
СУЧАСНІ ПІДХОДИ ТА ІННОВАЦІЙНІ ТЕХНОЛОГІЇ ФОРМУВАННЯ ІНШОМОВНОЇ КОМУНІКАТИВНОЇ КОМПЕТЕНТНОСТІ

Отримано: 4 червня 2026 р.

Прорецензовано: 10 червня 2026 р.

Прийнято до друку: 18 червня 2026 р.

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DOI: [http://doi.org/10.25264/2519-2558-2026-30\(98\)-147-150](http://doi.org/10.25264/2519-2558-2026-30(98)-147-150)

Tyron O. M., Kaminska S. V., Didenko M. O. Digital simulation environments as a training tool for real maritime operations and radio communication in English. *Наукові записки Національного університету «Острозька академія» : серія «Філологія»*. Острог : Вид-во НаУОА, 2026. Вип. 30(98). С. 147–150.

UDC: 811.111'276.6:378.147:316.46

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DIGITAL SIMULATION ENVIRONMENTS AS A TRAINING TOOL FOR REAL MARITIME OPERATIONS AND RADIO COMMUNICATION IN ENGLISH

This study explores the role of digital simulation environments in developing Maritime English competence and operational communication skills among maritime cadets. Grounded in the requirements of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and supported by contemporary cognitive learning theories, the research investigates how virtual reality (VR), full-mission bridge simulators, and specialized communication platforms contribute to improved communication performance in maritime contexts. Particular attention is given to the development of Standard Marine Communication Phrases (SMCP) accuracy, response efficiency, situational awareness, and the ability to communicate effectively under operational stress.

A mixed-methods research design involved 62 second- and third-year maritime cadets divided into experimental and control groups. The experimental group participated in a six-week simulation-enhanced training program, while the control group received traditional classroom-based instruction. Data were collected through SMCP performance tests, response-time measurements, stress perception surveys, structured instructor evaluations, and post-training interviews.

The findings indicate that simulation-based training significantly improves communication accuracy, message clarity, and adherence to standardized maritime phraseology. Participants exposed to simulation environments demonstrated faster response times, greater confidence, and stronger resilience when communicating in high-pressure situations. The study concludes that immersive simulation environments facilitate the integration of linguistic, cognitive, and operational competencies and should be considered an essential component of contemporary Maritime English education and training programs.

Keywords: Maritime English, simulation-based learning, SMCP (Standard Marine Communication Phrases), Virtual reality (VR) training, situational awareness.

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ЦИФРОВІ СИМУЛЯЦІЙНІ СЕРЕДОВИЩА ЯК ІНСТРУМЕНТ ПІДГОТОВКИ ДО РЕАЛЬНИХ МОРСЬКИХ ОПЕРАЦІЙ ТА РАДІОЗВ'ЯЗКУ АНГЛІЙСЬКОЮ МОВОЮ

У статті досліджується роль цифрових симуляційних середовищ у розвитку компетентності з морської англійської мови та навичок оперативної комунікації у курсантів морських закладів освіти. Спираючись на вимоги Міжнародної конвенції про підготовку, дипломування моряків і несення вахти (STCW), а також сучасні когнітивні теорії навчання, дослідження аналізує, яким чином технології віртуальної реальності (VR), повномасштабні навігаційні тренажери та спеціалізовані комунікаційні платформи сприяють підвищенню ефективності професійного спілкування в морському середовищі. Особливу увагу приділено розвитку точності використання Стандартних фраз морського спілкування (SMCP), швидкості реагування, ситуаційної обізнаності та здатності ефективно здійснювати комунікацію в умовах операційного стресу.

У дослідженні взяли участь 62 курсанти другого та третього курсів, розподілені на експериментальну та контрольну групи. Експериментальна група проходила шеститижневу програму навчання з використанням симуляційних технологій, тоді як контрольна група навчалася за традиційною аудиторною методикою. Дані збиралися за допомогою тестів на володіння SMCP, вимірювання часу реагування, опитувань щодо рівня стресу, структурованого оцінювання викладачами та післятренінгових інтерв'ю.

Результати свідчать, що навчання на основі симуляцій значно підвищує точність комунікації, зрозумілість повідомлень і рівень дотримання стандартизованої морської фразеології. Учасники, які навчалися в симуляційному середовищі, демонстрували швидші реакції, вищий рівень впевненості та більшу стійкість до стресу під час спілкування в умовах підвищеного навантаження. Зроблено висновок, що імерсивні симуляційні середовища сприяють інтегрованому розвитку мовних, когнітивних та професійно-операційних компетентностей і повинні розглядатися як важливий складник сучасної системи навчання морської англійської мови та підготовки майбутніх моряків.

Ключові слова: морська англійська мова, навчання на основі симуляцій, Стандартні фрази морського спілкування, навчання з використанням віртуальної реальності, ситуаційна обізнаність.

Effective communication in English remains critical in maritime safety, particularly during high-risk situations where clear radio interaction directly affects decision-making, vessel coordination, and accident prevention. Recent data from marine accident investigation branches continue to underscore that a striking majority of maritime incidents involve a human factor component, wherein flawed communication – ranging from misunderstood messages to incorrect phraseology or incomplete reports – acts as a primary catalyst.

Technological advancements in maritime education, including VR simulators, digital navigation platforms, and scenario-based training tools, offer new ways to prepare seafarers for real-world operations. Simulation environments allow cadets to rehearse emergency communication, apply Standard Marine Communication Phrases (SMCP), and experience operational pressure without real-world consequences.

This study investigates how digital simulation environments support Maritime English development and operational readiness in cadet training.

The effectiveness of simulation training can be explained through several cognitive learning theories. According to constructivist learning theory, knowledge is actively constructed through direct interaction with the environment rather than passively accumulated from instructional delivery. In this context, digital simulation environments establish authentic frameworks where learners construct experiential meaning by actively resolving realistic challenges and responding to dynamic, unpredictable operational events (Jonassen, 2011).

Situated Learning Theory (Lave & Wenger, 1991) emphasizes that learning is most effective when it occurs within contexts that reflect actual seamanship. Maritime simulators place learners in environments that closely imitate bridge operations, emergency responses, and vessel communication procedures. As a result, students develop not only linguistic knowledge but also contextual awareness regarding when and how specific communication strategies should be applied.

Cognitive Load Theory (Sweller, 1988) provides additional insight into performance under pressure. Real maritime operations require simultaneous processing of navigational, environmental, and communicative information. Simulation training manages to optimize working memory by facilitating the procedural automation of communication routines, particularly the highly structured SMCP formulas (Sweller, 2020).

From a sociocultural perspective (Lantolf, 2000), learning occurs through interaction and guided participation, both of which are strongly supported in collaborative simulation environments.

International maritime training standards, particularly the STCW Convention and IMO Model Course 3.17, require cadets to use standardized English phraseology accurately, demonstrate proficiency in radio communication, and apply English effectively during navigation and emergency procedures.

Despite the growing body of literature on maritime simulation technologies, much existing research focuses primarily on navigational performance and technical competencies. Fewer studies have examined the specific impact on Maritime English communication performance, particularly SMCP accuracy, response speed, and resilience under stress. This study addresses this gap.

Simulation-based learning is founded on several key principles that make it an effective approach to maritime education and training. One of the most important principles is authenticity, as simulation tasks are designed to reflect real operational challenges that seafarers may face on board. Another principle is repetitiveness, which allows learners to practise scenarios multiple times until the required level of competence is achieved. Feedback and debriefing are equally important, through which mistakes and performance gaps are analysed and transformed into valuable learning opportunities. Finally, simulation-based learning emphasizes transferability, ensuring that the knowledge and skills developed in simulated environments can be effectively applied in real-life maritime operations.

The importance of these principles is reflected in international maritime training standards. The International Maritime Organization requirements, particularly those outlined in the STCW Convention and the IMO Model Course 3.17, specify that cadets must be able to use standardized English phraseology accurately, demonstrate proficiency in radio communication, comprehend messages under stressful and adverse conditions, and apply English effectively during navigation, emergency response, and safety-related procedures. These requirements highlight the essential role of simulation-based training in preparing future seafarers for the communication demands of modern maritime operations.



Simulators support compliance with these requirements by providing controlled environments for integrated operational and linguistic practice.

Research in cognitive psychology suggests that stress, noise, and time pressure reduce working memory capacity. For seafarers, this means that during emergencies, communication clarity decreases unless operational language becomes automatic.

Simulation environments introduce controlled stressors such as strong winds and poor visibility, equipment failure, close-quarters navigation, simultaneous communication with multiple stations and time pressure.

This process facilitates the automatization of SMCP and operational English routines, enabling cadets to communicate more efficiently and accurately during maritime operations. Through repeated exposure to realistic scenarios, learners gradually develop the ability to retrieve and use language automatically, reducing the cognitive effort required during high-pressure situations.

Digital training tools used in maritime education vary considerably in their level of complexity and immersion, ranging from desktop-based simulators to fully immersive virtual reality (VR) bridge environments. Empirical evidence demonstrates that VR-driven educational approaches offer profound advantages over standard desktop frameworks (Merchant et al., 2014). It enhances situational awareness by providing learners with a 360-degree view of the operational environment, allowing them to better perceive and interpret surrounding conditions. VR also promotes a stronger sense of embodiment and presence, making trainees feel actively involved in the simulated situation rather than merely observing it. In addition, immersive environments have been shown to increase engagement and motivation, encouraging learners to participate more actively in training activities. Finally, the realistic and interactive nature of VR experiences contributes to improved memory retention, as information learned in immersive settings is often recalled more effectively than information acquired through traditional instructional methods.

A mixed-methods research design was employed. The study involved 62 second- and third-year maritime cadets (assigned to control $n=31$ and experimental $n=31$ groups). All participants had completed theoretical SMCP training.

Full-mission navigational bridge simulator, GMDSS communication simulator, VR-based incident scenarios, SMCP communication modules (MarEng, SeaSpeak Trainer), and scenarios designed by the teachers of the Department of Social Communication, the National Transport University were used. Control group received traditional classroom instruction and experimental group was engaged in simulation-enhanced training (12 classes, 6 weeks).

Both the experimental and control groups completed the same set of communication tasks, including routine VHF radio exchanges, transmission of distress and urgency messages, interaction with Vessel Traffic Services (VTS), collision-avoidance communication scenarios, and onboard bridge team communication exercises.

To evaluate participants' performance, several data collection instruments were applied. Communication accuracy was assessed using an SMCP Accuracy Test, while response efficiency was measured through response-time recordings during simulated communication tasks. Perceived stress was measured using a 10-item Likert-scale instrument (1-5), adapted for maritime simulation-based communication training. The scale included emotional stress, communication-related stress, and operational cognitive load dimensions.

Likert-scale test

- 1 – Strongly disagree
- 2 – Disagree
- 3 – Neutral
- 4 – Agree
- 5 – Strongly agree

1. I feel tense when communicating in English during simulation tasks.
1. I experience pressure when I must respond quickly in maritime communication scenarios.
2. I feel mentally overloaded during complex simulation exercises.
3. I remain calm during communication tasks under pressure.
4. I worry about making mistakes when using English in simulations.
5. I find it difficult to think clearly while communicating under time constraints.
6. I feel confident when using SMCP in simulation-based communication tasks.
7. Managing navigation and communication tasks at the same time is stressful for me.
8. Time pressure reduces the quality of my communication performance.
9. I can maintain effective communication even in complex operational situations.

Instructors also evaluated operational communication performance through a structured assessment checklist. In addition, post-training interviews were conducted to gather qualitative insights into cadets' experiences, perceptions of the training process, and perceived improvements in communication competence.

To analyse the data received, the authors used independent t-tests and ANOVA and thematic analysis for qualitative data. Ethical approval and informed consent were obtained.

Findings show that cadets in the simulation group showed notable improvements:

Indicator	Control Group	Simulation Group	p-value
Correct SMCP use	71%	92%	<0.01
Clarity of messages	66%	90%	<0.01
Avoidance of non-standard phrases	52%	88%	<0.01
Average response time (sec)	18.2	12.0	<0.01
Perceived stress (1-5 scale)	3.8	2.9	<0.05

The simulation group demonstrated significantly lower perceived stress levels ($M = 2.9$) compared to the control group ($M = 3.8$, $p < 0.05$). This reduction was consistent across all stress dimensions, including emotional tension, communication-related anxiety, and operational cognitive load.

In particular, cadets reported lower communication anxiety during SMCP use, reduced cognitive overload during multitasking tasks, improved emotional regulation in time-pressured scenarios.

These findings suggest that immersive simulation environments contribute not only to communication competence but also to stress adaptation and cognitive resilience, supporting the principles of stress inoculation and cognitive load optimization.

The findings revealed that cadets in the simulation-based training group demonstrated a 34% reduction in response times, suggesting enhanced communication readiness, quicker decision-making, and greater confidence when operating under pressure. The ability to respond more rapidly indicates that repeated exposure to realistic communication scenarios helped participants develop automaticity in the use of SMCP and operational procedures.

In addition, virtual reality scenarios integrating environmental stressors such as background noise, alarm signals, and strict time constraints highlighted notable differences between the two groups. While participants in the control group frequently experienced a decline in communication clarity and made a higher number of phraseology-related errors, those in the experimental group generally maintained composure, communicated more effectively, and adhered more consistently to SMCP standards.

These outcomes are consistent with stress inoculation theory, which proposes that repeated exposure to controlled stress improves performance in real operational conditions. Consequently, simulation-based training appears to strengthen both communication competence and resilience in high-pressure maritime environments.

Instructor evaluations indicated that cadets who participated in simulation-based training demonstrated stronger decision-making abilities and a higher level of situational awareness compared to those who received traditional instruction alone. These cadets showed a greater understanding of the navigational context while communicating, enabling them to relate communication exchanges more effectively to ongoing operational situations. They were also more successful in identifying and prioritizing critical information, ensuring that essential messages were conveyed clearly and efficiently. Furthermore, simulation-trained participants displayed improved multitasking skills, managing communication responsibilities alongside navigational and operational demands in complex and dynamic scenarios. These findings suggest that simulation environments help learners integrate linguistic competence with operational thinking, thereby enhancing overall bridge performance.

Analysis of post-training interviews illustrated positive perceptions of simulation-based learning among maritime cadets. Participants frequently highlighted the realism of the training experience, noting that the simulated scenarios closely resembled actual navigational operations and helped them better understand professional communication requirements. Cadets also appreciated the immediate feedback provided during training, which enabled them to identify mistakes and improve their performance in real time. Another commonly mentioned advantage was the opportunity to repeat challenging scenarios, allowing learners to refine their communication skills through practice and reflection. Additionally, many participants reported increased confidence when communicating in English, particularly in situations involving radio communication and the use of SMCP. Overall, the interview findings suggest that simulation-based training not only enhances operational communication skills but also strengthens learner motivation, engagement, and self-confidence.

The findings support previous research demonstrating that simulation-based training enhances procedural and communication skills in maritime operations. The study confirms that accurate Maritime English communication depends not only on linguistic knowledge but also situational awareness and cognitive readiness.

Simulators naturally combine navigation tasks with English communication. This integration aligns with the competency-based approach in STCW and represents a more authentic learning experience compared to classroom-only methods.

VR creates emotionally and cognitively impactful experiences, contributing to long-term memory retention. This is especially important in emergency communication training when not all institutions can afford full-mission simulators.

Instructor expertise in both navigation and linguistics is required. Simulation-based Maritime English training should include:

- structured progression from simple to complex scenarios,
- mandatory post-scenario debriefings,
- integration with GMDSS training,
- assessment rubrics for communication competence.

Digital simulation environments provide a highly effective framework for developing Maritime English competence and operational communication skills. They provide authentic communication practice aligned with real maritime operations, improved accuracy and speed of SMCP use, higher stress resilience and decision-making skills, integrated development of linguistic, cognitive, and technical competencies.

Digital simulation environments significantly enhance the training of seafarers in English-language radio communication and operational readiness. They provide authentic practice, improved SMCP accuracy and speed, higher stress resilience, and integrated development of linguistic, cognitive, and technical competencies. Simulation-supported training should be an essential component of Maritime English curricula and maritime education as a whole.

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