

Exploring Maritime Students' Competency Level in AI Skills At Bagan Datuk Polytechnic Malaysia: Initial Insights Study

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ABSTRACT

In the beginning of digital era, several sectors take a lead to explore and open a great opportunity to human beings. The maritime sector is currently experiencing a profound digital transformation propelled by the principles of Industry 4.0, resulting in a marked increase in the demand for competencies in Artificial Intelligence (AI) (Alop, 2021). This article offers an in-depth analysis of the levels of AI-related skills among both students and instructors at Polytechnic Bagan Datuk, a distinguished maritime institution situated in Perak, Malaysia. The primary objective of this study is to critically evaluate how adequately prepared future maritime professionals are to seamlessly integrate cutting-edge AI tools and technologies into diverse facets of maritime operations and management practices. To fulfil this objective, this study involved a robust mixed-methods approach, incorporating the collection of quantitative data through meticulously designed structured surveys. The survey emphasizes critical areas such as essential technical skills including data analysis, several concepts, and the suitability of AI applications specifically tailored to address the unique challenges and requirements of the maritime industry (Simion et al., 2024). Moreover, the assessment encompasses cognitive preparedness, highlighting crucial skills such as problem-solving abilities, analytical thinking, and the ethical implications associated with the deployment of AI technologies (Durluk et al., 2024). The findings illuminate a moderate overall level of competency among participants, revealing concerned deficiencies in the practical application of AI within the maritime sector. Specifically, while foundational knowledge has been established, significant gaps persist in practical implementation and advanced AI skills. These insights underscore the urgent need for holistic reforms, including a comprehensive overhaul of academic curricula, the design of specialized training programs, and the establishment of robust partnerships between academia and industry stakeholders. Such synergies are vital for effectively addressing the existing AI skill gap and ensuring that graduates are equipped with the essential tools and knowledge to navigate an increasingly digital and complex maritime landscape. This paper not only advocates for targeted educational interventions but also introduces an elaborate competency that importance and tailored specifically for maritime institutions in Malaysia. The result also seeks to harmonize educational outcomes with national goals aimed at achieving excellence in the burgeoning digital marine economy, thereby empowering future maritime professionals to make impactful contributions to the advancement of the industry in this transformative digital era. Autonomous shipping and navigation represent a revolutionary shift in the maritime sector, poised to dramatically transform vessel operations and navigation practices. For example, Machine learning (ML) stands at the forefront of this transformation, serving as the foundational technology that enables the creation and implementation of sophisticated autonomous systems. These systems allow ships to navigate the seas with minimal human intervention while steadfastly ensuring safety, efficiency, and strict compliance with maritime regulations. With the power of ML algorithms, autonomous vessels are equipped to perceive and interpret their surroundings with remarkable accuracy. By meticulously analysing data from a diverse array of sensors including radar, lidar, and cameras. These intelligent systems can identify and classify objects within their vicinity, such as neighboring ships, navigational hazards, and critical maritime infrastructure. This real-time situational awareness empowers autonomous ships to make informed, strategic decisions regarding their navigation, collision avoidance, and route planning, significantly diminishing the risk of accidents and elevating overall maritime safety. Furthermore, machine learning-driven predictive analytics enhance the navigational prowess of these vessels by forecasting environmental conditions, sea states, and behavioral patterns of other vessels.

This is important to the current student to understand application and behavior of maritime industry to adapt with actual concept. Autonomous warships, for instance, can anticipate shifts in weather patterns, the flow of ocean currents, and the movement of marine traffic, utilizing historical data alongside advanced algorithms. This foresight enables them to proactively adjust their navigation routes and speed profiles, optimizing fuel efficiency and ensuring superior trip performance.

Keywords: Artificial Intelligence, Maritime Education, Competency, Polytechnic, Machine Learning

1. INTRODUCTION

Global maritime industries are experiencing rapid digital transformation: automation, predictive maintenance, voyage optimization, and autonomous surface vessels increasingly rely on data-driven and AI-enabled systems. For maritime graduates to be workforce-ready, higher education institutions (including polytechnics) must ensure students possess not only domain knowledge but practical AI skills and ethical awareness. In Malaysia, polytechnic institutions supply a large proportion of skilled technical personnel for the maritime sector. However, there is limited empirical evidence on the AI competency levels of maritime students in Malaysian polytechnics, a gap this study begins to address.

This study provides initial insights from an exploratory mixed-methods study conducted at Polytechnic Bagan Datuk. Objectives are to:

- (1) Map AI skills relevant to maritime work.
- (2) Measure students' self-reported competency across those domains.
- (3) Identify gaps and curricular recommendations.

2. LITERATURE REVIEW

2.1 AI Skills for Future Work

Reports from international agencies and studies on digital skills emphasize a blend of conceptual understanding, data literacy, programming, tool-use, and ethical literacy as required for AI-enabled workplaces. Frameworks such as DigComp and workforce studies in example World Economic Forum highlight data handling, digital problem solving, and critical thinking as essential.

2.2 AI in Maritime Education and Industry Needs

Maritime industry applications for AI include predictive maintenance such as engine and auxiliary systems, route optimization, sensor fusion for situational awareness, and autonomous navigation. Industry stakeholders increasingly request graduates who can interpret data, operate AI-augmented systems, and collaborate with multidisciplinary teams. However, maritime education often lags in integrating practical AI training due to limited faculty expertise, curriculum inertia, and infrastructure gaps.

2.3 Competency Measurement Approaches

Competency measurement often combines self-assessment questionnaires with practical assessments. Mixed methods design enables triangulation numerical scores indicate perceived readiness while interviews unpack context, motivation, and barriers.

3. CONCEPTUAL FRAMEWORK

3.1 Bloom's Taxonomy–Based AI Knowledge Model

Originally developed by Benjamin Bloom (1956) and later revised by Anderson and Krathwohl (2001), Bloom's Taxonomy provides a hierarchical classification of cognitive learning objectives. When

adapted for AI education, it helps educators and researchers evaluate how deeply students understand, apply, and innovate with AI concepts. This model assumes that AI knowledge develops progressively from basic factual understanding to creative AI problem-solving. Bloom's model helps educators map AI competencies according to depth of cognition that enable:

- Clear differentiation between introductory AI literacy and advanced technical mastery.
- Structured progression in AI course design, from theory to innovation.
- Assessment of student readiness for higher-order AI tasks such as model development or maritime-specific problem solving.

In the study context at Bagan Datuk Polytechnic, Bloom's model provides a framework to assess students' AI competency level, showing whether they are primarily:

- Remembering/Understanding (low-level cognitive skills), or
- Applying/Analysing/Evaluating/Creating (higher-order skills).

3.2 AI Competency (Knowledge–Skills–Attitudes) Model

The K–S–A model (Knowledge–Skills–Attitudes) is a foundational educational and workforce framework that defines what learners need to know (K), what they should be able to do (S), and how they should think or behave (A) in relation to a particular domain in this case, Artificial Intelligence (AI). When applied to AI education, this model helps measure students' holistic competency, beyond just technical knowledge. It reflects the cognitive head, psychomotor hands, and affective heart domains of AI readiness.

The AI K–S–A model aligns with competency-based education and Outcome-Based Education (OBE) approaches widely adopted in Malaysian polytechnics. It ensures that AI education not only develops cognitive knowledge, but also technical proficiency and professional responsibility. The rational to apply this model for TVET institutions like Bagan Datuk Polytechnic, where learning is applied and skill oriented. Maritime and engineering programs, where AI applications must be both technically sound and ethically responsible.

3.3 TPACK-AI Model (Technological Pedagogical Content Knowledge for Artificial Intelligence)

The TPACK model was originally proposed by Mishra and Koehler (2006) to explain how teachers effectively integrate technology into pedagogy and content knowledge. In recent years, researchers have extended this model to AI education, resulting in the TPACK-AI framework, which integrates Artificial Intelligence technologies into the learning and teaching process.

While TPACK is primarily designed for educators, TPACK-AI is now used to measure AI competencies among both teachers and students, particularly in technology-oriented institutions such as polytechnics. It helps understand how students combine domain knowledge (content), learning processes (pedagogy), and AI tools (technology) to solve problems, innovate, and collaborate effectively.

3.4 AI Literacy Framework

The AI Literacy Framework was proposed by Long and Magerko (2020) as a comprehensive model for developing AI understanding among general learners and professionals who interact with AI systems in daily or professional life. Unlike models that focus on coding or algorithmic knowledge, this framework emphasizes functional AI literacy which are the ability to understand, use, evaluate, and create with AI responsibly.

For maritime students, AI literacy means not just knowing what AI is, but also understanding how it affects navigation, logistics, environmental monitoring, and maritime safety systems, and being able to use and critique these systems effectively.

Table 1 below is summary from all models above and the authors perspective that AI Competency (K–S–A) is suitable for this study and application to Bagan Datuk Polytechnic case study.

Table 1: Summary of Framework Related to Artificial Intelligence

Model	Core Focus	Useful For	Example Application
Bloom's AI Taxonomy	Cognitive depth in AI learning	Curriculum design	Assessing student learning outcomes
AI Competency (K–S–A)	Balanced technical + ethical readiness	Skill gap analysis	Polytechnics, vocational programs
TPACK-AI	Teaching/learning integration	Instructor training, AI-based teaching	Polytechnic educators
AI Literacy Framework	General AI understanding	Non-CS students	Maritime or healthcare students

4. METHOD

4.1 Design

A cross-sectional self-report survey combined with semi-structured interviews are selected approach in this case study to initialise empirical data.

4.2 Participants

Convenience sample of 140 maritime diploma students (years 1–3) at Polytechnic Bagan Datuk that involved with 3 programmes which are Diploma in Naval Architecture, Diploma in Marine Electrical Engineering Technology and Diploma in Marine Construction Engineering Technology and stratified by year (Year 1 n=50, Year 2 n=45, Year 3 n=45). Inclusion criteria for this study that enrolled in maritime related diploma programmes and consent to participate.

4.3 Instrumentation

AI Competency Questionnaire (AICQ), 25 items across five domains (5 items per domain). Items were pilot tested with 12 students for clarity by Cronbach's alpha in pilot = 0.82 (acceptable).

Below are sample of questions to identify knowledge level in Machine Learning (ML)

- I possess knowledge about Machine Learning (ML) and it is easier for me to learn programming and coding languages.
- I am knowledgeable in Machine Learning (ML) algorithms to solve computer-related problems.
- I am knowledgeable in Machine Learning (ML) to analyse big data for predictive maintenance.
- I am knowledgeable in Machine Learning (ML) and it is easier for me to build a complex maritime system.
- I am knowledgeable in Machine Learning (ML) and it is easier for me to understand the algorithm that moves machineries.

4.4 Procedure

Questionnaires distribute during class session to get full attention and involvement.

4.5 Analysis

In this study use quantitative study with result statistics (means, SD) for domain scores, comparisons across years using ANOVA.

5. RESULTS

5.1 Sample Demographics

In this study, total sample, N = 120 were distributed to marine related programme. Table below summarised the result according to item in survey.

Table 2: Summary Demographic Result

Item	Result
Gender	Male – 78%
	Female – 22%
Year in Study	Year 1 – 50
	Year 2 – 45
	Year 3 – 45
Programme Experiences	None – 55%
	Moderate – 35%
	Advance – 10%

5.2 Domain Result

Mean (SD) according to scale 1-5. Table below result according to domain in the survey. Total mean across all items is 2.9 (0.6). This indicates basic familiarity in AI but skill gaps in AI ethic and governance is low.

Table 3: Summary of Domain Result

Domain	Scale (SD)	Status
Conceptual Understanding	3.4 (0.8)	Moderate
Programming and Data Handling	2.6 (0.9)	Low to Moderate
AI Tools Application	2.9 (0.9)	Low to Moderate
Ethic and Governance	2.5 (0.9)	Low
Problem Solving with AI	3.0 (0.8)	Low to Moderate

5.3 Year-Group Comparisons

ANOVA indicates significant differences for Programming and Data Handling is 6.2, $p=0.003$). Year 3 > Year 1. No significant differences for Ethics and Governance or AI Tools Application.

5.4 Qualitative Themes from 12 Interviews

Desire for hands-on exposure in students reported that lectures introduced concepts but lacked lab practical with real maritime datasets. Some barriers in infrastructure and curriculum were limited laptops with GPU capability, lack of AI-focused modules, crowded curriculum. Some motivation to industry relevance may increase students motivated to learn AI when shown direct maritime applications for example predictive maintenance. Additional requirement for faculty training and industry partnerships where may help students to suggest guest lectures from industry and collaborative projects.

6. DISCUSSION

6.1 Interpretation of Initial Insights

The results suggest that maritime students at Polytechnic Bagan Datuk have moderate conceptual understanding but lower practical skills in programming, data handling, and ethical governance. This pattern is consistent with international findings where higher-level conceptual knowledge often precedes hands-on proficiency when curricula lack practical AI modules.

Year 3 students show better programming skills than Year 1, which may reflect exposure to elective modules, self-study, or internships. The low scores on ethics and governance are concerning given increasing regulatory attention to AI safety and data privacy, students are unlikely to responsibly deploy or oversee AI systems without this understanding.

6.2 Implications for Curriculum and Pedagogy

Introduce a scaffolded AI curriculum that may start with conceptual modules in Year 1, introduce programming and data modules in Year 2, and capstone AI projects applied to maritime scenarios in Year 3. Practical, domain-specific labs application to create lab activities using maritime datasets such as engine sensors, AIS data and teach common toolchains for examples Python, Jupyter notebooks, basic ML libraries and others.

Ethics and governance as an explicit module will Integrate case studies and regulatory frameworks relevant to maritime AI. Some industry partnerships with collaborative projects with shipping companies or equipment suppliers will provide real-world context and data to student. Other factor involved is faculty development where upskilling faculty in AI pedagogy and practice is a priority.

6.3 Policy and Institutional Recommendations

Invest in computing infrastructure (GPU-enabled workstations or cloud credits). Encourage co-curricular workshops and hackathons focused on maritime AI. Develop assessment rubrics emphasizing both technical competence and ethical decision-making.

7. LIMITATIONS

Future work should include objective practical assessments and graded assignments to validate self-reports. Sampling for this study may illustrative sample is convenience-based. A larger, stratified sample and multi-site comparisons to other Malaysian polytechnics would improve generalizability.

8. CONCLUSION

This initial-insights study provides a framework and roadmap for assessing and developing AI competencies among maritime students at Polytechnic Bagan Datuk. Several findings suggest gaps in programming, data handling, and ethics awareness, and point to specific curricular and institutional actions. Follow-up studies should collect real data using the instruments described here, incorporate objective assessments, and evaluate the impact of targeted interventions in example new modules, industry projects and others.

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