



Creative Education Utilising a Newly Built Training Vessel: (A Proposal for PBL Utilising the Marine Research Equipment on Board the Training Vessel Wakashio-Maru)

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Abstract: In March 2026, the Wakashio-maru, a new training vessel for the National Institute of Technology, Toyama College, was completed. Operating primarily in Toyama Bay, which features deep-sea areas exceeding 1,000 metres, the vessel continues a tradition of marine surveys and observation activities carried out for many years by its predecessor. Building on this tradition and past research, the new Wakashio-maru is equipped with state-of-the-art instruments for marine observation and research and is expected to further enhance educational and research activities. During marine surveys aboard the Wakashio-maru, students use observation equipment to collect actual data on water quality, ocean currents and marine life. By analysing and interpreting the data, they experience the entire process, from identifying issues to drawing conclusions. This practical learning environment is believed to contribute markedly to developing data science thinking and problem-solving skills and cultivating creativity - the ability to generate new perspectives and solutions to unfamiliar challenges. Furthermore, marine surveys in Toyama Bay can address topics such as marine-environment conservation, the ecology of plankton and small marine organisms, stock assessment of key fishery species, sustainable development of local fisheries and challenges faced by coastal communities. This study envisages implementing project-based learning centred on these regional and academic challenges. We propose specific project examples and report findings on how inquiry-based learning that uses real-world data as a form of creative education fosters students' autonomy, deepens specialist knowledge, enhances problem-solving skills and cultivates creative thinking and the ability to generate innovation.

Keywords: Training vessel Wakashio-maru, Marine research, Project-based learning (PBL), Plankton, Marine life.

INTRODUCTION

A distinctive feature of education at the National Institute of Technology (NIT; Kosen) is that the curriculum actively incorporates experiments and practical training alongside lectures. Students acquire specialist knowledge and theories through lectures and deepen their understanding by applying this knowledge through experiments and practical sessions, thereby developing the ability to apply acquired knowledge in practical situations [1]. Furthermore, by learning to operate various equipment and applying measurement techniques and data-analysis methods through experiments and practical sessions, students acquire practical technical skills alongside theoretical knowledge. Moreover, in tackling real-world problems, they develop problem-identification and -solving skills and teamwork abilities. Consequently, students at the National Institute of Technology are highly regarded by industry as possessing specialist knowledge and practical technical skills, contributing to

the development of engineers ready to make an immediate contribution in the workplace [2].

In this type of education at technical colleges, experiments and practical sessions often focus on pre-determined results or answers to acquire fundamental knowledge and skills. However, during marine research practicals utilising the various survey and observation instruments installed on the training vessel Wakashio-maru, students lead every stage of the process - from drawing up observation plans to data collection, analysis and interpretation and finally evaluation of results. As the marine environment constantly changes owing to factors, including weather, ocean conditions and the distribution of marine organisms, results are difficult to predict in advance, and students tackle 'tasks for which there is no single correct answer'.

Through these learning experiences, students acquire knowledge and skills while developing the ability to identify problems and formulate and test hypotheses to solve them. Furthermore, as marine research requires the comprehensive application of knowledge from multiple academic disciplines, such as oceanography, biology, environmental science and information science, it enables students to deepen their learning while developing an interdisciplinary perspective [3].

Moreover, depending on the subjects of observation and nature of the research, educational activities can be closely linked to challenges facing local communities, such as sustainable use of fishery resources, promotion of local fisheries, conservation of the marine environment, collection of baseline data for disaster prevention and mitigation and promotion of tourism utilising marine resources. Thus, students acquire specialist knowledge while learning how it is applied in the real world. Practical marine research training using the Wakashio-maru is therefore a hands-on technical education and an important means of fostering a perspective that contributes to solving local issues [4].

Additionally, by utilising observational data obtained from marine surveys, students can learn existing knowledge and theories while developing the 'ability to identify problems' - that is, the ability to discover new issues and questions within the data. While standard experiments and practical sessions often require students to derive answers to pre-set problems using prescribed methods, marine survey data can serve as a catalyst for generating new questions.

For example, questions such as 'Why do white shrimp congregate in this area?', 'Why do plankton levels rise and fall at specific times?' and 'Why were the observation results different from those in other areas?' can only be answered through detailed analysis of observational data. In response, students formulate their hypotheses and test them through further research, comparison with existing studies and statistical analyses.

This process requires technical data-processing skills and the ability to analyse phenomena from multiple perspectives and think logically. Furthermore, as the analysis accounts for the possibility that multiple factors may be involved in a single phenomenon, this helps foster flexible and creative thinking skills. Moreover, by organising their findings, explaining them to others and discussing their validity, students can improve their scientific inquiry and communication skills.

Thus, marine research practicals aboard the Wakashio-maru provide opportunities for inquiry-based learning, enabling students to identify problems independently and

proactively conduct research and analysis to resolve them. Consequently, they are crucial as an educational approach that enables the comprehensive development of specialist knowledge and skills, problem-identification and -solving abilities, logical thinking and the creativity required to generate new value and ideas.

Numerous previous studies have reported on the educational effectiveness of project-based learning (PBL). In particular, Bell (2010) highlights PBL as a learner-centred teaching method in which learners set their problems and produce outcomes while gathering and analysing information to solve them. The author argues that such activities can enhance creativity and problem-solving skills [5]. Furthermore, as collaboration and the exchange of ideas among learners are essential in PBL, it is expected to improve communication and collaborative abilities. This approach also contributes to developing critical thinking by analysing issues from diverse perspectives and evaluating the validity of solutions; therefore, it is recognised as an educational method that holistically fosters creativity, collaboration, and critical thinking [5]. Additionally, reports indicate that PBL effectively fosters creativity. Suyono et al. reviewed 44 research papers on PBL and creative thinking and demonstrated that PBL markedly improves creative thinking skills [6]. In particular, improvements have been observed in the key components of creative thinking: ‘fluency’, ‘flexibility’, ‘originality’ and ‘elaboration’. Fluency refers to the ability to generate diverse ideas. Flexibility refers to the ability to view matters from different perspectives. Originality refers to the ability to produce highly innovative ideas not found in others. Elaboration refers to the ability to develop ideas into concrete and feasible forms. All are essential skills for creative problem-solving and qualities required in engineering education.

The marine research practicals aboard the Wakashio-maru involve students collecting observational data, identifying issues from the results, formulating hypotheses and deriving solutions through analysis and reflection. This learning process is highly compatible with PBL principles and is considered to have considerable value as creative education that, in addition to specialist knowledge and technical skills, fosters creative thinking, problem-identification and -solving skills and collaborative abilities [7]. Furthermore, by focusing on real-world issues related to local communities and the marine environment, students can pursue their studies while remaining mindful of their connection to society, enabling them to develop the practical skills and creativity required of future engineers.

This study proposes a PBL project based on marine surveys as a practical educational programme utilising marine research and observation equipment installed on the Wakashio-maru. The project aims for students to conduct actual marine observations, collect data, identify issues through their analysis and explore and reflect on possible solutions. Consequently, beyond acquiring specialist knowledge and technical skills, students are expected to develop problem-identification and -solving abilities, creative thinking skills and collaborative abilities. This study presents specific PBL projects utilising the Wakashio-maru while examining their educational effectiveness and impact as creative education.

OVERVIEW OF THE WAKASHIO-MARU

The Wakashio-maru is a newly built training vessel constructed at Mitsubishi Heavy Industries, Ltd., Shimonoseki Shipyard. Following completion, it was transferred to a dedicated quay at Toyama New Port before being handed over to NIT Toyama College on 13 March 2026.

The vessel was built to fulfil diverse roles, including marine surveys, data science education and community engagement, in addition to traditional functions as a training vessel, such as practical navigation training and maritime education.

In addition to state-of-the-art navigational instruments and an integrated measurement system, the Wakashio-maru is equipped with an advanced simulation environment that enables education and training under real-world maritime conditions. Therefore, students can gain practical knowledge in their specialist fields through actual ship operations and marine observations. Furthermore, NIT Toyama College emphasises education in mathematics, data science and artificial intelligence (AI); by utilising navigation and oceanographic data collected by the Wakashio-maru in educational activities, the college fosters students' ability to make data-driven decisions and solve problems. Additionally, practical educational programmes are expected to provide comprehensive training - from observation to analysis and evaluation - to foster talent that can support digital transformation (DX) in the maritime sector.

Another characteristic of the Wakashio-maru is that support functions designed to meet societal needs during disasters were incorporated from the planning stage. It is not merely an education and training vessel but also functions as a 'maritime support base'. In addition to power and water-supply facilities, the vessel has high-capacity storage batteries, portable generators and water-making systems, enabling it to supply electricity and domestic water to coastal areas affected by power cuts and water shortages caused by major disasters, such as earthquakes and tsunamis. These facilities can also provide temporary shelter, including shower facilities and rest areas, and are expected to support daily life and recovery efforts in disaster-stricken areas. The Wakashio-maru is thus a multi-purpose vessel that conducts educational and research activities in normal times and supports the local community during disasters.

A key feature of the Wakashio-maru is its ability to conduct marine observations and research using the unique marine environment of Toyama Bay. Toyama Bay features a steep seabed topography extending close to the coast and deep-sea areas exceeding 1,000 metres in depth, enabling observation of diverse marine phenomena and ecosystems. On board the Wakashio-maru, deep-sea observation equipment can be hoisted and lowered using an A-frame crane, while seabed observations and surveys of seabed organisms can be conducted using a remotely operated vehicle. Furthermore, the vessel has infrastructure for multifaceted marine surveys, including conductivity, temperature and depth profiler (CTD) observations to determine vertical distributions of water temperature, salinity and density, water quality analysis, current observations and detailed seabed topography surveys [8, 9].

Through these functions, the Wakashio-maru serves as a training vessel for navigation and engineering and a research and educational platform contributing to the study of the marine environment, fisheries resources and marine disaster prevention and to the resolution of regional issues. Furthermore, it offers substantial educational value as a PBL platform where students collect and analyse real-world observational data and lead the process from problem identification to resolution. It is therefore expected to contribute to developing the next generation of engineers equipped with creativity, problem-solving skills and practical abilities. Figure 1 shows the exterior of the Wakashio-maru.



Figure 1: The training vessel Wakashio-maru

RESEARCH AND OBSERVATION EQUIPMENT INSTALLED ON THE WAKASHIO-MARU

The Wakashio-maru is equipped with diverse marine observation instruments for surveying the marine environment, biological resources and marine physical phenomena. This equipment enables the collection of marine environmental data, such as water temperature and salinity, and comprehensive surveys of biological distribution, ocean current patterns and seabed topography. Furthermore, using actual observation equipment to collect data and analysing and interpreting the results, students can gain practical experience in marine survey techniques and data science methodologies.

CTD and Water-Sampling Equipment [10]

The CTD is a fundamental marine observation instrument that continuously measures the electrical conductivity, temperature and depth of seawater. These measurements enable calculation of salinity and seawater density and simultaneous acquisition of environmental data, such as dissolved oxygen concentration and pH.



Figure 2: CTD and water-sampling device

The CTD system installed on the Wakashio-maru can measure high-precision vertical profiles of the marine environment throughout the water column and is equipped with a water-sampling device comprising 12 1.7-litre sampling bottles that enables seawater samples to be collected at any depth. The collected samples are used to analyse parameters such as nutrient concentrations, chlorophyll content and plankton abundance, enabling detailed investigation of the relationship between the marine environment and marine organism distributions. Figure 2 shows an external view of the CTD and water-sampling device.

Expendable Bathythermograph (XBT)/Expendable CTD (XCTD)

The XBT is a drop-down observation device that measures the vertical distribution of sea surface temperature, whereas the XCTD is an observation system that obtains salinity data by measuring electrical conductivity. As these devices can conduct observations simply by lowering a probe into the sea, the vessel need not stop for each observation, unlike with a CTD. Consequently, the vessel can continuously collect marine environmental data while underway, making this method well suited to assessing water temperature and salinity structures across extensive ocean areas. In particular, it is used to analyse ocean current structures, such as the Kuroshio and Tsushima Warm Current, and determine the distribution of water masses. For students, this provides an opportunity to understand the difference between stationary and underway observations and learn to select the appropriate method for each observation purpose.

Quantitative Fish Finder

A quantitative fish finder records and analyses echo intensity data from a fish finder as quantitative numerical information. While standard fish finders are primarily designed to detect the presence and location of fish schools, quantitative fish finders can estimate the biomass of organisms, such as fish and plankton. This equipment enables the analysis of fish stock distributions, seasonal variations and their relationship with habitat. It is also utilised to assess the stock levels of key fish species and elucidate factors influencing fishing-ground formation. By applying it to surveys of white shrimp and firefly squid in Toyama Bay, students can learn about the relationship between the marine environment and living resources.

Multi-layer Ultrasonic Direction-Velocity Flow Metre (Acoustic Doppler Current Profiler [ADCP])

An ADCP is a measuring instrument that emits ultrasonic pulses into the water and measures flow velocity using the frequency shift (Doppler shift) of sound waves reflected by scatterers, such as plankton and suspended particles. A key feature of this device is its ability to simultaneously measure flow direction and velocity across multiple vertical layers. This enables an understanding of ocean current structures from the sea surface to the deep ocean. As ocean currents strongly affect water temperature distributions, marine organism distributions and fishing-ground formation, they are crucial for understanding the marine environment. By analysing ADCP data, students can better understand the mechanisms underlying ocean circulation and material transport.

Other Observation Equipment

In addition to the main observation equipment mentioned above, the Wakashio-maru is equipped with various marine observation and environmental monitoring instruments, including the following:

- Tidal current monitoring equipment
- Seabed topography survey equipment
- Automatic weather observation equipment
- Microwave wave-height gauges
- Underwater acoustic hydrophones
- Sediment samplers

In addition to mapping marine structures, current-measuring devices and seabed topography survey equipment enable continuous collection of meteorological data, such as wind direction, wind speed, air temperature and atmospheric pressure. Furthermore, microwave wave-height gauges are used for wave observations, while underwater acoustic hydrophones monitor the underwater acoustic environment and the sounds emitted by marine organisms. Moreover, sediment samplers enable the collection of seabed sediments to investigate marine environmental history and benthic organism habitats. Additionally, the plankton net shown in Figure 3 enables the collection of marine organisms from the deep sea to the surface. The plankton and small marine organisms collected are used for taxonomic studies and ecological analyses and as teaching materials for exploring their relationship with the marine environment.



Figure 3: Collecting marine organisms using a plankton net

Using these observation instruments and other equipment to conduct marine surveys and collect real-world data allows for the design of PBL activities that address specific challenges based on the data obtained.

As outlined above, the Wakashio-maru is equipped with various observation instruments for surveys in marine physics, chemistry, biology and geology. Using this equipment to conduct observations in the open sea themselves and collect and analyse real data enables students to engage in inquiry-based learning, through which they can identify

issues relating to the marine environment and explore possible solutions. Consequently, the Wakashio-maru holds important educational value as a means of acquiring marine research skills and a platform for practicing PBL, fostering problem-identification and -solving abilities, data analysis and creative thinking.

PBL EDUCATION UTILISING MARINE OBSERVATION EQUIPMENT

PBL is a learning method in which students identify problems and take the initiative in conducting research, analysis and practical work to resolve them. Unlike traditional knowledge-transfer-based education, this approach is characterised by learner-centred activities and has been reported to be highly effective in improving learners' problem-identification and -solving abilities, creative thinking skills, communication skills and collaborative abilities [11]. Using the various marine observation instruments installed on the Wakashio-maru, students gain first-hand experience of the entire learning process - from marine observation and data collection to analysis, interpretation and making proposals for society. In particular, a key feature of this PBL is that it tackles real-world problems using data collected in actual marine environments, thereby enabling a practical learning experience unattainable through classroom-based exercises. Furthermore, as research focusing on the marine environment and living resources has no single correct answer, students tackle problem-solving through trial and error. This process is hoped to foster the investigative skills, data-analysis abilities and creativity required of future researchers and engineers.

This study proposes 'PBL to elucidate the relationship between the marine environment and biological resources in Toyama Bay' as a model case. Specifically, the course is based on the theme 'Elucidate the relationship between the marine environment of Toyama Bay and firefly squid, white shrimp and plankton' to help students gain a multifaceted understanding of Toyama Bay's marine environment and formulate proposals that benefit the local community. In this PBL, activities are performed with the following main learning objectives: 1) marine observation, 2) biological sampling, 3) data analysis, 4) AI-based forecasting and 5) solving local issues.

Drawing Up a Project Plan

First, students gather basic information on their chosen topic and draft an overall plan covering everything from marine observations to analysis, discussion and presentation of findings. Here, we discuss how to conduct the research, the division of roles and responsibilities and the research schedule while learning the basics of project management.

Team Formation and Division of Roles

Students form teams of several members, each with a different role: the Marine Observation Team, the Biological Survey Team, the DX and Data-Analysis Team and the Public Relations Team.

- Marine Observation Team: Ocean observations using CTDs and ADCPs

- Biological Survey Team: Collection and identification of plankton and small marine organisms
- DX and Data-Analysis Team: Data organisation, statistical analysis and development of AI predictive models
- Public Relations Team: Visualisation of results, preparation of presentation materials and dissemination of information

This activity is hoped to improve collaboration and communication skills across different fields of expertise.

Preliminary Study

Before conducting the observations, students study water temperature, salinity, density, ocean currents, nutrients, plankton and the oceanographic characteristics of Toyama Bay. In addition, they deepen their understanding of the principles behind the observation equipment, observation methods and safety management.

Literature and Data Review

As part of the preliminary investigation, academic papers, reports from research institutions and marine data published by public bodies are collected. Meteorological and oceanographic data published by the Japan Meteorological Agency and Toyama Prefecture as well as fisheries statistics and catch data are also examined. These activities are performed before observations and continue during the analysis and interpretation stages, enabling the results to be compared and evaluated.

Formulating Hypotheses

Based on the information gathered, each team formulates a research hypothesis.

For example,

- Could there be a link between firefly squid abundance and surface water temperature?
- Could white shrimp distribution be influenced by water temperature and salinity near the seabed?
- Could increase plankton levels affect the migration period of firefly squid?

This process of formulating hypotheses helps develop problem-identification skills and creative thinking.

Conducting Marine Observations

During practical training aboard the Wakashio-maru, students conduct CTD observations and water sampling. They gain an understanding of the marine-environment characteristics while observing the CTD as it is lowered and examining real-time vertical distribution data for water temperature, salinity, dissolved oxygen and other parameters. Figure 4 shows the

CTD profile. In addition, current observations using ADCP and wide-area ocean observations using XBTs and XCTDs are performed, thereby acquiring diverse oceanographic data.

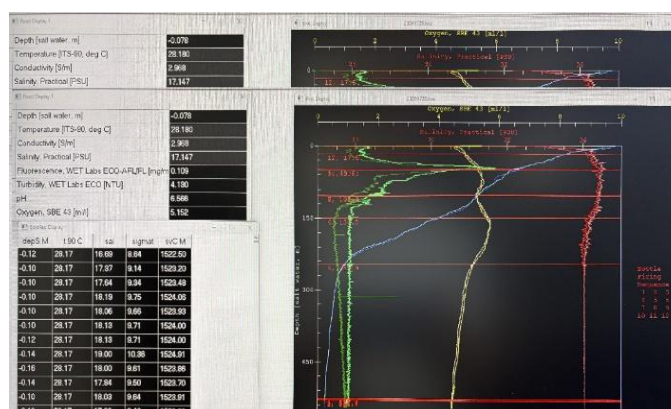


Figure 4: CTD data profile

Biological Sampling Surveys

Marine organisms are collected using plankton nets and other sampling equipment. The plankton and small organisms collected are examined under a microscope and classified, and the relationship between the distribution of these organisms and the marine environment is investigated. Students gain an understanding of the fundamentals of marine ecosystems while learning about biodiversity and food chains.

Data Analysis

Oceanographic and biological data obtained from observations are integrated, and statistical analysis and visualisation are performed.

- Production of water temperature and salinity distribution maps
- Production of vertical cross-sections
- Correlation analysis with biomass
- Distribution analysis using GIS (Geographic Information System)
- Development of predictive models using machine learning

These and other activities extract useful insights from the data, such as predicting the appearance of firefly squid and white shrimp using machine-learning models. Through this programme, students acquire practical skills in data science and DX.

Discussion of Results

The hypothesis is tested based on the analysis results.

For example,

- ‘Specific temperature zones had formed in the waters where firefly squid were found’

- ‘A correlation was observed between the distribution of white shrimp and the characteristics of deep-sea water’
- ‘A link was suggested between increases in plankton and fluctuations in the marine environment’

These and other findings are discussed.

When the expected results are not obtained, the causes are examined and new hypotheses are formulated to further the inquiry.

Proposals to Address Local Issues

Based on the results, proposals that will benefit the local community and the fishing industry are considered.

For example,

- Development of a fishing-ground prediction system
- Recommendations for the sustainable use of fishery resources
- Proposals for methods to monitor changes in the marine environment
- Proposals for utilising marine resources for education and tourism, among others.

This enables students to develop a perspective that links their research findings to the resolution of societal issues.

Presentation of Findings

Finally, each team summarises its research findings and proposals for the local community and delivers a presentation. During the presentation, participants explain the research findings and the validity of the research questions, analytical methods and proposals and deepen their understanding through a question-and-answer session. This presentation is expected to improve students’ ability to explain matters logically and their presentation and communication skills.

As outlined above, PBL utilising the Wakashio-maru is an educational approach that enables students to acquire marine observation and data-analysis skills while comprehensively developing problem-identification and -solving abilities, creative thinking, collaboration and the ability to apply learning in society. Furthermore, by focusing on local issues in the wider community, students learn while gaining a real sense of the connection between their studies and society, which is educationally important. Additionally, incorporating analyses using DX and AI is expected to help develop highly skilled engineers who will lead the next generation of the maritime and ocean sectors.

EDUCATIONAL IMPACT OF THE WAKASHIO-MARU PBL PROGRAMME

In the PBL programme utilising the Wakashio-maru, students lead a series of activities, from planning marine observations to conducting observations, analysing data, drawing conclusions and presenting findings. It is therefore expected to foster skills that are difficult

to acquire through traditional lectures, standardised experiments or practical sessions. In particular, it is believed that using real-world data to tackle challenges enables students to consolidate specialist knowledge and develop critical thinking skills, knowledge application, information literacy, communication skills and initiative.

Consolidation of Knowledge

In the Wakashio-maru PBL programme, students learn the basics of water temperature, salinity, ocean currents, plankton and marine resources before conducting ocean observations. Afterwards, by boarding the Wakashio-maru and participating in CTD observations, water sampling and biological sampling, students link classroom theories with the phenomena observed in the field, thereby deepening their understanding.

For example, students can understand ocean stratification and water mass characteristics while monitoring the vertical distributions of water temperature and salinity from CTD observations in real time. Furthermore, analysing the data they have gathered themselves and reflecting on its meaning transforms knowledge from memorisation into understanding rooted in real-life experience. Moreover, comparing and verifying observational results against prior learning is thought to deepen students' understanding of the subject matter and lead to long-term knowledge retention.

Plankton

As PBL involves students setting their own research questions and conducting investigations while formulating hypotheses, it is expected to foster logical and scientific thinking skills.

For example, in response to the question, 'Why do firefly squid appear in large numbers in specific seasons or marine areas?', students could propose various hypotheses: 'perhaps they are more likely to come close to shore when the water temperature is around 10°C', 'perhaps coastal currents and wave conditions play a role' or 'perhaps the abundance of plankton, their food source, is a factor'. Furthermore, they must test these hypotheses using observational data and formulate new ones if the expected results are not obtained. This trial-and-error process provides an opportunity to develop critical thinking, enabling students to examine issues logically and from multiple perspectives.

Developing Applied Skills

The Wakashio-maru PBL programme is expected to foster the development of applied skills, enabling students to integrate individual areas of knowledge and apply them to solve real-world problems.

For example, CTD observations are used to determine the temperature profile and thermocline, while ADCP observations are used to measure current direction and velocity. In addition, zooplankton, such as copepods, are collected using plankton nets to investigate their distribution. Students must understand individual observation results and examine relationships between the marine environment and biological resources by linking these results comprehensively. Figure 5 shows marine organisms collected using a plankton net examined under a microscope.



Figure 5: Observation under a microscope

For example, in waters where firefly squid have appeared in large numbers, students investigate whether water temperature, current conditions and the abundance of prey organisms have a combined effect. Through activities such as these, students can develop critical thinking while applying their knowledge to real-world phenomena and challenges.

Improving Information Literacy

As this PBL project involves observational data, existing research findings and data from public bodies, it is expected to foster a high level of information literacy. Students independently search for academic papers, examine reports from fisheries research organisations, collect data published by the Japan Meteorological Agency and marine research organisations and analyse Toyama Prefecture catch statistics. They then assess the reliability and usefulness of this information and use it in their research. Furthermore, by organising and consolidating the collected data and performing statistical analysis, graph creation and predictive analysis using AI, students develop fundamental data science skills. Such experiences are also expected to contribute markedly to developing DX talent, whose importance has grown in recent years.

Improving Communication and Presentation Skills

In the Wakashio-maru PBL programme, projects are performed collaboratively by several teams, including the Marine Observation Team, the Biological Survey Team, the DX and Data-Analysis Team and the Public Relations Team. Students gain experience working with others to achieve shared goals. Each team must regularly share information and discuss observation and analysis results. Through this process, students develop the ability to explain their ideas clearly and reach consensus while considering others' views. Furthermore, opportunities to discuss with students, academic staff and local stakeholders from different fields of specialisation are expected to improve students' communication and presentation skills, enabling them to collaborate effectively with people from diverse backgrounds.

Fostering Initiative

A key feature of the Wakashio-maru PBL programme is students' active involvement in observation planning and research activities. Entrusting students with key decisions, such as which sea areas to survey, what to collect, which data to utilise and which analytical methods to employ, fosters an attitude of independent thinking and action. Consequently, rather than engaging in passive learning where they simply complete set tasks, students begin to tackle these tasks proactively as part of their research. Furthermore, when things do not go as planned, they must devise solutions themselves, which helps to foster a sense of responsibility and self-discipline. In this context, the teacher acts as a facilitator who supports students' exploratory activities rather than an instructor who simply imparts knowledge. By providing appropriate guidance while respecting students' autonomy, independent learning can be promoted.

Fostering Creativity and the Ability to Generate Innovation

In the Wakashio-maru PBL programme, to make use of actual marine observation data, students are required to identify problems themselves and devise new solutions rather than simply seeking pre-determined answers.

For example, questions such as 'Why are white shrimp concentrated in this area?' and 'Why do plankton levels vary so greatly even within the same season?' are issues that only become apparent through the analysis of observational data. Students formulate hypotheses regarding these questions from their perspectives and, through repeated testing, work towards resolving them. This process cultivates problem-identification and creative thinking skills that enable the generation of new ideas from diverse perspectives. Consequently, the Wakashio-maru PBL programme is considered to have substantial educational benefits in developing problem-solving skills and as a creative education that fosters the creativity required for future research and development and innovation.

Through these activities, students apply existing knowledge while developing their ability to innovate through experiences of creating new value. This is expected to foster creative thinking and contribute to developing the ability to generate innovation in the future.

In light of the above, PBL utilising the Wakashio-maru is considered an educational approach that facilitates the acquisition of specialist knowledge and marine survey techniques and comprehensively fosters critical thinking, knowledge application, information literacy, communication skills, initiative, problem-identification skills and creativity. In particular, addressing marine environmental issues and regional challenges closely linked to the real world enables students to learn while gaining a sense of the subject matter's social importance and is expected to help them acquire the qualities required of the next generation of engineers and researchers. In the Wakashio-maru PBL programme, students identify new challenges from observational findings and devise solutions by combining existing knowledge and data. Through this process, they gain an understanding of existing knowledge and experience creating new value and ideas. Consequently, this PBL programme is not merely problem-solving education; it also offers substantial educational value as a form of creative education that fosters creativity.

CONCLUSION

Completed in March 2026, the Wakashio-maru is a training vessel equipped with state-of-the-art marine research and observation equipment capable of conducting educational and research activities using Toyama Bay's unique marine environment, which is renowned worldwide. Toyama Bay features a seabed topography that drops steeply from the coast, with deep-sea and coastal zones in proximity, making it a valuable site for observing diverse marine phenomena and ecosystems. The Wakashio-maru enables marine observations, biological surveys and environmental analyses in this favourable environment and serves as a valuable educational platform where students learn using actual observational data.

This study proposed PBL examples utilising various marine research instruments installed on the Wakashio-maru and examined their educational effectiveness. In the Wakashio-maru PBL programme, students lead every stage of the process - from planning marine observations to data collection, analysis, evaluation and presentation of findings - enabling them to progress in their learning by linking knowledge gained in lectures with practical experience. Therefore, alongside consolidating knowledge, this is expected to foster logical and scientific thinking, improve the application of knowledge to real-world problems, enhance information literacy, including information gathering and analysis, and improve communication and expression skills. Furthermore, allowing students to set their learning objectives and progress by formulating and testing hypotheses is considered to contribute considerably to developing initiative, problem-identification skills and problem-solving abilities.

In addition, as this PBL programme focuses on real-world issues related to the marine environment, fisheries resources and local communities, one of its distinctive features is that it enables students to learn while being mindful of their connection to society. Furthermore, analysing observational data and applying AI and data science technologies are expected to make it an effective form of creative education that fosters creative thinking and the ability to generate innovation. Therefore, PBL utilising the Wakashio-maru is considered an effective educational approach for training engineers and researchers who will play leading roles in the future maritime and marine sectors and for developing practitioners capable of contributing to the resolution of local issues.

Going forward, we plan to implement the proposed PBL approach in educational settings and verify its effectiveness in greater detail through quantitative and qualitative assessments of learning outcomes. Furthermore, while continuing to monitor the impact on students' skill development and motivation to learn, we will develop educational programmes using AI and data science to deliver effective marine and creative education that makes the most of the Wakashio-maru's unique characteristics.

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