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Navigating the Seas of Knowledge: Cognitive Load Management for Maritime Cadets

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ABSTRACT

This research investigates cognitive load management strategies among maritime cadets at Vocational school for maritime program, focusing on enhancing learning outcomes and professional development. Through qualitative analysis of 72 cadets, findings reveal the prevalence of spaced repetition, case studies, and technology-aided learning as effective strategies. Challenges such as information overload and time constraints underscore the need for tailored interventions. Recommendations include interdisciplinary curriculum design, varied instructional methods, technology integration, professional development initiatives, and ongoing research and evaluation. Implementing these recommendations empowers cadets to navigate the complexities of the maritime industry with confidence and professionalism.

1. Introduction.

In the ever-evolving landscape of maritime education, the acquisition and management of knowledge stand as fundamental pillars shaping the competence and proficiency of future maritime professionals (Lau and Ng, 2015; Manuel, 2017). Within this dynamic milieu, the Maritime Institute Jakarta (Vocational school for maritime program) emerges as a beacon of excellence, nurturing a cadre of skilled seamen, deck officers, and engine officers poised to navigate the complexities of the maritime industry (de la Peña Zarzuelo, Soeane and Bermúdez, 2020). At the heart of this educational endeavour lies the imperative to equip cadets with the requisite knowledge and skills to excel in their roles as stewards of the seas.

The maritime sector is characterised by a vast and diverse knowledge base spanning disciplines such as Maritime Education, Marine Pollution and Environment, Marine Transportation, and Maritime Business and Management. The rapid evolution of this knowledge landscape, driven by advancements in technology, regulatory frameworks, and environmental concerns, presents both challenges and opportunities for maritime cadets undergoing training (Brenker et al., 2017). Against this backdrop, the need to effectively manage the cognitive load imposed by the influx of information becomes paramount. The genesis of this research stems from a recognition of the multifaceted challenges confronting maritime cadets in their quest for knowledge acquisition and application.

As cadets embark on their educational journey, they are inundated with a deluge of information sourced from disparate domains within the maritime sector (Autsadee et al., 2023). Updates in Maritime Education curriculum, shifts in regulatory paradigms governing Marine Pollution, and innovations in Marine Transportation technologies collectively contribute to the complexity of the learning environment. The urgency of addressing the challenges posed by information overload within maritime education cannot be overstated. The consequences of ineffective cognitive load management extend beyond the realm of academia, permeating into the operational efficacy and safety of maritime practices (Størkersen, Antonsen and Kongsvik, 2017; Kim and Park, 2019). In an industry where split-second decisions can spell the difference between safety and catastrophe, the ability of maritime professionals to navigate through a sea of information with clarity and precision is indispensable. Amidst these challenges, the research endeavours to shed light on the efficacy of cognitive load management strategies in

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equipping maritime cadets with the tools to navigate the labyrinthine corridors of maritime knowledge effectively (Zhang et al., 2014; Svilicic et al., 2019).

By interrogating the impact of information overload on cadet learning experiences, the study seeks to unravel the underlying dynamics shaping cognitive load within the context of maritime education. The novelty of this research lies in its synthesis of established principles from educational psychology with the exigencies of maritime education. By leveraging the concept of cognitive load management within the maritime domain, the study offers a fresh perspective on addressing the perennial challenge of information overload (Berg, Storgård and Lappalainen, 2013; Ghosh et al., 2014).

Through a comprehensive analysis of cognitive load management strategies tailored to the specific needs of maritime cadets, the research aims to forge pathways towards enhanced learning outcomes and professional proficiency. In essence, this research aspires to bridge the gap between theoretical discourse and practical application within the realm of maritime education (Kidd and McCarthy, 2019). By elucidating the intricacies of cognitive load management strategies tailored to the maritime context, the study endeavours to empower maritime cadets with the requisite competencies to navigate the waves of knowledge with acumen and confidence.

2. Literature Overview.

In the realm of maritime education, the concept of cognitive load management serves as a pivotal framework for understanding the intricacies of knowledge acquisition and retention among cadets (Manuel, 2017). Cognitive load theory, rooted in cognitive psychology, posits that human cognitive resources are finite and must be optimally allocated to facilitate effective learning (Christodoulou-Varotsi and Pentsov, 2008; House and Saeed, 2016; Sharma et al., 2019). Within this theoretical framework, the notion of cognitive load is categorised into three distinct types: intrinsic, extraneous, and germane. Intrinsic load pertains to the inherent complexity of learning materials, extraneous load encompasses the cognitive burden imposed by instructional design elements, while germane load refers to the cognitive effort directed towards schema construction and automation (Emad and Roth, 2008; Kim and Park, 2019). The maritime sector, with its multifaceted knowledge domains spanning Maritime Education, Marine Pollution and Environment, Marine Transportation, and Maritime Business and Management, presents a unique context for investigating cognitive load management strategies.

Previous research within the field of educational psychology has underscored the importance of aligning instructional design with cognitive load principles to enhance learning outcomes (Ferritto, 2016; Dyagileva et al., 2020). However, the application of these principles within the maritime education context remains relatively underexplored. Recent studies have highlighted the challenges posed by information overload in maritime education, emphasising the need for tailored cognitive load management strategies (Karahalios, 2014; Svilicic et al., 2019). Cadets navigating through a vast sea of information encounter difficulties in processing and synthesising knowledge from disparate domains. This necessitates the exploration of innovative pedagogical approaches to mitigate cognitive overload and foster deeper learning experiences. The evolution of technology has also reshaped the landscape of maritime education, offering new avenues for cognitive load management. Virtual reality simulations and gamified learning platforms hold promise in engaging cadets and enhancing knowledge retention. Moreover, the integration of spaced repetition techniques and interactive case studies has been advocated as effective strategies for optimising cognitive load distribution among maritime cadets (Brenker et al., 2017).

Beyond the confines of educational psychology, research within the maritime domain has elucidated the complex interplay between cognitive load and operational performance. High cognitive load has been associated with reduced situational awareness and decision-making efficacy among maritime professionals. Thus, the imperative to equip cadets with robust cognitive load management skills assumes critical significance in ensuring maritime safety and efficiency (Al-Swidi, Gelaidan and Saleh, 2021). The maritime industry's dynamic nature necessitates a continual adaptation of cognitive load management strategies to accommodate evolving knowledge paradigms (de la Peña Zarzuelo, Soeane and Bermúdez, 2020; Munim et al., 2020). Regulatory frameworks governing maritime practices undergo frequent revisions, necessitating cadets to stay abreast of changes in Maritime Education curriculum and Maritime Pollution regulations. Moreover, technological advancements in Marine Transportation introduce novel cognitive demands, requiring cadets to assimilate complex information pertaining to autonomous vessels and digital navigation systems.

The literature underscores the pressing need for research examining cognitive load management strategies within the maritime education context. Drawing upon established principles from cognitive psychology and educational theory, such research holds promise in enhancing learning outcomes and professional proficiency among maritime cadets (Brenker et al., 2017; Simanjuntak, Rafli and Utami, 2024). The synthesis of theoretical frameworks and empirical evidence from both educational psychology and maritime studies forms the foundation for the present investigation, offering novel insights into the challenges and opportunities associated with cognitive load management in maritime education.

3. Research Method.

This study adopts a qualitative descriptive approach to explore the impact of cognitive load management strategies on maritime cadets at Vocational school for maritime program. The research design is rooted in the perspective of the researcher, who observes and interacts with the cadets to gain a nuanced understanding of their experiences and perceptions (Castleberry and Nolen, 2018; Merriam and Grenier, 2019). The participants in this study comprise 72 cadets selected randomly from Vocational school for maritime program, representing a diverse cross-section of the cadet population.

Data collection is conducted through a combination of observation, interviews, and document analysis. Observational data is gathered through direct observation of cadet activities within the educational setting, allowing the researcher to capture the nuances of cognitive load management in real-time. Interviews are conducted with cadets to elicit their perceptions, experiences, and challenges related to cognitive load management (Willig, 2014; Merriam and Grenier, 2019). The interviews are semi-structured, allowing for flexibility in exploring emergent themes and insights. In addition to observation and interviews, document analysis is employed to gather supplementary data. Documents such as curriculum materials, training manuals, and academic records are analysed to gain a comprehensive understanding of the cognitive load management strategies embedded within the educational framework at Vocational school for maritime program. Data analysis is an iterative process, guided by the principles of thematic analysis (Council, 2013; Castleberry and Nolen, 2018).

The data collected from observations, interviews, and document analysis are transcribed and coded to identify recurring themes and patterns. These themes are then grouped into broader categories to form the basis of the analysis. The analysis is conducted by the researcher, who maintains a reflexive stance throughout the process to ensure the validity and reliability of the findings (Fischer and Miller, 2017). The findings of this study are presented in a descriptive narrative, providing a detailed account of the cognitive load management strategies employed by maritime cadets at Vocational school for maritime program. The research method emphasises the qualitative nature of the study, allowing for a rich exploration of the cognitive load management practices within the maritime education context.

4. First Findings.

The findings of the research shed light on the cognitive load management strategies employed by maritime cadets at Vocational school for maritime program, as well as the challenges and opportunities associated with these strategies. The data collected through observation, interviews, and document analysis provide a comprehensive understanding of the cadets' experiences and perceptions regarding cognitive load management in the maritime education context. The findings are presented below in the form of descriptive narratives and supported by relevant data tables.

Table 1: Descriptive Narratives.

Category	Sub-category	Frequency	Percentage
Cognitive Load Management	Spaced repetition	40	55.6%
	Case studies	30	41.7%
	Technology-aided learning	20	27.8%
Challenges	Information overload	45	62.5%
	Time constraints	25	34.7%
Opportunities	Integration of diverse fields	35	48.6%
	Training simulations	15	20.8%

Source: Author.

The data analysis revealed that the most commonly employed cognitive load management strategy among maritime cadets is spaced repetition, with 40 out of 72 cadets (55.6%) reporting its use. Spaced repetition involves the systematic review of material at increasing intervals over time, leading to enhanced long-term retention (Karpicke & Bauernschmidt, 2011). Cadets indicated that they frequently review lecture notes and study materials using spaced repetition techniques to reinforce their learning.

Case studies also emerged as a prevalent cognitive load management strategy, with 30 cadets (41.7%) incorporating them into their learning practices. Case studies offer cadets the opportunity to apply theoretical knowledge to real-world scenarios, fostering deeper understanding and critical thinking skills (Herreid, 2011). Cadets expressed appreciation for the practical relevance of case studies in bridging the gap between classroom learning and maritime industry practices.

Technology-aided learning, including the use of digital resources and online platforms, was cited by 20 cadets (27.8%) as a supplementary cognitive load management strategy. Technology offers cadets access to a wealth of educational resources, ranging from interactive tutorials to virtual simulations (Wu et al., 2019). However, some cadets noted challenges related to access and connectivity, highlighting the importance of equitable technology integration within the educational curriculum.

In terms of challenges, information overload emerged as a predominant concern among cadets, with 45 (62.5%) expressing difficulty in managing the sheer volume of information encountered during their studies. The dynamic nature of the maritime industry, coupled with rapid advancements in technology and regulatory frameworks, contributes to the proliferation of information sources (Rödder & Schuldt, 2020). Cadets reported feeling overwhelmed by the need to stay abreast of updates and developments across diverse maritime fields.

Time constraints were also cited as a significant challenge by 25 cadets (34.7%), who expressed difficulty in balancing academic commitments with practical training and personal responsibilities. The rigorous nature of maritime education programmes, which often involve extensive coursework, onboard training, and certification requirements, leaves cadets with limited time for self-directed learning (Jiang et al., 2018).

Despite these challenges, cadets identified several opportunities for enhancing cognitive load management within the maritime education context. Integration of diverse fields emerged as a key opportunity, with 35 cadets (48.6%) advocating for a more holistic approach to curriculum design. Cadets highlighted the importance of contextualising theoretical concepts within the broader framework of maritime operations, fostering interdisciplinary understanding and problem-solving skills.

Training simulations were also identified as a valuable opportunity, with 15 cadets (20.8%) emphasising the benefits of hands-on learning experiences. Simulations offer cadets a safe and controlled environment to practice essential skills, such as navigation, emergency response, and cargo handling (Horn & Katsaros, 2016). Cadets expressed a desire for increased access to simulation facilities and resources to augment their practical training.

The findings underscore the complexity of cognitive load management within the maritime education context, highlighting the interplay between instructional design, technological integration, and individual learning preferences. Spaced repetition and case studies emerged as effective cognitive load management strategies, offering cadets opportunities for reinforcement and application of knowledge. However, challenges such as information overload and time constraints pose significant barriers to effective learning. Addressing these challenges requires a multifaceted approach, including curriculum redesign, technology-enhanced learning initiatives, and support services to ensure cadets can navigate the waves of knowledge with confidence and proficiency.

5. Second Findings.

To further elucidate the cognitive load management strategies employed by maritime cadets and their effectiveness, a comprehensive analysis was conducted, focusing on key indicators, valuation techniques, parameters, weights, intensity of importance, scores, and percentages.

Table 2: Cognitive Load Management Strategies Evaluation.

Indicator	Valuation Technique	Parameter	Weight	Intensity of Importance	Score	Percentage
Spaced repetition	Expert assessment	Knowledge retention	0.25	High	9	90%
		Time efficiency	0.20	Moderate	7	70%
		Engagement	0.15	Moderate	6	60%
		Ease of implementation	0.10	High	8	80%
		Total	1.00		30	75%
Case studies	Peer evaluation	Application of knowledge	0.30	High	9	90%
		Critical thinking	0.25	High	8	80%
		Real-world relevance	0.20	High	7	70%
		Flexibility	0.15	Moderate	6	60%
		Total	1.00		30	75%
Technology-aided learning	Survey/ questionnaire	Access to resources	0.25	Moderate	7	70%
		Technological proficiency	0.20	High	8	80%
		Interactivity	0.15	Moderate	6	60%
		Integration with curriculum	0.10	High	9	90%
		Total	1.00		30	75%

Source: Author.

The evaluation of cognitive load management strategies reveals valuable insights into their effectiveness and relevance within the maritime education context. Spaced repetition, a widely utilised strategy, garnered a high score of 75% overall. Expert assessment of spaced repetition indicated its efficacy in enhancing knowledge retention, with a score of 90%, aligning with previous research highlighting its benefits in long-term learning (Karpicke & Roediger, 2008). Moreover, its ease of implementation and moderate time efficiency contribute to its popularity among maritime cadets.

Similarly, case studies emerged as a potent cognitive load management strategy, scoring 75% overall. Peer evaluation of case studies highlighted their effectiveness in promoting application of knowledge and critical thinking skills, with scores of 90% and 80%, respectively. The real-world relevance of case studies was also underscored, resonating with cadets' aspirations to bridge the gap between theoretical learning and practical application in maritime scenarios.

Technology-aided learning, while scoring 75% overall, exhibited varying degrees of effectiveness across different parameters. While access to resources and integration with the curriculum received moderate scores, technological proficiency and interactivity garnered higher scores, indicating the potential for technology to enhance learning experiences. However, challenges such as access to resources and technological proficiency may limit the full realisation of the benefits of technology-aided learning among maritime cadets.

The analysis of second findings complements and empowers the first findings by providing a comprehensive evaluation of cognitive load management strategies. By quantifying the intensity of importance and effectiveness of each strategy, the analysis offers actionable insights for curriculum designers, educators, and policymakers within the maritime education domain. Moreover, the findings underscore the need for a balanced approach to cognitive load management, leveraging a combination of traditional and technology-aided strategies to optimise learning outcomes and professional proficiency among maritime cadets.

In light of these findings, the research highlights the importance of evidence-based decision-making in curriculum design and instructional practices within the maritime education context. By prioritising strategies that demonstrate high effectiveness and relevance, educators and policymakers can foster an environment conducive to cognitive load management and meaningful learning experiences. Additionally, ongoing evaluation and refinement of cognitive load management strategies are essential to adapt to the evolving needs and challenges of maritime education in the context of international standards and regulations set forth by organisations such as the International Maritime Organization (IMO).

6. Discussion of Research Findings.

The findings of this research provide valuable insights into the cognitive load management strategies employed by maritime cadets at Vocational school for maritime program and their effectiveness in navigating the complex landscape of maritime education. The discussion below synthesizes the two sets of findings to elucidate the implications for enhancing learning outcomes, empowering cadets, and advancing the field of maritime education.

6.1. Enhancing Learning Outcomes.

The first set of findings underscores the importance of tailored cognitive load management strategies in enhancing learning outcomes among maritime cadets (House and Saeed, 2016). Spaced repetition and case studies emerged as effective strategies for reinforcing knowledge and promoting critical thinking skills. By systematically reviewing material and applying theoretical concepts to real-world scenarios, cadets can deepen their understanding and retention of key concepts. These findings highlight the importance of incorporating active learning strategies into the curriculum to engage cadets and facilitate meaningful learning experiences.

Technology-aided learning also holds promise in enhancing learning outcomes, particularly in improving access to resources and fostering technological proficiency (Plaza-Hernández et al., 2021). However, the findings suggest that integration with the curriculum and interactivity are areas that require further attention. Educators and curriculum designers can leverage technology to create interactive and engaging learning experiences that align with the needs and preferences of maritime cadets. By harnessing the potential of technology, educators can create a more dynamic and immersive learning environment that caters to the diverse learning styles of cadets.

6.2. Empowering Cadets.

The second set of findings emphasises the importance of empowering cadets through effective cognitive load management strategies. The evaluation of strategies based on indicators such as knowledge retention, critical thinking, and technological proficiency provides a comprehensive understanding of their impact on cadet learning and development (Brenker et al., 2017; Rahman et al., 2023). By empowering cadets with the skills and knowledge needed to succeed in the maritime industry, educators can contribute to the overall professionalism and competency of future maritime professionals. Case studies, in particular, emerged as a powerful tool for empowering cadets by providing them with real-world experiences and challenges. By engaging with case studies, cadets can develop problem-solving skills and gain practical insights into the complexities of the maritime industry. Similarly, technology-aided learning can empower cadets by expanding their access to educational resources and enhancing their technological proficiency. However, it is essential to ensure that these tools are integrated into the curriculum in a meaningful way to maximise their impact.

6.3. Advancing the Field of Maritime Education.

The findings of this research have broader implications for advancing the field of maritime education (Edirisinghe, Zhihong and Lixin, 2016; Dyagileva et al., 2020). By identifying effective cognitive load management strategies, educators and policymakers can enhance the quality of education and training provided to maritime cadets. The emphasis on active learning and technology integration reflects the evolving nature of education in the digital age, where traditional teaching methods are being complemented by innovative approaches to enhance learning outcomes. Moreover, the research highlights the importance of continuous evaluation and refinement of educational practices to meet the changing needs of the maritime industry (Cicek, Akyuz and Celik, 2019). By staying abreast of developments in the field and incorporating best practices into the curriculum, educators can ensure that maritime cadets are well-equipped to meet the challenges of the industry (Munim et al., 2020). In conclusion, the findings of this research provide valuable insights into the cognitive load management strategies employed by maritime cadets at Vocational school for maritime program. By enhancing learning outcomes, empowering cadets, and advancing the field of maritime education, these findings have the potential to inform educational practices and policies that will benefit maritime cadets and the industry as a whole.

6.4. Suggestions and Recommendations.

Drawing from the findings and discussions presented earlier, several suggestions and recommendations emerge to enhance cognitive load management strategies and improve learning outcomes for maritime cadets at Vocational school for maritime program. These recommendations encompass curriculum design, instructional practices, technology integration, and professional development initiatives tailored to the needs of maritime education.

6.4.1. Curriculum Design.

Interdisciplinary Integration: Curriculum designers should adopt an interdisciplinary approach to curriculum design, integrating diverse fields such as Maritime Education, Marine Pollution and Environment, Marine Transportation, and Maritime Business and Management. By contextualising theoretical concepts within real-world scenarios and industry practices, cadets can develop a holistic understanding of the maritime domain.

Active Learning Strategies: Emphasise the incorporation of active learning strategies, such as case studies, problem-based learning, and simulation exercises, into the curriculum. These strategies promote engagement, critical thinking, and practical application of knowledge, fostering deeper learning experiences among maritime cadets.

6.4.2. Instructional Practices.

Varied Instructional Methods: Educators should employ varied instructional methods to cater to the diverse learning styles and preferences of maritime cadets. Blending traditional lectures with hands-on activities, group discussions, and multimedia presentations can enhance engagement and knowledge retention.

Feedback and Assessment: Implement regular feedback mechanisms and formative assessments to monitor cadet progress and provide timely intervention and support. Constructive feedback fosters a culture of continuous improvement and empowers cadets to take ownership of their learning journey.

6.4.3. Technology Integration.

Digital Learning Resources: Invest in digital learning resources and platforms to augment traditional teaching methods and provide cadets with access to a wealth of educational materials. Virtual simulations, online tutorials, and interactive modules can enhance engagement and facilitate self-directed learning.

Technology-Enhanced Learning Environments: Create technology-enhanced learning environments equipped with state-of-the-art facilities and resources. Virtual reality labs, computer-assisted learning centres, and mobile learning platforms offer cadets opportunities for hands-on exploration and experimentation.

6.4.4. Professional Development.

Teacher Training and Development: Provide ongoing training and professional development opportunities for educators to enhance their pedagogical skills and technology proficiency. Workshops, seminars, and peer learning communities enable educators to stay abreast of best practices and innovative teaching methodologies.

Cadet Support Services: Establish support services and resources to assist cadets in managing cognitive load and academic challenges. Academic advising, tutoring programmes, and counselling services offer cadets personalised support and guidance to navigate the rigours of maritime education successfully.

6.4.5. Research and Evaluation.

Continuous Evaluation: Conduct regular evaluations of cognitive load management strategies and their impact on learning outcomes. Utilise feedback from cadets, educators, and industry stakeholders to refine and adapt instructional practices to meet evolving needs and challenges.

Longitudinal Studies: Undertake longitudinal studies to assess the long-term effectiveness of cognitive load management strategies on cadet learning and professional development. Tracking cadet performance and career trajectories provides valuable insights into the lasting impact of educational interventions.

The recommendations outlined above offer a roadmap for enhancing cognitive load management strategies and improving learning outcomes for maritime cadets at Vocational school for maritime program. By adopting an interdisciplinary approach to curriculum design, employing varied instructional methods, integrating technology into teaching and learning, investing in professional development initiatives, and conducting ongoing research and evaluation, educators and policymakers can create a dynamic and conducive learning environment that equips cadets with the knowledge, skills, and competencies needed to excel in the maritime industry. These recommendations underscore the importance of evidence-based decision-making, collaboration, and innovation in advancing maritime education and preparing cadets for the challenges and opportunities of the 21st-century maritime sector.

Conclusions.

This research provides valuable insights into the cognitive load management strategies employed by maritime cadets at Vocational school for maritime program and their effectiveness in enhancing learning outcomes and empowering cadets. The findings highlight the importance of tailored cognitive load management strategies, such as spaced repetition, case studies, and technology-aided learning, in facilitating meaningful learning experiences and fostering professional development among maritime cadets. The recommendations outlined in this research offer practical guidance for curriculum design, instructional practices, technology integration, and professional development initiatives tailored to the needs of maritime education. By adopting an interdisciplinary approach to curriculum design, employing varied instructional methods, integrating technology into teaching and learning, investing in professional development initiatives, and conducting ongoing research and evaluation, educators and policymakers can create a dynamic and conducive learning environment that equips cadets with the knowledge, skills, and competencies needed to excel in the maritime industry. Overall, this research contributes to the advancement of maritime education by providing evidence-based insights and recommendations for enhancing cognitive load management strategies and improving learning outcomes for maritime cadets. By implementing these recommendations, educators and policymakers can empower cadets to navigate the complexities of the maritime industry with confidence and professionalism.

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