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Modeling Analysis of Lecturer Digital Competence at Maritime Colleges using Analytical Hierarchy Process and System Dynamics

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ABSTRACT

This Assessing lecturers' digital competence is necessary to understand educational technology and learning processes from a sociocultural perspective, particularly within maritime tertiary institutions. This research proposed a model and analysis of digital competency among lecturers at maritime universities in Indonesia. This qualitative research was performed based on the competency theory and statistical measures including analytical hierarchy processes and system dynamics modeling. The research revealed six main variables and 32 sub-variables, with the "Digitality" variable having the highest value of 0.252. Within the global weight, the "Digital literacy" sub-variable was a priority, with a weight of 0.071. The analysis of Lecturer Digital Competence in Maritime Colleges in Indonesia scored 3.163 (63.26%) under the proficiency category (level 4). The analysis resulted in "Personality" variable obtaining the highest value at 3.254 (65.07%). The results of simulation showed "digital divide" as the factor with the strongest influence on the decline in lecturers' digital competence with a value of 1.180. Lecturers' Digital Competence in Indonesian Maritime Colleges can be improved by lowering the initial digital divide value.

1. Introduction.

The maritime industry has witnessed significant developments in the evolution of seafarers throughout its history (Senbursa, 2020). The examination of maritime incidents over time has highlighted deficiencies in the capacity of operators to manage resources and respond to crises effectively. It is strongly recommended that maritime universities implement advanced educational strategies to enhance the learning experience of their students (Elashkar, 2016). Various countries have distinct systems for assessing the knowledge of seafarers researching in maritime colleges. It is essential to evaluate the competency levels of educators in higher education, alongside students (E-lashkar & Farag, 2015). To ensure the quality of education, it is not only necessary to meet administrative requirements but also to possess professional competence as an instructor (Lamatokan & Rahmadhani, 2022).

The current code of ethics lacks specificity in its competency assessment criteria, as it primarily relies on general performance outcome statements rather than specific behaviors (E-lashkar, 2016). In the context of a knowledge society, digital competence stands out as a crucial distinguishing factor (Zhao et al., 2021). Furthermore, professional digital competence is essential for comprehending educational technology and learning processes from a sociocultural perspective, a necessity applicable even in maritime universities (Pinto-Santos et al., 2022) (Hopcraft, 2021). Educators with digital competence are adept at effectively utilizing digital technologies, creating innovative teaching resources, and offering valuable guidance and support to their students (Zhao et al., 2021).

Currently, there are notable limitations concerning the availability of specific data that require attention to achieve comprehensive development of digital competency within the university context (Basantes-Andrade et al., 2022). Many universities rely on self-reported data for evaluation, which may not accu-

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rately reflect the true level of digital competency (Zhao et al., 2021). DeLuca et al. (2016) have pointed out the lack of coverage for all standards and potential assessment tools for assessing lecturer digital competency, thereby highlighting the absence of an appropriate instrument for measuring digital competency in higher education, especially in maritime universities (Saltos-Rivas et al., 2021). Consequently, DeLuca et al. (2016) have recommended the development of standards for assessing lecturer competence as a vital area for future research. Furthermore, Basantes-Andrade et al., 2022 emphasize the importance of focusing on identifying dimensions of digital competency for substantive higher education in forthcoming research endeavors. Zhao et al. (2021) propose a more holistic approach, suggesting the integration of quantitative and qualitative data methods to yield comprehensive results on digital competencies in higher education. Ersoy (2021) also underscores the need for future studies to adopt the MCDM (Multi-Criteria Decision Making) approach to bolster digital competency assessments among lecturers.

This research aims to model and analyze the digital competency of lecturers within Indonesian maritime universities. This investigation holds significance for several reasons. Firstly, lecturers in maritime universities must possess adequate digital competence to effectively educate and prepare students (Basilotta-Gómez-Pablos et al., 2022). Secondly, an understanding of the current levels of digital competency can help pinpoint gaps and areas in need of improvement (Saltos-Rivas et al., 2023; Torres-Hernández & Gallego-Arrufat, 2022). To gather data, the researchers employed a combination of surveys, interviews, and observations to assess faculty members' proficiency in using digital tools, their familiarity with digital pedagogy, and their ability to seamlessly integrate technology into their teaching practices. Thirdly, this research identified best practices and strategies (Bilbao-Aiastui et al., 2021) for the effective integration of technology into maritime education, with a focus on optimizing its benefits and enhancing student learning outcomes (Pinto-Santos et al., 2022).

This research is grounded in competency theory and employs statistical qualitative research methods, aligning with the framework outlined by Zhao et al. (2021), which includes analytical hierarchy processes and system dynamics modeling. Data collection is carried out across multiple maritime-focused universities in Indonesia, with a particular focus on institutions in East Java. This data serves as the foundation for the development of digital competency and is enriched by insights from 18 expert panels with relevant expertise. Data analysis utilizes Nvivo software for qualitative analysis and employs Microsoft Excel and Stella for quantitative analysis.

This research offers several significant contributions. Firstly, it introduces a comprehensive framework to comprehend the diverse dimensions and proficiency levels of digital competence required by lecturers in maritime colleges. This framework serves as a valuable tool for identifying areas in need of improvement and guiding professional development initiatives within the maritime sector. Secondly, the research identifies key stakeholders influencing the development of digital competence among maritime university lecturers, enabling the design of strategies aimed at enhancing lecturers' digital skills. Thirdly, it illuminates the intricate relationship between digital competence and teaching effectiveness in maritime education, facilitating the seamless integration of technology into maritime education while ensuring lecturers possess the necessary skills. Fourthly, by pinpointing the specific digital competencies essential for maritime college lecturers, this research assists in designing targeted training programs to elevate teaching practices. Lastly, the research lays the foundation for customized training initiatives, aligning technology use with maritime industry standards and best practices, thereby enhancing overall educational outcomes.

2. Literature Review.

2.1. Lecturer Competence.

Competency, as defined by Ismail et al., (2018), serves as an indicator of an employee's work performance within an organization, signifying excellence or highlighting areas for professional development. In the realm of lecturers, it encompasses attributes such as subject matter expertise, pedagogical skills, effective communication, and the ability to motivate students, as articulated by Baryanto, (2021). Yan et al., (2022) further expand on lecturer competency, describing it as a comprehensive amalgamation of knowledge, skills, attitudes, and beliefs that empower effective problem-solving. A competent lecturer, as outlined by Do et al., (2020), not only excels in their field of research but also possesses the teaching techniques necessary for impactful content delivery. Lecturer's competency involves the timely execution of responsibilities based on competence, experience, and dedication, emphasizing its crucial role in achieving educational goals and ensuring the success of educators and students alike (Retnowati et al., 2021).

2.2. Digital Competency.

Digital competency, as defined by Fernández-Batanero et al., (2021), represents an individual's capacity to effectively and efficiently harness digital technology for problem-solving, communication, and navigation within the digital realm. This encompassing concept includes a range of skills, knowledge, and attitudes essential for thriving in the digital age (Falloon, 2020). In an era marked by rapid technological advancement and its pervasive integration into various facets of human life, digital competence has assumed paramount significance in both personal and professional spheres (Fatkhurrochman et al., 2022; Shahbakhsh et al., 2022). Within the context of shipping companies, competence in this domain relies on the awareness and knowledge of staff, their proficiency in technology utilization, and their ability to leverage assets, such as ships, to bolster technological capabilities (Gavalas et al., 2022).

At its core, digital competency encompasses fundamental technical skills, such as proficiently operating digital devices (Basantes-Andrade et al., 2022), along with adeptly using various software applications and effectively navigating online platforms (Vishnu et al., 2022). However, digital competency extends beyond mere technical proficiency. It also embraces critical thinking skills, as emphasized by Lorencová et al., (2019), which are indispensable for evaluating online information in terms of credibility and accuracy (Sofyan et al., 2021). This entails the capacity to discern trustworthy sources from misinformation or fake news. Furthermore, digital competence encompasses the ability to safeguard personal information and uphold privacy and security while engaging with digital technology (Vishnu et al., 2022).

2.3. Maritime Digital Competence.

Maritime digital competency encompasses the capacity of individuals, organizations, and industries within the maritime sector to effectively harness digital technologies and tools in their operations (Cabaron, 2023; Hopcraft, 2021). In an increasingly interconnected and technology-driven world, the maritime industry is embracing digitalization as a means to enhance efficiency, safety, and sustainability (Shahbakhsh et al., 2022). This competence within the maritime sector encompasses a wide range of components, including technical skills, knowledge of digital tools and systems, proficiency in data analysis and cybersecurity, and adaptability to emerging technologies (Cabaron, 2023; Gavalas et al., 2022). It extends beyond the mere use of digital tools to encompass the ability to leverage data-driven insights for informed decision-making and effective problem-solving. Maritime digital competency plays a pivotal role in optimizing ship performance, streamlining logistics and supply chain management, enhancing safety measures, and mitigating environmental impact (Chlomoudis et al., 2022; Shahbakhsh et al., 2022).

The development of maritime digital competencies necessitates individuals to acquire a set of specialized skills aligned with the digital technologies prevalent in the industry. These skills encompass proficiency in utilizing electronic navigation systems, comprehension of maritime communication protocols, expertise in data analysis techniques, knowledge of cybersecurity measures, and command of utilizing Internet of Things (IoT) devices for monitoring and control purposes (X. Li et al., 2021; Shahbakhsh et al., 2022). Moreover, individuals must demonstrate adaptability to emerging technologies and stay abreast of the latest advancements in the field (Yuen et al., 2022).

The effective utilization of digital tools and systems in the maritime sector yields substantial benefits. Maritime professionals can significantly enhance operational efficiency by optimizing routes, minimizing fuel consumption, and reducing downtime (Gavalas et al., 2022). Furthermore, digitalization allows for real-time monitoring of vessel performance, enabling proactive maintenance and bolstering safety measures. Through data analysis, valuable insights into operational patterns are gleaned, empowering informed decision-making and efficient resource allocation (Li et al., 2021). Digital competencies play a pivotal role in promoting environmental sustainability by facilitating the adoption of eco-friendly practices and curbing carbon emissions (Kilpi et al., 2021).

3. Methodology.

This research employed a qualitative descriptive statistical method approach, combining qualitative and quantitative data collection sequentially (Manca et al., 2022; Yates et al., 2021). Initially, qualitative data were gathered to identify variables related to digital competency among lecturers in maritime universities. Subsequently, descriptive statistical analysis was used to present statistics, including the percentage weight of each variable derived from the Saaty scale, mean values, and competency level assessments. Primary data were obtained from experts, specifically maritime experts who encompassed both practitioners and academics. The criteria for selecting these experts included: 1) Academic experts with a minimum of a Master's degree (Hult Khazaie & Khan, 2020; Rioja-Lang et al., 2020); 2) Practitioners with relevance to the lecturer competency level in maritime colleges (Fallah & Ocampo, 2021); 3) Professionals with more than 5 years of work experience in the field (Khalilzadeh et al., 2020; Kim & Kim, 2022). Secondary data sources encompassed various materials such as news articles, information from print media, findings from previous research in online media, archival records, regulations and policies, official institutional documents, and content from official social media accounts.

This research was conducted in Jakarta, involving several maritime-based high school areas in East Java as representative samples reflecting lecturers' digital competence. The research entailed distributing questionnaires to experts, leveraging insights from several secondary data sources. Notably, assessing lecturers' digital competence has been a longstanding focus of researchers. In Indonesia, where there is a substantial demand for seafarers, this investigation assumes critical importance. Therefore, researchers recognize a significant opportunity to contribute to this field by offering theoretical insights and expanding the body of knowledge in the assessment of lecturers' digital competence in maritime universities.

3.1. Analytical Hierarchy Process (AHP).

AHP (Analytic Hierarchy Process) is a method used to represent intricate multi-factor or multi-criteria problems through a structured hierarchy. As defined by Saaty, this hierarchy constitutes a multi-level structure wherein the top level represents the primary goal, followed by subsequent levels consisting of factors, criteria, sub-criteria, and so forth, cascading down to more detailed levels. Another noteworthy aspect of AHP is that it allows complex problems to be grouped and organized hierarchically, resulting in a more systematic and structured representation (Saaty, 2006). One of AHP's distinctive advantages, setting it apart from other decision-making models, is its flexibility regarding absolute consistency requirements. This means that while problems can be perceived and assessed, the method does not require complete numerical data for quantitative problem modeling (Siekelova et al., 2021).

Humans can instinctively estimate simple quantities by comparing two objects. For this reason, Saaty established a quantitative scale of 1 to 9 to assess the comparative importance of other elements. There are 7 pillars of AHP modeling, including (Marzouk & Sabbah, 2021; Saaty, 2012): The ratio scale is a comparison of two values (a/b) where the values a and b are of the same type (units); 2) Pairwise comparison; 3) Eigenvector sensitivity conditions; 4) Homogeneity and grouping; 5)

Synthesis; 6) Maintaining and reversing the order of weight and order in the hierarchy; 7) Group considerations.

Table 1: AHP Rating Scale.

Scale of Interest	Definition	Explanation
1	Equal Important	The two activities contribute equally strongly to the goal
3	Moderate Important	One activity is slightly more important than the other
5	Strong Important	One activity is more important than the other activity
7	Very Strong Important	One activity is very important compared to other activities
9	Extreme Important	One activity is very important compared to other activities
2, 4, 6, 8	Intermediate Values	
Reciprocal	Describes the dominance of the second alternative compared to the first alternative	

Source: Authors.

The steps of the AHP method include:

a. Creating a pairwise comparison matrix:

$$A = a_{im} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

i, m = 1, 2, ... , n = related criteria index.

b. Creating a matrix value criteria.
c. Creating an additional Matrix for Each Row.
d. Assessing Consistency Index (CI) and Consistency Ratio (CR).

$$\text{CI} = \frac{\lambda_{\max} - n}{n}; \quad (2)$$

$$\text{CR} = \frac{CI}{RI} \quad (3)$$

N = Number of Elements,
RI = Random Consistency Index.

If the CR (Consistency Ratio) is 0.1 (i.e., 10%), the matrix is considered consistent, and the decision is accepted. Conversely, if CR is greater than that, it means there are too many contradictions in the matrix. Anticipating the latter situation involves reviewing the matrix and then revising the weights loaded by the vector.

Table 2: Random Consistency Index Value.

1	2	3	4	5	6	7	8	9	10
0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Authors.

3.2. System dynamics.

Modeling serves as an invaluable approach to tackling real-world problems, especially when direct implementation or experimentation becomes impractical. It enables system optimization before real-world execution, involving the abstraction of real-world issues into a model and subsequent analysis for implementable solutions (Sterman, 2018). In contrast, simulation is the operationalization of a system model, typically employed to anticipate and mitigate the impacts of changes in an existing system, eliminate unexpected challenges, conserve resources, and optimize system performance (Forrester, 2009).

According to the System Dynamics Society, System Dynamics (SD) is described as "a method for acquiring knowledge and handling complex comment structures." Originally proposed by Jay W. Forrester in the 1950s, System Dynamics offers a systematic approach to solving complex problems that arise due to various factors, trends, and the influence of multiple variables within a system. This approach was initially applied to address control problems, including issues such as stock fluctuations, business activity volatility, and market share decline. To implement System Dynamics, a model is constructed in the form of a centralized diagram, which is then translated into a flowchart that represents simulation variables and parameterization. This modeled system is subsequently prepared for simulation (Forrester, 2016). The definitions of variables within a dynamic structure are provided in Table 3.

Table 3: Symbol of system dynamics.

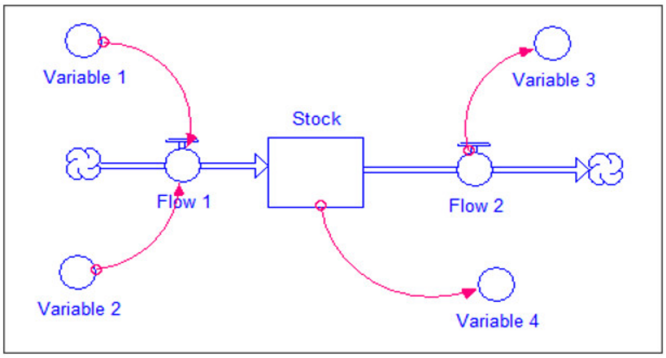
Variable	Symbol	Explanation
Level		Presenting the accumulated quantity that accumulates over time, its value can change in line with changes in the rate
Rate		Presenting a flow rate that can change the level value
Auxiliary		Presenting auxiliary variables containing formulations that can be input to the rate.

Source: Authors.

System Dynamics models often employ different types of diagrams to represent the structure of feedback loops. One common type is the Causative Loop Diagram (CLD), which serves as a cause-and-effect diagram. CLDs illustrate the direction of variable flow modification and its polarity, with flow polarity categorized as positive and negative. Another graphical representation used in System Dynamics is the flowchart. Flowcharts provide a comprehensive depiction of the relationships between variables, building upon the cause-and-effect diagram by using clear and standardized symbols to represent various interconnected variables (Forrester, 2010).

A Causative Loop Diagram (CLD) serves as a graphical language that interconnects different variables within a system using a circular diagram. Arrows in CLDs are used to indicate cause-and-effect relationships among variables. The arrowhead signifies the effect, while the base of the arrow represents the cause. For modelers, it is imperative to have a deep understanding of real-world processes to ensure that their logical model aligns with reality. This understanding is achieved through characterizing causal variables and distinguishing between dependent and independent variables (Sterman et al., 20-15). In this particular research, the analysis of system dynamics is facilitated using Stella 9 software, which provides tools and capabilities for modeling and simulating complex systems.

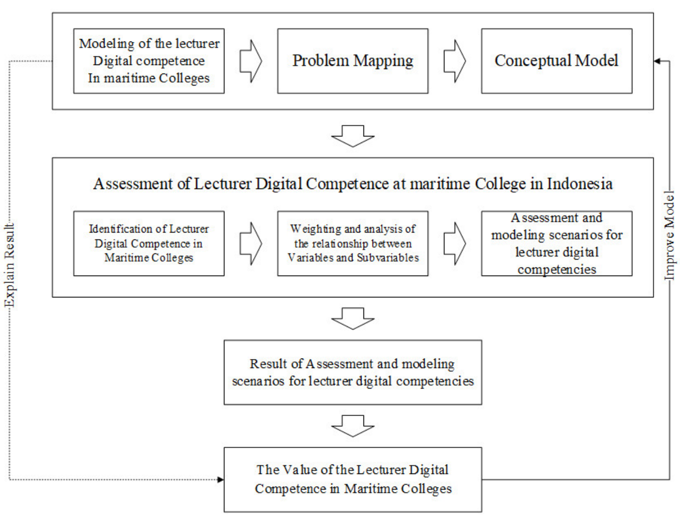
Figure 1: Minimal stock and flow diagrams in System Dynamics.



Source: Forrester, 2009; Morshedi & Kashani, 2020; Schoenenberger et al., 2021.

3.3. Conceptual Framework.

Figure 2: A Conceptual Framework for Assessment of Lecturer Digital Competence at Maritime College in Indonesia.



Source: Authors.

This research focuses on examining the resilience of the maritime cyber domain within Indonesian maritime regions, structured into three distinct stages. The first stage employs a literature review, brainstorming sessions with questionnaires, and expert assessments to identify critical variables and analyze the relationships between these variables concerning maritime cyber resilience. In the second stage, the measurement process involves assigning weights and evaluating maritime cyber resilience. Weighting is conducted using the Analytic Hierarchy Process (AHP) method, leveraging data collected from selected experts representing relevant stakeholders. Subsequently, assessment is carried out using a Likert scale. Finally, the third stage involves evaluating and analyzing the value of maritime cyber resilience through the application of system dynamics modeling, providing a comprehensive perspective on the resilience of the maritime cyber domain in the Indonesian context.

In the assessment of maritime cyber resilience analysis, the process begins by computing the average score for the resilience dimensions across all sub-variables identified. Subsequently, the overall resilience rating is calculated for each variable and its associated sub-variables, with the weights assigned based on expert evaluations. Experts are tasked with distributing a total weight of 100% among the variables and sub-variables, ensuring proportional allocation. The resilience rating calculation follows a methodology adapted from previous research sources such as Herrera (2017), Li et al. (2020), and Mbanaso et al. (2019).

$$\text{Resilience Index} = \frac{(\text{Variable 1} \times \text{weight}) + (\text{Variable 2} \times \text{weight}) + \cdots + (\text{Variable x} \times \text{weight})}{100} \quad (4)$$

Table 4: AHP scale values and Likert scores and Resilience Categories values.

Scale AHP	Description	Likert	Competence
9	Performance-based on experience and intuition	5	Advance
7-8	Performance is largely based on experience	4	High
5-6	Performance is not solely based on rules and guidelines but also on previous experience	3	Medium
3-4	Guideline-based performance	2	Low
1-2	Rule-based performance (protocols)	1	Very Low

Source: Octavian et al. (2021); Aksha et al. (2019); Rehak et al., (2019).

Table 5: Resilience Level of Maritime Cyber.

Level	Score	Percent (%)	Competence Level	Description
V	4.01-5	81-100	Expertise	Achieving outstanding performance:
IV	3.01-4	61-80	Proficiency	In complex situations, seamlessly transitioning between analytical and intuitive solutions; Considering all options related to the given task.
III	2.01-3	41-60	Competency	Capable of working up to routinely acceptable standards; Able to handle complexity analytically; Relevant options are also considered beyond the assigned task.
II	1.01-2	21-40	Advance Beginner	Capable of dealing with complexity through analysis and planning; Tasks are viewed as a single construct of performance.
I	0-1	0-20	Novice	Capable of achieving partial resolution of complex tasks; Tasks are seen as a series of steps.

Source: Authors.

4. Results and Discussion.

4.1. Identification of key variables in Lecturer Digital Competence in Maritime Colleges.

Identifying key variables is a pivotal step in the comprehensive analysis of lecturers' digital competence within maritime universities. Through the identification and comprehension of these variables, researchers and educators can gain valuable insights into the factors that contribute to lecturers' digital competence and craft effective strategies for enhancing their proficiency in this domain. The evaluation of lecturers' technological aptitude yields critical information concerning their preparedness to embrace and effectively utilize digital tools in their instructional practices. These essential variables can be ascertained via a thorough examination of existing literature, expert consultations, or exploratory research. Key variables, being those that exert a substantial influence on research outcomes, are of paramount importance for comprehending the phenomenon of Lecturer Digital Competence in Maritime Colleges.

In the realm of maritime universities, the significance of lecturers possessing digital competence cannot be overstated, as it plays a pivotal role in preparing students to navigate the challenges and advancements within the maritime industry. Given the swift integration of technology across various facets of maritime operations, lecturers must possess digital competence to effectively educate and train the next generation of professionals in this domain. Digital competence, in this context, encompasses the aptitude to confidently, critically, and creatively harness digital technology to attain objectives related to work, learning, and societal participation. Within maritime universities, lecturers endowed with digital competence are equipped with the requisite knowledge and skills essential for harnessing digital tools and resources in their pedagogical, research, and administrative pursuits.

To conduct a thorough analysis of Lecturer Digital Competence in Maritime Colleges, it is essential to identify the primary variables. In the process of selecting variables as indicators, this article takes into account the context and framework established by the primary objective of this research: the identification of Lecturer Digital Competence in Maritime Colleges. Several modifications are necessary to tailor these variables to this specific context. Therefore, the variables associated with Lecturer Digital Competence, while not generally deemed representative, have been either eliminated or replaced with more pertinent alternatives. The approach employed here involves utilizing expert judgment as a valuable tool to extensively validate the empirical determination of the indicators outlined above, including:

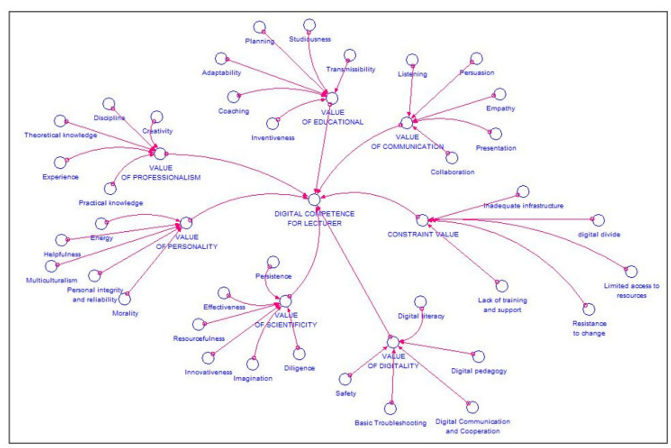
Having successfully identified six main variables and 32 sub-variables for Lecturer Digital Competence in Maritime Colleges, the subsequent phase involves establishing relationships between these variables and sub-variables. This is accomplished through the utilization of a stock-flow diagram, which aids in identifying cause-and-effect connections within the system. The primary objective of this stage is to construct a quantitative model conducive to simulation. The modeling process entails the translation of each relationship between variables and system model components into mathematical equations, rendering them amenable to operation by a simulation program. The stages in the development of the quantitative model encompass the selection of the overarching quantitative structure of the model, determination of the fundamental time unit for simulation, identification of the functional form of the model equation, estimation of the model equation's parameters, inputting the equation into the simulation program, executing the reference simulation, and finalizing the model equation as seen in Figure 5.

Table 6: Selected Variables for Lecturer Digital Competence in Maritime Colleges.

Variable	Definition	Sub-variable	Code
Personality (A)	The "Personality" competence dimension concerns purely personal aspects of the teacher. It refers to mental and spiritual traits and behaviors that uniquely characterize the teacher.	Energy	C1
		Helpfulness	C2
		Personal integrity and reliability	C3
		Multiculturalism	C4
		Morality	C5
Professionalism (B)	The "Professionalism" competence dimension refers to the subject of one's professional activity about how specialized a teacher is and how recognized he/she is in the field in which they teach.	Theoretical knowledge	C6
		Practical knowledge	C7
		Experience	C8
		Discipline	C9
		Creativity	C10
Educational (C)	The "Educational" competence dimension refers purely to aspects related to didactics. It is directly related to the way that a teacher explains a subject to their students and how well he/she combines methods and techniques to understand it by adapting them to the intellectual ability of their students.	Transmissibility	C11
		Studiousness	C12
		Planning	C13
		Adaptability	C14
		Coaching	C15
		Inventiveness	C16
Scientificity (D)	The "Scientificity" competence dimension concerns the expansion of new ways of thinking and not one-dimensional views. It includes the creation of the necessary connections with the acquired knowledge, preventing its isolation. It supports that science and research are the guides to the well- being of people	Resourcefulness	C17
		Innovativeness	C18
		Imagination	C19
		Diligence	C20
		Persistence	C21
		Effectiveness	C22
Communication (E)	The "Communication" competence dimension concerns the listening competencies, accuracy in verbal communication, persuasion and empathy that the teacher uses as a tool for the educational goal.	Listening	C23
		Persuasion	C24
		Empathy	C25
		Presentation	C26
		Collaboration	C27
Digitality (F)	The "Digitality" competence dimension concerns the set of skills, knowledge and attitudes that enable creative and critical use of digital technology for didactic purposes. It mainly includes key components of digital competence to locate and retrieve digital data, as well as to interact, communicate and collaborate through digital technologies.	Digital literacy	C28
		Digital pedagogy	C29
		Digital Communication and cooperation	C30
		Safety	C31
		Basic Troubleshooting	C32

Source: Dervenis et al. (2022).

Figure 3: Causal loop diagram of Lecturer Digital Competence in Maritime Colleges.



Source: Authors.

In evaluating dynamic system modeling for Lecturer Digital Competence in Maritime Colleges, alignment with the model's objectives and scenarios is crucial. This evaluation scenario assumes that the results emanate from a simulation devoid of interventions, serving to gauge the consistency of Lecturer Digital Competence. The close relationship between predictions for Lecturer Digital Competence from 2022 to 2026 and their impact is intricately linked to six key factors: Personality (A), Professionalism (B), Educational (C), Scienti?city (D), Communication (E), and Digitality (F). The model's development is focused on identifying behavioral patterns and the complex relationships among variables to ensure its suitability to real-world conditions (Octavian et al., 2021).

4.2. Weighting of Variable and Sub-variable.

At this stage, each expert is tasked with evaluating the primary indicators deemed most crucial for defining or predicting Lecturer Digital Competence. They assess these indicators' significance based on their extensive experience across various maritime college domains. Experts are allowed to conduct multiple ranking alternatives to reflect their nuanced perspectives. Furthermore, experts are prompted to consider whether differentiation among the primary indicators representing Lecturer Digital Competence is warranted. The weighting process is conducted employing the Analytical Hierarchy Process (AHP) method, aligning with the established criteria for evaluating the relationships between variables and sub-variables over time.

The model's outputs vary, contingent upon the specific problem under examination. It yields a vector comprising the local weights assigned to the considered alternatives for each sub-criterion. Subsequently, this local vector, representing sub-criteria weights, undergoes normalization and is then multiplied by the global vector, which encapsulates the weights assigned to higher-level criteria (parent criteria). This process culminates in the final vector for the decision problem as made by Improta et al., (2018). To summarize, this hierarchical simulation entails the consideration of each criterion, accounting for not only the intricate interdependencies among sub-criteria under the same parent criterion but also their temporal variability, mirroring the principles of system dynamics modeling.

By utilizing the weights assigned to the scenario rating criteria, it becomes possible to derive decision vectors at each time step within the simulation process. This approach effectively transcends the static nature of conventional AHP methodologies and facilitates the implementation of dynamic, time-varying decision-making processes. The AHP formula is applied to both criteria and sub-criteria, with the resulting outcomes being compared to the simulation results generated by the model. This decision-making process yields evaluation values and scenarios, ultimately identifying the optimal combination of parameters. The results of the weighting process are presented in Figure 4 and Table 14.

Table 7: Pairwise comparison matrix aggregation for Lecturer Digital Competence in Maritime Colleges.

Criteria	A	B	C	D	E	F	Weight
A	1	1/2	1/2	1/2	1	1/3	0.091
B	2	1	1	1/2	1	1/2	0.141
C	2	1	1	1	2	1	0.196
D	2	2	1	1	1	1	0.200
E	1	1	1/2	1	1	1/3	0.119
F	3	2	1	1	3	1	0.252
CR =	0.026						1.000

Source: Authors.

Table 7 highlights the priority criterion variables, with Digitality (F) bearing the highest weight value at 0.252, followed by Scienti?city (D) with a weight of 0.200, and Educational (C) ranking third with a weight of 0.196. The emphasis on Digitality underscores the acceleration of workflow, rendering low-skilled tasks, bureaucratic processes, paperwork, and simple duties obsolete (Edler & Infante, 2019). The increasing importance of digital information literacy skills and competencies for maritime professionals and students is evident (Chlomoudis et al., 2022). Ensuring seafarers possess adequate digital skills for safe operations is imperative (Hopcraft, 2021). Moreover, lecturers must grasp the significance of digital competence to adapt to the evolving educational landscape, where technology plays a pivotal role in teaching and learning processes (Cabaron, 2023). 3). The advent of digitalization offers opportunities for maritime educators to integrate immersive technologies like virtual reality and augmented reality into training programs, bridging the gap between classroom-based and real-life training (Yuen et al., 2022).

Table 8: Pairwise comparison matrix aggregation pada variable Personality for Lecturer Digital Competence in Maritime Colleges.

Criteria	C1	C2	C3	C4	C5	Weight
C1	1	1	1	2	1/2	0.190
C2	1	1	1/2	2	1/2	0.165
C3	1	2	1	2	1	0.249
C4	1/2	1/2	1/2	1	1/2	0.109
C5	2	2	1	2	1	0.286
CR =	0.022					1.000

Source: Authors.

Table 8 sheds light on the priority sub-variables within the Personality variable, with Morality (C5) garnering the highest weight value at 0.286. Following closely is the sub-variable Personal Integrity and Reliability (C3) with a weight of 0.249, and in third place is the Energy sub-variable (C1) with a weight of 0.190. This prioritization of Morality aligns with the observation that individuals tend to attach greater importance to negative behaviors when assessing morality over positive behaviors (Kharouf & Lund, 2019). Despite the advancements in digitalization, human morality remains reliant on direct communication and interaction among individuals (Rahmawati et al., 2021). The cultivation of morality from the outset of one's professional journey is vital, as it instills values that contribute to the establishment of an ethical organizational culture (Wantanakomol & Silpcharu, 2020).

Table 9 highlights the priority sub-variables within the Professionalism variable, with Discipline (C9) commanding the highest weight value at 0.323. Following closely is the sub-variable Practical Knowledge (C7) with a weight of 0.213, and in third place is the Theoretical knowledge sub-variable (C6) with a weight of 0.188. This prioritization of Discipline aligns with the observation that current educators exhibit strong emotional control and discipline when dealing with students requiring additional teaching efforts (Ismail et al., 2018). Discipline emerges as a pivotal factor influencing the level of digital in-

Table 9: Pairwise comparison matrix aggregation pada variable Professionalism for Lecturer Digital Competence in Maritime Colleges.

Criteria	C6	C7	C8	C9	C10	Weight
C6	1	1	2	1/2	1	0.188
C7	1	1	2	1/2	2	0.213
C8	1/2	1/2	1	1/2	2	0.148
C9	2	2	2	1	2	0.323
C10	1	1/2	1/2	1/2	1	0.128
CR =	**0.044**					**1.000**

Source: Authors.

formation literacy (Saltos-Rivas et al., 2023). In the maritime sector, which draws from diverse disciplines and practical experience, a profound understanding of maritime concepts and the ability to integrate knowledge from various scientific fields are essential to achieving learning objectives and preparing students for the workforce (Yuen et al., 2022).

Table 10: Pairwise comparison matrix aggregation pada variable Educational for Lecturer Digital Competence in Maritime Colleges.

Criteria	C11	C12	C13	C14	C15	C16	Weight
C11	1	1/2	1/2	1	1	2	0.149
C12	2	1	1/2	1/2	1/2	1/2	0.122
C13	2	2	1	1	1	2	0.216
C14	1	2	1	1	2	2	0.222
C15	1	2	1	1/2	1	2	0.176
C16	1/2	2	1/2	1/2	1/2	1	0.115
CR =	0.064						1.000

Source: Authors.

Table 10 reveals the priority sub-variables within the Educational variable, with Adaptability (C14) claiming the highest weight value at 0.222. Following closely is the sub-variable Planning (C13) with a weight of 0.216, and in third place is the Coaching sub-variable (C15) with a weight of 0.188. This prioritization underscores the growing recognition of the need to enhance adaptability in the face of rapid change (Mikkonen et al., 2019). The concept of adaptability can be likened to resilience in the context of coping with external shocks, as exemplified by the proposed adaptive cycle model by Dziembała, (2021). Furthermore, internal flexibility, represented by adaptability, pertains to the capacity to adjust to new circumstances and demands, thereby enabling more effective responses and the exploitation of existing opportunities that can foster innovation (Silva et al., 2021).

Table 11: Pairwise comparison matrix aggregation pada variable Scientificity for Lecturer Digital Competence in Maritime Colleges.

Criteria	C17	C18	C19	C20	C21	C22	Weight
C17	1	1/2	1/2	2	2	1/2	0.145
C18	2	1	1	2	1	1	0.201
C19	2	1	1	2	2	1	0.219
C20	1/2	1/2	1/2	1	1	1/2	0.099
C21	1/2	1	1/2	1	1	1/2	0.116
C22	2	1	1	2	2	1	0.219
CR =	**0.027**						**1.000**

Source: Authors.

Table 11 highlights the priority sub-variables within the Scientificity variable, with both Imagination (C19) and Effectiveness (C22) sharing the top position, each with a weight of 0.219. In third place is the sub-variable Innovativeness (C18) with a weight of 0.201. Imagination and effectiveness emerge as pivotal factors in the scientific facets of digital competence among maritime lecturers. In this context, imagination pertains to the capacity for creative thinking and the generation of innovative ideas, while effectiveness refers to the ability to achieve desired results or goals.

Lecturers should possess the ability to envision the seamless integration of technology into their teaching methodologies, with the ultimate aim of elevating the overall learning journey for their students. For instance, they could consider the utilization of virtual reality simulations to offer practical, hands-on training to maritime students, or harnessing online collaborative tools to streamline group projects. In the realm of digital competence, the efficacy factor carries equal weight. Lecturers must ensure that technology deployment harmonizes with educational objectives and contributes positively to student learning achievements. This necessitates meticulous planning and a rigorous evaluation of how digital tools impact the teaching and learning processes.

Table 12: Pairwise comparison matrix aggregation pada variable Communication for Lecturer Digital Competence in Maritime Colleges.

Criteria	C23	C24	C25	C26	C27	Weight
C23	1	2	1	1	2	0.251
C24	1/2	1	1/2	1/2	1	0.125
C25	1	2	1	2	2	0.287
C26	1	2	1/2	1	1	0.194
C27	1/2	1	1/2	1	1	0.144
CR =	**0.017**					**1.000**

Source: Authors.

As seen in Table 12, within the Communication variable, the sub-variable Empathy (C25) holds the highest priority with a weight of 0.287, followed closely by the Listening sub-variable (C23) at 0.251, and in third place, the Presentation sub-variable (C26) with a weight of 0.201. In the context of maritime education, empathy in communication assumes critical importance for effective interpersonal interaction. Maritime educators with strong digital competencies can leverage various elements to enhance their empathetic communication skills, fostering emotional connections with students and creating a supportive, inclusive learning environment. This empathy, in turn, helps instructors better understand students' needs and challenges, leading to improved communication and enhanced learning outcomes. In a rapidly evolving maritime industry influenced by technological advances, educators must stay updated and integrate relevant digital tools into their teaching practices. Empathy plays a crucial role in this process, aiding instructors in comprehending students' struggles with technology adaptation and providing tailored guidance and support for a smooth transition to digital platforms.

Table 13: Pairwise comparison matrix aggregation pada variable Digitality for Lecturer Digital Competence in Maritime Colleges.

Criteria	C28	C29	C30	C31	C32	Weight
C28	1	2	2	1	2	0.283
C29	1/2	1	1	1/2	2	0.164
C30	1/2	1	1	2	2	0.224
C31	1	2	1/2	1	2	0.223
C32	1/2	1/2	1/2	1/2	1	0.106
CR =	**0.053**					**1.000**

Source: Authors.

Referring to Table 13, it is evident that within the Digitality variable, the sub-variable Digital literacy (C28) assumes top priority, carrying a weight of 0.283. Following closely, the Digital Communication and Cooperation (C30) sub-variable secures the second position with a weight of 0.224, while the Safety sub-variable (C31) takes the third spot with a weight of 0.223. Digital literacy encompasses the competence to effectively and responsibly utilize digital technology, covering a broad spectrum of skills, including navigating online platforms, conducting efficient information searches, critically evaluating digital content, proficiently communicating and collaborating through digital tools, and safeguarding personal information and privacy within the digital realm. In the context of maritime college lecturers, digital literacy plays a pivotal role in enhancing their digital competence, necessitating a strong foundation in navigating online platforms, conducting research using online databases and search engines, critically assessing the reliability and credibility of online content, and effectively utilizing communication tools for interactions with students. To bolster digital literacy among maritime higher education lecturers, institutions must extend adequate support and resources, such as training programs, technology access, and a culture of innovation and collaboration.

4.3. Consistency test results.

To assess the data's consistency from the completed questionnaire, we conducted a comparison matrix consistency test for each method before calculating the total weight for each variable/criterion. In the Analytic Hierarchy Process (AHP) method, this consistency test is represented by the Consistency Ratio (CR). Data is considered consistent if the CR value is ≤ 0.1; if it exceeds 0.1, it indicates (Arora et al., 2020; Maletič et al., 2021; Sharma et al., 2019). Based on our calculations, it is evident that the consistency test using the AHP method yielded CR values of < 0.1 for each variable and sub-variable (Table 7; Table 8; Table 9; Table 10; Table 11; Table 12; Table 13), confirming the consistency of the pairwise comparison results.

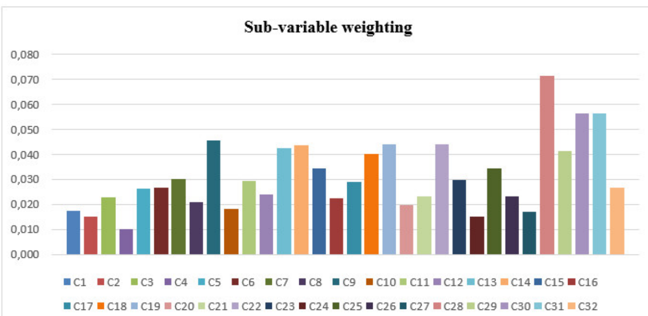
Table 14: Pairwise comparison matrix aggregation pada variable Digitality for Lecturer Digital Competence in Maritime Colleges.

Variable	Weight	Sub-variable	Code	Local Weight	Overall Weight	Rank
Personality		Energy	C1	0.190	0.017	28
		Helpfulness	C2	0.165	0.015	30
	0.091	Personal integrity and reliability	C3	0.249	0.023	23
		Multiculturalism	C4	0.109	0.010	32
		Morality	C5	0.286	0.026	19
Professionalism		Theoretical knowledge	C6	0.188	0.027	18
		Practical knowledge	C7	0.213	0.030	13
	0.141	Experience	C8	0.148	0.021	25
		Discipline	C9	0.323	0.046	4
		Creativity	C10	0.128	0.018	27
Educational		Transmissibility	C11	0.149	0.029	15
		Studiousness	C12	0.122	0.024	20
	0.196	Planning	C13	0.216	0.042	8
		Adaptability	C14	0.222	0.044	7
		Coaching	C15	0.176	0.034	11
		Inventiveness	C16	0.115	0.023	24
Scientificity		Resourcefulness	C17	0.145	0.029	16
		Innovativeness	C18	0.201	0.040	10
	0.200	Imagination	C19	0.219	0.044	5
		Diligence	C20	0.099	0.020	26
		Persistence	C21	0.116	0.023	21
		Effectiveness	C22	0.219	0.044	5
Communication		Listening	C23	0.251	0.030	14
		Persuasion	C24	0.125	0.015	31
	0.119	Empathy	C25	0.287	0.034	12
		Presentation	C26	0.194	0.023	22
		Collaboration	C27	0.144	0.017	29
Digitality		Digital literacy	C28	0.283	0.071	1
		Digital pedagogy	C29	0.164	0.041	9
	0.252	Digital Communication and Cooperation	C30	0.224	0.056	2
		Safety	C31	0.223	0.056	3
		Basic Troubleshooting	C32	0.106	0.027	17

Source: Authors.

Table 14 presents both local and global weights for factors and subfactors. The AHP methodology allows for the incorporation of assessments based on intangible qualitative criteria alongside tangible quantitative criteria. This approach involves pairwise comparisons of the primary criteria as well as pairwise comparisons of multiple subcriteria for each primary criterion. Once these pairwise comparisons for primary and sub-criteria are completed, the global weight of the sub-criteria is determined by multiplying the local weight of the sub-criteria by the weight of the primary criteria. Subsequently, weights are calculated through a series of four steps, leading to the determination of both local and global weights. Local weights signify the significance of factors within their respective groups, while global weights indicate the priority of these factors concerning Maritime cyber resilience. These global weights enable decision-makers to make conclusions regarding the ranking of subcriteria in terms of their importance, aligning with the perspective of decision-makers (Sharma et al., 2019). In practical applications, obtaining these weights can be achieved by directly soliciting the opinions of stakeholders. It becomes essential to ensure that these weights accurately reflect the spectrum of criteria values, as demonstrated in the research conducted by Mustajoki et al., (2020).

Figure 4: Global weight of Sub-variable Lecturer Digital Competence in Maritime Colleges.



Source: Authors.

Table 14 and Figure 4 provide a comprehensive overview of the local and global weights, as well as the overall rankings for each main criterion and sub-criterion. In terms of global weights, the Digital literacy sub-variable (C28) within the Digitality category emerges as the top priority with a weight of 0.071. Following closely, both the Digital Communication and Cooperation (C30) and Safety (C28) sub-variables in the Digitality category share the same weight of 0.056. Within the context of maritime universities, digital literacy holds immense significance for lecturers as it empowers them to effectively engage with students and deliver educational content through digital technology. Digital communication entails the utilization of various digital tools and platforms, including email, instant messaging, video conferencing, and social media, to interact with others. Proficiency in digital communication equips lecturers to provide timely feedback on assignments, address student queries, and facilitate meaningful online discussions. It also enables collaboration with peers on research projects and curriculum development. In an era marked by increasing reliance on digital technology, it is crucial to acknowledge potential risks associated with online communication and data sharing. Faculty members must remain vigilant regarding these risks and take appropriate measures to safeguard themselves and their students. Ensuring digital security encompasses protecting personal information from unauthorized access or identity theft, avoiding phishing scams and malicious software, and promoting responsible online conduct among students.

To enhance lecturers' digital competence, focusing on digital literacy, digital communication, and safety, maritime universities can implement customized training programs and workshops tailored to these specific areas. These initiatives may encompass a range of topics, including honing information literacy skills, mastering the effective utilization of digital communication tools, and implementing strategies for maintaining online safety.

4.4. *Assessment of Maritime Cyber Resilience.*

The assessment of Lecturer Digital Competence is conducted using a simulation model, wherein each model represents the values of variables and sub-variables within decision-making problems. These values are determined using the AHP weighting method and Likert scale assessments. Moreover, it is possible to create simulation models for each criterion within the dynamic system hierarchy. Each simulation model takes as input a vector, with the vector's size matching the number of alternatives considered in the decision-making process. Each row of this vector signifies an alternative or preference related to a specific decision problem, encompassing all relevant data about that particular alternative (Octavian et al., 2021). Figure 3 illustrates the simulation model, with its primary purpose being to facilitate the assessment of maritime cyber resilience. The outcomes of the model simulation are presented in Figure 5.

Table 15: Evaluation value of Lecturer Digital Competence on Personality (A) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Energy	0.190	2.944	0.560	58.889	Competence
Helpfulness	0.165	3.667	0.606	73.333	Proficiency
Personal integrity and reliability	0.249	3.222	0.804	64.444	Proficiency
Multiculturalism	0.109	3.611	0.395	72.222	Proficiency
Morality	0.286	3.111	0.889	62.222	Proficiency
Personality (A)			**3.254**	**66.222**	**Proficiency**

Source: Authors.

Table 16: Evaluation value of Lecturer Digital Competence on Professionalism (B) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Theoretical knowledge	0.188	3.167	0.595	63.333	Proficiency
Practical knowledge	0.213	3.222	0.686	64.444	Proficiency
Experience	0.148	3.056	0.453	61.111	Proficiency
Discipline	0.323	3.111	1.004	62.222	Proficiency
Creativity	0.128	3.056	0.391	61.111	Proficiency
Professionalism (B)			**3.130**	**62.444**	**Proficiency**

Source: Authors.

Table 17: Evaluation value of Lecturer Digital Competence on Educational (C) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Transmissibility	0.149	3.000	0.448	60.000	Competence
Studiousness	0.122	3.222	0.392	64.444	Proficiency
Planning	0.216	3.000	0.649	60.000	Competence
Adaptability	0.222	3.000	0.666	60.000	Competence
Coaching	0.176	3.278	0.576	65.556	Proficiency
Inventiveness	0.115	3.500	0.401	70.000	Proficiency
Educational (C)			**3.133**	**63.333**	**Proficiency**

Source: Authors.

Table 18: Evaluation value of Lecturer Digital Competence on Scientificity (D) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Resourcefulness	0.145	3.000	0.435	60.000	Competence
Innovativeness	0.201	2.944	0.592	58.889	Competence
Imagination	0.219	3.000	0.658	60.000	Competence
Diligence	0.099	3.278	0.326	65.556	Proficiency
Persistence	0.116	3.167	0.367	63.333	Proficiency
Effectiveness	0.219	3.000	0.658	60.000	Competence
Scientificity (D)			**3.036**	**61.296**	**Proficiency**

Source: Authors.

Table 19: Evaluation value of Lecturer Digital Competence on Communication (E) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Listening	0.251	3.000	0.752	60.000	Competence
Persuasion	0.125	2.944	0.369	58.889	Competence
Empathy	0.287	3.222	0.925	64.444	Proficiency
Presentation	0.194	3.500	0.677	70.000	Proficiency
Collaboration	0.144	3.333	0.478	66.667	Proficiency
Communication (E)			**3.201**	**64.000**	**Proficiency**

Source: Authors.

Table 20: Evaluation value of Lecturer Digital Competence on Digitality (F) criteria.

Sub-variables	Weight	Score	Result	%	Explanation
Digital literacy	0.283	3.333	0.944	66.667	Proficiency
Digital pedagogy	0.164	2.889	0.473	57.778	Competence
Digital Communication and cooperation	0.224	3.222	0.721	64.444	Proficiency
Safety	0.223	3.333	0.744	66.667	Proficiency
Basic Troubleshooting	0.106	3.222	0.342	64.444	Proficiency
Digitality (F)			**3.224**	**64.000**	**Proficiency**

Source: Authors.

The evaluation of Lecturer Digital Competence encompasses six key variables. In the Personality (A) variable, there are five sub-criteria, with four sub-variables falling within the Proficiency category at level 4, while one sub-variable is categorized under Competency at level 3. Overall, the Personality (A) variable is rated at the Proficiency level, attaining a value of 0.6244 (Table 15). Moving to the Professionalism (B) variable, it encompasses five sub-variables, all of which are situated within the Proficiency category (Table 16). In the Educational (C) variable, three sub-variables are classified as Competency level, while the remaining three are rated at the Proficiency level. The overall assessment places the Educational (C) variable within the Proficiency category (Table 17). Similarly, in the Scienticity (D) variable, four sub-variables are rated at the Competency level, while two are at the Proficiency level, resulting in an overall Proficiency categorization for the Scienti?city (D) variable (Table 18). Within the Communication (E) variable, two sub-variables are categorized as Competency level, while the other three are situated at the Proficiency level. Overall, the Communication (E) variable falls within the Proficiency category (Table 19). Lastly, in the Digitality (F) variable, one sub-variable is deemed Competency level, while the remaining four are at the Proficiency level, resulting in an overall Proficiency categorization for the Digitality (F) variable (Table 20).

Table 21: The evaluation value of Lecturer Digital Competence in Maritime Colleges.

Criteria	Result	%	Explanation
Personality	3.254	65.071	Proficiency
Professionalism	3.130	62.598	Proficiency
Educational	3.133	62.664	Proficiency
Scientificity	3.036	60.715	Competence
Communication	3.201	64.028	Proficiency
Digitality	3.224	64.478	Proficiency
Result of Lecturer Digital Competence	**3.163**	**63.259**	**Proficiency**

Source: Authors.

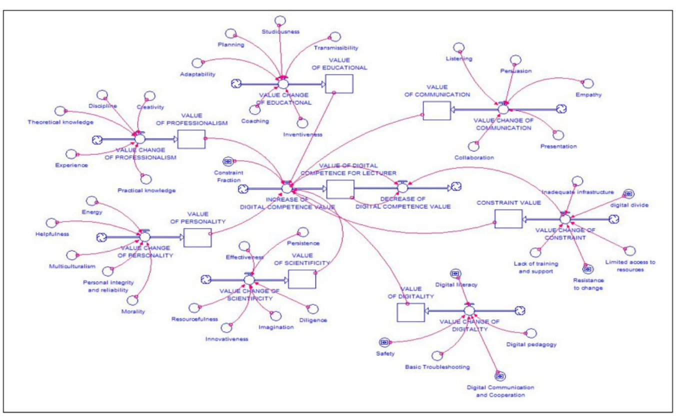
According to Table 21, the assessment of Lecturer Digital Competence in Maritime Colleges yields a score of 3,163 (63.26%), placing it within the proficiency category. Among the variables, one variable is rated at level 3 (Competence), while the remaining five variables are positioned at level 4 (Proficiency). Notably, the Personality variable (A) boasts the highest score at 3,254 (65.07%). Personality variables can significantly influence the determination of digital competence among lecturers in maritime universities. These personality traits can impact an individual's motivation, attitudes, and behaviors concerning the adoption and utilization of technology. Several personality variables have been identified as potential predictors of digital competence among lecturers in maritime universities. Lecturers with a high level of openness are more inclined to develop advanced digital competencies, as they actively seek opportunities to enhance their technological skills. Moreover, lecturers who possess a positive disposition toward technology usage tend to engage in technology-related activities, actively pursue professional development opportunities, and demonstrate resilience in overcoming technological challenges.

In the contemporary digital landscape, educators must possess the requisite skills and knowledge to seamlessly incorporate technology into their teaching methodologies. This not only enhances the learning experience for students but also equips them with the digital acumen required by the maritime industry. The digital competence of lecturers in maritime universities pertains to their proficiency in employing technology and digital tools for educational purposes within the maritime education sector. In the case of maritime higher education lecturers in Indonesia, their digital competence stands at the proficiency level. In recent years, the integration of digital technology into education has gained substantial importance, underscoring the vital need for educators to be well-versed in digital skills. This proficiency is essential for effective teaching and interaction with students in digital learning environments, particularly in maritime-focused universities.

Maritime universities in Indonesia have recognized the paramount significance of digital competence among their lecturers and have taken proactive measures to enhance the digital skills of their teaching faculty. These initiatives are geared toward furnishing lecturers with the requisite knowledge and abilities to adeptly harness digital tools and resources in their teaching methodologies. Operating at the Proficiency Level empowers lecturers to craft captivating and interactive learning materials, facilitate dynamic online discussions, offer prompt and constructive feedback, and effectively evaluate student performance. Equally vital is the capacity to seamlessly integrate technology into pedagogical practices. Lecturers must possess the aptitude to devise and implement technology-driven learning activities that align with the learning objectives of their courses. This entails the judicious selection of appropriate teaching strategies, the design of meaningful assessments, and the provision of opportunities for students to collaborate and engage with course content using digital tools, thereby fostering an enriched learning experience.

4.5. Model simulation of Lecturer Digital Competence in Maritime Colleges.

Figure 5: Stock-flow diagram of Lecturer Digital Competence in Maritime Colleges.



Source: Authors.

Stella 9 software was used to simulate the dynamic process of Lecturer Digital Competence in Maritime Colleges with results as shown in Figure 6. Figure 6 shows the dynamic process of Lecturer Digital Competence in Indonesia Maritime Colleges. From 2022 to 2026 Lecturer Digital Competence will still be at level 4 (proficiency), however, this value tends to decrease, due to aspects of digitalization that tend to continue to develop (Figure 6a). The decline in digital competence of maritime university lecturers in Indonesia is affected by several factors; a) Lack of training and support; b) Remain unchanged; c) Limited access to resources; d) Inadequate infrastructure; e) Digital imparity.

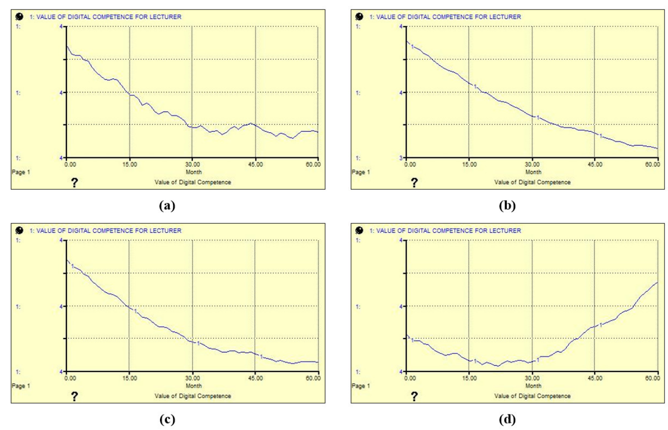
Figure 6a reveals a noteworthy pattern in the assessment of Lecturer Digital Competence at maritime-based universities in Indonesia. In the initial year of evaluation (2022), there is a discernible decline. However, as we progress into the third and fourth years, the trend becomes more dynamic and eventually

Table 22: The value and Factors of decreasing Lecturer digital competence in Indonesian Maritime Colleges.

Code	Variable	Weight	Score	Value
G	Lack of training and support	0.122	2.889	0.353
H	Resistance to change	0.195	3.556	0.692
I	Limited access to resources	0.182	3.056	0.557
J	Inadequate infrastructure	0.128	3.667	0.469
K	The digital divide	0.373	3.167	1.180
				3.252

Source: Authors.

Figure 6: Output value of Lecturer Digital Competence in Maritime Colleges every year within 60 months.



Source: Authors.

stabilizes, settling at level 4 (Proficiency) after experiencing a decline to that level. The decrease in lecturer digital competence in Indonesian maritime colleges can be attributed to a combination of five variables. Among these variables, the most influential one is the "digital divide," which holds a substantial value of 1,180 (Table 22).

In the context of Maritime Universities in Indonesia, the digital divide emerges as a pivotal factor profoundly affecting the digital competence of lecturers. This digital divide within Indonesia is rooted in a multitude of factors, including limited infrastructure, unequal distribution of resources, and socioeconomic disparities. Numerous maritime universities in Indonesia grapple with insufficient technological infrastructure required to facilitate digital learning effectively. This deficiency encompasses inadequate internet connectivity, reliance on outdated computer systems, and a shortage of funding for essential technology upgrades.

The impact of the digital divide on the digital competence of maritime university lecturers in Indonesia is multifaceted. Firstly, it leads to knowledge and skills disparities among lecturers, with those having access to resources and training outperforming their peers. Secondly, it adversely affects the quality of education as digitally incompetent lecturers may struggle to deliver engaging learning experiences and utilize technology effectively, impeding students' skill development for future maritime careers. Thirdly, it exacerbates existing social and economic disparities, as students from privileged backgrounds or better external educational resources may already possess digital familiarity, while lecturers lacking digital competence may struggle to bridge this gap, further disadvantaging students from less privileged backgrounds. Consequently, the digital divide not only impacts lecturer competence but also significantly influences equity and education quality within Indonesia's maritime universities, necessitating concerted efforts to address this divide.

Scenarios and Simulations. The simulation analysis presents three distinct scenarios regarding the digital competence of lecturers in maritime-based universities in Indonesia. In the first scenario, where the primary factor causing the decline is the Digital Divide with the highest value, the results (Figure 6b) indicate a continuous decrease in Lecturer Digital Competence over the years until the fifth year (2026). In the second scenario, the focus is on enhancing the values of digital competency factors, particularly Digital Literacy (C28), Digital Communication and Cooperation (C30), and Safety (C28), while the Digital Divide remains unchanged. The results (Figure 6c) show a decline in Lecturer Digital Competence until the fourth year (2025), followed by a stabilization trend in 2026. In the third scenario, the emphasis is on increasing the value of the digital competency factor with the highest value while concurrently reducing the Digital Divide. The results (Figure 6d) demonstrate a decline initially, followed by a rebound in the third year (2024) and a subsequent increase, which continues beyond 2026. From these simulation outcomes, it can be inferred that enhancing Lecturer Digital Competence in Indonesia's Maritime Colleges is significantly influenced by reducing the impact of the digital divide.

To bridge the digital divide and enhance the digital competence of maritime university lecturers in Indonesia, a multifaceted approach is essential. Firstly, concerted efforts must be made to expand internet connectivity, even in remote maritime university locations. This may entail collaborative initiatives involving government support and private-sector partnerships to ensure universal access to reliable and affordable internet services. Secondly, maritime universities need to prioritize investments in technological and infrastructure resources, equipping faculty members with essential tools like personal computers, tablets, or other devices that facilitate effective digital teaching and learning. Adequate funding should be allocated for the consistent maintenance and upgrading of technological resources. Thirdly, implementing professional development programs is pivotal to improving lecturers' digital competence, including training sessions, workshops, and online courses focused on digital literacy and effective technology-enabled teaching. Collaboration with education technology experts and organizations can offer valuable insights and support.

4.6. Implications.

Theoretical. Research on the evaluation model for Lecturer Digital Competency in Indonesian Maritime high schools has several noteworthy theoretical implications. Firstly, it advances the field of digital competency assessment by introducing a specialized evaluation model tailored to the distinctive context of maritime universities in Indonesia, considering the unique needs and challenges of lecturers in this domain. This extends digital competency theory within the maritime education field. Secondly, the research underscores the paramount significance of digital competence for lecturers in maritime universities, highlighting the critical role of technology integration in teaching practices. The developed evaluation model offers a structured framework for assessing and enhancing lecturers' digital competence, ultimately elevating education quality in this sector. Thirdly, the research identifies influential factors affecting lecturers' digital competence, encompassing technological skills, pedagogical knowledge, and attitudes towards technology. This understanding allows educational institutions to design targeted interventions and training programs to bolster lecturers' digital competence effectively. Consequently, this research informs strategies for enhancing digital proficiency among maritime university lecturers while considering the unique maritime education context in Indonesia.

Practical. The research findings hold significant implications for maritime universities on multiple fronts. Firstly, they empower these institutions to discern the digital strengths and weaknesses of their lecturers comprehensively, utilizing the evaluation model as a tool for precise assessment and identification of areas requiring improvement. Secondly, the model facilitates informed decisions in faculty recruitment and selection, ensuring that maritime universities hire educators equipped with the essential digital competencies necessary for effective technology integration in teaching. Lastly, the standardized framework provided by the evaluation model has the potential to be embraced by regulatory bodies and policy-makers, paving the way for the establishment of minimum digital competency standards for lecturers across maritime universities which in turn fosters a commitment to delivering high-quality education aligned with the evolving demands of the digital era throughout the maritime education sector.

Conclusions.

In the context of maritime education, each country possesses its unique system for cultivating and evaluating the comprehension of aspiring seafarers within their respective maritime colleges. However, it is equally imperative to scrutinize the competency levels of educators, namely teachers, at these institutions. In the era of the knowledge society, digital competence emerges as a paramount distinguishing factor. Yet, it is essential to emphasize the necessity for professional digital competence, especially in comprehending educational technology and learning processes through a sociocultural lens, even within the specialized domain of maritime universities. The overarching objective of this research is to furnish a comprehensive modeling and analysis of lecturer digital competency within the maritime university landscape in Indonesia, thus addressing a vital aspect of the evolving maritime education sector.

The research findings unveiled a comprehensive structure comprising six main variables and 32 sub-variables, with Digitality (F) emerging as the most substantial variable, boasting a weight value of 0.252. It was closely followed by Scienticity (D) with a weight of 0.200 and Educational (C) at 0.196. In the global weighting scheme, the Digital literacy sub-variable (C28) took precedence, commanding a weight of 0.071, trailed closely by Digital Communication and Cooperation (C30) and Safety (C28) sub-variables, both with identical weights of 0.056. Moreover, the analysis of Lecturer Digital Competence in Maritime Colleges culminated in a proficiency rating of 3,163 - (63.26%), firmly establishing it within the proficiency category at level 4. Notably, the Personality variable (A) claimed the highest score at 3,254 (65.07%), underscoring the pivotal role of personality traits in shaping the digital competence levels of maritime university lecturers.

The simulation results highlighted the digital divide as the most influential factor leading to a decline in lecturers' digital competence, with a substantial value of 1,180. Across the three scenarios, distinct trends emerged: In the first scenario, Lecturer Digital Competence at maritime-based universities in Indonesia consistently declined each year, reaching its lowest point by the fifth year (2026). In the second scenario, the decline persisted until the fourth year (2025), followed by signs of stabilization in 2026. The third scenario indicated a more moderate decline, with a resurgence in the third year (2024) and a subsequent steady increase until 2026. These simulation outcomes underscore the critical role of reducing the digital divide in enhancing Lecturer Digital Competence within Indonesia's Maritime Colleges, suggesting that targeted efforts to address this factor can substantially influence competence levels.

Limitations and Future Work.

This research is subject to several limitations. Firstly, it employs a relatively limited number of variables. In introducing the HR approach to lecturer digital competence, the research deliberately adopts a simplified model with a minimized number of variables to effectively illustrate the potential utility of this methodology. Notably, despite these imposed limitations, the model reveals unforeseen patterns in the interaction between lecturer digital competence and various influencing variables contributing to the decline in lecturer digital competence scores. Future research endeavors can explore increased model complexity by incorporating additional strategic variables aimed at enhancing lecturer digital competence.

Secondly, the research acknowledges that variables associated with factors influencing the decline in lecturer digital competence may not fully capture real-world conditions. Validating the questions of these influencing factors would offer valuable insights into the practical applicability of the proposed simulation model. Thirdly, the limitations stem from the subjective nature of the content analysis method, the assessment process, the involvement of a limited number of experts, and the deliberately broad scope of the research. A more focused analysis of the identified system dynamics models within colleges from diverse fields (e.g., defense, transportation, economics) could provide deeper insights into system dynamics modeling.

Fourthly, further exploration of model-based studies can enhance our comprehension of the role of stakeholder influence and the associated risks linked to lecturer digital competence, along with their consequential impacts. This review has demonstrated that System Dynamics (SD) modeling serves as a potent method for capturing intricate interactions and dynamic relationships among various causal factors which contribute to the advancement and broader utilization of SD models in future research about lecturer digital competence.

Fifthly, while the assessment model presented in this paper is comprehensive and applicable for estimating dynamic changes in lecturer digital competence at maritime colleges in Indonesia, it does have some inherent limitations within its framework. Notably, trends in changes in lecturer digital competence at these colleges may evolve gradually or exhibit an average progression, primarily due to the unavailability of daily data. Therefore, future enhancements to the digital competency assessment model for maritime college lecturers should focus on variable selection and data collection improvements. Additional pertinent factors can be incorporated into the model to provide a more precise and nuanced description of digital competence.

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