

DEVELOPING A REMOTE-CONTROLLED LIFE-SAVING BUOY AS INFORMATION TECHNOLOGY-BASED LEARNING MEDIA FOR MARITIME VOCATIONAL EDUCATION: AN ADDIE-BASED DESIGN AND USABILITY STUDY

Siti Zulaikah¹, Welem Ada², Nurwahidah³, Andi Muh. Akbar Saputra⁴, Ashabul Taufik⁵

^{1,2,3}Program Studi Nautika, Politeknik Ilmu Pelayaran Makassar

^{4,5}Program Studi Pendidikan Teknologi Informasi, Universitas Islam Makassar

email: Sitizulaikah@pipmakassar.ac.id¹

Abstract

Maritime vocational education requires learning media that can connect safety theory, digital technology, and authentic emergency-response practice. Conventional lifebuoy training is often limited to manual throwing procedures and does not sufficiently expose cadets to remote-control communication, propulsion, telemetry readiness, and technology-assisted rescue decision-making. This study developed and evaluated a remote-controlled life-saving buoy as information technology-based learning media for maritime safety education. An applied Research and Development design was adopted using the ADDIE framework: analysis, design, development, implementation, and evaluation. The prototype integrated an ExpressLRS 2.4 GHz transmitter-receiver system, dual propulsion, electronic speed control, and a resin-composite floating body. Evaluation combined technical performance testing and formative user acceptance involving ten maritime instructors, crew members, and cadets. The prototype achieved a mean response time of 0.092 s, reliable control up to 80 m, and a battery endurance of 22-25 min. User acceptance reached a mean score of 4.58 out of 5, with the highest ratings on response speed and signal reliability. The findings suggest that the prototype is not only feasible as a nearshore rescue-training device but also valuable as a project-based learning media for strengthening digital safety literacy, systems thinking, and applied problem-solving in maritime vocational education. However, the study remains a formative design evaluation and should be extended through expert validation, learning-gain measurement, and open-sea trials.

Keywords : Technology-Enhanced Learning, Maritime Vocational Education, Remote-Controlled Lifebuoy, ExpressLRS, ADDIE

Abstrak

Pendidikan vokasi maritim membutuhkan media pembelajaran yang mampu menghubungkan teori keselamatan, teknologi digital, dan praktik respons darurat yang autentik. Pelatihan pelampung konvensional umumnya masih terbatas pada prosedur pelemparan manual dan belum cukup memperkenalkan taruna pada komunikasi kendali jarak jauh, sistem propulsi, kesiapan telemetri, serta pengambilan keputusan penyelamatan berbasis teknologi. Penelitian ini mengembangkan dan mengevaluasi pelampung penyelamat kendali jarak jauh sebagai media pembelajaran berbasis teknologi informasi untuk pendidikan keselamatan maritim. Metode yang digunakan adalah Research and Development dengan kerangka ADDIE yang meliputi analisis, desain, pengembangan, implementasi, dan evaluasi. Prototipe mengintegrasikan sistem transmitter-receiver ExpressLRS 2.4 GHz, propulsi ganda, electronic speed control, dan bodi resin komposit. Evaluasi dilakukan melalui uji performa teknis dan uji penerimaan pengguna secara formatif yang melibatkan sepuluh instruktur maritim, awak kapal, dan taruna. Hasil menunjukkan waktu respons rata-rata 0,092 detik, kendali yang masih andal hingga 80 meter, serta daya tahan baterai 22-25 menit. Penerimaan pengguna memperoleh skor rata-rata 4,58 dari 5, dengan nilai tertinggi pada kecepatan respons dan keandalan sinyal. Temuan ini menunjukkan bahwa prototipe tidak hanya layak sebagai perangkat latihan penyelamatan dekat pantai, tetapi juga bernilai sebagai media project-based learning untuk memperkuat literasi keselamatan digital, berpikir sistem, dan pemecahan masalah terapan dalam pendidikan vokasi maritim. Namun, penelitian ini masih berupa evaluasi desain formatif sehingga perlu dilanjutkan dengan validasi ahli, pengukuran hasil belajar, dan uji laut terbuka.

Kata kunci: pembelajaran berbasis teknologi, pendidikan vokasi maritim, pelampung kendali jarak jauh, ExpressLRS, ADDIE



1. Introduction

Digital transformation has reshaped technical and vocational education by positioning technology not only as a delivery tool but also as a core competence, a learning environment, and an instrument for institutional innovation [1]. In maritime vocational education, this transformation is particularly important because safety competence requires more than conceptual knowledge; it requires repeated practice, situational judgement, communication, and the ability to operate technology under high-risk conditions. The Future of Jobs Report 2025 also highlights the increasing importance of technology literacy, analytical thinking, resilience, and lifelong learning, suggesting that vocational institutions must prepare learners for technologically mediated work systems [2].

Maritime safety training traditionally relies on standards-based drills, manual rescue appliances, and instructor-led demonstrations. While these practices remain essential, they may not fully represent the emerging reality of technology-assisted rescue operations. Conventional lifebuoys are passive flotation devices; their effectiveness depends on the rescuer's physical accuracy, environmental conditions, and the victim's ability to reach the buoy. In rough water, panic situations, or distance-related constraints, manual deployment can become unreliable. These limitations create an opportunity to introduce remote-controlled rescue technology into maritime safety learning as both a functional prototype and an instructional media.

International safety frameworks, including the International Life-Saving Appliance (LSA) Code, emphasize that life-saving appliances must support survivability and rescue operations under demanding maritime conditions [3]. Maritime training must also remain consistent with professional competence standards and supervised practice requirements [12]. However, from an education and information technology perspective, the challenge is not only whether a device can float or move, but also whether the device can be used to teach learners about system architecture, wireless communication, propulsion control, operational risk, and rescue decision-making. A technology-enhanced lifebuoy can therefore serve as a bridge between maritime safety education and applied information technology.

Previous studies have reported the development of remote-controlled lifebuoys and smart rescue devices. Thanakodi et al. designed a lightweight smart lifebuoy prototype to reduce risk to rescuers during water rescue operations [4], Ada et al. developed a remote-controlled life-saving buoy ring using an ADDIE development model [5], and related work on remotely operated marine rescue vehicles has further emphasized the feasibility of propulsion-based rescue devices [10]. These studies are valuable, yet most of the available work emphasizes engineering feasibility, weight reduction, or rescue functionality. Less attention has been given to how such prototypes can be reframed as learning media for vocational education and how their technical performance can be interpreted as pedagogical affordances.

This study addresses that gap by repositioning a remote-controlled life-saving buoy as information technology-based learning media for maritime vocational education. The study does not claim to certify the prototype as a commercial life-saving appliance; rather, it examines the prototype as a formative instructional innovation that enables cadets to engage with remote-control systems, operational testing, emergency-response procedures, and project-based problem solving. This positioning is aligned with maritime simulation research, which emphasizes the need to connect practice, reflection, learning outcomes, and authentic technology-supported experience [6].

Accordingly, this article seeks to answer four research questions: (1) how can a remote-controlled life-saving buoy be designed as technology-based learning media for maritime safety education? (2) what are the prototype's technical performance characteristics in terms of response time, range, and endurance? (3) how do users perceive its usability and instructional value? and (4) what pedagogical implications can be derived for project-based learning in maritime vocational education? The contribution of this study lies in integrating educational design, information technology, and maritime safety innovation into a single applied research framework.



2. Literature Review and Conceptual Positioning

2.1 Digital Transformation in TVET and Maritime Learning

Technical and vocational education and training (TVET) is strongly affected by digital transformation because technology now functions as a learning resource, an operational tool, and a competence domain [1]. In the maritime sector, digitalization includes navigation systems, communication technology, automation, remote operation, data-based monitoring, and safety management systems. Therefore, maritime learners need opportunities to understand how digital systems operate in authentic safety contexts, not only through abstract explanation but also through practice with functioning prototypes.

The pedagogical literature on maritime simulation indicates that technology-enhanced environments can encourage deep learning when they are supported by clear learning outcomes, opportunities for exploration, structured reflection, and assessment linked to professional standards [6]. A remote-controlled lifebuoy is not a full simulator, but it can provide a tangible micro-simulation of maritime rescue technology. It enables students to observe how commands are transmitted, how propulsion produces movement, how signal stability affects operational decisions, and how rescue procedures can be improved through digital intervention.

2.2 Remote-Controlled Rescue Technology as Learning Media

Learning media in vocational education should represent real tools, procedures, and problem contexts. A remote-controlled lifebuoy can be categorized as an instructional technology artifact because it combines hardware, wireless communication, control logic, materials engineering, and user interaction. Its educational value is derived from two domains: the technical domain, where learners study system components and performance; and the safety domain, where learners practice rescue decision-making and evaluate operational constraints.

ExpressLRS is an open-source radio-control link designed for range, speed, and data throughput across 900 MHz and 2.4 GHz hardware ecosystems [7]. These characteristics make it relevant for prototype-based learning because students can investigate latency, packet rate, signal stability, failsafe behavior, antenna placement, and hardware configuration. When these elements are integrated into a project-based module, students engage with authentic engineering and information-technology problems that support higher-order thinking.

2.3 ADDIE, Project-Based Learning, and User Acceptance

The ADDIE model provides a systematic instructional design process consisting of analysis, design, development, implementation, and evaluation [8]. Its relevance in this study lies in the need to convert a technical prototype into learning media. The analysis stage identifies learning problems and operational needs; the design stage maps hardware functions to learning objectives; the development stage produces the prototype and learning module; the implementation stage exposes users to authentic tasks; and the evaluation stage measures technical and user acceptance indicators.

Project-based learning is also relevant because the lifebuoy prototype requires learners to solve an integrated problem: how to design, test, operate, and improve a technology-based rescue device. Such projects can develop technical skills, teamwork, communication, and reflective thinking. User acceptance is important because technology-based learning media will only be adopted if users perceive it as useful, easy to use, and relevant to their learning or work tasks. This principle is consistent with the Technology Acceptance Model, which explains the importance of perceived usefulness and perceived ease of use in technology adoption [9].

Table 1. Repositioning the prototype from engineering artifact to EIT-oriented learning media

Dimension	Engineering-oriented Draft	Education and Information Technology Repositioning
Main focus	Remote-controlled buoy performance	Technology-based learning media for maritime safety education
Primary outcome	Response time, distance, battery endurance	Technical feasibility, usability, and pedagogical affordance
Learning role	Not explicitly articulated	Project-based learning artifact for digital safety literacy
Technology emphasis	ExpressLRS and propulsion system	Wireless communication, control logic, system testing, and user interaction
Research contribution	Prototype development	Integration of educational design, IT prototype, and maritime safety training

3. Methodology

3.1 Research Design

This study used an applied Research and Development design with the ADDIE framework. The design was selected because the study aimed to produce, test, and evaluate a prototype-based learning media rather than merely describe an existing practice. The research combined formative development, technical testing, and user acceptance evaluation. The design should be interpreted as an early-stage design and usability study; it does not yet include controlled measurement of learning gains.

The object of development was a remote-controlled life-saving buoy intended for maritime safety learning. The prototype was designed to demonstrate four instructional domains: (1) wireless control and signal reliability; (2) propulsion and movement stability; (3) material selection and buoyancy; and (4) rescue-task simulation. These domains were mapped into learning activities for cadets and instructors.

3.2 Participants and Context

The formative evaluation involved ten participants consisting of maritime instructors, ship crew members, and cadets. They were selected purposively because they represented potential users of the prototype in training, demonstration, and operational familiarization contexts. The small number of participants is appropriate for formative usability evaluation, but it limits generalization and should be expanded in future studies.

The implementation took place in a controlled marine or nearshore training environment. This setting was chosen to reduce safety risk while still allowing the prototype to be tested under realistic conditions involving water movement, operator distance, and line-of-sight control.

3.3 ADDIE-Based Development Procedure

Table 2. ADDIE procedure used in the development of the lifebuoy learning media

Stage	Development Activity	Educational Output
Analysis	Identify limitations of conventional lifebuoy practice and needs for digital rescue training	Learning needs, user requirements, and operational constraints
Design	Design prototype architecture, learning objectives, testing scenario, and practice tasks	Blueprint of hardware, learning scenario, and assessment indicators



Development	Assemble resin-composite body, propulsion system, ExpressLRS link, ESC, battery, and controller	Functional prototype and instructional demonstration unit
Implementation	Conduct response-time, range, endurance, and user operation tests	Field-test data and user experience records
Evaluation	Analyze technical results and user acceptance; identify limitations and improvement priorities	Validated formative findings and revision recommendations

3.4 Prototype Architecture and Learning Components

The prototype consisted of a resin-composite floating body, dual brushless motors, an electronic speed controller, battery power system, ExpressLRS 2.4 GHz transmitter-receiver link, and control interface. The resin-composite body was selected to improve durability, water resistance, and structural stability during repeated training use. The dual propulsion configuration was placed to improve balance and maneuverability.

As learning media, the prototype was accompanied by a practice scenario that guides learners to identify components, operate the system, measure technical performance, evaluate risk, and propose design improvements. This structure allows the prototype to function as both a rescue-technology demonstrator and a project-based learning artifact.

Table 3. Technical architecture and learning function of each component

Component	Technical Function	Learning Function
ExpressLRS 2.4 GHz transmitter and receiver	Transmit and receive low-latency remote-control commands	Introduce wireless communication, signal stability, failsafe, and radio-link configuration
Dual propulsion system	Generate forward motion and directional control	Demonstrate thrust, balance, motor synchronization, and maneuverability
Electronic speed controller	Regulate motor speed based on operator command	Teach control logic, motor response, and command-output relationship
Resin-composite body	Provide buoyancy, water resistance, and impact tolerance	Connect material selection with maritime safety equipment design
Battery system	Supply electrical power for the propulsion and control system	Support learning about endurance, energy management, and operational planning
User operation scenario	Guide controlled testing and simulated rescue operation	Develop procedural understanding, teamwork, and reflective decision-making

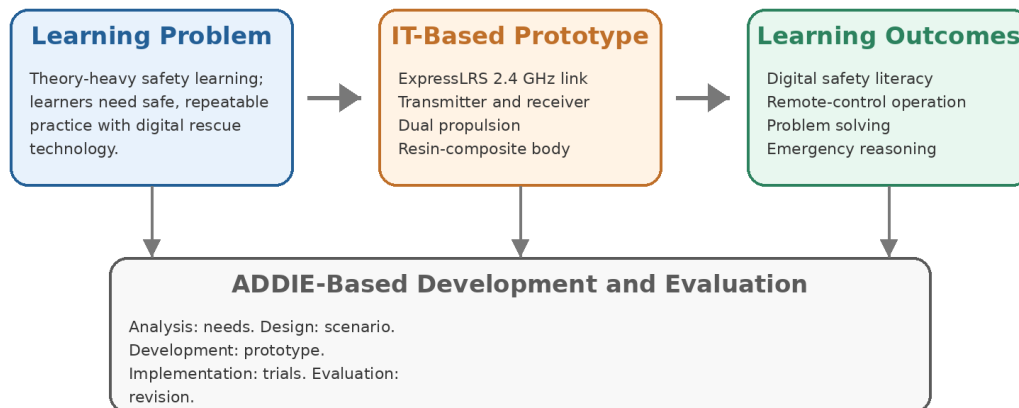


Figure 1. Pedagogical and technical framework of the remote-controlled lifebuoy learning media

3.5 Instruments and Data Analysis

Technical performance was evaluated using three indicators: response time, operational range, and battery endurance. Response time was measured as the interval between operator command and propeller movement. Operational range was measured through incremental distance testing from 10 m to 90 m. Battery endurance was measured as the duration of stable operation under training-use conditions.

User acceptance was measured using a five-point Likert questionnaire covering control ease, movement stability, response speed, design and ergonomics, and signal reliability. The results were analyzed descriptively using mean scores and categorical interpretation. Technical and user data were then interpreted in relation to the prototype's pedagogical affordance as learning media.

4. Results and Discussion

4.1 Learning Needs and Design Rationale

The analysis stage showed that conventional lifebuoy training can introduce basic rescue procedures but does not sufficiently support learning about digital rescue systems. Learners need to understand how remote-control links, propulsion, latency, signal degradation, and power endurance affect rescue performance. Therefore, the developed media was designed to make invisible technological processes visible through testing and reflection.

The design rationale was based on three principles. First, the media must be authentic enough to represent maritime rescue tasks. Second, the media must be safe enough for repeated training. Third, the media must be analyzable so that learners can collect data, interpret performance, and improve the system. These principles align with technology-enhanced vocational learning, where learners are expected to interact with tools, data, and work-like problems.

4.2 Prototype Performance as a Learning Affordance

The developed prototype functioned as intended during controlled field testing. The resin-composite body maintained buoyancy and structural stability, while the dual propulsion system provided forward motion and directional control. The ExpressLRS communication link enabled rapid command transmission and allowed learners to observe the relationship between signal condition, operator distance, and device response.

From an educational perspective, the prototype's performance data are not merely engineering results. They become learning objects that can be discussed, calculated,

compared, and improved. For example, latency data can be connected to communication systems, signal stability can be connected to radio-frequency behavior, and endurance can be connected to energy management and operational planning.

Table 4. Response-time performance of the prototype

Test	Condition	Response Time (s)	Signal Status	Performance Interpretation
1	Full signal, line of sight	0.091	Stable	Fast response
2	Full signal, line of sight	0.089	Stable	Normal
3	Full signal, line of sight	0.094	Stable	Consistent
4	Signal about 80% at 60 m	0.095	Stable	No meaningful delay
5	Signal about 70% at 80 m	0.093	Stable	Responsive at boundary range
Mean	-	0.092	-	Very responsive for training use

The mean response time was 0.092 s, which indicates near-real-time responsiveness for controlled training use. This result is educationally important because students can directly observe how command transmission and actuator response determine rescue-device performance. In practical learning, the response-time test can be used to teach measurement accuracy, repeated trials, descriptive statistics, and the relationship between system design and operational reliability.

Table 5. Operational range test results

Distance (m)	Signal Stability	Observation Notes	Educational Interpretation
10	100% strong	Instant response	Baseline control condition
30	100% strong	Smooth movement	Stable short-range operation
50	90% stable	Accurate direction	Signal remains suitable for training task
70	85% stable	Slight delay but controlled	Upper optimal range for stable learning operation
80	80% moderate	Boundary of reliable operation	Useful for discussing risk and safety margin
90	60% weak	Minor failsafe detected	Demonstrates operational limitation and need for failsafe planning

The operational range results indicate that the prototype remained controllable up to 80 m under the tested conditions, while 70 m represented a stronger optimal range with approximately 85% signal stability. At 90 m, signal degradation and minor failsafe behavior were observed. This finding is valuable for instruction because it allows learners to identify operational boundaries rather than assuming that a system works equally well under all conditions.

4.3 User Acceptance and Usability

The user acceptance results showed positive perceptions of the prototype as both a rescue-training device and a learning media. The overall mean score was 4.58 out of 5, categorized as excellent. The highest scores were obtained for response speed and signal reliability, suggesting that users perceived the prototype as responsive and operationally



convincing. Movement stability and ergonomics received slightly lower but still positive scores, indicating areas for future improvement.

Table 6. User acceptance results

Aspect	Mean Score	Category	Interpretation for Learning Media
Control ease	4.60	Excellent	Users can operate the media with minimal difficulty
Movement stability	4.40	Good	Movement is acceptable but can be improved through body and motor optimization
Response speed	4.80	Excellent	Strong affordance for demonstrating real-time control
Design and ergonomics	4.40	Good	Physical design is usable but weight and grip can be refined
Signal reliability	4.70	Excellent	Supports confidence in remote-control training
Overall mean	4.58	Excellent	Feasible for formative instructional use

These results align with the logic of technology acceptance: a learning technology is more likely to be adopted when users perceive it as useful, responsive, and easy to operate. In this study, user acceptance does not prove learning effectiveness, but it provides initial evidence that the prototype is acceptable for learning implementation. Future studies should add validated usability instruments, expert media validation, and learning outcome measurement.

4.4 Integration into Project-Based Maritime Safety Learning

The prototype can be integrated into maritime vocational education through project-based learning. Rather than treating the device as a demonstration tool only, instructors can organize learning around a rescue-technology project in which students analyze a problem, inspect system components, operate the device, collect performance data, identify limitations, and propose design revisions. This approach supports technical competence and soft skills such as collaboration, communication, and reflective problem solving.

Table 7. Suggested project-based learning scenario using the lifebuoy prototype

Learning Phase	Student Activity	Expected Competence
Problem orientation	Analyze limitations of manual lifebuoy deployment in emergency scenarios	Risk awareness and problem identification
System exploration	Identify transmitter, receiver, ESC, motors, battery, and body structure	Digital safety literacy and systems thinking
Operational practice	Operate the prototype in controlled water and observe command response	Remote-control skill and procedural discipline
Data collection	Measure response time, range, battery endurance, and movement stability	Measurement skill and data literacy
Evaluation	Discuss signal degradation, failsafe behavior, and design limitations	Critical thinking and safety reasoning
Improvement proposal	Design GPS, telemetry, motor guard, or power optimization improvements	Innovation, teamwork, and applied engineering design

4.5 Discussion



The main finding of this study is that a remote-controlled life-saving buoy can be reframed as information technology-based learning media for maritime vocational education. Its value lies not only in its ability to move across water but also in its capacity to expose learners to interconnected technological systems. The prototype transforms safety learning from a primarily procedural activity into an inquiry-based and data-supported activity.

Compared with previous engineering-focused smart lifebuoy studies [4], this study adds a pedagogical layer by mapping technical features to learning outcomes. The response-time test supports learning about latency and control systems; the range test supports learning about signal reliability and risk margin; the endurance test supports learning about energy management; and the user acceptance test supports reflection on human-technology interaction. This makes the prototype suitable for education and information technologies journals because the research connects instructional design, digital systems, and vocational competence development.

The study also contributes to maritime safety education by providing a practical example of how remote-control technology can be introduced into training without replacing conventional rescue principles. Instead, the prototype complements existing training by allowing learners to compare manual and technology-assisted rescue strategies. Such comparison is important because future maritime work will increasingly involve automation, remote operation, and digital decision support.

Nevertheless, several limitations must be acknowledged. First, the study involved only ten participants and therefore cannot support broad statistical generalization. Second, the evaluation focused on usability and technical feasibility rather than learning outcomes. Third, the test was conducted under controlled conditions and has not yet demonstrated reliability in strong waves, high current, heavy rain, or open-sea environments. Fourth, the prototype should not be interpreted as a certified life-saving appliance until it undergoes formal safety, material, buoyancy, and regulatory testing according to relevant standards.

Future research should therefore use a stronger educational evaluation design, such as pre-test and post-test comparison, quasi-experimental classroom implementation, expert validation of learning media, System Usability Scale measurement, and long-term adoption analysis. Technically, future development should include GPS telemetry, waterproof enclosure refinement, motor guards, autonomous return, victim-detection sensors, and dashboard-based monitoring. Integration with immersive simulation, augmented reality, and AI-supported vocational learning can also be explored to strengthen the educational value of the platform [13]-[15].

5. Conclusion and Recommendations

This study developed a remote-controlled life-saving buoy as information technology-based learning media for maritime vocational education using the ADDIE framework. The prototype integrated an ExpressLRS 2.4 GHz communication system, dual propulsion, electronic speed control, battery power, and a resin-composite buoy body. The results showed a mean response time of 0.092 s, controllable operation up to 80 m under tested conditions, and battery endurance of 22-25 min. User acceptance reached an excellent mean score of 4.58 out of 5.

The findings indicate that the prototype is feasible as a formative learning media for maritime safety education. It supports project-based learning by enabling learners to operate digital rescue technology, collect performance data, analyze system limitations, and propose improvements. The study contributes to the field of education and information technologies by demonstrating how a technical maritime safety artifact can be transformed into an instructional media that strengthens digital safety literacy, systems thinking, and applied problem-solving.

It is recommended that maritime vocational institutions use the prototype as a supervised training and demonstration media rather than as certified rescue equipment. Future development should include expert validation, learning-gain assessment, larger user testing, and open-sea trials. The prototype should also be improved through GPS telemetry,



dashboard monitoring, motor protection, battery optimization, and alignment with relevant safety standards [11]. These steps are necessary to advance the system from formative learning media toward a more mature technology-enhanced maritime safety training platform.

Acknowledgment

The authors thank Politeknik Ilmu Pelayaran Makassar, instructors, crew members, and cadets who supported the formative development and field evaluation of the prototype. The authors also acknowledge prior development work on remote-controlled life-saving buoy systems that provided an important foundation for this educational technology-oriented study.

References

- [1] UNESCO-UNEVOC, "Digital transformation in TVET," UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training, 2023. [Online]. Available: <https://connect.unevoc.unesco.org/home/Digital+Transformation+in+TVET>.
- [2] World Economic Forum, The Future of Jobs Report 2025. Geneva: World Economic Forum, 2025. [Online]. Available: <https://www.weforum.org/publications/the-future-of-jobs-report-2025/>.
- [3] International Maritime Organization, International Life-Saving Appliance (LSA) Code, Resolution MSC.48(66). London: IMO, 1996. [Online]. Available: <https://www.imo.org/>.
- [4] S. Thanakodi, M. L. Talib, S. A. Syed Ali, N. A. Wahab, A. F. Ahmad, N. M. Noor, M. I. B. A. Zahari, and M. A. Ahmad, "A study into the development of a light weight smart life buoy prototype (LWSLB)," *Transactions on Maritime Science*, vol. 10, no. 2, pp. 383-389, 2021, doi: 10.7225/toms.v10.n02.008.
- [5] W. Ada, S. Zulaikah, I. S. Yusyarif, A. Muh. A. Saputra, and A. Taufik, "Development of life-saving buoy ring with remote control system," *MSJ: Majority Science Journal*, vol. 2, no. 4, pp. 64-72, 2024, doi: 10.61942/msj.v2i4.247.
- [6] M. G. Jamil and Z. Bhuiyan, "Deep learning elements in maritime simulation programmes: A pedagogical exploration of learner experiences," *International Journal of Educational Technology in Higher Education*, vol. 18, article 18, 2021, doi: 10.1186/s41239-021-00255-0.
- [7] ExpressLRS, "High performance open source radio control link," ExpressLRS Documentation, 2026. [Online]. Available: <https://www.expresslrs.org/>.
- [8] R. M. Branch, *Instructional Design: The ADDIE Approach*. New York: Springer, 2009, doi: 10.1007/978-0-387-09506-6.
- [9] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319-340, 1989, doi: 10.2307/249008.
- [10] N. B. Shetty, N. Rao, P. Umesh, and K. V. Gangadharan, "Remotely operated marine rescue vehicle," *AIP Conference Proceedings*, vol. 2247, 2020, doi: 10.1063/5.0004147.
- [11] International Organization for Standardization, ISO 12402-7:2020, Personal flotation devices - Part 7: Materials and components - Safety requirements and test methods. Geneva: ISO, 2020.
- [12] International Maritime Organization, *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*, 1978, as amended. London: IMO, 2020.
- [13] H. Thomann, J. Zimmermann, and V. Deutscher, "How effective is immersive VR for vocational education? Analyzing knowledge gains and motivational effects," *Computers & Education*, vol. 220, 105127, 2024, doi: 10.1016/j.compedu.2024.105127.



- [14] S. Supriyanto, Q. Joshua, A. G. Abdullah, E. O. Tetehfio, and S. D. Ramdani, "Application of augmented reality (AR) in vocational education: A systematic literature review," *Jurnal Pendidikan Vokasi*, vol. 13, no. 2, pp. 205-213, 2023, doi: 10.21831/jpv.v13i2.54280.
- [15] M. I. Rosyadi, I. Kustiawan, E. O. Tetehfio, and Q. Joshua, "The role of AI in vocational education: A systematic literature review," *Journal of Vocational Education Studies*, vol. 6, no. 2, pp. 244-263, 2023, doi: 10.12928/joves.v6i2.9032.