INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH
2026, Vol. 7, No. 2, 836 – 846
http://dx.doi.org/10.11594/ijmaber.07.02.26

Research Article

Development of Instructional Package for Marine Automation Course (IPMAC) of the Marine Engineering Department of the Philippine Merchant Marine Academy

Wenceslao M. Cawagas III*

College of Marine Engineering Department, Philippine Merchant Marine Academy, PMMA Complex Natividad San Narciso 2205 Zambales, Philippines

Article history:
Submission 04 December 2025
Revised 12 February 2026
Accepted 23 February 2026

**Corresponding author:*
E-mail:
Wenceslaocawagas311@gmail.com

ABSTRACT

Maritime systems are becoming increasingly automated, creating a need for highly skilled engineers in marine automation with strong knowledge of control engineering, instrumentation, and ways to run automated systems. The inadequacy of traditional teaching techniques to offer sufficient interactivity, accessibility, and uniformity needed for learning in a technologically complex world has resulted in a need for new forms of delivering instruction. This study aimed to produce, implement, evaluate a web-based instructional package that would improve teaching of Basic Control Engineering (BCE) through use of an Internet-based package (IPMAC) at the Philippine Merchant Marine Academy. The IPMAC system was developed using PHP and MySQL, and had interactive lecture presentations, visualisations of control systems, automated assessment and feedback, and an ability to monitor progress, all from one web-based application. A descriptive evaluative research methodology was developed to assess the usability, effectiveness and satisfaction of use by Engineering students at the Philippine Merchant Marine Academy, faculty members, and IT professionals through a structured survey. Based on the answers provided by participants, all participants agreed that using this system was useful in providing support for their lesson plans and keeping students engaged throughout the learning process. Participants also indicated they better comprehended the concept of automation and that they could successfully teach students both the benefit of automated systems as well as the effectiveness of using automated systems when teaching students through assessments/tests. These results demonstrate that the IPMAC digital learning environment provides a stable, user-friendly, and highly effective means of supporting maritime education through an outcome-based

How to cite:
Cawagas III, W. M. (2026). Development of Instructional Package for Marine Automation Course (IPMAC) of the Marine Engineering Department of the Philippine Merchant Marine Academy. *International Journal of Multidisciplinary: Applied Business and Education Research*. *7*(2), 836 – 846. doi: 10.11594/ijmaber.07.02.26

approach. The research also shows that web-based instructional systems like IPMAC present a feasible and expandable method for modernizing marine automation training and enhancing the quality of engineering education in maritime institutions.

***Keywords**: Marine Automation, Web-Based Instruction, Engineering Education, E-Learning Systems, Control Engineering, Outcomes-Based Education*

Background

The implementation of digital technologies for shipboard operations has led to the creation of highly connected, automated cyber-physical environments on modern vessels. Merchant vessels now employ advanced technologies, including programmable logic controllers (PLCs), distributed control systems (DCS), electro-pneumatic actuators, and smart sensor technologies for operating propulsion, auxiliary machinery, safety systems, and energy management systems. Consequently, marine engineers require not only a mechanical background but also substantial understanding of automation, control, and system diagnostics.

In response to these technological advances, the International Maritime Organization (IMO) has strengthened the Standards of Training, Certification, and Watchkeeping (STCW), mandating that students demonstrate competency with automated and electronically controlled systems. Compliance with these standards requires modernized training methods, emphasizing non-linear approaches over traditional lecture-based instruction. However, many maritime colleges continue to rely on multiple separate resources, manual demonstrations, and instructor-dependent materials, limiting opportunities for structured and independent learning.

At the Philippine Merchant Marine Academy (PMMA), students in the Basic Control Engineering/Marine Automation Course previously relied on instructor-written notes and physical model demonstrations, with no digital instructional platform to facilitate independent learning or systematic assessment. The absence of proper instructional materials is particularly problematic in automation education, where conceptual understanding must be reinforced through visual aids, simulations, and repeated interaction. Research in technical education supports the need for interactive, simulation-based, and technology-enhanced learning environments. For instance, Salas, Cannon-Bowers, and Johnston (2021) found that students achieve a deeper understanding of automation components in interactive, simulation-based training environments. Similarly, Olivares, De Leon, and Padua (2020) demonstrated that lecture-based, system-focused instruction significantly improves learning outcomes in control engineering courses. Additionally, Yap and Hernandez (2022) highlighted that technology-enhanced teaching increases cadet proficiency in automation compared to traditional methods.

The design and evaluation of instructional systems for engineers are informed by established learning theories. The Dick and Carey (1996) instructional systems design model ensures alignment among learning objectives, instructional content, and assessment, enabling measurable learning outcomes. Outcome-Based Education (OBE) frameworks also guide instructional unit design based on defined engineering competencies (Spady, 1994). Cognitive Load Theory emphasizes teaching complex automation concepts without overwhelming learners (Sweller, 1988), while Dual Coding Theory supports comprehension through combined textual and visual representations (Paivio, 1986). Constructivist perspectives further advocate interactive, problem-centered learning environments that allow active knowledge construction and feedback (Bruner, 1961; Vygotsky, 1978). Keller's ARCS Motivation Model stresses the importance of sustaining learner attention, relevance, confidence, and satisfaction to enhance engagement (Keller, 1983).

Empirical research also informs the development of effective digital instructional systems. Al-Fraihat, Joy, and Sinclair (2020) identified system quality and interface usability as critical factors for e-learning success. Salloum, Al-Emran, and Shaalan (2018) verified that PHP- and MySQL-based web platforms offer scalable and reliable solutions for delivering interactive engineering education. Guided by these theories and findings, the Instructional Package for Marine Automation Course (IPMAC) was designed as a web-based instructional platform to support the Basic Control Engineering course at PMMA. The platform integrates interactive lectures, visualized representations of control systems, online assessments, grading modules, and learner progress tracking, all within a single digital environment aimed at improving instructional consistency, learner engagement, and accessibility.

General Objective

The general objective of this study is to design, deploy, and evaluate a web-based Instructional Package for Marine Automation Course (IPMAC) that enhances the delivery of the Basic Control Engineering course at PMMA by improving accessibility, instructional consistency, and learner engagement.

Specific Objectives

Specifically, this study aims to:

1. Design IPMAC using a suitable programming language and database system to ensure ease of use, cross-device accessibility, and user-friendly navigation for students and faculty.
2. Deploy IPMAC on an online platform enabling remote access to instructional materials, interactive lectures, and assessment tools to support flexible learning.
3. Integrate interactive instructional modules and assessment tools to promote active learning, reinforce theoretical concepts, and develop practical automation skills.
4. Evaluate the usability, instructional alignment, and user satisfaction of IPMAC through feedback from Marine Engineering cadets, faculty, and IT experts to identify areas for improvement and optimize effectiveness.

Methods

This study employed a descriptive-evaluative research design to evaluate the performance and acceptability of IPMAC as an instructional system. Descriptive-evaluative research is commonly used in educational technology to assess usability, learning support, and instructional quality of newly developed e-learning platforms by collecting systematic user feedback without manipulating independent or dependent variables (Creswell & Creswell, 2018; Best & Kahn, 2006). The IPMAC system was tested in a real academic setting, with success evaluated based on feedback from Marine Engineering cadets, faculty members, and IT specialists.

Participants were purposively sampled volunteers with direct experience using IPMAC. Participation was voluntary, and participants were informed of their right to withdraw at any time. All respondents provided informed consent, and data were treated confidentially in accordance with ethical research guidelines (World Medical Association, 2013).

Structured Likert-scale instruments measured usability, instructional effectiveness, engagement, and technical reliability. Instruments were adapted from established e-learning evaluation frameworks, including Al-Fraihat et al. (2020). Expert reviews ensured content validity, and pilot testing was conducted to verify internal consistency and clarity.

The IPMAC platform was implemented on a secure web server. Students accessed interactive lectures, assessments, and other learning resources, while faculty monitored student progress and performance. Participants completed online questionnaires assessing system usability, instructional effectiveness, engagement, and technical reliability. Data were recorded in a MySQL database for analysis.

Descriptive statistics, including mean, frequency, and percentage distributions, were used to analyze survey results, providing an overview of user perceptions and system performance (Creswell & Creswell, 2018; Al-Fraihat et al., 2020). Likert-scale scores were classified to facilitate meaningful interpretation.

Responses to develop an overview of the user's perception of the overall acceptability and utility (usefulness) of the IPMAC system for each assessment dimension. Data were extracted from the IPMAC database and analyzed with a statistical package that uses spreadsheets to produce summaries and descriptive statistics and facilitate data interpretation.

The study was conducted in accordance with the ethical policies of Bulacan State University and the Philippine Merchant Marine Academy. All participants provided informed consent and were assured anonymity throughout the research. It was made clear that no personally identifiable information about the participants would be released in any reports or publications. There was no external funding for this research and no conflicts of interest were declared regarding the conduct of the research.

Result and Discussion

The IPMAC application was developed with a suitable programming language (PHP and MySQL) to support stability, usability and cross-platform accessibility in an educational environment. User feedback was obtained through two surveys, the Ease of Use Survey, shown in Table 1 and the survey on the Effectiveness of the Platform, shown in Table 2.

Table 1. Ease of Use (Usability) Survey

Ease of Use of the Platform	Mean Score	Interpretation
The layout and navigation of the IPMAC platform were easy to understand.	4.19	Easy to Use
It was easy to access the IPMAC platform and log in without technical issues.	4.12	Easy to Use
I experienced technical difficulties (e.g., internet issues and system errors) when using IPMAC.	3.43	Easy to Use
I found the instructions provided within IPMAC for using the simulations and activities clear and helpful.	4.19	Easy to Use
IPMAC was accessible to me on my preferred device (e.g., laptop, tablet, mobile phone).	4.19	Easy to Use
	4.02	Easy to Use

Table 2. Effectiveness of the Platform Survey

Effectiveness of the Platform	Mean Score	Interpretation
The platform improved student engagement with the course content, particularly in laboratory sessions	4.25	Very High Effectiveness
IPMAC made it easier to teach complex topics by providing interactive and visual learning tools	4.5	Very High Effectiveness
Students demonstrated better understanding and performance after using IPMAC for practical exercises	4.25	Very High Effectiveness
The platform aligns well with the learning outcomes of the Basic Control Engineering course	4.25	Very High Effectiveness
	4.31	Very High Effectiveness

The user responses to the surveys demonstrated that both students and faculty rated the responsiveness of the application as high, the clarity of the navigation as high, and the reliability of the application as high. Most users did not encounter any technical problems when they logged onto the application, accessed course modules, submitted assessments, and viewed results, which further supports the conclusion that the use of PHP and MySQL provides a solid foundation for delivering dynamic learning materials and for managing multiple transactions by different users. The effective use of this technology for creating the application also supports the infographic diagram (Block Diagram of IPMAC), which represents a full course, application server, and data storage working together through a single cloud-based application.

These results are consistent with prior research suggesting that PHP-based e-learning applications are environmentally sustainable, scalable, and cost-effective in providing a foundation for delivering e-learning content in higher education settings (Martin & Bolliger, 2018). Likewise, the survey findings align with the Success Model for E-Learning proposed by Al-Fraihat et al. (2020), which identifies system quality and interface usability as the primary factors affecting user acceptance and satisfaction.

The survey results also demonstrated that IPMAC created greater access and flexibility for students to complete their coursework. Students indicated that there were opportunities to view lectures, use multimedia resources, and take quizzes at times of their own choosing, which made it easier for them to balance their school schedules with other activities. Faculty also confirmed that the use of this platform allowed them to continue providing instruction to their students even when face-to-face meetings were not possible. Overall, the results indicated that the online deployment approach, evident in the IPMAC Login Page as shown in Figure 1 and Student Registration Page shown in Figure 2, created a safe, secure, and functioning access point for personalized learning.

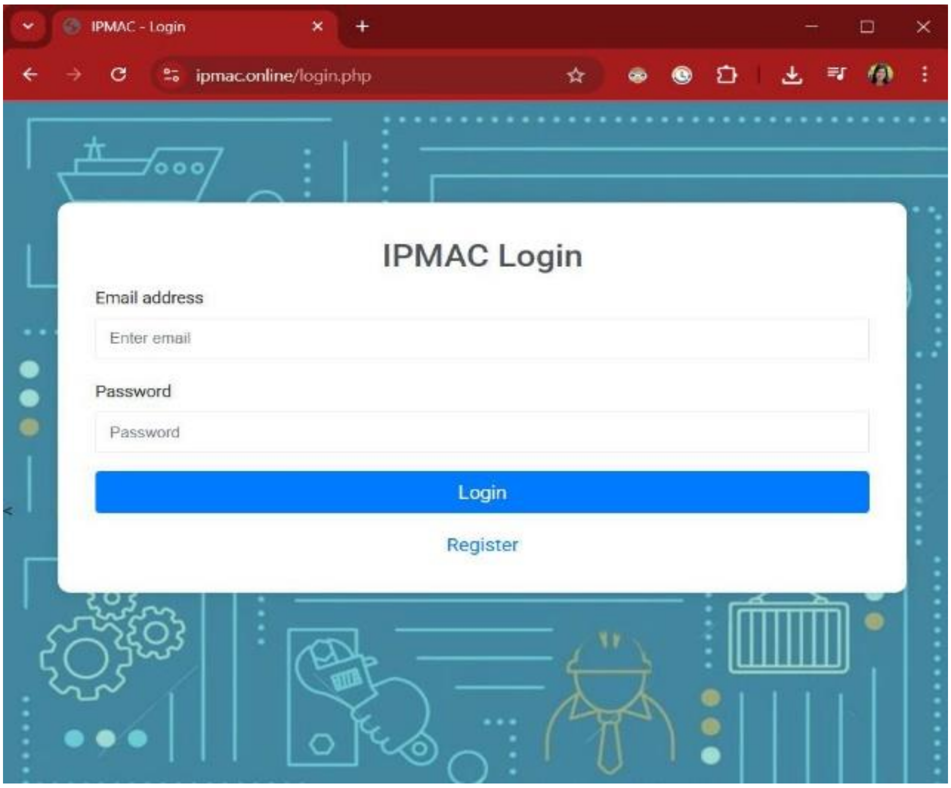

Figure 1. IPMAC Login Page

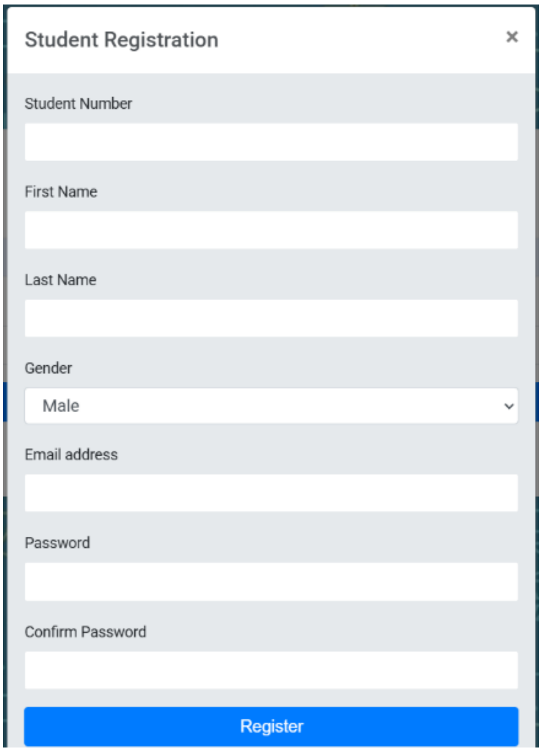

Figure 2. The Registration Page for Students

Additionally, these findings further support prior research indicating that the use of web-based learning resources improves learner autonomy, engagement, and retention rates in vocational and technical education (Al-Fraihat et al., 2020). In maritime training contexts, where cadets are often subject to operational time pressures and shipboard exposure, online instructional systems help sustain cadets' interest and promote academic engagement (Yap & Hernandez, 2022).

As shown in Table 3, the result of the Learning Outcomes Survey, and Table 4 shows the result of the Teaching Efficiency Survey.

Table 3. Learning Outcomes Survey

Learning Outcomes	Mean Score	Interpretation
IPMAC enhanced my understanding of automation and control systems compared to traditional lectures.	4.12	High Learning
The simulations and experiments in IPMAC helped me better understand how automation works in real-life marine systems.	4.14	High Learning
The quizzes and assessments on IPMAC allowed me to test and improve my knowledge effectively.	4.14	High Learning
After using IPMAC, I feel more confident applying automation and control concepts in practical laboratory sessions.	4.10	High Learning
	4.13	High Learning

Table 4. Teaching Efficiency Survey

Teaching Efficiency	Mean Score	Interpretation
IPMAC helped streamline lesson planning and made it easier to align with course objectives.	4.25	Very High Efficiency

Teaching Efficiency	Mean Score	Interpretation
The instructional materials provided in IPMAC (e.g. videos, simulations) were useful for explaining automation concepts.	4.5	Very High Efficiency
I found the structure of the IPMAC platform beneficial for organizing lessons and coherently delivering content	4.25	Very High Efficiency
The IPMAC platform helped me better assess student learning through its built-in quizzes and assessments	4.5	Very High Efficiency
	4.38	Very High Efficiency

The review of the feature ratings indicated that students and staff consistently found interactive quizzes, visualised control diagrams and automation of grading to be the most useful aspects of the platform. The interactive quizzes allowed them to interact with marine automation concepts and self-evaluate themselves on a given topic, while the observed control diagrams provided a dynamic interface for the visualization of real time features. Automated assessment allowed faculty to track students' progress in real time and reduced the amount of time they spent grading their assessments manually. The findings were also illustrated by the system interfaces shown in the Interactive PID Presentation (Figure 3), the Grading Criteria Page (Figure 4), and the Summative Assessment Module (Figure 5).

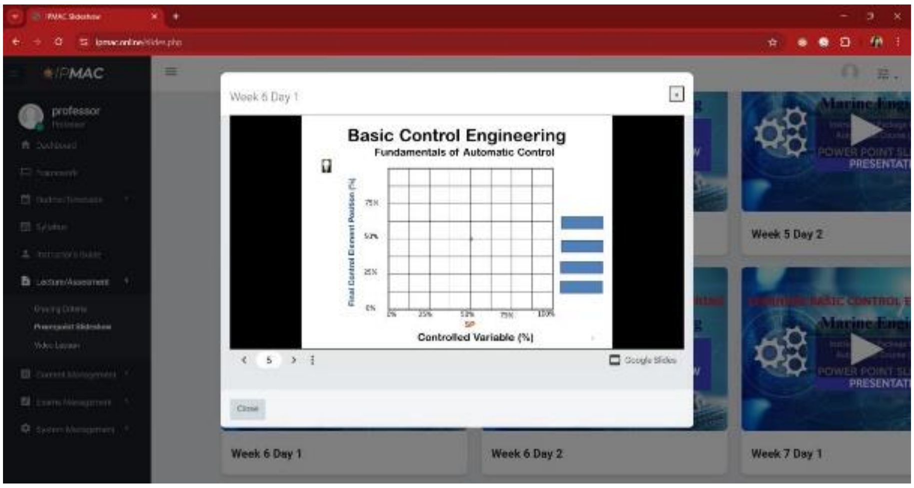

Figure 3. Interactive Presentation of PID in IPMAC

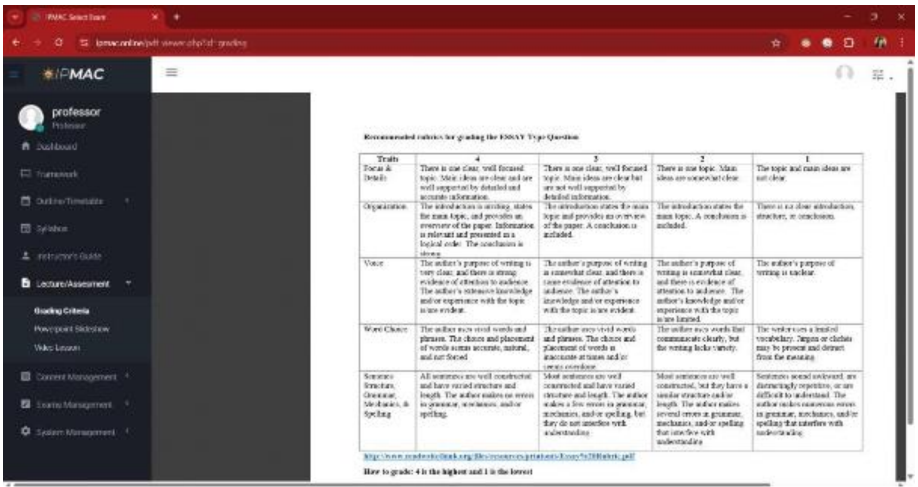

Figure 4. Grading Criteria Posted in IPMAC

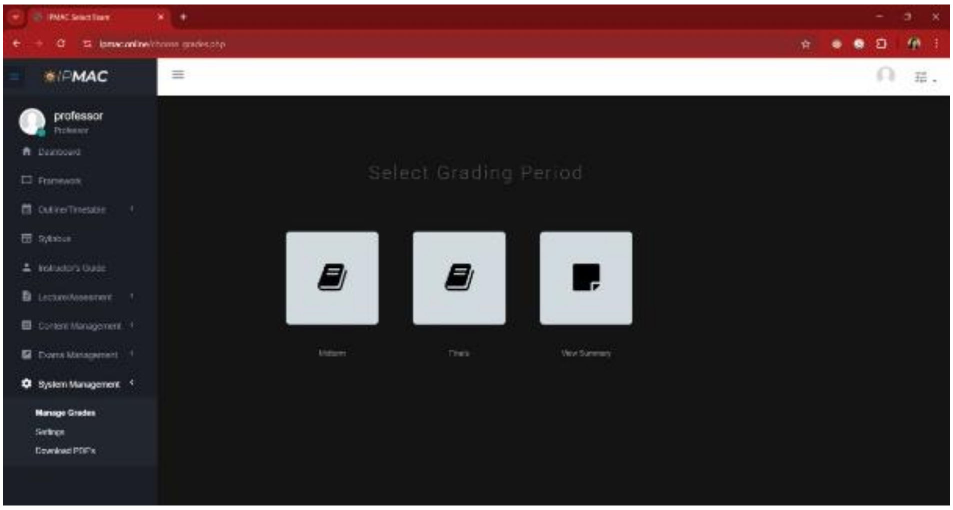

Figure 5. Summative Assessment of IPMAC

From a learning theory perspective, these results provide support for Cognitive Load Theory, which posits that learners process complex technical information more effectively when it is presented in an organized and visually supported format (Sweller, 1988). The graphical representations of control systems further align with Dual Coding Theory, which suggests that learners process visual and verbal information through separate but interconnected channels, resulting in stronger comprehension and retention (Paivio, 1986). Moreover, because IPMAC enables learners to interact with content and receive feedback through interactive quizzes and graded assessments, the findings are also consistent with Constructivist Learning Theory. This theory emphasizes that active engagement with learning materials fosters deeper understanding and knowledge construction (Bruner, 1961; Vygotsky, 1978).

The results of Tables 5 and 6 show the total usability of the IPMAC tool, its alignment with the instructional goals of the course, the tool's usability in teaching, and the level of satisfaction experienced by participants.

Table 5. Challenges and Improvements Survey

Challenges and Improvements	Mean Score	Interpretation
I found it difficult to complete the tasks on IPMAC because of internet connectivity issues.	3.50	High Challenge
I prefer additional in-person support or resources alongside IPMAC to better understand difficult topics.	3.77	High Challenge
The platform could benefit from having more offline resources (e.g., downloadable materials).	4.02	High Challenge
	3.76	High Challenge

Table 6. Implementation Challenges Survey

Implementation Challenges	Mean Score	Interpretation
I encountered technical challenges (e.g. platform errors and internet issues) while using IPMAC for teaching	3.75	High Challenges
It took me some time to adjust to using the platform in my teaching	3.25	High Challenges
I would have appreciated additional support or training when implementing IPMAC in my courses	4.00	High Challenges
	3.67	High Challenges

The findings reflect that students, faculty, and information technology service providers all expressed a very favorable view of their experience with IPMAC. Most respondents felt that there was some alignment between the results achieved from the course and the original course objectives, and they believed that IPMAC significantly supported both teaching and learning in Basic Control Engineering. The respondents identified some areas that could be improved, such as increasing the amount of multimedia content and creating an offline version of the tool. However, these areas were viewed as opportunities for development rather than major weaknesses in the system. The results are consistent with an Outcomes-Based Education (OBE) approach, which focuses on how well instructional content is aligned with the assessment and evaluation The findings further support the principles of Outcome-Based Education, which emphasize clearly defined learning outcomes and measurable processes of learner achievement (Spady, 1994). Additionally, the high level of satisfaction expressed by participants reinforces Keller's ARCS Model of Motivation, as the application fosters attention, relevance, confidence, and satisfaction among learners (Keller, 1983).

Collectively, the findings indicate that all four research objectives have been achieved and that the PHP–MySQL structural design provides a robust framework for developing functional and user-centered systems. Through internet accessibility, IPMAC serves as a centralized repository of learning materials that users can access remotely. Its interactive instructional features—also reflected in LMS and AC-CDC—enable assessment and immediate feedback, thereby supporting learners' comprehension and performance monitoring. Users reported high levels of satisfaction and perceived strong alignment between the system's competencies and those defined by PMMA.

These findings also reflect global trends in maritime training and engineering education, where instructional models increasingly promote technology-driven learning environments focused on achieving measurable student outcomes (Yap & Hernandez, 2022; Salas et al., 2021). The integration of engineering systems design with evidence-based instructional methodologies is essential to modernizing maritime education and ensuring the continued compliance of PMMA with international standards.

Conclusion

The findings further support the principles of Outcome-Based Education, which emphasize clearly defined learning outcomes and measurable processes of learner achievement (Spady, 1994). Additionally, the high level of satisfaction expressed by participants reinforces Keller's ARCS Model of Motivation, as the application fosters attention, relevance, confidence, and satisfaction among learners (Keller, 1983).

Collectively, the results indicate that all four research objectives have been achieved and that the PHP–MySQL structural architecture provides a robust framework for developing functional and user-centered systems. Through internet-based accessibility, IPMAC functions as a centralized repository of instructional materials that users can access remotely and asynchronously. Its interactive instructional features—also integrated within the LMS and AC-CDC—facilitate assessment and immediate feedback, thereby strengthening learners' comprehension, self-monitoring, and academic performance. Participants reported high levels of satisfaction and perceived a strong alignment between the system's embedded competencies and those defined by PMMA.

These findings likewise reflect global developments in maritime training and engineering education, where instructional models increasingly emphasize technology-enhanced learning environments designed to achieve measurable student outcomes (Yap & Hernandez, 2022; Salas et al., 2021). The integration of engineering systems design with evidence-based instructional methodologies is therefore essential to the modernization of maritime education and to sustaining PMMA's compliance with international standards.

Acknowledgement

In acknowledgment of the help, advice, and cooperation that were provided by many people in helping author to accomplish this work, the author would like to express genuine thanks for their cooperation. The author specifically thanks Engr. Romano A. Gabrillo, the research adviser for his support, valuable remarks and suggestions which enhances technical quality as well as format of this manuscript. Engr. Nancy M. Santiago, the research critic, has also been instrumental in this manuscript through her critical feedback, as well as being an outstanding scholar who provided invaluable assistance in enhancing the quality and comprehensiveness of this work.

The author also acknowledges Dr. Joseline M. Santos, a panel member, for her academic contributions and important suggestions regarding the development of IPMAC as a viable online instructional platform. Thanks are extended to Mr. Drick L. Moñiza, Database Programmer for the IPMAC Online Platform, for his outstanding database design skills and expertise in the design and development of PHP-based systems. Without him, the transformation of IPMAC into fully functional web-based instructional systems would not have been possible.

The Author expresses his appreciation to C/E Arcelio V. Niedo, the industry adviser, for providing his insights into both the instructional and operational requirements of the Academy and for assisting in making the IPMAC project relevant to industry work. The Author is also grateful to school administrators, staff and students of the Marine Engineering Curriculum of the Philippine Merchant Marine Academy (PMMA) for assistance in the conduct of System and Data Collection phase.

The Author wishes to acknowledge with heartfelt appreciation the unbroken dedication, support, and encouragement provided by his wife, Kresta Jae, family members, and daughter, Wynn Cheska, throughout his education. He is also grateful to everyone else who has played a part in helping to make this project a success, thanks to the wisdom, strength, and guidance of God.

References

Al-Fraihat, D., Joy, M., & Sinclair, J. (2020). Evaluating e-learning systems success: An empirical study. *Computers in Human Behavior, 102*, 67–86. https://doi.org/10.1016/j.chb.2019.08.004

Best, J. W., & Kahn, J. V. (2006). *Research in education* (10th ed.). Boston, MA: Pearson Education.

Borg, W. R., & Gall, M. D. (2007). *Educational research: An introduction* (8th ed.). Boston, MA: Allyn & Bacon.

Bruner, J. (1961). *The act of discovery*. Cambridge, MA: Harvard University Press.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Thousand Oaks, CA: Sage.

DeVellis, R. R. (2016). *Scale development: Theory and applications* (4th ed.). Thousand Oaks, CA: Sage.

Dick, W., & Carey, L. (1996). *The systematic design of instruction* (4th ed.). New York, NY: Harper Collins.

Keller, J. M. (1983). Development and use of the ARCS model. *Journal of Instructional Development, 10*(3), 2–10.

Martin, J., & Bolliger, D. U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning Journal, 22*(1), 205–222. https://doi.org/10.24059/olj.v22i1.1092

Olivares, R., De Leon, M., & Padua, A. (2020). Systems-based instruction for control engineering. *IEEE Transactions on Education, 63*(2), 120–128.

Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, England: Oxford University Press.

Salas, E., Cannon-Bowers, J. A., & Johnston, J. H. (2021). Training for automated systems. *Human Factors, 63*(4), 556–570.

Salloum, S., Al-Emran, M., & Shaalan, K. (2018). Web-based learning platforms using PHP and MySQL. *IEEE Access, 6*, 56523–56535.

Salloum, S., Al-Emran, M., Shaalan, K., & Tarhini, A. (2019). Factors affecting the adoption of e-learning systems in higher education. *IEEE Access, 7*, 27844–27853. https://doi.org/10.1109/ACCESS.2019.2899467

Spady, W. (1994). *Outcome-based education: Critical issues and answers*. Arlington, VA: American Association of School Administrators.

Sweller, J. (1988). Cognitive load during problem solving. *Cognitive Science, 12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

World Medical Association. (2013). Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191–2194.

Yap, L., & Hernandez, R. (2022). Digital instructional systems for maritime automation training. *Journal of Maritime Education and Training, 14*(2), 45–58.

Yap, L., & Hernandez, R. (2022). Digital instructional toolkits in maritime automation training. *Maritime Education Review, 14*(2), 45–58.