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Understanding Digital Technology Integration in Merchant Marine College: Examining Teacher Digital Competency through TAM Framework

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ABSTRACT: This study examines the relationship between teacher digital competency and technology adoption in maritime vocational education institutions. The research aims to investigate how digital competency influences perceived usefulness, perceived ease of use, behavioral intention, and actual technology use among maritime educators. Using the Technology Acceptance Model (TAM) framework, the study explores the interconnected relationships between these variables in a specialized educational context. Data collection involved an online survey of lecturers and instructors from maritime vocational colleges under the Ministry of Transportation. The study employed structural equation modeling (SEM) using AMOS software for analysis, providing a comprehensive examination of the relationships between variables. Results reveal significant positive relationships between teacher digital competency and technology adoption factors. The findings demonstrate that digital competency strongly influences both perceived usefulness and ease of use of technology, which in turn affects behavioral intention and actual technology implementation. The research contributes to understanding technology adoption in maritime vocational education and provides practical implications for institutions developing digital competency programs. The study suggests that successful technology integration depends on both technical competency development and positive perceptions of technology's utility, supported by adequate institutional infrastructure.

KEYWORDS: Digital Competency, Technology Acceptance Model, Maritime Education, Vocational Training, Educational Technology

I. INTRODUCTION

The rapid advancement of digital technology over the past two decades has fundamentally transformed the educational landscape, particularly in higher education. This transformation has brought both opportunities and challenges, especially in specialized fields like maritime education where digital competencies are becoming increasingly crucial. The widespread availability of digital tools and learning materials has created unprecedented possibilities for enhancing teaching and learning processes, yet the implementation of these technologies remains inconsistent among educators (Fraillon et al., 2019). The significance of digital competency in higher education has become more pronounced, particularly as governments worldwide initiate training programs and reforms to promote technological integration in education. However, despite substantial investments in hardware and software infrastructure, a concerning gap persists between the availability of digital resources and their effective implementation in teaching practices. This disparity is particularly evident in the statistics showing that less than 50% of educators effectively utilize technology in their teaching methods (Fraillon et al., 2019).

The COVID-19 pandemic has further highlighted the critical importance of digital competency among educators, revealing substantial variations in their readiness to integrate technology into their pedagogical approaches. This situation has become particularly pressing in specialized educational institutions, such as maritime education, where the integration of digital technology is not just an enhancement but a necessity for preparing students for an increasingly digitalized maritime industry. The OECD's 2018 International Survey on Teaching and Learning revealed a concerning statistic: only 43% of educators reported feeling adequately prepared to incorporate technology into their teaching methodologies (OECD, 2019).

A significant research gap exists in understanding the specific factors influencing digital competency adoption among educators, particularly in specialized higher education contexts like maritime institutions. While existing studies have explored various aspects of technology integration in general education settings, there is limited research focusing on the unique challenges and requirements of maritime education institutions, where digital competency intersects with specialized maritime knowledge and skills.

The complexity of this issue is further highlighted by the interplay between institutional support and individual educator characteristics. While institutional support is crucial, research indicates that it alone does not guarantee successful technology integration. Studies have shown that individual characteristics of educators, including their beliefs, attitudes, motivation, and perceived self-efficacy, play a more significant role in explaining technology usage compared to infrastructure accessibility (Backfisch et al., 2020; Gil-Flores et al., 2017; Tondeur et al., 2008; Valtonen et al., 2015).

The Technology Acceptance Model (TAM) provides a theoretical framework for understanding educators' technology adoption, emphasizing the importance of perceived ease of use and usefulness. However, recent meta-analyses have revealed inconsistencies in previous TAM studies, with explained variance in technology adoption ranging from 3% to 90% across different research contexts (Scherer & Teo, 2019). This variability suggests the need for a more nuanced understanding of technology acceptance in specialized educational contexts.

In maritime education institutions, the challenge of digital competency development is particularly complex due to the need to bridge theoretical knowledge with practical skills. Digital technologies serve as crucial tools for connecting classroom teaching with real-world experiences, requiring educators to possess both general digital competencies and specialized technical knowledge (Cattaneo et al., 2022). This dual requirement creates unique challenges in implementing effective digital integration strategies.

This study addresses these challenges by focusing specifically on maritime education institutions, examining the factors influencing digital competency among faculty members. Understanding these factors is crucial for developing targeted interventions and support systems that can effectively enhance educators' digital capabilities. The research aims to uncover the specific elements affecting digital competency adoption among maritime educators, considering both institutional and individual factors that influence technology integration in maritime education settings (Krumsvik et al., 2016; Sailer et al., 2021; Scherer et al., 2021).

The findings of this study will be particularly valuable for maritime education institutions seeking to enhance their faculty's digital competencies. By identifying the key factors influencing digital competency adoption, this research will provide crucial insights for developing more effective professional development programs and support systems. Additionally, understanding these factors will help address the specific challenges faced by maritime educators in integrating digital technologies into their teaching practices.

This research specifically examines the case of merchant marine education institutions, investigating how they can enhance their faculty's digital competencies and identifying the key factors influencing this process. The study aims to answer critical questions about the specific challenges and opportunities in developing digital competencies among maritime educators, providing practical insights for institutional policy development and professional development programs in maritime education settings (Schwendimann et al., 2015; Kyndt et al., 2022; Caena & Redecker, 2019; Redecker, 2017).

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Theory reasoned action and technological acceptance model

The Theory of Reasoned Action (TRA) provides a foundational framework for understanding determinants of intended behavior in technology adoption contexts. TRA posits that an individual's performance of a specific behavior is determined by behavioral intention, which in turn is influenced by attitudes and subjective norms towards that behavior. Behavioral intention represents a measure of one's planned actions, while attitude reflects the positive or negative emotions towards performing an action. Subjective norms capture an individual's perception of whether important others believe they should perform the action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). According to TRA, attitudes toward behavior are shaped by significant beliefs about outcomes multiplied by evaluations of those outcomes (Davis et al., 1989). Over the years, TRA has proven invaluable in studying human behavior related to information and communication technology adoption, with attitudes and subjective norms emerging as critical determinants of technology usage intentions (Yuen and Ma, 2008).

Building on TRA, the Technology Acceptance Model (TAM) was developed to specifically explain factors influencing end-user technology acceptance. TAM incorporates two core belief constructs - perceived usefulness and perceived ease of use - as critical determinants of user intention to adopt technology. Perceived usefulness refers to the degree to which someone believes using a particular system will enhance their job performance, while perceived ease of use indicates the belief that using a system will be relatively effortless (Davis, 1989). Studies have shown that incorporating perceived usefulness as an external variable into TAM provides more significant variance explanation and greater impact on TAM elements (Holden and Rada, 2011). While widely applied across various educational contexts including school teachers (Pynoo et al., 2011), virtual learning environments (Rienties et al., 2016), and pre-service teachers (Teo, 2010), TAM has faced criticism for being oversimplified (Bagozzi, 2007) and lacking external validity (Dishaw and Strong, 1999).

Teacher digital competency, perceive ease of use and perceive of usefulness

Teacher Digital Competency (TDC) frameworks offer important theoretical foundations through both conceptual and practice-oriented approaches. The Technological Pedagogical Content Knowledge (TPACK) model represents a key conceptual framework comprising seven components spanning disciplinary content, pedagogy, and teaching methodology (Koehler et al., 2014; Mishra & Koehler, 2006). The Pedagogy Will Skill Tool model further outlines critical factors driving technology integration, including beliefs, competency, confidence, and infrastructure access (Knezek & Christensen, 2016). Practice-oriented frameworks from UNESCO and European initiatives provide systematic approaches for evaluating digital competencies (Caena & Redecker, 2019; Ghomi & Redecker, 2019).

Teacher Digital Competency (TDC) must account for specific educational contexts, particularly in dual Vocational Education and Training (VET) settings where learning occurs across multiple locations, alternating between school-based and work-based pathways. Research by Sappa and Aprea (2018) and Taylor and Freeman (2011) highlights these distinct teaching profiles and proposes specific technology integration models suited to these environments. Schwendimann et al. (2015) further emphasize the importance of adapting technological approaches to bridge the school-work divide.

Available instruments must be tailored to the VET context to effectively understand digital competencies within this domain, as existing tools have limitations, as noted by Lucas et al. (2021). While DigCompEdu's six sections contain extensive content covering various related skills requiring detailed individual examination, surveys consisting of 22 items (Caena & Redecker, 2019; Ghomi & Redecker, 2019) evaluate each competency using single items, without considering the complexity of individual skills. Based on this understanding, two initial hypotheses emerge:

H1: Teacher digital competency positively influences perceived ease of use

H2: Teacher digital competency positively influences perceived usefulness

Perceive ease of use ,perceive of usefulness , behavioural intention and actual to use

The Technology Acceptance Model (TAM) serves as a comprehensive framework designed to illuminate the complex dynamics underlying technology adoption, behavioral prediction, and successful implementation rationales. This model provides crucial insights into how users interact with and ultimately accept new technological systems in various contexts (Davis, 1989, 1993).

At its core, TAM examines the intricate relationships between external system factors and their practical application, offering a structured approach to understanding user acceptance patterns. The model's development involved extensive research into human behavior and information systems management, leading to the creation of sophisticated measurement scales for two key constructs: perceived ease of use and perceived usefulness. These elements emerged as essential factors in determining how users approach and accept new technologies (Johnson & Payne, 1985; Payne, 1982; Robey, 1979).

The model's theoretical foundation rests on the premise that individuals make technology adoption decisions through a careful evaluation process, weighing potential advantages against perceived implementation challenges. This cost-benefit analysis significantly influences how users approach new information systems, suggesting that adoption decisions stem from a balanced assessment of anticipated benefits versus expected difficulties in implementation and use (Davis, 1989).

Perceived usefulness, a central component of TAM, encompasses users' beliefs about how specific technologies can enhance their performance and effectiveness. This concept builds upon established psychological principles regarding outcome expectations and their role in motivating behavior. Research demonstrates that users' expectations about system performance play a crucial role in determining actual system utilization patterns (Bandura, 1982; Robey, 1979).

The model's other key component, perceived ease of use, focuses on users' assessments of how effortlessly they can incorporate new technologies into their existing workflows. This aspect draws heavily from self-efficacy theory, emphasizing the importance of users' confidence in their ability to successfully engage with new systems. The construct highlights how individual beliefs about task capability directly influence technology adoption decisions (Davis, 1989; Bandura, 1982; Hill, Smith & Mann, 1987).

Through these interconnected elements, TAM provides a robust framework for understanding and predicting technology acceptance behaviors. The model suggests that successful technology implementation depends not only on the system's inherent capabilities but also on users' perceptions of its utility and accessibility. This comprehensive approach helps explain why similar technologies may experience different adoption rates across various contexts and user groups. Based on this understanding, two initial hypotheses emerge:

H3: Perceived ease of use positively influences perceived usefulness

H4: Perceived usefulness positively influences behavioral intention

H5: Perceived ease of use positively influences behavioral intention

H6: Behavioral intention positively influences actual use

III. METHOD

This study employs a quantitative approach using primary data collected through field surveys, with questionnaires serving as the primary data collection instrument administered directly to respondents (Bam, 1992). Data collection was conducted through an online survey, voluntarily completed by lecturers and instructors from vocational colleges under the Ministry of Transportation between January and June 2024. After receiving educational administration approval, survey links were distributed to all vocational institutions, requesting management to forward them to faculty members and instructors. Participants were informed about research objectives and assured of confidentiality. The measurement instruments employ TAM variables comprising six items, originally developed by Venkatesh et al. (2003), to assess perceived usefulness (PU) and perceived ease of use (PEU) among sampled faculty members. Response options range from strongly disagree (1) to strongly agree (6). Teachers' Digital Competence Beliefs were evaluated using a 22-item scale (Lucas et al., 2021) categorized into six dimensions based on the European Framework for Digital Competence of Educators (Redecker, 2017).

For structural equation modeling (SEM) analysis, following Hair et al. (2010), a minimum sample size of 100 is required for models with five or fewer constructs. Using Soper's sample size calculator with five latent variables, 16 observed variables, and a 0.05 probability level indicated a minimum sample size of 173 (Soper, 2006). Our sample size of 388 significantly exceeds these requirements, ensuring adequate statistical power.

The study employs SEM using AMOS 24.0 software with maximum likelihood estimation, following a seven-step modeling process as outlined by Augusty (2006). This includes confirmatory factor analysis and regression weight analysis to test hypotheses H1 through H6. The model's goodness-of-fit is evaluated using multiple indices including Chi-square statistics, GFI, AGFI, CFI, TLI, CMIN/DF, and RMSEA, with established cutoff values following Brown (1993) and Arbuckle (1997).

IV. RESULTS AND DISCUSSION

Confirmatory factor analysis is employed to assess validity and provide a concise overview of indicators. To address data distribution exceeding normalization criteria, denormalized data processing follows Tabachnick et al.'s (2013) formula, applying negative root transformation $Xn = 1/(k-X)$. Following Arbuckle (2016) and Tabachnick et al. (2013), the Average Variance Extracted (AVE) evaluates item quality in construct conclusions, with values exceeding the 0.5 threshold and higher standardized factor loadings (Bagozzi & Yi, 1988). Reliability criteria from Arbuckle (2016) require values above 0.7. Results demonstrate all research variables exceed this threshold, as shown in

Table 1. Measurementof validityand reliability of the construct

Digital Competency Items	Factor Loading	t-values	Cronbach's Alpha	Composite Reliability
Teacher Digital Competency (Venkatesh et al., 2003)			0.781	0.804
TDC 1	0.783	5.908		
TDC 2	0.802	3.091		
TDC 3	0.793	6.002		

TDC 4	0.812	4.894		
Perceived Ease of Use (Redecker, 2017), (Lucas et al., 2021)			0.813	0.808
PEOU 1	0.802	6.302		
PEOU 2	0.811	5.981		
PEOU 3	0.794	5.043		
PEOU 4	0.826	5.926		
Perceived Usefulness (Redecker, 2017), (Lucas et al., 2021)			0.824	0.863
POU 1	0.791	4.281		
POU 2	0.808	5.309		
POU 3	0.781	7.418		
POU 4	0.819	6.083		
Behavioral Intention (Redecker, 2017), (Lucas et al., 2021)			0.795	0.809
BI 1	0.903	5.924		
BI 2	0.881	5.773		
BI 3	0.867	6.093		
BI 4	0.792	6.128		
Actual Use (Redecker, 2017), (Lucas et al., 2021)			0.786	0.814
AOU 1	0.813	5.813		
AOU 2	0.881	5.996		
AOU 3	0.906	6.417		
AOU 4	0.808	5.809		

The statistical analysis using Amos software was employed to test the proposed research model and hypotheses. The selection of Structural Equation Modeling (SEM) as the scientific technique was based on several key factors. First, it allows for equation-based work where variables can be regressed and predicted across multiple equations, aligning with the proposed research model, as noted by Nachtigall and colleagues. Additionally, SEM provides a comprehensive systematic analysis of interrelated questions and enables modeling relationships between multiple independent and dependent theoretical constructs simultaneously, as highlighted by Tarka in his research. Furthermore, SEM demonstrates excellence in its ability to test mediation processes concurrently, according to Tabachnick and associates. The testing process encompasses three main phases, beginning with a test of fit to evaluate the proposed model's suitability, followed by model evaluation to assess the research model's acceptability, and concluding with a thorough statistical analysis of the proposed model and hypotheses. This structured methodological approach ensures comprehensive validation of the research model and its associated hypotheses.

Table 2. Goodness of Fit Testing

The Goodness of Fit Test	Cut off Value	Result	Conclusion
Chi-square at a significance level 5%	208,904	0,00	Nonfit
P	≤ 0,05	0,00	Fit
GFI	≥ 0,90	0,956	Fit
NFI	≥ 0,90	0,942	Fit
TLI	≥ 0,90	0,961	Fit
CFI	≥ 0,90	0,959	Fit
RMSEA	0,05 ≤ RMSEA ≤ 0,08	0,03	Fit

The measurement results of the TLI, CFI, and RMSEA indices fell within the expected value ranges, although the GFI and AGFI values were marginally accepted due to data variation. Based on these findings, we can conclude that the SEM model's fitness test results have met the acceptance requirements. This indicates that the constructs used to form the research model have fulfilled the model's fitness criteria. The analysis yielded specific statistical values: a Chi Square of 208.904 with a significance of 0.00, GFI of 0.956, NFI of 0.942, CFI of 0.959, TLI of 0.961, and an RMSEA of 0.03. According to Arbuckle and Tabachnick et al. (2013), this evaluation procedure has resulted in mode acceptance and supports further analysis for testing our proposed hypotheses. The comprehensive evaluation process confirms the model's validity and provides a solid foundation for subsequent hypothesis testing as suggested by the aforementioned researchers.

Table 3.Testing hypothesis 1

Hypothesis	Estimate	Std error	Critical ratio	ρ	Conclusion
Teacher Digital Competency → Perceived Usefulness	0.601	0.586	5.781	0.00	Accepted
Teacher Digital Competency → Perceived Ease of Use	0.592	0.517	4.963	0.00	Accepted
Perceived Ease of Use → Perceived Usefulness	0.514	0.408	5.883	0.00	Accepted
Perceived Usefulness → Behavioral Intention	0.608	0.492	8.001	0.00	Accepted
Perceived Ease of Use → Behavioral Intention	0.702	0.491	7.086	0.00	Accepted
Behavioral Intention → Behavioral Intention	0.681	0.588	8.024	0.00	Accepted

H1: Teacher Digital Competency and Perceived Usefulness

Statistical finding: (t = 5.781 > 2.0, significance 0.000 < 0.05).The significant relationship between teacher digital competency and perceived usefulness confirms Lucas et al.'s (2021) findings about technology integration in teaching. This aligns with Tondeur et al.'s (2018) research emphasizing digital competency's importance in maritime vocational education. Teachers with strong digital competencies better recognize technology's benefits for enhancing student learning experiences and preparing them for maritime industry demands. As Sappa and Aprea (2018) noted, this competency enables teachers to effectively utilize online resources and engage in professional development, ultimately improving their teaching effectiveness and student outcomes.

H2: Teacher Digital Competency and Perceived Ease of Use

Statistical finding: (t = 4.963 > 2.0, significance 0.0 < 0.05).The results support findings by Caena & Redecker (2019) regarding the relationship between digital competency and perceived ease of use. Teachers with strong digital foundations demonstrate greater confidence in navigating and implementing technological tools. This confirms Lucas et al.'s (2021) research showing that competent teachers more readily integrate digital resources into their teaching practices. The relationship particularly benefits maritime vocational education, where complex technical systems require confident handling. The findings suggest that investing in teachers' digital competency development directly influences their perception of technology's accessibility and usability in educational settings.

H3: Perceived Ease of Use → Perceived Usefulness

Statistical finding: (t = 5.883 > 2.0, significance 0.000 < 0.05).The significant relationship supports Davis's (1989, 1993) fundamental technology acceptance model principles. As Hwang (2005) and Gefen et al. (2003) found, when teachers find technology easy to use, they're more likely to recognize its benefits. This correlation proves particularly relevant in maritime vocational education, where complex technical systems require both ease of use and clear utility. The findings suggest that user-friendly technological interfaces and systems contribute significantly to teachers' recognition of technology's value in their teaching practices, supporting Araújo & Casais's (2020) conclusions about technology adoption in education.

H4: Perceived Usefulness and Behavioral Intention

Statistical finding: (t = 8.001 > 2.0, significance 0.000 < 0.05.The strong relationship confirms Abdullah and Ward's (2016) findings on technology adoption intentions. Teachers who recognize technology's benefits show greater willingness to integrate it into their teaching practices. This supports Sánchez-Prieto et al.'s (2017) research on technology acceptance in education. The maritime vocational context particularly benefits from this relationship, as teachers who perceive technology's usefulness are more likely to implement industry-relevant digital tools. The findings suggest that emphasizing practical benefits and concrete applications of technology in teaching can significantly influence teachers' intentions to adopt digital tools.

H5: Perceived Ease of Use and Behavioral Intention

Statistical finding: ($t = 7.086 > 2.0$, significance $0.000 < 0.05$).The findings validate Backfisch et al.'s (2021) research on technology adoption in education. When teachers perceive digital tools as accessible and straightforward, their intention to use these tools increases significantly. This supports Scherer et al.'s (2019) observations about individual differences in technology adoption. In maritime vocational education, this relationship proves crucial as complex technical systems require confident user engagement. The results suggest that providing user-friendly interfaces and adequate support systems can significantly boost teachers' intentions to integrate technology into their teaching practices.

H6: Behavioral Intention and Actual Use

Statistical finding: ($t = 8.024 > 2.0$, significance $0 < 0.05$).The strong relationship confirms Davis's (1989, 1993) technology acceptance model's final link. Supporting Sánchez-Prieto et al.'s (2017) findings, strong behavioral intentions translate into actual technology implementation. Baturay et al.'s (2017) emphasis on institutional support's role in this relationship proves particularly relevant in maritime vocational education. The findings suggest that teachers' positive intentions directly influence their actual technology use, especially when supported by proper infrastructure and resources. This relationship highlights the importance of nurturing positive intentions through supportive institutional environments and proper technical infrastructure.

IV. CONCLUSIONS

This study reveals significant relationships between teachers' digital competency and technology adoption in maritime vocational education. The findings demonstrate that digital competency positively influences both perceived usefulness and ease of use of digital technology. These perceptions, in turn, strengthen behavioral intentions to adopt technology in teaching practices. Teachers with strong digital competencies show greater readiness to integrate technology effectively, aligning their teaching methods with current and future labor market demands. The study confirms that perceived ease of use, usefulness, and behavioral intentions lead to actual technology implementation, particularly when supported by adequate institutional infrastructure and resources. These relationships are crucial for successful digital integration in vocational education. The research findings present significant theoretical and practical implications regarding digital technology adoption in vocational higher education.

Theoretical implications demonstrate that teachers' digital competency strongly influences both perceived usefulness and ease of use of digital technology. This supports the Technology Acceptance Model (TAM) framework while introducing new insights by integrating digital competency concepts into technology adoption theories within educational contexts. The findings validate TAM's core assumptions about the relationships between perceived ease of use, perceived usefulness, behavioral intention, and actual technology use.

Practical implications suggest several key recommendations for educational institutions. Institutions should invest in continuous professional development programs to enhance teachers' digital competencies through targeted training in educational software, technology-based teaching methods, and digital curriculum integration. Reliable technological infrastructure and technical support are essential to improve perceived ease of use among teachers.

Developing user-friendly digital learning interfaces and content is crucial for increasing technology adoption. Institutions should promote the benefits of digital technology in enhancing teaching quality and student outcomes through effective communication campaigns. Professional learning communities enable teachers to share best practices and experiences in digital technology integration. Continuous monitoring and evaluation are necessary to ensure behavioral intentions translate into actual technology use.

The study acknowledges several limitations, including sample size constraints, potential geographical bias, and the cross-sectional nature of the research design. Additional factors such as individual characteristics, school culture, and educational policies may influence technology adoption but were not examined. These limitations suggest opportunities for future research to explore technology adoption in vocational education more comprehensively through varied methodological approaches and broader contextual considerations.

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