies/manning agencies (Appendix D); and the last was created for the seafarers (Appendix E). The questionnaires were composed of two parts. The first part asked about the demographic profile of the respondents while the second part was composed of 6-point Likert scale statements and three open questions as

[1] IMO document repository

summarized in Table 4. The 6-point Likert scale statements asked for the degree of agreement/disagreement of the respondents, 6 being “strongly agree” and 1 being “strongly disagree”. These statements were categorized based on the key constructs of the UTAUT model which includes performance expectancy, effort expectancy, social influence, and facilitating conditions.

Table 4

Survey Questionnaires Summary

Questionnaire Summary	Item Number		
	MARAD	**Shipping Companies**	**Seafarers**
Likert Scale			
Performance Expectancy	1-8	1-8	1-8
Effort Expectancy	9-13	9-13	9-12
Social Influence	14-17	14-17	13-16
Facilitating Conditions	18-27	18-22	17-23
Open Questions	28-30	23-25	24-26

Prior to the dissemination of the survey questionnaires, pilot testing and validation were conducted. In addition, the WMU Research Ethics Committee’s approval was obtained (REC Decision No. REC-23-044(M)). The draft questionnaires that were input in Google Forms were pilot-tested by two seafarers and three individuals from MARAD to determine how long would it take when responding to the survey. Technical inputs from the pilot testing were also gathered and used as a guide in revising the questionnaires.

The revised instruments were then sent to two subject-matter experts for language and content validation. Both validators are experts in maritime education and training curriculum design and development. The validation tool used was adopted from Nalupa (2022) as presented in Appendix F. The survey questionnaires were then updated based on the comments from the validators. The final questionnaires used a 6-point Likert scale with no neutral or middle category of the level of agreement or

disagreement. Nemoto & Beglar (2014) suggest the use of a 6-point scale as this allows for more precise measurement.

3.2.1.1 Selection of Participants

Taking into consideration the involvement of the MARAD, the shipping companies/manning agencies, and the seafarers in seafarers e-certification, they were purposely identified as the participants for the survey.

Maritime Administrations

The MARAD was identified as among the key participants in the study in recognition of their substantive role in the implementation of e-certification as stipulated in IMO guidelines on the use of e-certificates. Determining their experiences and perceptions about the merits and demerits of the application of e-certification for seafarers as well as their views about the possible future challenges to e-certification was deemed essential for the attainment of the research objectives.

Shipping Companies/Manning Agencies

The shipping companies or manning agencies are the responsible entities for the deployment of seafarers onboard ships. They manage and ensure the completeness and validity of seafarers' certificates before embarking on ships. As such, their thoughts about the implementation of e-certification for seafarers are also important to the study.

Seafarers

Seafarers were selected for this study because they are an integral part of the shipping industry. They are end-users of operational technology and systems which are essential in promoting onboard e-certification. Their in-the-field perception is crucial in determining the importance, need, and effectiveness of e-certification in this study.

3.2.1.2 Sampling Technique

Convenience sampling was employed in gathering data from the target respondents of the survey questionnaires. It is a non-probability sampling technique that involves gathering data from a population that is readily available and accessible to the researcher (Suen et al., 2014). Since the research study aims to analyze the global

application of e-certification to seafarers, the researcher aimed to gather as many responses from as many countries as possible. As such, the validated and approved survey questionnaires were distributed to different parts of the world through e-mail and the use of social media.

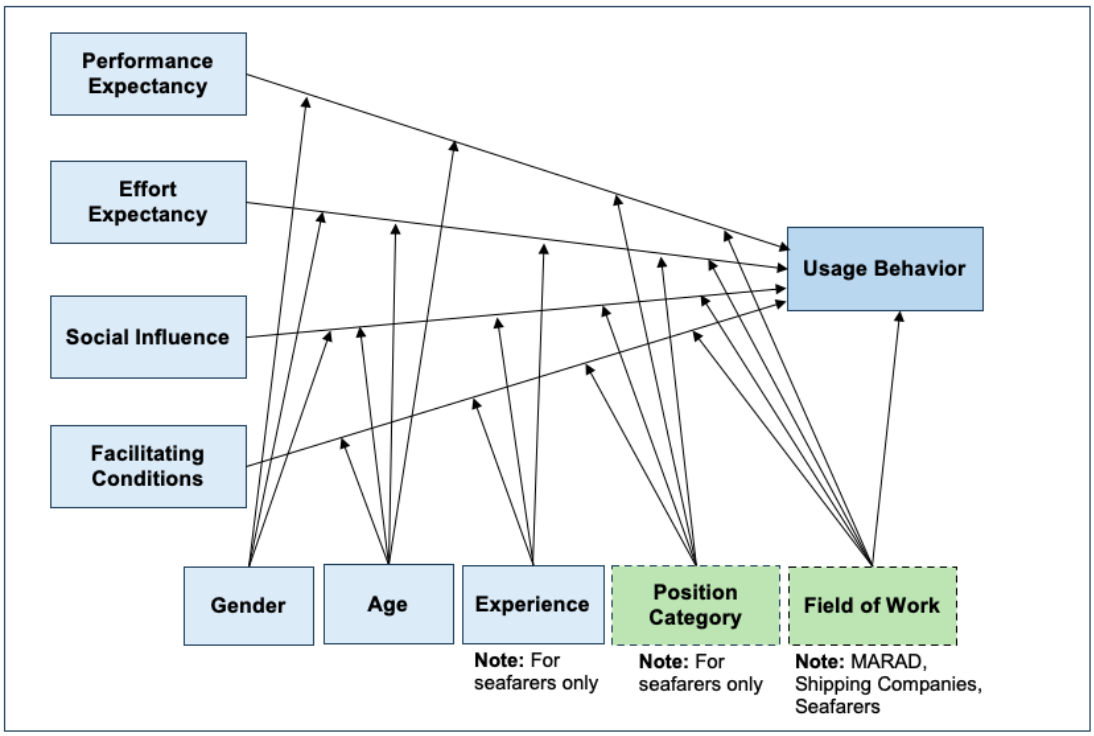
3.2.1.3 Data Analysis

The collected data from the survey questionnaires were analyzed both quantitatively and qualitatively. In preparing the collected data for statistical analysis, one statement/item in the questionnaire that was phrased negatively was reverse coded. The analysis was guided by the UTAUT model which was modified by the researcher, as presented in Figure 7, to fit within the scope of the study. Taking into consideration that the application of e-certification to seafarers, although not mandatory, is guided by an international legal framework through the STCW Convention and Code, the constructs “behavioral intention” and “voluntariness of use” that are part of the original UTAUT model proposed by Venkatesh et al. (2003) were not included in the study. As can be recalled, the Parties to the STCW Convention give the Convention full and complete effect. As such, the application of e-certification is not dependent of seafarers or other stakeholders’ behavioral intention or voluntariness of use. It is, however, dependent on the State’s choice to implement the e-certification for seafarers.

As part of the modification of the UTAUT model, the researcher tested instead additional moderators to the key constructs which include the position category of the seafarers (either cadet/trainee, support level, operational level, or management level) and the field of work of the respondents (either seafarers, MARAD, or shipping companies/shipping agencies).

Figure 7

Modified UTAUT Model



A set of null hypotheses was formulated 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;
- **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).

Descriptive and inferential statistics were conducted in analyzing the data through the use of IBM SPSS Version 29.0.1.0 (171). Non-parametric tests were applied for all the hypotheses following the results of the normality tests described later in this Chapter. In addition, the sample data is not based on numbers but rather on ranking or categorical data. According to Gardner & Martin (2007) and Jamieson (2004), Likert data is considered to possess an ordinal or rank order characteristic and only non-parametric tests may produce reliable and accurate outcomes when analyzing such data. Specifically, a two-tailed Spearman Correlation Coefficient was applied for H1 to H5 while Kruskal-Wallis H Test was used to test H6.

Conversion of Qualitative Data into Quantitative Values (QQVs)

Prior to testing the hypotheses, the researcher transformed the collected qualitative data from an open question about the respondents' thoughts on the entire replacement of a traditionally printed certificate with an e-certificate into quantitative values. The converted data were used as the score for the construct Usage Behavior.

The quantification of qualitative data by assigning a score indicating the strength or intensity of each identified theme has been used in other studies. Mehl-Madrona et al. (2004) converted the scenarios generated from clinical notes and interviews into quantitative ratings on a 1-5 Likert scale in order to conduct further statistical analysis of the study. Likewise, Febiana et al.'s (2019) research on the automotive engineering chemistry module converted qualitative data into quantitative data using Likert scales. Moreover, this technique was also applied by Hasanah & Khasanah (2020) where the qualitative data from the interviews and questionnaire instruments were transformed into quantitative data using a Likert scale for the scoring rules.

Despite several applications of such a conversion, Hanbury et al. (2011) stressed that the process of converting qualitative data to a numerical form can lead to a loss of meaning since the values are arbitrarily assigned, as well as a loss of context and information. As such, in order to strengthen the reliability of the conversion, the researcher adopted the QQV process proposed by Hochwald et al. (2023). First, the researcher developed a Likert-type numerical value for the level of agreement/disagreement based on the collected qualitative data as follows:

1 = Disagree

2 = Neither agree or disagree

3 = Agree but with conditions

4 = Agree

Thereafter, all responses (n = 286) were rated by two individuals separately. The first rater was the researcher while the second rater was another individual who also studies MSc in Maritime Affairs at WMU. To examine the interrater reliability of the QQV analysis, a Kappa statistic was then conducted using IBM SPSS Version 29.0.1.0 (171) which resulted in .942 Cohen's Kappa, p-value <.001. According to Cohen (1960), a Kappa value between 0.81 – 1.00 means almost perfect agreement. Such a test is essential to ensure the overall level of confidence in the accuracy of a research study (McHugh, 2012). Moreover, although a very high Kappa value was achieved, the two raters discussed the five responses that were rated differently and settled the disagreement which resulted in 100% agreement out of 286 responses.

Reliability and Normality Tests

Tests for reliability and normality helped the researcher decide on the appropriate statistical tools to be used in data analysis. The internal consistency reliability of the survey questionnaires was analyzed using Cronbach's Alpha coefficient. Developed by Lee Cronbach in 1951, Cronbach Alpha aims to offer a quantitative assessment of the internal consistency of a test or scale. This measure is represented as a numerical value ranging from 0 to 1. Internal consistency refers to the degree to which the items within a test are measuring a consistent concept or construct. It is closely related to the interconnectedness of the things within the test (Tavako & Dennick, 2011). According to McMillan and Schumacher (2001), it is recommended to use caution when utilizing groupings of items with a coefficient alpha < .70.

Furthermore, skewness was used to measure whether the data were distributed symmetrical or asymmetrical. Parametric tests are utilized when data exhibit normal distribution whereas nonparametric approaches are employed in cases when data are not normally distributed. Otherwise, a transformation of data should be done (Leech et al., 2007). This study adopted the guidelines of Leech et al. (2007) where more than +1.0 or less than -1.0 skewness value means the distribution is highly

skewed while skewness of zero represents a perfectly normal curve. The result of the test is presented in Chapter 4.3.2.1.

3.2.2 Semi-Structured Interview

In addition to online survey questionnaires, the researcher used a semi-structured interview to answer RQ3 and RQ4. Magaldi and Berler (2020) asserted that the semi-structured interview is a widely utilized technique within the realm of qualitative research as it facilitates the exploration and adaptability in pursuing several thematic trajectories as the discourse unfolds. The instrument was developed based on the results of the scoping review and document analysis in Stage 1. It was composed of two parts: the first part contained general questions about the profile of the respondents and the second part was composed of 10 questions regarding e-certification to seafarers (see Appendix G). The WMU Research Ethics Committee's approval was obtained before conducting the interview (REC Decision No. REC-23-044II(M)).

3.2.2.1 Selection of Participants

The researcher purposefully identified the participants who are thought to provide the necessary information on e-certification in terms of its implementation merits, demerits, and possible future challenges. According to Palinkas et al. (2015), purposeful sampling is generally used to gather rich information about the topic. The respondents were selected based on the following criteria:

- Knowledge and experience in establishing and implementing e-certification systems;
- Role in managing seafarers' certificates; and
- Flag of registration by dead-weight tonnage based on 2022 United Nations Conference on Trade and Development (UNCTAD) Report.

To support the credibility of the interviews, Table 5 outlines the general profile of the eight participants without divulging their personal identity to keep their confidentiality. Further, for purposes of this study, fictitious names were given to the participants for easier discussion.

Table 5

Profile of the Interviewees

Assigned Fictitious Name	Participants Profile
1. *Captain James*	● An experienced Master Mariner working in one of the MARAD in Europe where one of the leading shipping companies in the world is situated ● Has direct involvement in the development of IMO guidelines on the use of e-certificates of seafarers and the corresponding amendments to the STCW Convention and Code relating to e-certification ● Directly involved in the establishment and implementation of e-certification for seafarers of his particular Administration
2. *Ms. Amanda*	● Working in the MARAD of one of the leading seafarer-supplying countries in the world ● Has direct involvement in the establishment and full implementation of e-certification for seafarers of her particular Administration
3. *Mr. John*	● Working in the MARAD of one of the leading seafarer-supplying countries in the world ● An IT expert with direct involvement in establishing, monitoring, and managing the full e-certification for seafarers of his particular Administration
4. *Mr. Paul*	● An experienced seafarer working in the MARAD of one of the leading flags of registration by dead-weight tonnage (based on UNCTAD (2022) statistics); one of the representatives of his country's permanent mission to IMO ● Has also direct involvement in the evaluation of seafarers' documentation and issuance of seafarers' certification ● Has direct involvement in the development of IMO guidelines on the use of e-certificates of seafarers and the corresponding amendments to the STCW Convention and Code relating to e-certification
5. *Mr. Joseph*	● An experienced management level seafarer working as a regional manager of seafarer services in a private company that runs the ship registry of one of the leading flags of registration by dead-weight tonnage (based on UNCTAD (2022) statistics) ● Has previous work experience as a crewing manager

Assigned Fictitious Name	Participants Profile
6. *Capt. Anthony*	● An experienced Master Mariner working in one of the MARAD in Europe for nearly 10 years in various roles such as a surveyor doing port state control inspection, and as client technical manager responsible for providing technical advice ● Currently assigned as Chief Examiner in training and certification branch
7. *Ms. Margaret*	● Working as an assistant manager in one of the state-owned shipping companies in Asia ● Responsible for managing ships' crew
8. *Mr. Patrick*	● A top management official of one of the biggest seafarers' union in one of the leading seafarer-supplying countries in the world ● Concurrently, a President of a maritime higher education institution

In summary, the participants represent 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 conducted online using Zoom Video Conferencing and Microsoft Teams except for Ms. Margaret who sent a written response.

3.2.2.2 Data Analysis

The interview recordings were transcribed using open-source software called Whisper (OpenAI, 2023) which was run in Google Colab. In addition, interviews that used another language was translated into English using the aforementioned software. Thereafter, the transcribed and translated interviews including the written responses were imported into NVivo (Release 1.7.1) software for qualitative analysis. Both inductive and deductive approaches were applied. This flexibility allowed the researcher to identify other emerging themes and codes from the interviews (inductively) aside from the pre-identified themes which are the merits, demerits, and challenges to e-certification of seafarers (deductively). Some of the responses were associated with two or more codes.

3.3 Ethical Issues

The WMU Research Ethics Committee's rules and guidelines governing the use of human participants in data gathering were followed in this study. The researcher focused heavily on respondent safety when gathering data, according to recognized research ethics norms including avoiding harming participants, receiving informed consent, taking into account participants' privacy, and always being truthful. After being handled with utmost confidentiality, the researcher will delete all data completely as soon as the degree is awarded.

3.4 Chapter Summary

Chapter 3 presented the detailed research methodology. Specifically, it discussed the application of the qualitative and quantitative methods in the study. In addition, it described how the data were collected and analyzed.

The succeeding chapters present the results, analysis, and discussion regarding the global application of e-certification to seafarers using qualitative and quantitative methods applied in this study.

Chapter 4: Research Findings

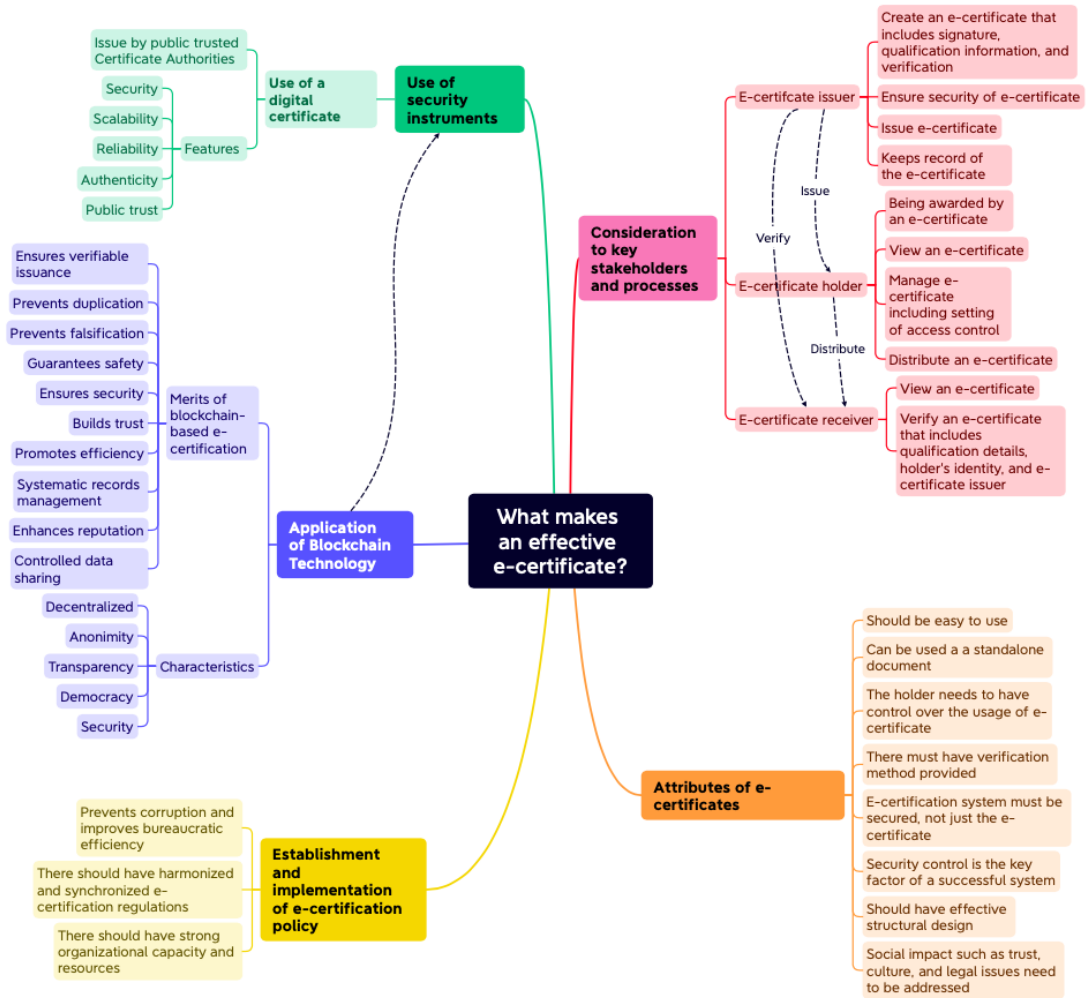
This chapter presents the results of the study. Chapters 4.1 and 4.2 present the results of the first stage of the study while Chapter 4.3 presents the combined results of quantitative and qualitative data from the survey questionnaires and the interviews.

4.1 Scoping Review Results

As a result of the scoping review, five main ideas came out about the components of an effective e-certificate, which is presented in the form of a mind map in Figure 8.

Figure 8

Components of an Effective E-Certificate



The literature search was conducted exclusively in the Google Scholar database using the keywords mentioned in Chapter 3.1.1. Taking into account the criteria set for inclusion and exclusion, the search was filtered for peer-reviewed journal articles that were published from 2010 onwards. This resulted initially in a total of 128 journal articles. After the conduct of a surface review to determine whether the articles pertain to e-certification, 97 articles were excluded for further analysis, having 31 remaining articles at hand. 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 and extracted the information about e-certification. The synthesized results are attached as Appendix A and are presented in Figure 8 as a mind map.

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 to key stakeholders and processes; 4) establishment and implementation of e-certification policy; and 5) attributes of e-certificates.

The literature highlighted the importance and use of security measures to prevent security breaches in an e-certification system such as the use of digital certificates (Chen-Wilson et al., 2009; Maulani et al., 2021; Belaa, 2022) and blockchain technology (Agustin et al, 2020; Bao et al., 2020; Ghani et al., 2022). Agustin et al. (2020) highlighted that blockchain technology is not only concerned with the prevention of security breaches but is also essential in the management and control of e-certificates. Alruwaili (2020) stressed that blockchain provides efficiency, security, credibility and reliability, interoperability, and enhances records management. Similarly, Bao et al. (2020) and Ghani et al. (2022) outlined that blockchain-based certification offers decentralization, anonymity/privacy, transparency, democracy, security, and efficiency in terms of faster issuance and verification. Moreover, Li et al. (2019) highlighted that this technology offers different smart contract schemes.

Three key stakeholders are involved in the e-certificate processes: an issuer, an owner/holder, and a reviewer/receiver. Consideration must be given to all users in

designing the e-certification system. It must be user-friendly and suitable for users without IT skills; must provide varied verification options; and controlled accessibility (Chen-Wilson et al., 2009). Chen-Wilson & Argles (2010) are in agreement that e-certification necessitates the implementation of robust security measures, the capacity to be seamlessly integrated, and the consideration of social impact concerns.

Additionally, the presence of e-certification policies contributes to the effective implementation of an e-certification system. It reduces the falsification of data in digital records, prevents corrupt practices, and enhances administrative effectiveness (Mubarak et al.,2022). To further ensure the effective implementation of an e-certification system, Mubarak et al. (2022) also recommended that e-certification regulations should be harmonized and synchronized. Moreover, there should be strong organizational capacity and resources.

The key attributes of e-certificates and e-certification systems were also elicited from the literature reviewed. The e-certification system should be easy to use; should offer various methods for verification (Chen-Wilson et al., 2009); and must have an effective structural design (Li et al., 2019). Chen-Wilson & Argles (2010) emphasized the control of the holder over the usage of e-certification as well as the security of the system and the e-certificate itself. Moreover, social impact is another factor that needs to be addressed when implementing e-certification such as trust (Agustin et al, 2020), culture, and legal issues (Mubarak et al., 2022). It can be argued that the last two are also related to trust as far as e-certification is concerned.

4.2 Document Analysis Results

This section examined the development of IMO regulations and guidelines pertaining to the use of electronic certificates for seafarers which served as the foundation for analyzing the nature of the global legal structure of the e-certification of seafarers and its operational applications.

Historically, the first guidelines were issued by the Facilitation Committee in 2013 for the purposes of reducing the administrative burden of maritime industry stakeholders resulting from the use of traditional paper certificates, and to facilitate *"the use and acceptance of printed versions of electronic certificates"* (FAL.5/Circ.39). Such guidelines cover all certificates issued by an Administration for purposes of

demonstrating adherence to the regulations set forth by the IMO. It was then amended in 2014 (FAL.5/Circ.39/Rev.1) and in 2016 (FAL.5/Circ.39/Rev.2) with the aim of facilitating the *"use and acceptance of electronic certificate".* In 2018, some Member States, including the Government of Malta (IMO Circular Letter No. 3794) and the Government of Portugal (IMO Circular Letter No. 3822) informed the IMO about their acceptance and use of e-certificates.

Taking into account the advancement in electronic documentation and the practices in the maritime sector, Belarus and the Russian Federation submitted a proposal to the HTW Sub-Committee, in May 2018, for an STCW Circular providing a unified interpretation of Regulation I/2 of the STCW Convention (IMO, 2018a). Paragraph 11 of Regulation I/2 of STCW Convention, 1978, as amended (2010 Manila Amendments) states that: *"...any certificate required by the Convention must be kept available in its original form on board the ship on which the holder is serving."* The proposal sought to provide clarification that the phrase "original form" could be either a paper or an electronic certificate. The merits of the proposal were acknowledged by the HTW Sub-Committee and reported to MSC (HTW 5/16). Further submissions to IMO were made by Belarus and the Russian Federation in August 2018 (MSC 100/17/7) and China in February 2019 (HTW 6/9) proposing a comprehensive review of the pertinent provisions outlined in the STCW Convention and Code to enhance the utilization of e-certificates and documents of seafarers. Work to be carried out to address the use of e-certificates and documents of seafarers pursuant to the Convention was submitted by the Russian Federation in February 2019 (HTW 6/9/1).

A Correspondence Group on the development of amendments to the STCW Convention and Code for the use of electronic certificates and documents of seafarers was established. The Group, coordinated by the Russian Federation with the participation of 38 Member States, one intergovernmental organization (IGO), and two non-governmental organizations (NGOs) in consultative status, provided a report on its progress (HTW 7/9 dated 20 February 2020) where the draft amendment to the Convention and the draft STCW Circular (guidelines) are attached. It was then reported by the HTW Sub-Committee to MSC in March 2021 (HTW 7/16). The finalized draft was submitted by the Correspondence Group to HTW Sub-Committee in November 2021 (HTW 8/9). In December 2021, an intervention from the Islamic

Republic of Iran was submitted containing a report on e-certificates and IMO standards, digital signature validation, and various perspectives on issuing and updating certificates in digital format.

During the 8th session of the HTW Sub-Committee in February 2022, the Sub-Committee agreed to the submitted drafts by the Correspondence Group and invited MSC to approve the draft documents at its 106th session (HTW 8/16). On the other hand, further modifications to the draft guidelines were proposed by Cook Islands, Dominica, Liberia, Palau, and Republic of Turkiye in August 2022 (MSC 106/10/2). During the 106th session of MSC, the draft amendments to the STCW Convention and Code were approved by the Committee with the view to adoption at MSC 107 while the draft guidelines together with the proposal contained in MSC 106/10/2 and the comments made on the session were referred to HTW 9 for further consideration. In addition, bearing in mind that the draft guidelines will coexist with FAL.5/Circ.39/Rev.2, the FAL Committee was requested to examine the draft guidelines for any potential inconsistencies between the two sets of guidelines (MSC 106/19 paragraph 10.3 to 10.9). In March 2023, the Sub-Committee agreed to refer the draft guidelines as contained in HTW 8/16 to MSC for approval.

With the instruction of the MSC to finalize the draft amendments to the Convention including the associated MSC Resolutions, and the guidelines (MSC 107/WP.4), the Correspondence Group finalized the texts accordingly (MSC 107/WP.8). Finally, on 26 June 2023, the draft amendments to the STCW Convention and Code including the draft guidelines on the use of an electronic certificate of seafarers was adopted unanimously by the MSC including the delegations of 107 Parties to the 1978 STCW Convention (MSC 107/20). Annexes 10 and 11 of MSC 107/20/Add.1 provide for Resolution MSC.540(107) – Amendments to Regulation I/1 and I/2 of the STCW Convention, 1978, and Resolution MSC.541(107) – Amendments to Section A-I/2 of the STCW Convention, 1978, respectively. On the other hand, MSC.1/Circ.1665 provides guidelines on the use of electronic certificates to seafarers

In summary, Figure 9 presents the development of the regulations and guidelines on the use of electronic certificates to seafarers.

Figure 9

Development of Regulations and Guidelines on the Use of Electronic Certificates of Seafarers

4.3 Survey Questionnaires and Semi-Structured Interviews Results

The survey via questionnaires was conducted from 17 July to 07 August 2023. Table 6 presents the demographic profile of the respondents from the survey questionnaires.

Table 6

Demographic Profile of the Respondents

Demographic Profile	Category	MARAD (n = 38)		Shipping Companies (n = 23)		Seafarers (n = 225)		Total (n = 286)	
		Count	%	Count	%	Count	%	Count	%
Age	26 years old and below	1	2.6%	2	8.7%	65	28.9%	68	23.8%
	27 - 42 years old	25	65.8%	13	56.5%	122	54.2%	160	55.9%
	43 - 58 years old	10	26.3%	6	26.1%	32	14.2%	48	16.8%
	Over 58 years old	1	2.6%	2	8.7%	6	2.7%	9	3.1%
Gender	Female	16	42.1%	9	39.1%	9	4.0%	34	11.9%
	Male	20	52.6%	13	56.5%	215	95.6%	248	86.7%
	Preferred not to say	1	2.6%	1	4.3%	1	0.4%	3	1.0%
Position Category	Rank and file	11	28.9%	8	34.8%				
	Supervisory	9	23.7%	2	8.7%				
	Managerial	13	34.2%	11	47.8%				
	Top Management	3	7.9%	2	8.7%				
	Others	2	5.3%	0	0.0%				
	Trainee Officer/Cadet					36	16.0%		
	Support Level					56	24.9%		
	Operational Level					82	36.4%		
	Management Level					51	22.7%		
Trade Route of Operation	International			22	95.7%				
	Regional			0	0.0%				
	Both International & Regional			1	4.3%				
Total Years of Seagoing Experience	Below 5 years					90	40%		
	5 - 10 years					60	27%		
	11 - 15 years					36	16%		
	16 years and above					39	17%		

Although more than 400 emails were personally sent by the researcher to shipping companies and manning agencies, aside from posts on social media, only 23 responses were received from this group. On the other hand, 46 responses were received from MARAD and 225 responses from seafarers. The responses were comprehensively screened based on respondents' demographic information to establish the authenticity of the dataset. Eight responses from the MARAD questionnaires were excluded from the analysis as it was confirmed that the respondents were not affiliated with the MARAD of their respective countries leaving a final total of 38 responses.

In addition, to ensure that all responses represent the personal perspectives of the respondents, thus ensuring the ethical value of the research, all responses to open questions were checked if they were human-written or AI-generated (like ChatGPT) through https://www.zerogpt.com[2]. It was found that two responses to the question asking about the respondents' thoughts on the challenges to e-certification of seafarers were 73.24% and 62.5% AI-generated. These datasets were likewise excluded from the analysis.

In terms of respondents' nationality, the majority of the respondents from the MARAD and the seafarers are from the Philippines[3] as presented in Table 7. The Philippines is among the top seafarer-supplying countries in the world (BIMCO/ICS, 2021).

[2] ChatGPT, GPT4, and AI content detector

[3] The researcher is from the Philippines. High response rate from the Philippines may or may not have been influenced by this.

Table 7

Respondents' Nationality

Category	MARAD (n = 38)		Seafarers (n = 225)	
	Count	%	Count	%
Algeria			3	1.3%
Antigua and Barbuda	1	2.6%		
Benin			1	0.4%
Bulgaria			1	0.4%
China	1	2.6%		
Egypt			1	0.4%
Fiji			1	0.4%
Georgia	1	2.6%		
Ghana	1	2.6%	6	2.7%
India	1	2.6%	3	1.3%
Indonesia	1	2.6%	3	1.3%
Iraq			1	0.4%
Liberia	1	2.6%		
Malaysia			1	0.4%
Nigeria	9	23.7%	2	0.9%
Peru	1	2.6%		
Philippines	17	44.7%	189	84.0%
Sierra Leone			1	0.4%
South Korea	1	2.6%	1	0.4%
Thailand			1	0.4%
Turkiye			1	0.4%
Ukraine			7	3.1%
Tanzania	2	5.3%		
Vietnam	1	2.6%	2	0.9%

Reliability and Normality Test

Prior to conducting the inferential statistics, the internal consistency reliability of each questionnaire was assessed by Cronbach Alpha[4] in order to evaluate the extent to which the tests effectively capture various dimensions and produce reliable scores. In addition, a normality test was conducted to determine the distribution of the data. Table 8 presents the results of the tests.

[4] Under normal circumstances, Cronbach Alpha is done prior to actual administration of the questionnaire. However, if view of time constraint, it was done at the end of data collection.

Table 8

Reliability and Normality Test

Variables	Indicator	Median			Skewness			Cronbach's Alpha		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
Performance Expectancy	PE1	6	6	6	-1.052	-3.602	-2.275	0.801	0.83	0.831
	PE2	4	5	5	-0.385	-0.631	-1.102			
	PE3	4	5	5	-0.412	-0.222	-1.038			
	PE4	6	6	6	-1.710	-3.287	-2.316			
	PE5	5	5	5	-1.363	-0.163	-1.387			
	PE6	4	3	3	0.056	0.187	0.433			
	PE7	5.5	5	5	-1.143	-2.069	-2.073			
	PE8	6	6	6	-1.978	-1.218	-2.438			
Effort Expectancy	EE1	5.5	5	5	-2.151	-1.842	-1.952	0.733	0.89	0.917
	EE2	6	6	6	-1.382	-3.479	-2.249			
	EE3	5.5	6	5	-0.898	-1.345	-1.596			
	EE4	5	5	5	-1.249	-0.875	-2.101			
	EE5**	5	5		-1.377	-0.796				
Social Influence	SI1	5	5	5	-0.106	-1.474	-1.350	0.828	0.839	0.908
	SI2	5	5	5	-0.318	-0.947	-1.533			
	SI3	5	5	5	-0.543	-1.364	-1.675			
	SI4	5	5	5	-0.590	-1.794	-1.891			
Faciliating Conditions	FC1***	5	-	5	-1.083	-	-1.716	0.925	0.723	0.921
	FC2***	5	-	5	-1.542	-	-1.839			
	FC3*	6	-	-	-1.577	-	-			
	FC4	5	5	4	-0.842	-0.280	-0.666			
	FC5	5	5	5	-0.964	0.093	-1.476			
	FC6	5	5	5	-0.859	-0.982	-1.545			
	FC7*	5	-	-	-1.202	-	-			
	FC8*	5	-	-	-0.865	-	-			
	FC9*	5	-	-	-0.995	-	-			
	FC10	5	5	5	-1.002	-0.929	-1.580			
	FC11	5	5	5	-1.323	-0.448	-1.291			
Usage Behavior	UB	4	4	4	-1.642	-3.670	-2.718	-		

Notes: G1 = MARAD, G2 = Shipping Companies/Manning Agencies, G3 = Seafarers

Indicators: * G1 only; ** G1 and G2 only; *** G1 and G3 only

As can be gleaned from the Table, the questionnaires for MARAD (G1) and seafarers (G3) yielded acceptable reliability ($\alpha > 0.7$). However, shipping companies/manning agencies' (G2) performance expectancy and facilitating conditions yielded an Alpha value less than 0.7. It was determined that P6 and F4 caused the lower result, as such, the data for these variables were removed as these will not provide reliable statistical analysis. After removal, the reliability of the Performance Expectancy and the Facilitating Conditions was tested again and passed the acceptable value (0.831 and 0.921, respectively) as shown in Appendix H. P6 and F4 of shipping companies/manning agencies were not used in the succeeding statistical analysis.

In terms of normality test, the data from the MARAD (G1) shows that 14 out of 27 variables are negatively highly skewed with varying frequency distribution ranging from – 1.392 (flat) to 5.597 (more peaked). Likewise, data from the shipping companies/manning agencies (G2) and the seafarers (G3) revealed that 10 out of 21 and 19 out of 22 variables, respectively, have the same result as the MARAD, with frequency distribution ranging from -2.19 to 14.844 and -0.863 to 7.002, respectively. No variables were found to be positively highly skewed. Since the data was not normally distributed, the researcher used non-parametric tests to test the hypotheses of the study.

4.3.1 Merits and Demerits of E-Certification for Seafarers

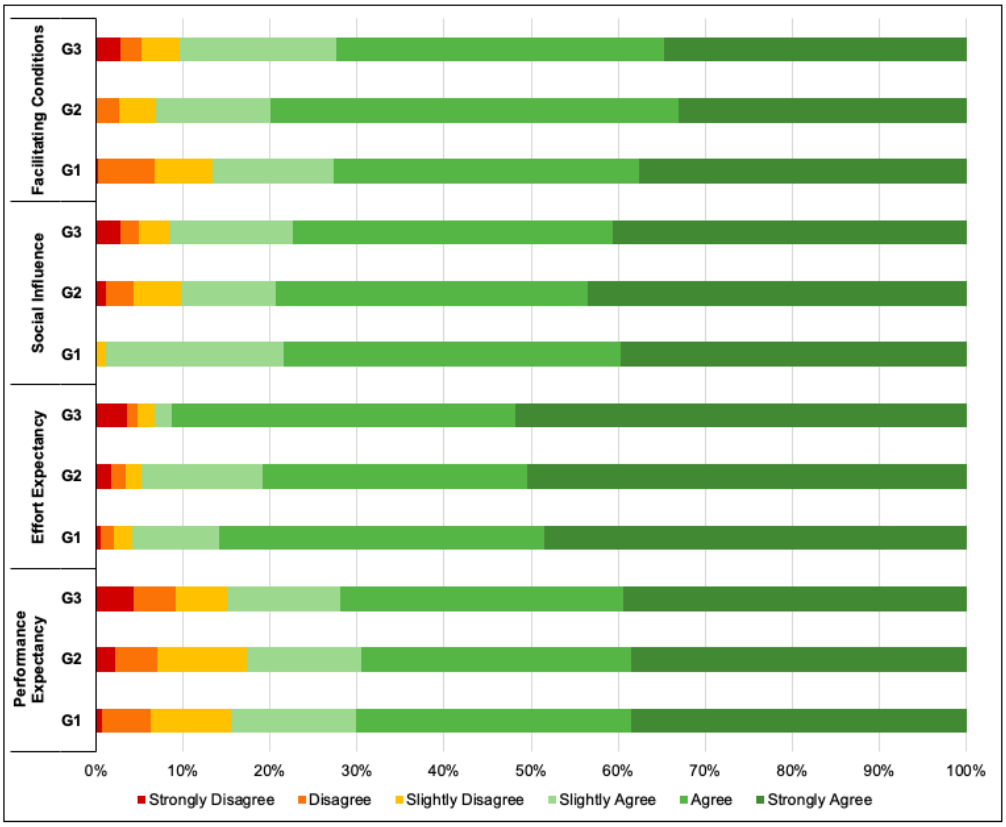
This sub-section presents the combined quantitative and qualitative results from the survey questionnaires and the interviews.

4.3.1.1 Findings Relating to Acceptance and Use of Technology

The responses of the three key stakeholders from the Likert Scale in the survey questionnaires were summarized per key construct. As previously discussed, the specific constructs are performance expectancy, effort expectancy, social influence, and facilitating conditions. In general, as shown in Figure 10, more than 80% across all groups have positive feedback on acceptance and use of technology with reference to the four constructs.

Figure 10

Stakeholders' Level of Agreement/Disagreement on Acceptance and Use of Technology



Note: G1 = MARAD, G2 = Shipping Companies/Manning Agencies, G3 = Seafarers

The **Performance Expectancy**[5] results show that around 40% of the participants strongly agree with the aforementioned merits of e-certification, while around 30% and 10% "agree" and "slightly agree", respectively. Looking at the results for each statement, a high percentage of disagreement, 26% and 29%, was recorded for the confidence of the participants from the MARAD about the protection of the system against: 1) fraud; and 2) security breaches. The disagreement rate of participants from shipping companies/manning agencies are 18% and 30% respectively showing great

[5] It assesses the extent to which participants perceive that utilizing e-certificates and e-certification systems would enhance the: verification of e-certificates; protection against fraud and security breaches; compliance with privacy laws; reliability of the e-certification system; and acceptance by Port State control officers, and reduction of administrative burden on the stakeholders.

concern about the security of the e-certification system. On the other hand, seafarers' disagreement with the aforementioned statements is much lower, with percentages of 12% and 13%, respectively.

The **Effort Expectancy**[6] construct resulted in around 50% and 30% of the three stakeholders "strongly agree" and "agree", respectively, with the degree of ease associated with using the system. On the other hand, 5% of the participants from the MARAD, 6% from shipping companies/manning agencies, and 7% of seafarers expressed disagreement.

The **Social Influence**[7] construct revealed that 99% of the participants from the MARAD, 92% of seafarers and 90% from the shipping companies/manning agencies believe that there is a need for the implementation of e-certification systems as influenced by the society.

Finally, the results of **Facilitating Conditions**[8] construct showed that 87%, 93%, and 90% of the participants from the MARAD, shipping companies/manning agencies, and seafarers, respectively are in agreement with a positive statement about the readiness of the industry for effective facilitation of e-certificates in terms of organizational and technological infrastructure. Looking closely at the responses of the key stakeholders, there are around 20% of the participants from the MARAD who disagreed with the notion that the MARAD has the capacity to provide appropriate computer software or mobile applications for e-certificates' verification, ensuring the protection of e-certificates from edits and modification, as well as having an approved procedure in place for the implementation of e-certificates. On the other hand, 21% of the seafarers showed disagreement with having access to stable internet

[6] It determines the extent to which participants express agreement or disagreement with the level of ease associated with using the e-certificates in terms of acquisition, accessibility and retrieval of e-certificates, convenience of use at port, ease of verification, and ease of using the system.

[7] It examines the degree to which the participants feel the need to use e-certificate taking into consideration the influence of their social circle and their perception of support from the shipping industry.

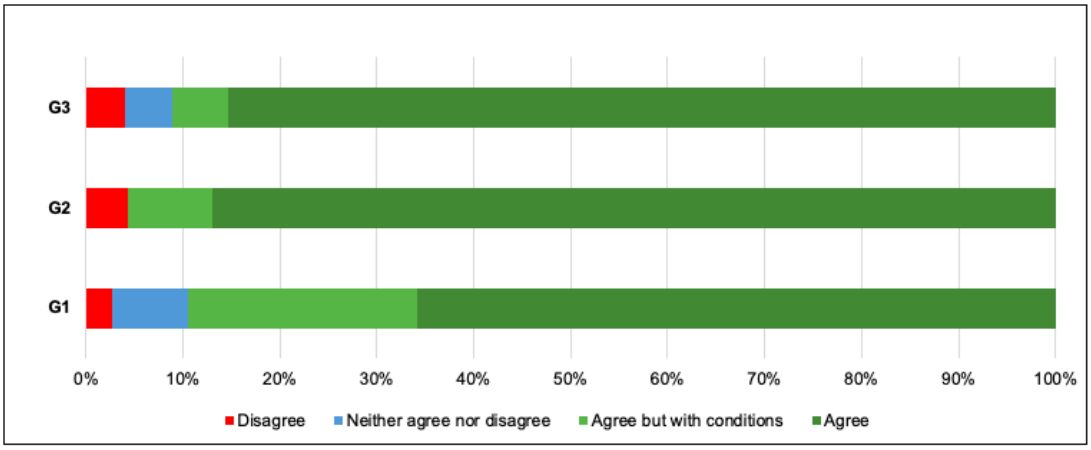
[8] It determines the degree to which the participants hold the belief that there is organizational and technological infrastructure in place to effectively facilitate the utilization of the e-certification system.

connections onboard a ship for them to present e-certificates to different concerned officers.

Separately, the qualitative data from an open question asking about the participants' thoughts on the entire replacement of traditional printed certificates was converted into quantitative values using 4-point Likert Scale to determine the usage behavior of the participants. As presented in Figure 11, there was a positive response among the three key stakeholders. There were 66%, 87%, and 85% of participants from the MARAD, shipping companies/manning agencies, and seafarers, respectively who completely agreed with the total replacement. On the other hand, there were 24%, 9%, and 6% respectively, who agreed but with some conditions which include ensuring data privacy protection, lesser processing time, lesser burden to 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. Eight percent of the participants from the MARAD and 5% from the shipping companies neither agreed nor disagreed while 3% and 4% of them, respectively, disagreed. Likewise, 4% of the seafarers disagreed with the entire replacement of traditional printed certificates with e-certificates.

Figure 11

Stakeholders' Thoughts on Entire Replacement of Traditional Printed Certificates with E-Certificates



Note: G1 = MARAD, G2 = Shipping Companies/Manning Agencies, G3 = Seafarers

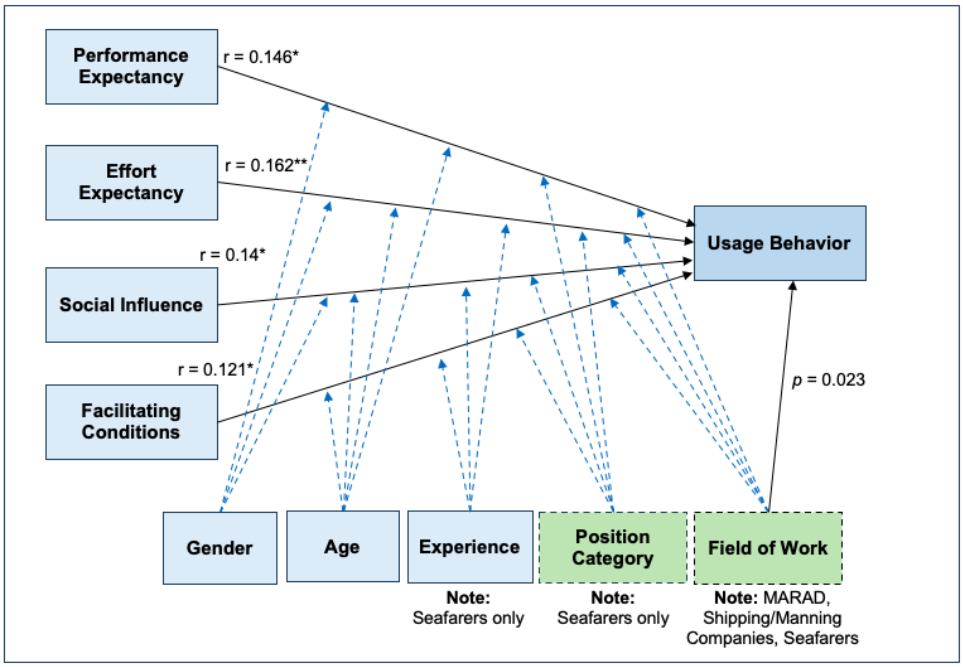
4.3.1.2 Hypotheses Tests

Hypotheses tests were conducted to determine the relationships between performance expectancy, effort expectancy, social influence, facilitating conditions, and field of work on the one hand, with usage behavior of the key stakeholders of e-certification of seafarers on the other hand, as well as to determine whether the aforementioned constructs are moderated by the demographic variables. The formulated null hypotheses are outlined in Chapter 3.2.2.3.

Using the modified UTAUT model as a guide, Figure 12 illustrates the summary of the inferential statistics conducted to determine the relationships between the indicated key constructs and usage behavior as well as the significant differences in terms of demographic profile.

Figure 12

Summary Result of Hypotheses



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

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

Very weak positive correlations were found between usage behavior and the key constructs. Further, the age and gender of individuals in the three key stakeholder

categories, as well as the position category and experience of seafarers were found to have no statistical significance regarding their mediating influence on the relationship between performance expectancy, effort expectancy, social influence, and facilitating conditions (on one hand) and usage behavior (on the other hand). This outcome is shown by the broken blue arrows in Figure 12. Interestingly, only the field of work of the stakeholders as a mediating variable of usage behavior was found to have a statistically significant difference (*p*-value = 0.023), particularly, for the seafarers and the MARAD. The following sub-sections comprehensively describe the statistical results of the hypotheses tests.

Relationship to Usage Behavior

Spearman's Correlation Coefficient tests, presented in Table 9, showed that usage behavior of the key stakeholders to e-certification has statistically positive but very weak 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. Additionally, it should be noted the correlation does not provide conclusive evidence regarding the causal relationship between variables.

Table 9

Results of Hypotheses 1 – 5

Hypothesis	Relationship	Spearman's rho	Significance (2-tailed)	95% Confidence Intervals (2-tailed)[a,b]	
				Lower	Upper
H1	PE - UB	0.146*	0.013	0.027	0.261
H2	EE - UB	0.162**	0.006	0.043	0.276
H3	SI - UB	0.140*	0.018	0.021	0.255
H4	FC - UB	0.121*	0.041	0.002	0.237
H5	GROUP - UB	0.125*	0.034	0.006	0.241

a. Estimation is based on Fisher's r-to-z transformation.

b. Estimation of standard error is based on the formula proposed by Fieller et al. (1957).

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

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

Differences to Key Constructs by Demographic Variables

Using the Independent-Samples Kruskal-Wallis Test, the null hypothesis H6[9] was tested and yielded results as shown in Table 10. Prior to conducting the test, the data collected from the three stakeholders were combined per key constructs except for position category and experience as these were only tested for seafarers. In addition, 3 responses were removed prior to gender analysis as three of the respondents preferred not to share their gender.

Table 10

Results of Hypothesis 6

Variables	Kruskal-Wallis H	df	Asymptomatic Sig. (2-sided)
PE x Age	1.778	3	0.62
EE x Age	1.227	3	0.746
SI x Age	0.862	3	0.835
FC x Age	0.763	3	0.858
PE x Gender	0	1	0.987
EE x Gender	1.065	1	0.302
SI x Gender	3.673	1	0.055
FC x Gender	0.171	1	0.679
PE x Position Category	0.317	3	0.957
EE x Position Category	1.321	3	0.724
SI x Position Category	4.05	3	0.256
FC x Position Category	2.709	3	0.439
PE x Experience	1.555	3	0.67
EE x Experience	0.73	3	0.866
SI x Experience	1.881	3	0.597
FC x Experience	3.554	3	0.314
PE x Nature of Work	0.285	2	0.867
EE x Nature of Work	3.087	2	0.214
SI x Nature of Work	1.422	2	0.491
FC x Nature of Work	0.257	2	0.88
UB x Nature of Work	7.583	2	0.023

a. The significance level is .050.
b. Asymptotic significance is displayed.

[9] The distribution of the Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), and Usage Behavior (UB) is the same across the categories of demographic profiles (age, gender, position category, experience, and field of work).

As presented in Table 10, the results revealed that the null hypotheses are to be retained across all tests except for the UB and field of work ($H(2) = 7.583$, p-value = 0.023) at 0.05 significance level. There are no statistically significant differences in the performance expectancy, effort expectancy, social influence, and facilitating conditions across age, gender, and field of work of the stakeholders. Likewise, there are no statistical differences in the aforementioned key constructs across the position category and experience of seafarers.

A post hoc test was conducted on the rejected null hypothesis (statistical significance between Usage Behavior and Field of Work). It was revealed in the pairwise comparison that the MARAD and the seafarers have statistical differences in terms of usage behavior as reflected in Table 11 and Figure 13.

Table 11

Pairwise Comparisons of Field of Work as to Usage Behavior

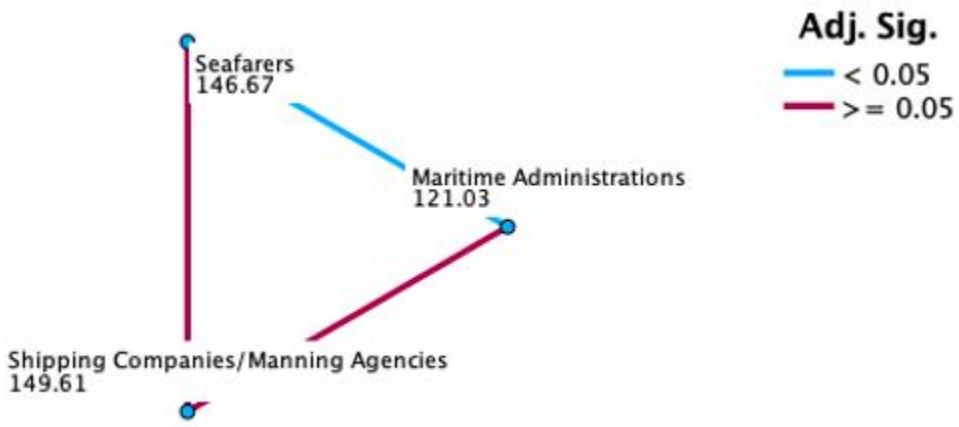
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
MARAD - Seafarers	-25.645	9.514	-2.695	.007	**.021**
MARAD - Shipping Companies/Manning Agencies	-28.582	14.331	-1.994	.046	.138
Seafarers - Shipping Companies/ Manning Agencies	2.938	11.875	.247	.805	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significance (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Figure 13

Illustration of Pairwise Comparisons of Field of Work as to Usage Behavior



Note. Each node shows the sample average rank of the Field of Work

Comparing the qualitative responses of both the seafarers and the MARAD to the open question in the survey questionnaire where the usage behavior quantitative values were drawn, a big difference in the percentage of the level of agreement was revealed. Eighty-five percent of the seafarers and 66% of the MARAD totally agreed with the entire replacement of traditionally printed certificates with e-certificates. Similarly, 24% of the MARAD and only 6% of the seafarers viewed that totally replacing the conventional certificates with e-certificates has many advantages on condition that the e-certification system is protected against security and data breaches and that the challenges in using the system are addressed.

4.3.1.3 Converged Results of Survey Questionnaires and Semi-Structured Interviews

In analyzing the extent of merits and demerits of e-certification for seafarers, the researcher converged the quantitative and qualitative results drawn from the three survey questionnaires and the eight semi-structured interviews. Specifically, the researcher combined the frequency of comments from the semi-structured interviews and the open questions from the survey questionnaires which were both analyzed thematically, as well as the number of responses from the Likert Scale in the survey

questionnaires showing the level of agreement and disagreement with the statements pertaining to the use of e-certificates. Responses from the open questions in the survey questionnaires were coded into themes using MS Excel (Version 16.77). Separately, the same process was done with the eight interviews using NVivo (Release 1.7.1). Responses were sometimes assigned to one or both codes depending on their context. The tabulated summaries of merits and demerits of implementing e-certificates for seafarers are attached as Appendices I and J.

Figure 14 illustrates the extent of 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 demerits. Nevertheless, the drawbacks associated with e-certification are overshadowed by the benefits it offers.

Figure 14

Converged Results of Merits and Demerits of E-Certification of Seafarers

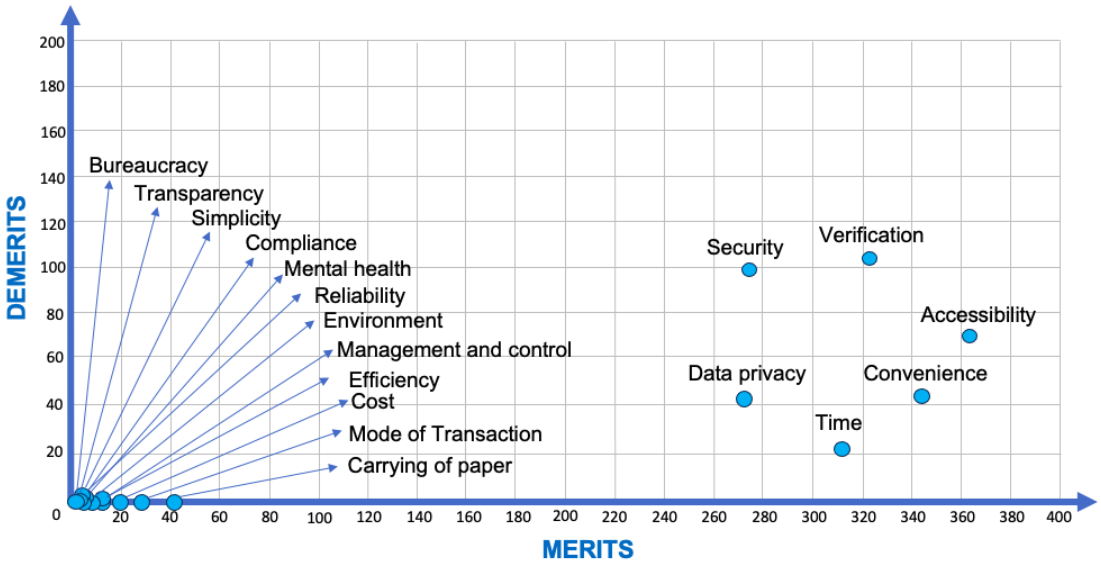


Table 12 presents the summarized description of merits and demerits of e-certification for seafarers based on the qualitative data from the interviews and survey questionnaires.

Table 12

Description of Merits and Demerits of E-Certificates for Seafarers

Subject	Merits	Demerits
Accessibility	• Can be accessed anytime and anywhere • Can be printed if a paper certificate is needed • Information is easy to access • Can be stored on mobile phones • Can be downloaded and be accessed offline	• Possible inaccessibility due to loss or unavailability of internet connection in some ships, ports, or regions • Possible inaccessibility due to system failure that can be caused by power interruption, corrupted or crashed system, or other technical problems
Convenience	• The use of e-certificates is "hassle-free", "less hassle", and "convenient" • Reduces the administrative burden on both the MARAD and the seafarers in relation to the application and processing of e-certificates	• E-certificates require digital literacy to be able to navigate and use the system or the platform appropriately
Verification	• Can be verified 24/7 • Easy to verify as it contains QR code and other means of verification such as a unique tracking number	• Verification can be hindered by the unavailability of infrastructure in some areas around the world such as reliable internet connection and uninterrupted e-certification system which is free from system errors or system glitches
Time	• Because of automated application mechanism, e-certificates has faster processing time which saves the time of both the seafarers and the MARADs	• Faster services and processing time by MARAD can be hindered by delays within the processes such as data encoding, or by submitting incorrect or low resolution documents by the seafarers

Subject	Merits	Demerits
Security	• E-certificates enhance protection against fraud and security breaches because of their embedded security features	• Since it is an electronic system, 100% assurance of protection against cybersecurity threats and data breaches is not guaranteed
Data privacy	• The use of blockchain technology and the adoption of a mechanism of data-sharing with seafarer consent provides better data privacy	• The digital nature of e-certification poses a potential threat to the protection of data privacy as it involves the storage and transfer of sensitive personal and professional information
Carrying of printed certificates	• Seafarers do not have to carry a bulk of printed paper certificates onboard the ship proving the qualifications and competence	-
Mode of transaction	• E-certificates utilize paperless and digital transactions which reduces the administrative burden of both the seafarers and the MARADs	-
Cost	• It saves cost for the seafarers in terms of travelling cost when processing for e-certificates	-
Efficiency	• It gives efficiency to the maritime industry in terms of ship and crew management.	-
Management of control	• It enhances the management and control of seafarers' data by the MARADs because of integrated or centralized records of seafarers which drives faster processing and issuance of electronic documents	• Having a centralized system means it would be difficult to share data with others while handling the system securely. Data-sharing is the tricky part about implementing e-certification for seafarers.

Subject	Merits	Demerits
Environment	• It is environmentally friendly. E-certificates do not need paper for printing and also do not need transportation to send them to international crew	-
Reliability	• It is reliable in terms of data completeness and accuracy	• There is a potential loss of data with the implementation of an e-certification system
Mental health	• The relatively easy processing of e-certificates helps reduce stress on the seafarers as well as MARAD personnel	-
Compliance	• It promotes better compliance with international regulations taking into consideration its security features and the means of verification	-
Simplicity	• E-certificates are simple and not complicated to use	-
Transparency	• It promotes transparency and thus potentially engenders increased trust	-
Bureaucracy	• Due to its streamlined and seamless application processing, it lessens bureaucracy	-

4.3.2 Challenges to Global Implementation of E-certification to Seafarers

The qualitative and quantitative results of the surveys and the interviews were converged by comparing and contrasting both results. For an easier understanding of what was gained from the quantitative and qualitative findings, Figure 15 illustrates 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 pertaining to the facilitating

conditions and performance expectancy (quantitative results). The detailed tabulation of the results is attached as Appendix K.

Figure 15

Converged Results of Challenges to the Global Implementation of E-Certification to Seafarers

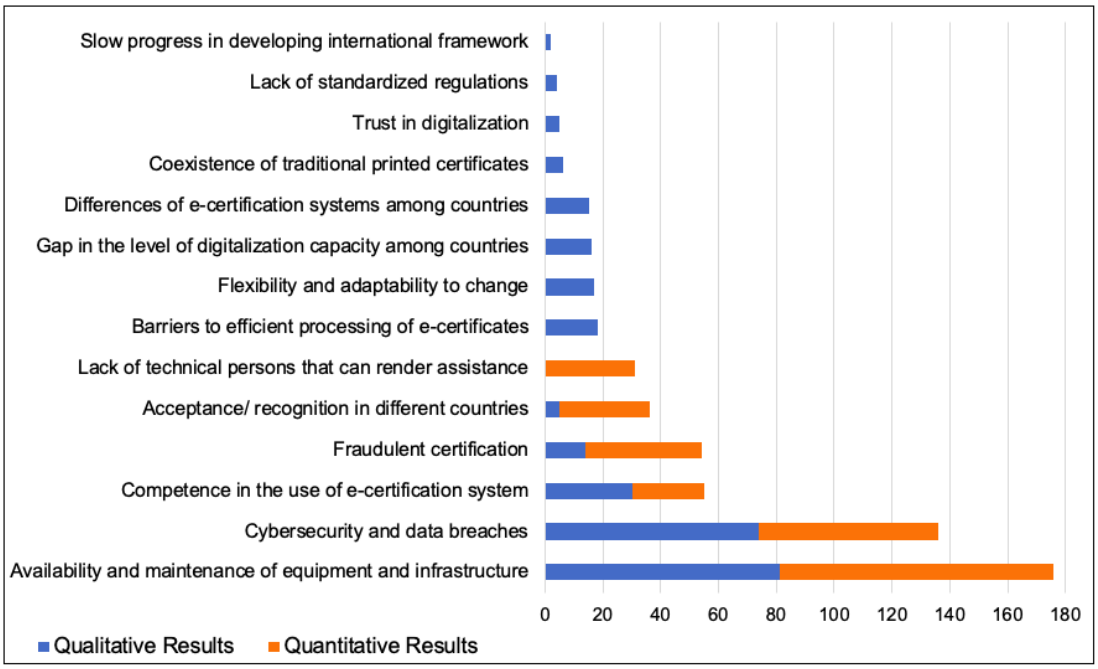


Table 13 presents the summarized description of the challenges to e-certification for seafarers based on the qualitative data from the interviews and survey questionnaires.

Table 13

Challenges of Using E-certificates

Main Themes	Brief Description
Availability and maintenance of equipment and infrastructure	It includes the challenges of the availability of reliable internet connections to facilitate the verification of e-certificates as well as the availability and maintenance of servers, computers, and the locations of the whole system
Cybersecurity and data breaches	100% assurance of protection against cybersecurity and data is not guaranteed. As such,

Main Themes	Brief Description
	a robust mechanism for cybersecurity and data privacy protection is needed
Competence in the use of e-certification system	Not all end-users have the competency or knowledge to use a digital platform such as the e-certification system. Seafarers might struggle to learn new technology and comprehend how an online system operates.
Barriers to the efficient processing of e-certificates	It includes delayed encoding of data in the e-certification system by MARAD's partner agencies; and delayed approval and release of e-certificates
Flexibility and adaptability to change	It includes the resistance to change by some countries and the administrations, and the adaptability of end-users to use new technologies
Gap in the level of digitalization capacity among countries	The level of digitalization capacity of different countries varies
Differences of e-certification systems among countries	Different jurisdictions may have different e-certification systems which require different knowledge and competencies. This lack of standardization poses an obstacle in the verification of e-certificates.
Fraudulent certifications	E-certificates are at risk of fraud. There are people who do everything possible and use the latest technology to falsify and forge these electronic certificates
Coexistence of traditional printed certificates	The blend of both certificates might be confusing and shipping companies with international crew would not have all the data that are readily available
Trust in digitalization	It is difficult to prove the legitimacy of a document to people who do not trust the e-certification system
Acceptance or recognition in different countries	There might be instances where some countries represented by their respective Port State Control officers would not recognize or accept the validity and authenticity of e-certificates.
Lack of standardized regulations	There is a challenge to the legal and regulatory framework in countries where e-certification is not recognized. In addition, the lack of standardized international regulation on what information of

Main Themes	Brief Description
	seafarers the MARAD may show in the verification of e-certificates is also a challenge.
Slow progress in developing and implementing the international governance framework	The changes in the STCW Convention clarifying the use of e-certificates for seafarers took eight years before it was finally agreed upon in the IMO and is to enter into force by 2025. There are a lot of countries that have not started the use of e-certificate or even developed the system because they have been awaiting the regulations.

4.3.3 Entire Replacement of Traditional Printed Certificates

Generally, all participants were not against the entire replacement of traditional certificates with e-certificates when they were asked about their thoughts during the interview. The highlight of their views are presented verbatim in Table 14.

Table 14

Participants Thoughts about the Entire Replacement of Traditional Printed Certificates with E-Certificates

Participants	Response Highlight
Mr. Patrick	*"I think it's a lot easier for the seafarers to be having all of their certificates in their smartphones, they can have access to their certificates using their gadgets and show it anytime and it can be verified at any time and if they require a hard copy they can actually have a hard copy they just need to print it out."*
Ms. Margaret	*"It is a demand of time."*
Capt. James	*"I'm looking very much forward to it…We've basically been awaiting this approval from the IMO on whether we could work towards removing paper in the manner that we saw most beneficial…I really see that it's something that would change this industry and hopefully for the better."*
Mr. Joseph	*"I think it's a good thing…because of the efficiency and the ease. But there is a bit of sentimental value attached to paper certificates and licenses. But again, like I say, that's already been changing*

Participants	Response Highlight
	through the years…We've got to roll with the times."
Ms. Amanda	*"I would totally agree in replacing hard copies or printed certificates with digital…in the assurance that all the security measures and the verification measures, verification protocols are all in place prior to such implementation."*
Mr. John	*"It's more helpful both in administration and for seafarers. Because it's digital, it's easy to reproduce and restore. And anytime, you can download it from your account."*
Mr. Paul	*"When I sail, I use hard copy charts, navigation charts. Now, …the best that is provided with electronic chart display systems. So, the hard copy charts don't use anymore. So, I think the maritime administration and the IMO as well, both are working in that way in order to reduce and remove at all the hard copy certificates in all aspects."*
Capt. Anthony	*"It will happen and it's got to be, why not? …I have stopped carrying money in my purse… It's three years now. I never thought that it would come to that. So, but we are, isn't that so? I think there will be a time when it will be accepted as the norm."*

4.3.4 Other Emerging Themes from the Semi-Structured Interviews

As a result of the inductive thematic analysis where predetermined categories were not applied, there were three other significant themes that emerged during the conduct of the qualitative analysis, namely: 1) best practices in e-certificate implementation; 2) the key to the success of the global application of e-certificate to seafarers; and 3) other suggestions for the effective implementation of e-certification to seafarers. Table 15 presents the contents of the findings.

Table 15

Emerging Themes from Inductive Thematic Analysis

Overarching Themes	Sub-Themes	Short Description
Best practices in the e-certificate implementation	Security	High-level focus should be given to the establishment of security measures to protect the system as well as the data of the seafarers against cyber-attacks and data breaches.
	Measures on equipment and infrastructure readiness	There should be measures in place for the readiness of equipment and infrastructure necessary for the application of e-certification. It includes having a backup internet connection, and backup hardware and software including the planned maintenance of the whole system. Having a backup server mirroring the main database and is placed on a separate site may ensure continued operation of the system.
	Use of Blockchain Technology	It is advantageous to use Blockchain Technology in the e-certification system. Although there is no system that is not "hackable", blockchain technology helps to increase the security of the system.
	Continual improvement	The MARAD should look for the continuous improvement of the e-certification system. Ms. Amanda stressed that although their Administration is already fully implementing the e-certification system for seafarers, they are continuously looking for further improvements to streamline the processes relating to seafarers' certification.
	Data privacy protection	To protect the privacy of the seafarers, the data privacy law of MARAD's respective country should be introduced and observed.
	Data sharing mechanism	A mechanism for data sharing with seafarers' consent should be established to protect the privacy of seafarers. Capt. James shared that their Administration developed some self-service platforms for the seafarers and the shipping companies allowing the sharing of

Overarching Themes	Sub-Themes	Short Description
		data between these platforms. The seafarers can access all their information and certificates in the platform and are able to share those data with the shipping companies of their choice by giving them a consent with time limit. On the other hand, the shipping companies have their own platform where they can access the data shared by the seafarers. Consequently, both seafarers and shipping companies have the capability in the system of ending the given consent immediately.
	Exchanges of best practices	The exchanges of best practices among MARAD make e-certificate implementation more effective.
Key to the success of the global application of e-certificates to seafarers	Accessibility of e-certification system	When the e-certification system of every country is accessible by all MARAD allowing data-sharing for purposes of verification of seafarers' certificates as required by the STCW Convention
	Clear and harmonized regulations and guidelines	When there are clear and harmonized regulations and guidelines from the IMO for the standardization of e-certification system to ensure compatibility of all systems and to avoid confusion of seafarers and other concerned parties
	Sufficient resources and capacity	When all Parties to the STCW Convention have sufficient resources and capacity in terms of level of digitalization to implement the e-certification
	Build trust	The trust in using digital systems should be built by demonstrating how the e-certification system works
	E-certification system model	When the maritime industry agrees on and establishes a model of e-certification system where seafarers are able to provide consent to MARAD to share their data with shipping companies, and the MARAD, on the other hand, are able to share the data with the

Overarching Themes	Sub-Themes	Short Description
		relevant shipping companies for those specific seafarers.
Other suggestions for the effective implementation of e-certification for seafarers	E-certification being data	With e-certification, the maritime industry should start looking at certification being data rather than something in a presentable file format.
	MARAD as originator of data	The data in the e-certificate of seafarers should always originate from the Maritime Administration of the certificate-issuing country.
	Extending e-certificates to seafarers' training	To fully implement the e-certification for seafarers, even training certificates of seafarers should also be in electronic format, not only the Certificates of Competency (COCs), Certificates of Proficiency (COPs), or Certificates of Endorsement (COEs) of seafarers.
	Integration of seafarers' certificates	The maritime industry should take into consideration integrating all certificates of every seafarer into one e-certificate.
	Free flow of communication	There should be free flow of communication among MARAD for purposes of efficient verification of e-certificates.

4.4 Chapter Summary

This Chapter, in presenting the findings of the research, described the components of an e-certificate in general and outlined the international legal framework of e-certification for seafarers which informed the development of survey questionnaires and semi-structured interviews. Further, the merits and demerits of e-certification of seafarers as well as the challenges assuming its global application were also presented based on the results of qualitative and quantitative analysis of collected primary data.

Chapter 5: Analysis and Discussion

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

5.1 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, 2022); in-place security measures (Agustin et al., 2020; Bao et al., 2020; Ghani et al., 2022; Publico, 2018; Maulani et l., 2021; Belaa, 2022); and effective structural design (Li et al., 2019) where it allows 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 of the aforementioned components for the effective implementation of e-certificates were also found to be present in the IMO guidelines on the use of e-certificates of seafarers (MSC.1/Circ.1665). 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 prior to 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.

5.2 Nature and Functions of an International Legal Framework on E-Certification of Seafarers

Based on the chronology of events explained in Chapter 4.2, the nature of the international legal framework on e-certification of seafarers was realized. It was found

that the IMO Member States play an essential role in the development and implementation of e-certification of 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, together with IGOs and NGOs, shape the contents of the amendments to the STCW Convention and Code as well as the contents of the guidelines. They have a voice when participating in the Correspondence Group, in HTW Sub-Committee, as well as in MSC sessions, and they can also submit proposals to IMO. 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. They acknowledge all submissions or proposals made by the Member States. Moreover, the MSC, together with the Parties to the Convention, approves and adopts amendments and guidelines after tedious processes have been undertaken.

The sessions of the HTW Sub-Committee and the MSC are conducted annually. Since all proposals submitted by the Member States, as well as the comments made during the session, are recognized by the Committee and the Sub-Committee, the progress toward the approval of STCW Convention amendments and the guidelines is slow as can be inferred from Figure 9 in Chapter 4. It took five years to finally adopt such amendments and guidelines on the use of e-certificates of seafarers.

The international legal framework on e-certification of seafarers functions is based on the approved and adopted amendments to the Convention. It serves as the mandatory reference by all Parties to the Convention in using either paper or electronic form of the STCW-required certificates. MSC 107/20/Add.1 Annex 10 provides an amendment to the STCW Convention adding the definition of “original form” under Regulation I/1 (Definition and clarifications) paragraph 1. It states that “*original form* means a paper or an electronic form of any certificate required by the Convention,...”. Further, Regulation I/2 (Certificates and endorsements) paragraph 11, requires that any certificate required by the Convention must be maintained in its *original form* onboard the ship on which the holder is serving and that when using an electronic form, *“the minimum required data must be accessible as defined by the Administration in accordance with the STCW Code, which is necessary to initiate a verification procedure”.* Moreover, MSC 107/20/Add.1 Annex 11 replaced paragraph

4 of Section A-I/2 (Certificates and endorsements) outlining the standards when using formats that are different from those set forth in the aforementioned Section. On the other hand, the associated guidelines on the use of e-certificates of seafarers (MSC.1/Circ.1665) will serve as a reference for the Parties to the Convention and other stakeholders when implementing the e-certification.

5.3 Merits and Demerits of E-Certification for Seafarers

Taking into account the findings of the study, 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 existing literature across different fields of industry. The ease of accessing and verifying e-certificates across different fields of industry was highlighted in the studies of Wu et al., (2001), Chen-Wilson et al. (2009), Cosgrave (2018), and Herbert et al. (2022). Meanwhile, it was also revealed that e-certification primarily relies upon the availability of reliable internet connections (Wu et al., 2001; Cosgrave, 2018; Song, 2021) which serves as a demerit of using e-certificates. Nevertheless, Behforouzi et al. (2022) suggested that MARAD may develop an application enabling seafarers to securely save their certificates and retrieve them offline. This solution is already being implemented in one of the MARADs as confirmed by a participant in the interview.

The convenience of using e-certificates was also underscored in the research findings. However, it was also revealed that the effective use of e-certificates requires digital literacy which contributes to one of the drawbacks. Some seafarers do not have the appropriate competence to navigate digital platforms. They may have difficulties in adapting to new technologies and understanding how an online system works. The same finding was also highlighted in Chen-Wilson et al. (2009) explaining that the use of e-certificates can be challenging and contentious, particularly for individuals without proficiency in computer literacy and familiarity with electronic devices. As such, they suggested that the design of an e-certification system must also cater to those without IT skills. On the other hand, taking into account the global digitalization trend, the

need for the development of standardized digital competences for all seafarers was asserted by Hopcraft (2021).

In terms of faster processing time and reduction of administrative burden to seafarers, shipping companies, and other stakeholders in the maritime industry, Cosgrave (2018) demonstrated the same analysis outcome, explaining that e-certificates have the potential to expedite administrative processes while also ensuring their regulated execution and the accuracy of data input. The reduction of administrative burden on stakeholders as a result of e-certificate implementation for seafarers is likewise revealed in the study of Behforouzi et al. (2022) regarding the implementation of digital certification for seafarers in the Sultanate of Oman, and is also expected by the Danish Maritime Authority (DMA, 2021). In addition, Behforouzi et al. (2022) claimed that digitalization serves as a means to expedite the process of retrieving data and minimizing the occurrence of errors.

In terms of data privacy protection, aside from using blockchain technology, the study found that a robust e-certification system structural design would allow better data privacy protection, for example, with the incorporation of a feature of seafarers' consent to allow data-sharing with the shipping companies. The IMO guidelines on the use of electronic certificates of seafarers also require, among other features, the inclusion of an electronic signature as a means of verifying the identity of the issuer and the integrity of the electronic data. This feature, however, was not mentioned by the participants in the study. Nevertheless, it can be recalled in the literature review that HM Government of Gibraltar uses digital signatures for its ships' and seafarers' certificates (HM Government of Gibraltar, 2022). Further, Mubarak et al. (2022), Gillis et al. (2023), and Adobe (2023) emphasized that digital signatures prevent the falsification or tampering of documents.

However, there are differing views about the security assurance afforded by e-certification. Similar to the findings of Cosgrave (2018), e-certificates face significant obstacles in terms of security concerns. It was contended that an excessive number of system users and managers compromises the security of the system. As such, the significance of implementing resilient cybersecurity measures was highlighted which is consistent with the study of Agustin et al. (2022) and Ghani et al. (2022). This study finds that utilizing blockchain technology provides better protection against data and

security breaches, and better management of seafarers' documentation. The participants in the study also expressed that making a certificate electronic enhances its protection against fraud and security breaches which is consistent with the findings of Mubarak et al. (2022). For instance, Capt. James stated:

> *We believe that e-certification and e-certificates are a lot better protected against fraud because a digital or an e-certificate is a lot more difficult to manipulate compared to a paper certificate because everything should always be connected to the verification part...You would have to change the certificate in our systems as well. Not only the certificate available to you, but also the certificate in our systems behind our security. So it's a lot more difficult to have a successful fraud, so to say, because you have to make changes in more places and it's a lot more difficult.*

On the contrary, Mr. Paul, from one of the largest flag registries in deadweight tonnage, shared his experience with fraudulent certificates in the maritime industry where people created fraudulent certificates that can be verified in fake online database:

> *In spite of the technology getting better every day, there are people who do everything possible and use the last technology to falsify and forge those electronic certificates… I have received several certificates issued by another Administration where the template of the certificate or the QR code or the identification number is fake. And in the worst case, they also create a false database. So, when I say they create a false database, it's because they submit a fake certificate and that certificate is provided on a QR code. And when you use your phone and you try to scan the QR code, automatically, they will direct you to the website with fake database.*

On the other hand, as Ghani et al. (2022) highlighted, e-certificates are digital in nature. Hence they eliminate the carrying of the bulk of printed paper certificates by seafarers onboard the ships which could help eliminate the risk of loss of certificates. Further, the implementation of e-certificates for seafarers reduces processing and traveling costs, as well as stress on individuals. The same was also supported by Behforouzi et al. (2022) highlighting that digitalization decreases its associated overhead expenses. Moreover, it gives efficiency to the maritime industry in terms of

ship and crew management and also enhances the management and control of seafarers' data by the MARADs because of integrated or centralized records of seafarers which drives faster processing and issuance of electronic documents. This finding aligns with the IMO's objective of offering a solution for the effective management and control of seafarers' documentation (IMO, 2023b).

With regard to the environmental impact of e-certificate implementation, the interviews in the study stressed that e-certificates are more environmentally friendly, not only because they do not require the use of paper but also because they do not need to be transported physically. However, an argument can be made that such systems contribute to an emerging environmental threat from the increased energy consumption of global computer servers. Sharma & Dash (2022) emphasized that every online engagement carries a consequential environmental footprint emanating from digital carbon emissions and power usage due to technological progress. Jungblut (2019) and Sharma & Dash (2022) explained the adverse environmental impact of using the internet on mobile phones, cloud computing, computers, servers, and blockchain technologies. In order to achieve global sustainability when using technology, they outlined some strategies such as placing the data centers in cooler countries, using green electricity such as wind and solar power, effective data management, and individual discipline in efficient use of the technology.

When it comes to the usage behavior of the three key stakeholders - the issuer, the owner, and the receiver (Chen-Wilson et al., 2009) i.e., the MARAD, the seafarers, and the shipping companies, respectively in the maritime context, the use of a modified UTAUT model originally developed by Venkatesh et al. (2003) led to findings consistent with those of Venkatesh et al. (2003). Performance expectancy, effort expectancy, social influence, and facilitating conditions are direct determinants of the stakeholders' usage behavior. However, it was found that these determinants have only very weak significant relationships with usage behavior in the field of seafarers' e-certification. Therefore, when the level of these key constructs increases or decreases, it cannot be guaranteed that their usage behavior will move the same way. Furthermore, it was found that the gender and age of individuals in the three key stakeholder groups as well as the experience and position category of seafarers do not affect their performance expectancy, effort expectancy, social influence,

facilitating conditions, and usage behavior. As such, the study does not (in the specific case of seafarer e-certification) support the findings of Venkatesh et al. (2003) that gender, age, and experience serve as moderators. Moreover, the study contributed to the understanding that “position category” of seafarers likewise does not moderate the usage behavior and its key determinants. Interestingly, it was found that the usage behavior of the key stakeholders has significant differences in terms of their field of work. In other words, “field of work”, as a variable, moderates usage behavior, unlike the other variables gender, age, experience, and position category.

5.4 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 such as the possible cybersecurity and data breaches, and the challenge of the competence of end-users in the use of an e-certification system. Additionally, other challenges include the availability and maintenance of equipment and infrastructure; fraudulent certification; acceptance or recognition in different countries; lack of technical persons that can render assistance; barriers to efficient processing of e-certificates; flexibility and adaptability to change; gap in the level of digitalization capacity among countries; coexistence of traditional printed certificates; trust in digitalization; lack of standardized regulations; and slow progress in developing an international framework.

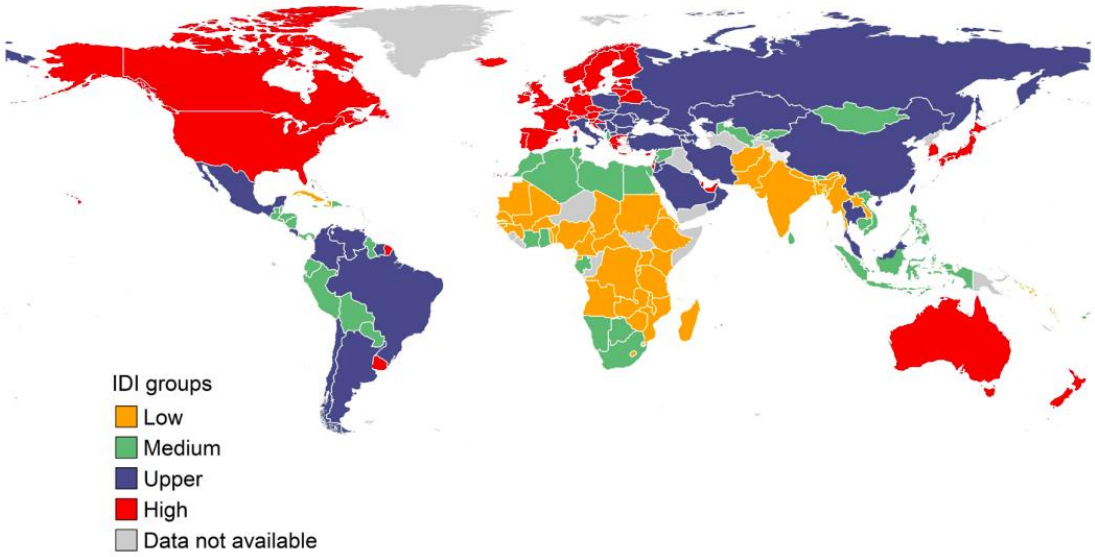
The challenge to technological equipment and infrastructure when implementing e-certificates has also been highlighted in the study of Mubarak et al. (2022). The authors asserted the need for sufficient funds to strengthen the resources of an organization. In terms of seafarers' e-certificates, this challenge is mainly in connection with the unavailability of reliable internet connections. With regard to the challenge of possible non-acceptance or non-recognition of e-certificates by Port State Control officers in different countries, this can be associated with trust in technology (McKnight et al., 2009) as well as the effectiveness of policy implementation (Mubarak et al., 2022) at a global level.

Moreover, the varying levels of digitalization capacity among countries were also confirmed by the International Telecommunication Union (ITU) (2017) as shown in Figure 16 and by UNCTAD (2021). The figure illustrates the Information and Communication Technology (ICT) Development Index (IDI)[10] performance differences across regions and economic development levels.

[10] The IDI serves as a robust instrument employed by the ITU to effectively track the advancements made in achieving a comprehensive global information society. The scope of this monitoring encompasses the ICT infrastructure, utilization, and skills, hence facilitating cross-country and temporal comparisons.

Figure 16

IDI Quartiles by IDI value, 2017



Note. From *Measuring the Information Society Report,* Volume 1 by International Telecommunication Union (ITU), 2017, (https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf).

In order to adapt to the ongoing development of the e-certification of seafarers, there is a need for further ICT advancements in countries with low IDI values. It necessitates strong national commitment (Akiwumi, 2022) and international cooperation to augment the innovative capabilities of emerging nations and enable the transfer of technology (UNCTAD, 2021).

Finally, regarding the lack of standardized regulations that was mentioned in the interview where countries provide different amounts of seafarers' information when e-certificates are being verified, the recent amendments to Regulation I/2 paragraph 11 and Section A-I/2 of the STCW Convention contained in MSC 107/20/Add.1 provide the standard minimum required data that must be accessible to initiate a verification process. Full compliance with the STCW Convention and its relevant guidelines on the use of e-certificates of seafarers would further protect the data privacy of seafarers.

Chapter 6: Summary and Conclusions

This Chapter provides the summary and conclusions of the study. In addition, the limitations and the recommended considerations for future research are also outlined.

6.1 Conclusions

This research study investigated the global application of e-certificates to seafarers which is one of the contemporary issues in the maritime industry regarding digitalization. The study employed a mixed-method approach to quantitative and qualitative data. Specifically, data triangulation (through the aid of documents, survey questionnaires, and interviews) and methodological triangulation (through scoping review, document analysis, thematic analysis, and statistical methods).

As a result of the study, it can be concluded that the implementation of e-certificates to seafarers is generally useful and brings a number of benefits. Although there are some demerits in using e-certificates, they are outweighed by its merits which include, among others, better accessibility to certificates; convenience not only for the seafarers but also in the MARAD and the shipping companies/manning agencies; easier and real-time verification; and increased efficiency through optimized processes. E-certificates also offer an increased level of data privacy and cybersecurity protection provided that the e-certification system employs robust mechanisms such as the use of blockchain technology, application of digital signatures, and by having a good structural design of the system.

In terms of acceptance and use of e-certification system, the usage behavior of the MARAD, the shipping companies, manning agencies, and the seafarers relative to e-certificates has a positive correlation, to some extent, with their performance expectancy, effort expectancy, social influence, and facilitating conditions. More specifically, their usage behavior has only weak positive correlations with the aforementioned constructs. This implies that there is no certainty that when these key constructs rise or decrease, the usage behavior of the stakeholders will follow the same pattern. Further, it was found that the distributions of the aforementioned key constructs have no statistically significant differences across the three stakeholders' age and gender, and the seafarers' length of experience and position category.

However, the field of work as a variable moderates usage behavior, unlike the other aforementioned variables.

While this study recognizes that the use of e-certificates for seafarers is widely advantageous, its global application is hindered by some challenges as presented in the previous Chapters. Addressing these challenges is crucial for the successful implementation of e-certification of seafarers. The integration of the best practices shared by the participants in the study who are already implementing the e-certification system for seafarers in their respective jurisdictions, along with the consideration of their perspectives regarding the success of e-certificates global implementation of e-certificates, may offer viable solutions to these challenges.

In terms of the challenge of the availability and maintenance of equipment and infrastructure, consideration of having backup hardware and software including backup internet providers helps address this challenge. As for the risk of cybersecurity and data breaches, although it is recognized that nothing can guarantee the 100% security of the system, having robust security measures in place is necessary. This may include the use of blockchain technology and a good e-certification system structural design. The implementation of such measures could also reduce the attempts at forging or tampering with the e-certificates. Fraudulent certification can also be combatted by promoting open communication among MARAD as this facilitates efficient verification of e-certificates.

Continuous improvement of the system is necessary taking into account the competency of end-users in utilizing the system, the unavailability of technical persons who can provide assistance, and the barriers to efficient application processing. It is viewed that further simplification of the system and streamlining of processes may help the end-users better facilitate its use.

Regarding the concerns of non-acceptance by some countries of seafarers' e-certificates, building trust in using digital technology may help address this issue. This can be achieved through raising awareness and by providing tangible proof of the functionality and efficacy of e-certification or by demonstrating how it actually works.

Another challenge that could be addressed by considering the perspective of the participants in the study is the differences in e-certification systems among countries. In order to have harmonious e-certification systems where different knowledge and competencies will no longer be required for each system, the establishment of a model of an e-certification system with a mechanism of data-sharing through seafarers' consent is necessary. This will facilitate better and faster verification of seafarers' e-certificates.

The researcher finally concludes that, although there is strong support from the maritime industry toward the entire replacement of seafarers' traditionally printed certificates with e-certificates, its global implementation would 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 of seafarers, and 3) have the adequate digitalization capacity (skills and infrastructure) to facilitate the use and acceptance of e-certificates for seafarers. Further, it can be stated that the coexistence of the conventional printed certificates and e-certificates of seafarers will remain while effectively addressing the hindrances identified in this study. Moreover, national dedication and international cooperation will play an important role in the achievement of the global application of e-certificates to seafarers. In terms of the international legal framework, the STCW Convention along with the corresponding IMO guidelines serve as instruments for the standard and effective implementation of seafarers' e-certification.

6.2 Limitation and Future Research

- This study only focused on the global application of e-certification to seafarers; it did not examine the specific challenges being faced by specific countries on the implementation of e-certification. As such, there may be other challenges that were not revealed in the research.
- The study applied a modified UTAUT model to understand the e-certification usage behavior of seafarers, MARAD, and shipping companies/manning agencies. In order to have a full understanding of the behavioral intention and usage behavior of the participants towards the e-certification system of

seafarers, future researchers may apply the original UTAUT model proposed by Venkatesh et al. (2003) where different statistical methods are used.

- The researcher employed convenience sampling to gather data through online survey questionnaires. Therefore, this study does not guarantee that the population being studied (seafarers, MARADs, shipping companies/manning agencies) is fully represented.
- The results from the survey questionnaires of this study are limited based on the data collected from 225 seafarers from 18 countries, wherein 189 or 84% of them are from the Philippines. On the other hand, MARADs were represented by 38 respondents from 13 countries, where 17 or 44.7% are from the Philippines. Further, there were only 23 respondents from the shipping companies/manning agencies. Future researchers can add more respondents with different nationalities to ensure representation of the global perceptions.

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Appendices

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Appendix A: Summarized Results of the Scoping Review

Author(s)	Type and Background	Information about E-certification
(Agustin et al., 2020)	Library study method by implementing e-certificate in an open journal system with blockchain technology tools such as blockcerts.	• The application of blockchain technology is essential for validating and distributing managed e-certificates in open journal systems, ensuring verifiable issuance, data management, and preventing duplication or falsification. This enhances the reputation and ensures e-certificate safety and authenticity.

(Alruwaili, 2020)	Design science research (DSR) methodology	• Advantages of using E-learning Chain System Architecture using Blockchain:
		  • Efficiency
		  • Security
		  • Credibility and reliability
		  • Interoperability
		  • Record management

(Bao et al., 2020)	Blockchain applications in the energy sector	• Blockchain characteristics:
		  • Decentralized
		  • Anonymity
		  • Transparency
		  • Democracy
		  • Security

(Belaa, 2022)	Modern payment methods in Algeria	• Electronic certification verifies the validity of a signature through an impartial intermediary, ensuring integrity and credibility in data. This digital certificate or document attests to the signatory's identity, demonstrating the security and legitimacy of electronic transactions, ensuring legal protection.
(Chen-Wilson & Argles, 2010)	Through analysis of the existing systems	• Implementing an electronic e-certificate system is crucial for validating qualification certificates, suitable for all levels, and ensuring high security measures. Holders should have control over usage and a verification method, and the system must be secure beyond the e-certificate itself. • An e-certificate is a crucial end product of a successful certification process, requiring security control, adaptability to e-portfolios, and addressing social

Author(s)	Type and Background	Information about E-certification
		impact issues.
(Chen-Wilson et al., 2009)	Addresses the issues at stake, explores the gap between current e-Portfolio tools and an e-Certificate system, and presents an approach which solves the related problems.	● The three stakeholders involved in e-certificate processes are an issuer, an owner, and a reviewer. ● E-certification processes require standard control for low and high level qualification certificates. Security methods must be in place. Holder must be able to control which e-certificates to send to employers and how long they will be valid. The system should be user-friendly and suitable for users without IT skills. Employers must view received e-certificates and provide varied verification options, with no e-certificates displayed for users without e-certificates. The system should be able to verify any level qualifications issued from any education institution using the same standard.
(Ghani et al., 2022)	Blockchain-based framework for students e-certification management and system sharing	● Blockchain-based certification offers immutability, privacy, and decentralization, faster issuance and verification, controlled data sharing through smart contracts, reduced latency, and transparency. It also contributes to digital transformation, reducing paper consumption, and allows access to private information with blockchain-authorized user approval.
(Li et al., 2019)	Blockchain system of e-learning assessment and certification	● A blockchain system for e-learning assessment and certification combines public and private blockchains, offering four smart contract schemes for e-learning assessment, credit exchange, digital certificate issuance, storage, verification, and voucher allocation.
(Maulani et al., 2021)	Digital certificate authority with blockchain in education	● Digital certificate refers to information issued by a Certificate Authority ● Digital certificate promotes authenticity, security, reliability, and public trust. ● Digital certificate signature is different from traditional electronic signature ● The issuance of blockchain-secured

Author(s)	Type and Background	Information about E-certification
		certificates provides autonomy, trust, backup, savings, and accuracy
(Mubarak et al., 2022)	Qualitative and quantitative analysis of impacts and constraints on implementing e-certification policies in Indonesia	● The implementation of the e-certification policy has had positive impacts including, impact on reducing the counterfeiting of information in digital documents, preventing corruption and improving bureaucratic efficiency. However, the implementation of this policy also faces obstacles, including a long bureaucracy, insufficient human resources, responsibility overlapping, and limitation of Indonesia's Electronic Certification Office authority in managing the required resources. ● There should be harmonized and synchronized e-certification regulations; strong organizational capacity and resources; and involvement of actors and improvement of service quality
(Ryan et al., 2023)	Electronic sanitary certificates for trade in animal products	● The utilization of electronic certificate exchange can provide advantages for both exporting and importing nations by facilitating increased efficiency benefits, heightened transparency, and improved traceability. Additionally, it can contribute to enhanced risk management throughout the entirety of the food supply chain.

Appendix B: Chronology of Events on the Amendments to STCW Convention and the Development of IMO Guidelines on the Use of Electronic Certificates of Seafarers

Date	Document Number	Document Title	Details
18 April 2013	FAL.5/Circ.39	Interim guidelines for use of printed versions of electronic certificates	• Provides guidelines to facilitate the use and acceptance of printed versions of electronic certificates. These interim guidelines are limited to the use of printed versions of electronic certificates.
07 October 2014	FAL.5/Circ.39/Rev.1	Guidelines for the use of electronic certificates	• Revokes FAL.5/Circ.39 • Aims to facilitate the use and acceptance of electronic certificates. • Clarified the definition of a certificate, electronic certificate • Added a definition of an electronic signature, and verifying. • Features of an electronic certificates were clarified. • The term validation was replaced by verification.
20 April 2016	FAL.5/Circ.39/Rev.2	Guidelines for the use of electronic certificates	• Revokes FAL.5/Circ.39/Rev.1 • The purpose of these Guidelines is to facilitate the use and acceptance of electronic certificates. • Clarified the definition of verifying • Provided additional feature requirement of electronic certificates
05 January 2018	Circular Letter No.3794	Communication from the Government of Malta on the issuance of statutory electronic certificates	• The Government of Malta communicated that the Maltese Registry begun accepting electronic documents and certificates to comply with FAL.5/Circ.39/Rev.2
06 March	Circular	Communication	• Informed all concerned that the

Date	Document Number	Document Title	Details
2018	Letter No.3822	from the Government of Portugal regarding its acceptance of the use of electronic certificates on board ships flying the Portuguese flag	Government of Portugal accepts the use of electronic certificates on board ships flying the Portuguese Flag compliant with FAL.5/Circ.39/Rev.2
11 May 2018	HTW 5/15/5	Any other business: Unified interpretation of regulation I/2 of STCW Convention (Submitted by Belarus and the Russian Federation)	● Provides a proposal for an STCW circular containing a draft unified interpretation of STCW regulation I/2 clarifying the meaning of the term "original form" for seafarers' certificates
30 August 2018	HTW 5/16	Report to the Maritime Safety Committee	● The Sub-Committee considered document HTW 5/15/5 (Belarus and Russian Federation) proposing a draft unified interpretation of STCW regulation I/2 intended to clarify the meaning of the term "original form" for seafarers' certificates (Paragraph 15.19). The Sub-Committee recognized that there was a need to address the use of electronic certificates and the issues raised (Paragraph 15.21.1).
31 August 2018	MSC 100/17/7	Proposal for a new output to address the use of electronic certificates pursuant to the STCW Convention and Code (Submitted by Belarus and Russian	● Proposal for a new output for the current biennial agenda of the Committee in order for the HTW Sub-Committee to address the use of electronic certificates and documents issued pursuant to the STCW Convention and Code

Date	Document Number	Document Title	Details
		Federation)	
10 January 2019	MSC 100/20	Report of the Maritime Safety Committee on this one hundredth session	● MSC considered the proposal for a new output to address the use of electronic certificates and documents pursuant to the STCW Convention and Code (MSC100/17/7), and decided to include a new output in the provisional agenda for HTW 6.
15 February 2019	HTW 6/9	Development of amendments to the STCW Convention and code or the use of electronic certificates and documents of seafarers (Proposal for better use of seafarers' electronic certificates and documents submitted by China)	● Proposes reviewing the relevant provisions of the 1978 STCW Convention, as amended, and makes arrangements for the better use of seafarers' electronic certificates and documents.
21 February 2019	HTW 6/9/1	Development of amendments to the STCW Convention and Code for the use of electronic certificates and documents of seafarers (Work to be carried out to address the use of electronic certificates and documents of seafarers pursuant to STCW Convention and Code submitted	● Contains proposals on the work to be carried out to address the use of electronic certificates and documents of seafarers pursuant to STCW Convention and Code

Date	Document Number	Document Title	Details
		by the Russian Federation)	
20 February 2020	HTW 7/9	Development of amendments to the STCW Convention and Code for the use of electronic certificates and documents of seafarers (Report of the Correspondence Group submitted by the Russian Federation)	● Contains a report of the Correspondence Group on the Use of Electronic Certificates for Seafarers. ● The Group developed the light touch amendments to the 1978 STCW Convention, as amended, with the aim to allow the use of electronic certificates and decided to put the rest of the work outcome into a draft STCW circular for the sake of minimizing the administrative burden to Member States.
12 March 2021	HTW 7/16	Report to the Maritime Safety Committee	● The Sub-Committee outlined the report of the Correspondence Group on the use of electronic certificates and documents of seafarers, and invited the Committee to extend the target completion year for this output to 2022.
01 November 2021	HTW 8/9	Development of amendments to the STCW Convention and Code for the use of electronic certificates and documents of seafarers (Report of the Correspondence Group submitted by the Russian Federation)	● Contains the report on the work of the Correspondence Group on STCW Matters. ● The Group developed amendments to the STCW Convention and Code and finalize draft guidelines on the use of electronic certificates of seafarers and the associated draft STCW.7 circular.
02 December 2021	HTW 8/9/1	Development of amendments to the STCW Convention and Code for the use of electronic	● Contains the report on the use of electronic certificates and the requirements for achieving the standards as recommended by IMO. Hence, the document further explains the

Date	Document Number	Document Title	Details
		certificates and documents of seafarers (Guidelines on the use of electronic certificates and digital signature of the certificates submitted by the Islamic Republic of Iran)	requirements for a digital signature validation as well as different perspectives on issuing and updating the certificates in the digital format.
18 March 2022	HTW 8/16	Report to the Maritime Safety Committee	● The Sub-Committee agreed to the draft amendments to STCW Convention: - Regulations I/1 and I/2, concerning the inclusion of a new definition for "original form of any certificate required by the Convention" emanating from the use of electronic certificates, as set out in annex 7, for approval by MSC 106 with a view to adoption (Paragraph 9.7) - Section A-I/2 of the STCW Code, clarifying the application of existing terms and terminologies to the certificates and endorsements in electronic form (Paragraph 9.8). ● The Sub-Committee agreed to the draft guidelines on the use of electronic certificates of seafarers (Paragraph 9.10).
29 August 2022	MSC 106/10/2	Human Element, Training and Watchkeeping (Draft guidelines on the use of electronic certificates of seafarers submitted by Cook Islands, Dominica, Liberia,	● This document presents further modifications on the draft guidelines on the use of electronic certificates of seafarers to clarify the responsibilities of the parties involved when an electronic certificate is issued on recognition by endorsement in accordance with regulation I/10 of the STCW Convention, of a

Date	Document Number	Document Title	Details
		Palau and Republic of Turkiye)	certificate issued by or under the authority of another Party.
12 September 2022	MSC 106/10/4	Comments on document MSC 106/10 submitted by Japan	● Japan submitted a document proposing to align the terminology in the draft definition for original certificates (regulation I/1) with the terminology in the STCW Convention and referring to the draft guidelines on the use of electronic certificates of seafarers in the draft amendments to regulation I/2
30 November 2022	MSC 106/19 Para 10.3 to 10.9	Report of the Maritime Safety Committee on its 106th session	● The MSC approved draft amendments to STCW Convention: - Regulations I/1 and I/2 (Paragraph 10.4) - Section A-I/2 (Paragraph 10.5) ● Requested the Secretary-General to circulate approved documents in accordance with article XII of the STCW Convention, with a view to adoption at MSC 107 ● The draft guidelines on the use of electronic certificates of seafarers was referred together with document MSC 106/10/2 and the comments made at this session, to HTW 9 for further consideration and advice to MSC 107, having agreed that the proposed modifications needed detailed consideration (Paragraph 10.8). ● The Committee invited the FAL Committee to consider whether there might be any discrepancies between the two sets of guidelines and inform MSC 107 accordingly (Paragraph 10.9)

Date	Document Number	Document Title	Details
10 March 2023	HTW 9/15	Report to the Maritime Safety Committee	● The Sub-Committee agreed to refer the draft guidelines on the use of electronic certificates of seafarers to the MSC, for approval, as initially submitted to MSC 106 (HTW 8/16, annex 9)
26 May 2023	MSC 107/WP.4*	Adoption of the agenda; Report on credentials (Provisional terms of reference for the working and drafting groups expected to be established during MSC 107) note by the Chair	● The Drafting Group on Amendments to Mandatory Instruments, taking into account the decisions made in plenary, is instructed to finalize the draft amendments to Chapter I, Section A-I/2 of the STCW Code, and the draft associated MSC Resolution, based on Annex 10 to document MSC 107/WP.5 (Paragraph 4.7) and the draft MSC Circular on guidelines on the use of electronic certificate of seafarers based on MSC 107/WP.5 Annex 20 (Paragraph 4.11.7), for consideration by the Committee, with a view to adoption or approval as appropriate, on 08 June 2023.
07 June 2023	MSC 107/WP.8*	Consideration and adoption of amendments to mandatory instruments (Report of the Drafting Group)	● The Correspondence Group prepared the final text of the draft amendments to STCW Convention and Code, together with the associated draft MSC resolutions (Paragraph 26), and the text of the draft MSC circular on guidelines on the use of electronic certificates of seafarers (Paragraph 30.9) ● The MSC was invited to approve the aforementioned finalized texts.
26 June 2023	MSC 107/20	Report of the Maritime Safety Committee on its 107th session	● The expanded Committee, including delegations of 107 Parties to the 1978 STCW Convention, considered the final text of the proposed amendments to STCW Convention and Code and

Date	Document Number	Document Title	Details
			adopted unanimously: - Chapter I, by resolution MSC.540(107), annex 10 (Paragraph 3.81). - Section A-I/2 by resolution MSC.541(107), annex 11. ● The MSC approved MSC.1/Circ.1665 on Guidelines on the use of electronic certificates of seafarers (Paragraph 3.86.7)
28 June 2023	MSC.1/Circ. 1665	Guidelines on the use of electronic certificates to seafarers	● Provides guidelines and information on the use of electronic certificates of seafarers.
10 July 2023	MSC 107/20/Add. 1	Report of the Maritime Safety Committee on its 107th session	● Provides copy of the following Resolutions: ○ Resolution MSC.540(107) on the Amendments to regulations I/1 and I/2 of the STCW Convention, 1978 relating to the use of electronic certificates of seafarers including its annex is attached as Annex 10 to this document. ○ Resolution MSC.541(107) on the Amendments to Section A-I/2 of the STCW Convention, 1978 relating to the use of electronic certificates of seafarers including its annex is attached as Annex 11 to this document.

Appendix C: Survey Questionnaire for Maritime Administrations

Concept of e-certification: Interrogating its global application to seafarers

Survey Questionnaire

With the aim of reducing the administrative burden on Administrations, port State control officials, ships' crews, and other stakeholders caused, amongst other reasons, by reliance on traditional paper certificates, the International Maritime Organization (IMO) issued guidelines for the use of electronic certificates (e-certificates) in 2013. Currently, the existing approved guidelines which were issued in 2016 cover all documents issued by an Administration or its representatives that are used to show compliance with IMO requirements and used to describe operating conditions, crewing requirements, and ship equipment carriage requirements. In addition, in June 2023, guidelines on the use of electronic certificates of seafarers was issued by the IMO.

The study aims to interrogate the global application of e-certification of seafarers. The questionnaire is composed of two sections. **Section A** pertains to your demographic profile while **Section B** is composed of a set of questions to help the researcher gain insights into how the Maritime Administrations think about the implementation of e-certification for seafarers. It should take no more than 10 minutes to complete the questionnaire.

Thank you very much in advance for taking part in this survey. Your answers will make a significant contribution to my study.

SECTION A

Name *(optional)* _____

Age ◯ 26 and below ◯ 27 - 42 ◯ 43 - 58 ◯ Over 58

Sex ◯ Male ◯ Female ◯ Prefer not to say

Country/Flag State _____

Name of Organization _____

Position Category ◯ Rank and file ◯ Supervisory ◯ Managerial ◯ Top Management

SECTION B

Kindly express your degree of agreement or disagreement with the statements below by ticking the appropriate box. There are also three open questions that will further help the researcher obtain your thoughts about e-certification. Your comprehensive answer is much appreciated.

1 = Strongly Disagree

2 = Disagree

3 = Slightly Disagree

4 = Slightly Agree

5 = Agree

6 = Strongly Agree

Items	1	2	3	4	5	6
1. The use of an e-certification system will enable my Organization to verify seafarers' certificates issued by different Maritime Administrations faster.						
2. I am confident that all e-certification systems are protected against fraud.						
3. I am confident that all e-certification systems are protected against security breaches.						
4. I believe that e-certificates should be in compliance with the privacy laws of the issuing Administration.						
5. I am confident that all port State control officers will accept electronic certificates of seafarers.						
6. In general, I am doubtful of the reliability of the e-certification system in terms of data retention or storage.						
7. The use of an e-certification system will reduce the administrative burden on our Organization.						
8. The use of an e-certification system will reduce the administrative burden on seafarers.						
9. I believe that it takes less time to acquire an e-certificate than the traditional printed certificate.						
10. By using an e-certification system, my Organization can easily access and retrieve e-certificates of seafarers.						

Items	1	2	3	4	5	6
11. At ports, it is more convenient to use an e-certificate over a printed certificate.						
12. I expect that all e-certification systems for seafarers are user-friendly.						
13. I believe that my Organization can easily verify the e-certificates issued by other Parties.						
14. My Organization is already implementing e-certification for seafarers. **Note:** If your answer is yes, please skip Question Nos. 15 to 17.	○ Yes			○ No		
15. I believe that there is a need to implement the use of e-certificate in my country because other nations are implementing it already.						
16. I believe that there is a need to implement the use e-certificates in my country because other nations also want to implement it.						
17. I believe my Organization supports the implementation of an e-certification system for seafarers.						
18. In general, I believe the shipping industry is supporting the use of e-certificates.						
19. My Organization has a computer server available that is controlled or approved as the main location of electronic certificates.						
20. My Organization has the capability of including electronic signatures in seafarers' e-certificates for verification purposes.						
21. My Organization has the capability of including a unique tracking number in seafarers' e-certificates for verification purposes.						
22. My Organization has a stable internet connection to verify e-certificates issued by different Maritime Administrations.						
23. My Organization has an appropriate computer software or mobile application (such as pdf reader) to verify e-certificates issued by different Maritime Administrations.						

Items	1	2	3	4	5	6
24. My Organization has an approved procedure in place for the implementation of e-certification for seafarers.						
25. My Organization has the capability of ensuring the validity and consistency of e-certificates in line with the format and content required by the relevant international regulations, as applicable.						
26. My Organization has the capability of ensuring that e-certificates are protected from edits, modifications or revisions other than those authorized by the Administration.						
27. My Organization has the capability of providing visible confirmation of the source of e-certificate issuance.						
28. I have the knowledge necessary to use e-certificates.						
29. In my Organization, there are available persons to assist me with the e-certification system challenges.						

30. What do you think is the greatest benefit of implementing the use of e-certification of seafarers?

_____
_____
_____
_____

31. Do you think there will be any challenges to using e-certification? Please explain.

_____
_____
_____
_____

32. How do you feel about entirely replacing traditional printed certificates with e-certificates?

_____
_____
_____
_____

Thank you for your time in completing the survey. Your participation is highly appreciated.

Appendix D: Survey Questionnaire for Shipping Companies/Manning Agencies

Concept of e-certification: Interrogating its global application to seafarers

Survey Questionnaire

With the aim of reducing the administrative burden on Administrations, port State control officials, ships' crews, and other stakeholders caused, amongst other reasons, by reliance on traditional paper certificates, the International Maritime Organization (IMO) issued **guidelines for the use of electronic certificates (e-certificates)** in 2013. Currently, the existing approved guidelines which were issued in 2016 cover all documents issued by an Administration or its representatives that are used to show compliance with IMO requirements and used to describe operating conditions, crewing requirements, and ship equipment carriage requirements. In addition, in June 2023, guidelines on the use of electronic certificates of seafarers was issued by the IMO.

The study aims to interrogate the global application of e-certification of seafarers. The questionnaire is composed of two sections. **Section A** pertains to your demographic profile while **Section B** is composed of a set of questions to help the researcher gain insights into how the Shipping Companies think about the implementation of e-certification for seafarers. It should take no more than 10 minutes to complete the questionnaire.

Thank you very much in advance for taking part in this survey. Your answers will make a significant contribution to my study.

SECTION A

Name *(optional)* _____

Age ◯ 26 and below ◯ 27 - 42 ◯ 43 - 58 ◯ Over 58

Sex ◯ Male ◯ Female ◯ Prefer not to say

Name of Organization _____

Trade Route ☐ Regional ☐ International ☐ Other: ____

Position Category ◯ Rank and file ◯ Supervisory ◯ Managerial ◯ Top Management

SECTION B

Kindly express your degree of agreement or disagreement with the statements below by ticking the appropriate box. There are also three open questions that will further help the researcher obtain your thoughts about e-certification. Your comprehensive answer is much appreciated.

1 = Strongly Disagree

2 = Disagree

3 = Slightly Disagree

4 = Slightly Agree

5 = Agree

6 = Strongly Agree

Items	1	2	3	4	5	6
1. The use of an e-certification system will enable my Organization to verify seafarers' certificates issued by different Maritime Administrations faster.						
2. I am confident that all e-certification systems are protected against fraud.						
3. I am confident that all e-certification systems are protected against security breaches.						
4. I believe that e-certificates should be in compliance with the law of privacy of the issuing Administration.						
5. I am confident that all port State control officers will accept electronic certificates of seafarers.						
6. In general, I am doubtful of the reliability of the e-certification system in terms of data retention or storage.						
7. The use of an e-certification system will reduce the administrative burden on our Organization.						

Items	1	2	3	4	5	6
8. The use of an e-certification system will reduce the administrative burden on seafarers.						
9. I believe that it takes less time to acquire e-certificates than the traditional printed certificate.						
10. By using an e-certification system, I can easily access and retrieve e-certificates of seafarers.						
11. At ports, it is more convenient to use an e-certificate over a printed certificate.						
12. I expect that all e-certification systems for seafarers are user-friendly.						
13. I believe that my Organization can easily verify the e-certificates issued by different Administrations.						
14. I support the use of e-certificates because other shipping companies are also supporting it.						
15. There is a need for our seafarers to use e-certificates because I believe they prefer using them over traditional printed certificates.						
16. I believe my Organization supports the implementation of an e-certification system for seafarers.						
17. In general, I believe the shipping industry is supporting the use of e-certificates.						
18. My Organization has a stable internet connection to verify e-certificates issued by different Maritime Administrations.						
19. My Organization has appropriate computer software or mobile application (such as pdf reader) to verify e-certificates issued by different Maritime Administrations.						

Items	1	2	3	4	5	6
20. My Organization has an approved procedure in place for the implementation of e-certification for seafarers.						
21. I have the knowledge necessary to use e-certificates.						
22. There are available persons to assist me with the e-certification system challenges.						

23. What do you think is the greatest benefit of implementing the use of e-certification of seafarers?

_____

_____

_____

_____

24. Do you think there will be any challenges to using e-certification? Please explain.

_____

_____

_____

_____

25. How do you feel about entirely replacing traditional printed certificates with e-certificates?

_____

_____

_____

_____

Thank you for your time in completing the survey. Your participation is highly appreciated.

Appendix E: Survey Questionnaire for Seafarers

Concept of e-certification: Interrogating its global application to seafarers

Survey Questionnaire

With the aim of reducing the administrative burden on Administrations, port State control officials, ships' crews and other stakeholders caused, amongst other reasons, by reliance on traditional paper certificates, the International Maritime Organization (IMO) issued **guidelines for the use of electronic certificates (e-certificates)** in 2013. Currently, the existing approved guidelines which were issued in 2016 cover all documents issued by an Administration or its representatives that are used to show compliance with IMO requirements and used to describe operating conditions, crewing requirements, and ship equipment carriage requirements. In addition, in June 2023, guidelines on the use of electronic certificates of seafarers was issued by the IMO.

The study aims to interrogate the global application of e-certification of seafarers. The questionnaire is composed of two sections. **Section A** pertains to your demographic profile while **Section B** is composed of a set of questions to help the researcher gain insights into how the seafarers think about the implementation of e-certification for seafarers. It should take no more than 10 minutes to complete the questionnaire.

Thank you very much in advance for taking part in this survey. Your answers will make a significant contribution to my study.

SECTION A

Name *(optional)* _____

Age ◯ 26 and below ◯ 27 - 42 ◯ 43 - 58 ◯ Over 58

Sex ◯ Male ◯ Female ◯ Prefer not to say

Nationality _____

Seagoing Service Experience ◯ Below 5 years ◯ 5 – 10 years ◯ 11 – 15 years ◯ 16 years above

Position Category ◯ Trainee Officer/ Cadet ◯ Support Level (Ratings i.e. OS, AB, Bosun, Wiper, Oiler, Fitter, ETR, etc.) ◯ Operational Level ◯ Management Level

SECTION B

Kindly express your degree of agreement or disagreement with the statements below by ticking the appropriate box. There are also three open questions that will further help the researcher obtain your thoughts about e-certification. Your comprehensive answer is much appreciated.

1 = Strongly Disagree

2 = Disagree

3 = Slightly Disagree

4 = Slightly Agree

5 = Agree

6 = Strongly Agree

Items	1	2	3	4	5	6
1. The use of the e-certification system will enable me to present my STCW Certificates to Port State Control Officers and other concerned parties faster.						
2. I am confident that my personal data in the e-certification systems are protected against fraud.						
3. I am confident that my personal data in the e-certification systems are protected against security breaches.						
4. I believe that e-certificates should be in compliance with the privacy laws of the issuing Administration.						
5. I am confident that all port State control officers will accept electronic certificates of seafarers.						
6. In general, I am doubtful of the reliability of the e-certification system in terms of data retention or storage.						
7. The use of an e-certification system will reduce the administrative burden on our Organization.						

Items	1	2	3	4	5	6
8. The use of an e-certification system will reduce the administrative burden on seafarers.						
9. I believe that it takes less time to acquire an e-certificate than the traditional printed certificate.						
10. By using an e-certification system, I can easily access and retrieve the e-certificates online.						
11. At ports, it is more convenient to use an e-certificate over a printed certificate at ports.						
12. I expect that all e-certification systems for seafarers are user-friendly.						
13. I am already using e-certificates.	Yes			No		
14. I want to use e-certificate because other seafarers are using it already.						
15. I want to use e-certificates because other seafarers also want to use them.						
16. I believe my Organization supports the implementation of e-certification systems for seafarers.						
17. In general, I believe the shipping industry is supporting the use of e-certificates.						
18. I believe that the issuing Administration of my certificate is capable of having a computer server as the main location of electronic certificates.						
19. I believe that the issuing Administration of my certificate is capable of including electronic signatures in an e-certificate.						
20. I believe that the issuing Administration of my certificate is capable of including a unique tracking number in an e-certificate.						
21. I have a stable internet connection onboard a ship to present e-certificates to different concerned officers.						

Items	1	2	3	4	5	6
22. I have appropriate computer software or mobile application (such as pdf reader) to present e-certificates to different concerned officers.						
23. I believe that the issuing Administration of my STCW certificates has an approved procedure in place for the implementation of e-certification for seafarers.						
24. I have the knowledge necessary to use e-certificates.						
25. There are available persons to assist me with the e-certification system challenges.						

26. What do you think is the greatest benefit of implementing the use of e-certification of seafarers?

_____

_____

_____

_____

27. Do you think there will be any challenges to using e-certification? Please explain.

_____

_____

_____

_____

28. How do you feel about entirely replacing traditional printed certificates with e-certificates?

_____

_____

_____

_____

Thank you for your time in completing the survey. Your participation is highly appreciated

Appendix F: Validation Tool for the Survey Questionnaires

Validation Rating Scale for Survey Instrument:

Concept of e-certification: Interrogating its global application to seafarers

Instruction: Please indicate your degree of agreement or disagreement with the statements provided below by encircling the number which corresponds to your best judgment.

1	2	3	4	5	6
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

Items	1	2	3	4	5	6
1. The items in the instrument are relevant to the development of materials that will be used to answer the objectives of the study.						
2. The item in the instrument can obtain depth of constructs being measured.						
3. The instrument has an appropriate sample of items for the constructs being measured.						
4. The items and their alternatives are neither too narrow nor limited in its content.						
5. The items in the instrument are stated clearly.						
6. The items on the instrument can elicit responses which are stable, definite, consistent, and not conflicting.						
7. The layout or format of the instrument is technically sound.						
8. The responses on the instrument can show a reasonable range of variation.						

Items	1	2	3	4	5	6
9. The instrument is not too short or long enough that the participants will be able to answer it within a given time.						
10. The instrument is interesting such that the participants will be induced to respond to it and accomplish it fully.						
11. The instrument as a whole could answer the basic purpose for which it is designed.						
12. The instrument is culturally acceptable on how it will be administered in the local setting.						

13. Please indicate your other comments and suggestions below:

_____

_____

_____

_____

_____

Signature over printed name of the validator

Note. Adapted from Nalupa (2022)

Appendix G: Semi-Structured Interview Questions

Concept of e-certification: Interrogating its global application to seafarers

Semi-structured Interview Questions

Thank you very much for accepting my invitation to participate in my research study about electronic certification for seafarers.

To provide you with a brief background, the International Maritime Organization (IMO) issued guidelines for the use of electronic certificates (e-certificates) in 2013 with the aim of reducing the administrative burden on Administrations, port State control officials, ships' crews and other stakeholders caused, amongst other reasons, by reliance on traditional paper certificates. Currently, the existing approved guidelines which were issued in 2016 cover all documents issued by an Administration or its representatives that are used to show compliance with IMO requirements and used to describe operating conditions, crewing requirements, and ship equipment carriage requirements (FAL.5/Circ.39/Rev2). In addition, in June 2023, guidelines on the use of electronic certificates of seafarers was issued by the IMO (MSC.1/Circ.1665).

In this regard, my study aims to interrogate the global application of e-certification to seafarers. For this interview, I would like to ask you a series of questions regarding this matter. Rest assured that your personal information will be kept confidential and that the information that you provide within the context of this interview will only be used for research purposes. All findings from the interviews will be anonymized in the presentation of results. Accordingly, please feel free to express your thoughts during the interview as this will make a significant contribution to my study.

Part A

1. What is the name of your organization and what is its nature?
2. What is your role in the organization?
3. How long have you been working in your organization?
4. Do you have experience with e-certification of any kind?
5. How familiar are you with IMO’s work as related to e-certification?

Part B

I would like to ask about your thoughts on using electronic certification for seafarers' STCW Certificates:

1. How would you describe the usefulness of an e-certification system in terms of managing and controlling seafarers' documentation by the Maritime Administration?

2. What are your thoughts about the security assurance of e-certification systems in terms of protection from fraud and security breaches?

3. What are your thoughts about seafarers' data privacy when using e-certificates?

4. What can you say about the degree of ease in using an e-certification system in terms of the verification of e-certificates?

5. What can you say about the global application of e-certificates to seafarers as a response of the maritime industry to the global digitalization trend?

6. In order to facilitate the management and control of seafarers' documentation, appropriate facilities would be necessary such as a server or physical storage location of e-certificates, stable internet connections, and a computer or mobile software to read the e-certificate file format. Do you think there will be any challenges for the Maritime Administration in securing and maintaining such facilities?

7. In general, what do you think are the merits or the positive qualities of electronic certification taking into consideration its application to seafarers?

8. In general, what do you think are the demerits or the negative qualities of electronic certification taking into consideration its application to seafarers?

9. Do you foresee any other challenges to using e-certification? Please explain.

10. How do you feel about entirely replacing seafarers' traditional printed certificates with e-certificates?

Thank you so much for lending me your valuable time and for actively responding to my questions. It is highly appreciated.

Appendix H: Reliability Test Results of the Survey Questionnaire for Shipping Companies/Manning Agencies

Group	Key Determinants	Cronbach's Alpha of Original Dataset	Cronbach's Alpha After Deletion of P6 and F4	Questionnaire
Shipping Companies / Manning Agencies (n = 23)	Performance Expectancy	0.695	0.831	**P6:** In general, I am doubtful of the reliability of the e-certification system in terms of data retention or storage.
	Facilitating Conditions	0.696	0.921	**F4:** My Organization has a stable internet connection to verify e-certificates issued by different Maritime Administrations.

Appendix I: Tabulated Summary of Merits of Implementing E-Certification for Seafarers (from Surveys and Interviews)

Merits of Using E-Certificate	From Interview		From Survey Questionnaire								Overall Total
	No. of Interview	Frequency of Comments	MARAD		Shipping Companies/ Manning Agencies		Seafarers		Total		
		Qual	Qual	Quan	Qual	Quan	Qual	Quan	Qual	Quan	
1. Better accessibility	6	**24**	13	38	10	22	64	194	**111**	**254**	**365**
2. Gives convenience	5	**12**	6	37	7	22	82	179	**107**	**238**	**345**
3. Easier and real-time verification	8	**23**	7	38	4	21	16	213	**50**	**272**	**322**
4. Saves time	5	**11**	11	36	7	21	37	189	**66**	**246**	**312**
5. Improved security assurance	7	**18**	6	36	1	22	11	214	**36**	**272**	**308**
6. Lesser printed document to carry onboard the ship	4	**5**	4	27	3	16	30	195	**42**	**238**	**280**
7. Paperless and digital transaction	5	**7**	5	-	2	-	13	-	**27**	**-**	**27**
8. Saves cost	2	**9**	1	-	1	-	9	-	**20**	**-**	**20**
9. Efficiency to the industry	5	**7**	4	-	1	-	3	-	**15**	**-**	**15**
10. Easier management and control of seafarers' documentation	4	**9**	3	-	-	-	3	-	**15**	**-**	**15**
11. More environment friendly	1	**1**	-	-	2	-	5	-	**8**	**-**	**8**
12. Reliable	-	-	-	-	1	-	5	-	**6**	**-**	**6**
13. Helps reduce stress	1	**2**	1	-	-	-	2	-	**5**	**-**	**5**
14. Better means of compliance with international regulations	1	**3**	1	-	-	-	1	-	**5**	**-**	**5**
15. Simple	1	**1**	1	-	1	-	1	-	**4**	**-**	**4**
16. More transparent	-	-	2	-	-	-	1	-	**3**	**-**	**3**
17. Less bureaucracy	-	-	0	-	1	-	1	-	**2**	**-**	**2**
18. Better data privacy	1	**1**	0	-	-	-	1	-	**2**	**-**	**2**

Appendix J: Tabulated Summary of Demerits of Implementing E-Certification for Seafarers (from Surveys and Interviews)

Demerits of Using E-Certificate	From Interview		From Survey Questionnaire								Overall Total
	No. of Interview	Frequency of Comments	MARAD		Shipping Companies/ Manning Agencies		Seafarers		Total		
		Qual	Qual	Quan	Qual	Quan	Qual	Quan	Qual	Quan	
1. Possible inaccessibility due to loss of internet connection	2	**3**	8	-	2	1	37	12	**50**	**13**	**63**
2. Potential security breach	3	**4**	11	-	6	-	30	-	**51**	-	**51**
3. Potential threat to data privacy	2	**3**	6	2	4	1	18	11	**31**	**14**	**45**
4. Requires digital literacy	2	**5**	5	-	3	-	15	-	**28**	-	**28**
5. Takes time to acquire	-	-	-	2	-	2	-	17	**0**	**21**	**21**
6. Inconvenient to use at ports	-	-	-	1	-	1	-	15	**0**	**17**	**17**
7. Difficult to access or retrieve	-	-	-	-	-	1	-	12	**0**	**13**	**13**
8. Possible inaccessibility due to system failure	-	-	-	-	-	-	6	-	**6**	-	**6**
9. Potential loss of data	1	**1**	1	-	1	-	-	-	**3**	-	**3**
10. Complexity of data sharing	2	**2**	-	-	-	-	1	-	**3**	-	**3**

Appendix K: Tabulated Summary of Challenges to E-Certification of Seafarers (from Surveys and Interviews)

Challenges to Using E-Certificate	From Interview		From Survey Questionnaire								Overall Total
	No. of Interview	Frequency of Comments	MARAD		Shipping Companies/ Manning Agencies		Seafarers		Total		
		Qual	Qual	Quan	Qual	Quan	Qual	Quan	Qual	Quan	
1. Availability and maintenance of equipment and infrastructure	5	**8**	14	16	5	-	54	79	**81**	**95**	**176**
2. Cybersecurity and data breaches	5	**8**	15	13	11	8	40	41	**74**	**62**	**136**
3. Competence in the use of e-certification system	2	**5**	5	5	3	3	17	17	**30**	**25**	**55**
4. Fraudulent certification	1	**3**	-	10	-	4	11	26	**14**	**40**	**54**
5. Acceptance/ recognition in different countries	1	**1**	-	4	-	3	4	24	**5**	**31**	**36**
6. Lack of technical persons that can render assistance	-	-	-	4	-	1	-	26	**0**	**31**	**31**
7. Barriers to efficient processing of e-certificates	1	**4**	2	-	2	-	10	-	**18**	**-**	**18**
8. Flexibility and adaptability to change	4	**5**	2	-	4	-	6	-	**17**	**-**	**17**
9. Gap in the level of digitalization capacity among countries	3	**4**	6	-	-	-	6	-	**16**	**-**	**16**
10. Differences of e-certification systems among countries	3	**3**	3	-	2	-	7	-	**15**	**-**	**15**
11. Coexistence of traditional printed certificates	2	**2**	-	-	1	-	3	-	**6**	**-**	**6**
12. Trust in digitalization	1	**2**	-	-	2	-	1	-	**5**	**-**	**5**
13. Lack of standardized regulations	1	**1**	-	-	-	-	3	-	**4**	**-**	**4**
14. Slow progress in developing international framework	2	**2**	-	-	-	-	-	-	**2**	**-**	**2**