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Application of the Generative Artificial Intelligence in Subsea Engineering Based on Outcome Based Education
- Case Study of Subsea Engineering at UTM, Malaysia -

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ABSTRACT

This study explores the integration of The OcARI Generative Artificial Intelligence (The OcARI Gen-AI) within the Outcome-Based Education (OBE) framework in undergraduate subsea courses. The findings indicate that the enhanced OBE model utilizing The OcARI Gen-AI significantly outperforms the traditional OBE approach, particularly in boosting student performance and increasing the proportion of high-achieving students in Subsea Engineering studies. The OcARI Gen-AI plays a crucial role in addressing the challenges faced by Indonesia's traditional OBE-based education system by enabling students to learn anytime, anywhere, and on any device. Furthermore, it allows for the minimization of educational costs while simultaneously making the process more effective, accurate, and transparent.

KEY WORDS: *Generative Artificial Intelligence; Subsea Engineering; Outcome Based Education; UTM; Malaysia*

1.0 INTRODUCTION

Indonesia's most pressing education challenges include regional disparities due to its vast maritime territory and infrastructure, as well as poor learning outcomes and a high demographic of the Generation Z population which is more interested in learning digitally anytime, anywhere, and on any device [*Tim SMERU Research, 2025, 2. Ihsan Arbiyanta, 2025*]. Indonesia's education system struggles with severe regional disparities, poor infrastructure in rural areas, particularly the 3T [Frontier, Outermost and Disadvantaged] regions, and low student learning outcomes reflected in international assessments. Despite high enrollment rates, the country faces critical challenges related to education quality, policy inconsistencies, and inadequate funding for marginalized communities [*Annisa Az Zahra, et.al, 2026*].

1.0.1 Regional Disparities and Infrastructure
Vast geographical differences separated by vast oceans and zoning systems create inequality.

1.0.2 Remote and underdeveloped areas [known as 3T areas:
Frontier, Outermost, and Disadvantaged] often suffer from a lack of physical facilities, internet access, and inadequate basic teaching resources.

1.0.3 Quality of Learning Outcomes
Indonesian students consistently score below the Organization for Economic Co-operation and Development (OECD) average in reading, mathematics, and science on the PISA tests. The focus often leans toward rote memorization rather than developing critical and analytical thinking skills [*OECD, 2023*].

1.0.4 High Demographic of the Generation Z Population
Generation Z has now become the largest population group in Indonesia. According to the Dynamic Clean Population Data (DKB) from the Directorate General of Population and Civil Registration (Dukcapil) of the Ministry of Home Affairs as of June 15, 2026, the number of individuals belonging to Generation Z stands at 64,040,121, making it the generation with the largest population compared to other generational groups [*Ashabul Yamin, et.al, 2026, Kania Aisha Pasaman, 2024, Petir Garda Bhwana, 2024*]. With over 64 million inhabitants as of mid-June 2026, Generation Z is now officially the largest population. This is where they become their most strategic asset. Generation Z in Indonesia faces a complex set of educational challenges stemming from outdated formal curricula, critical skills mismatches with the job market, a glaring digital infrastructure gap, and a growing student mental health crisis. As the core demographic intended to drive Indonesia's "Golden Vision 2045" demographic bonus, Generation

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Z often finds the traditional classroom environment sharply at odds with their technology-based learning preferences. Generation Z is more interested in learning digitally anytime, anywhere, and on any device.

Structural and Curricular Mismatch
The gap between what is taught in schools and what the modern workforce demands remains the most urgent hurdle for Indonesian students.

- *Theory over practice*: High school and university curricula emphasize heavy memorization rather than practical application.
- *Skills gap*: Graduates frequently lack advanced digital literacy, automation knowledge, data processing, and numerical analysis capabilities.
- *Low tertiary enrollment*: Only about 10% of Indonesians proceed to higher education, with the vast majority concluding their schooling at the high school level.
- *Policy inconsistency*: Frequent shifts in national education policies and curriculum changes create confusion for both teachers and students on the ground.

The Digital Divide and Infrastructure Gaps
While Gen Z are natural digital natives, their access to quality digital education is severely fragmented by geographic and economic realities.

- *Urban-rural inequality*: Students in major urban hubs like Jakarta enjoy high-speed internet and modern tech, while peers in rural and 3T regions (Frontier, Outermost and Disadvantaged) struggle with basic connectivity and lacking hardware [*Annisa Az Zahra, et.al, 2026*].
- *Skepticism toward formal systems*: Frustrated by rigid textbooks, Indonesian Gen Z increasingly turns to self-directed micro-learning through YouTube, TikTok, and interactive apps to gain job-ready skills.
- *Varying teacher readiness*: Many educators across the archipelago lack the technological training necessary to effectively design hybrid or digitally immersive lessons.



Figure 1: Indonesian population demographics [*Ashabul Yamin, et.al, 2026*]

- *Mental Health and the "Comparison Trap"*
  The intersection of digital immersion and high societal expectations has triggered an unprecedented wave of emotional strain among Indonesian youth.
- *Shorter attention spans*: The consumption of quick-cut social media content has lowered classroom engagement and reduced deep-reading comprehension habits.
- *Peer comparison anxiety*: Constant visibility on social media platforms causes rampant academic and lifestyle comparisons, worsening feelings of inadequacy and insecurity.
- *Public speaking anxiety*: Despite being highly collaborative online, many students exhibit severe anxiety regarding face-to-face academic presentations and public speaking.

The NEET Phenomenon and Economic Anxiety
Educational struggles have directly fed into post-graduation economic uncertainty.

- *High NEET rates*: Data highlights that roughly 20.31% of Indonesian Gen Z fall under the NEET category (Not in Education, Employment, or Training) [*Petir Garda Bhwana, 2024*].
- *Underemployment*: Over 60% of youth report a direct skills mismatch, forcing thousands of formal graduates into low-paying, unstable informal jobs [*Petir Garda Bhwana, 2024*].

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The paper discusses an implementation of an educational system based on The Generative AI-OBE to solve three factors of educational problems in Indonesia. As a case study, Subsea Engineering at UTM, Malaysia is taken.

2.0 RESEARCH METHODOLOGY

2.1 The OcARI Gen-AI Based OBE

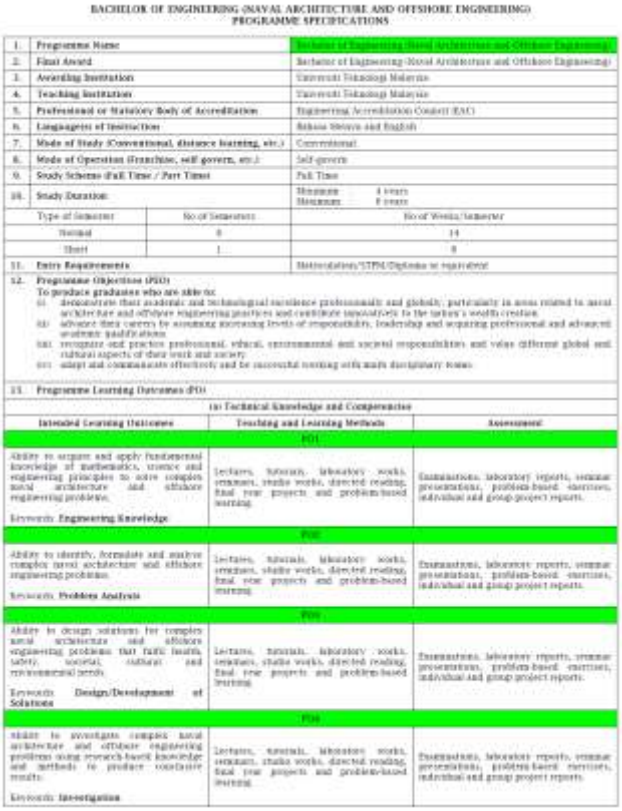
The Generative AI (The Gen-AI) is an artificial intelligence that creates new content by recognizing patterns in large training data sets and generating original material. Instead of just analyzing existing information, it functions as a creative partner that generates entirely new, contextually relevant material based on user prompts. The Gen-AI models rely on deep learning algorithms and are trained on billions of parameters to understand the relationship between words, pixels, or notes.

The Gen-AI and Outcome-Based Education (OBE) are a perfect match in which The Gen-AI automates the alignment of curricula, dynamically generates assessment rubrics, and tailors personalized learning pathways. Together, they ensure teaching directly meets specific, measurable learning outcomes while reducing faculty workload.

The OcARI Gen-AI project was initiated by Jaswar Koto in early 2013 at Aeronautical and Naval Architecture and Offshore Engineering, UTM, Malaysia. The OcARI Generative AI is a Generative-AI that is used for specific purposes such as aerospace and ocean like the OcARI GEN-AI "Bahari". The OcARI Gen-AI project is a collaboration project with colleagues from Tokyo University and Hiroshima University, Japan and University of Riau, Indonesia. In 2019, a computer version of The Gen-AI was released to identify fish which was named Bahari, The Bahari was assembled at Mechanical Engineering, UNRI.

2.2 Curriculum Design and Mapping Based on OBE

Outcome-Based Education (OBE) Curriculum Design and Mapping is an educational framework where every component of instruction, learning, and assessment is centered on what students should know and be able to do (outcomes) upon completing a program. The process relies on designing backwards and aligning content perfectly. The OBE hierarchy defines outcomes from the broadest to the most specific, ensuring every assignment contributes to a graduate's overall employability. Curriculum mapping visually tracks how well each course supports the overall PLOs. This ensures there are no gaps or unnecessary overlaps in the learning journey as follows: Develop a Matrix, Determine Mapping Strength, Align Assessments and Taxonomy Integration. The following is an example of a program specification, course outline, and course learning outcome matrix of Naval Architecture and Offshore Engineering, UTM, Malaysia.



BACHELOR OF ENGINEERING (NAVAL ARCHITECTURE AND OFFSHORE ENGINEERING)
PROGRAMME SPECIFICATIONS

1.	Programme Name	Bachelor of Engineering (Naval Architecture and Offshore Engineering)
2.	Final Award	Bachelor of Engineering (Naval Architecture and Offshore Engineering)
3.	Awarding Institution	Universiti Teknologi Malaysia
4.	Teaching Institution	Universiti Teknologi Malaysia
5.	Professional or Statutory Body of Accreditation	Engineering Accreditation Council (EAC)
6.	Language(s) of Instruction	Bahasa Melayu and English
7.	Mode of Study (Conventional, distance learning, etc.)	Conventional
8.	Mode of Operation (Franchise, self govern, etc.)	Self-govern
9.	Study Scheme (Full Time / Part Time)	Full Time
10.	Study Duration	Minimum 4 years Maximum 8 years
	Type of Semester / No of Semesters / No of Weeks/Semester	
	Normal: 8 / 14	
	Short: 1 / 8	
11.	Entry Requirements	Matriculation/STPM/Diploma or equivalent
12.	Programme Objectives (PEO) To produce graduates who are able to: (i) demonstrate their academic and technological excellence professionally and globally, particularly in areas related to naval architecture and offshore engineering practices and contribute innovatively to the nation's wealth creation (ii) advance their careers by assuming increasing levels of responsibility, leadership and acquiring professional and advanced academic qualifications (iii) recognize and practice professional, ethical, environmental and societal responsibilities and value different global and cultural aspects of their work and society (iv) adapt and communicate effectively and be successful working with multi disciplinary teams	
13.	Programme Learning Outcomes (PO)	

(a) Technical Knowledge and Competencies

Intended Learning Outcome	Teaching and Learning Methods	Assessment
PO1		
Ability to acquire and apply fundamental knowledge of mathematics, science and engineering principles to solve complex naval architecture and offshore engineering problems. Keywords: Engineering Knowledge	Lectures, tutorials, laboratory works, seminars, studio works, directed reading, final year projects and problem-based learning.	Examinations, laboratory reports, seminar presentations, problem-based exercises, individual and group project reports.
PO2		
Ability to identify, formulate and analyze complex naval architecture and offshore engineering problems. Keywords: Problem Analysis	Lectures, tutorials, laboratory works, seminars, studio works, directed reading, final year projects and problem-based learning.	Examinations, laboratory reports, seminar presentations, problem-based exercises, individual and group project reports.
PO3		
Ability to design solutions for complex naval architecture and offshore engineering problems that fulfil health, safety, societal, cultural and environmental needs. Keywords: Design/Development of Solutions	Lectures, tutorials, laboratory works, seminars, studio works, directed reading, final year projects and problem-based learning.	Examinations, laboratory reports, seminar presentations, problem-based exercises, individual and group project reports.
PO4		
Ability to investigate complex naval architecture and offshore engineering problems using research-based knowledge and methods to produce conclusive results. Keywords: Investigation	Lectures, tutorials, laboratory works, seminars, studio works, directed reading, final year projects and problem-based learning.	Examinations, laboratory reports, seminar presentations, problem-based exercises, individual and group project reports.

Figure 2: Programme Specifications [*UTM, 2015*]

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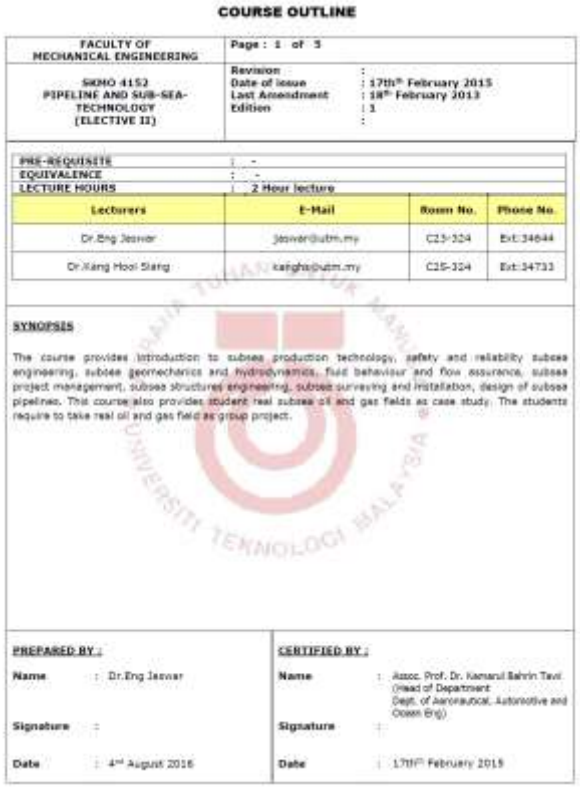

COURSE OUTLINE

FACULTY OF MECHANICAL ENGINEERING	Page : 1 of 3
SKMO 4152 PIPELINE AND SUB-SEA-TECHNOLOGY (ELECTIVE II)	Revision : Date of Issue : 17th February 2015 Last Amendment : 18th February 2013 Edition : 3

PRE-REQUISITE	: -
EQUIVALENCE	: -
LECTURE HOURS	: 2 Hour lecture

Lecturers	E-Mail	Room No.	Phone No.
Dr.Eng Jasvar	jasvar@utm.my	C23-324	Ext:34644
Dr.Kang Hooi Siang	kanghs@utm.my	C25-324	Ext:34733

SYNOPSIS

The course provides introduction to subsea production technology, safety and reliability subsea engineering, subsea geomechanics and hydrodynamics, fluid behaviour and flow assurance, subsea project management, subsea structures engineering, subsea surveying and installation, design of subsea pipelines. This course also provides student real subsea oil and gas fields as case study. The students require to take real oil and gas field as group project.

PREPARED BY :	CERTIFIED BY :
Name : Dr.Eng Jasvar	Name : Assoc. Prof. Dr. Kamarul Bahrin Tavi (Head of Department Dept. of Aeronautical, Automotive and Ocean Eng)
Signature :	Signature :
Date : 4th August 2016	Date : 17th February 2015

Figure 3: Course Outline [*UTM, 2015*]



COURSE LEARNING OUTCOMES MATRIX

PROGRAMME : BACHELOR OF ENGINEERING (NAVAL ARCHITECTURE AND OFFSHORE ENGINEERING)
COURSE CODE & NAME : SKMO4152 PIPELINE AND SUBSEA TECHNOLOGY

Figure 4: Course Learning Outcomes Matrix [*UTM, 2015*]

2.3 Tailored Assessments

Tailored assessments in Outcome-Based Education (OBE) are designed to measure whether students have mastered specific, pre-determined competencies rather than how well they memorize facts. These evaluations are highly aligned, student-centered, and personalized to verify that learners can apply their knowledge in real-world scenarios.

Tailored assessments ensure that the learning process, teaching methods, and evaluations are all aligned to hit specific target goals.Defined Outcomes: Evaluations are tied to specific Course Learning Outcomes (CLOs) and Program Learning Outcomes (PLOs).Criterion-Referenced: Students are evaluated against clear performance criteria, not graded on a curve or compared against their peers.Constructive Alignment: The way you test students must directly reflect the skills they need to demonstrate.

Instead of relying solely on traditional pen-and-paper exams, tailored OBE assessments utilize a variety of practical and applied methods:Project-Based Assessments: Require students to design or create something that solves a complex, real-world problem.Rubrics: Provide structured, transparent criteria that show students exactly what skills or knowledge are being measured (e.g., assessing accuracy, logic, and presentation).Portfolios: Collections of student work collected over time to demonstrate continuous skill development and mastery.Case Studies: Measure analytical and problem-solving abilities by giving students real-life scenarios to troubleshoot.

2.4 Continuous Quality Improvement

Continuous Quality Improvement (CQI) within Outcome-Based Education (OBE) is a systematic, data-driven cycle. It ensures educational programs continuously evaluate and refine teaching methods, assessments, and curriculum based on measured student outcomes to meet industry and international standards

CQI transforms OBE from a static administrative task into a dynamic, evolving system. By constantly measuring what students learn and adjusting the curriculum, institutions produce graduates who are highly competent and ready for the workforce.The CQI process in an OBE framework generally operates in a structured, cyclical approach:

1. *Define Outcomes*: Define the Program Learning Outcomes (PLOs) and Course Learning Outcomes (CLOs) aligned with professional, societal, and accreditation standards.Design Curriculum: Structure the syllabus to ensure every topic actively contributes to these expected outcomes.
2. *Execute Teaching*: Deliver lessons using outcome-based learning and teaching methods (e.g., project-based learning, case studies).
3. *Measure Progress*: Evaluate student performance through targeted assessments (rubrics, portfolios, presentations) specifically designed to test the CLOs.
4. *Analyze Attainment*: Collect assessment data to see if students met the Key Performance Indicators (KPIs) for each outcome.
5. *Gather Feedback*: Compile evaluations and surveys from students, alumni, and employers to gauge real-world effectiveness.
6. *Identify Gaps*: Pinpoint exactly where student outcomes fell short of expectations (e.g., if only 75% of students met the threshold for a specific practical skill).
7. *Implement Changes*: Revise teaching materials, adjust assessment weights, or modify curriculum content to address these shortcomings for the next academic year.

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CQI is a core requirement for international academic quality frameworks like the Washington Accord, ABET, or AUN-QA [*Tooba Sikander, et.al, 2017*].

- *Continuous Relevance*: As industry needs change, CQI ensures educational content never becomes obsolete.
- *Student Success*: It provides a personalized, proactive approach by identifying learning gaps and ensuring every student can achieve the target competencies.

3.0 RESULTS AND ANALYSIS

3.1 The OcARI Gen-AI "EDUCATION

The OcARI Gen-AI for Education is an Artificial Intelligence-Outcomes Based Education [AI-OBE] that can automatically analyze competencies and reasoning abilities through question and answer analysis in assignments, projects, experiments, and exams, thereby assisting lecturers in the creation of Course Review Reports [CRR] for students.

3.2 Subsea Engineering, UTM, Malaysia

As a case study, the subject Platform, Pipeline, and Sub-Sea Technology [SKMO 4152] based on Outcomes Based Education [OBE] was used for the following reasons:

- The syllabus taught it in the 2010-2018 period at the Aeronautical and Naval Architecture and Offshore Engineering, UTM, Malaysia
- The standards and expectations of the course material are very high which is based on International Journals and Real Projects from around the world, so that graduates are ready to work in oil companies around the world.
- Universiti Teknologi Malaysia (UTM) holds strong global positions across major academic assessments. In the QS World University Rankings, UTM is placed 153rd globally and Oil and Gas Engineering: Placed in the global Top 50
- Lecturers in charge of the course was required to use their own books and software as references for lecture materials and having a strong background in the oil and gas industries.
- The course is supported by international class laboratory facilities such as Towing Tank and Low Speed Wind Tunnel (UTM-LST)

3.1 Features of The OcARI Gen-AI OBE Based

The OcARI Gen-AI based on OBE has the following features: Registration, Lecturers & Assessment, Class Minutes & Self Study, Projects Industrial Attachment, Experiments, Final Project, Grade & Transcripts and Continuous Quality Improvement [CQI].



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https://ai.ocari.net/Kampus/UTM/UTM

Figure 5: Features of The OcARI Gen-AI Based on OBE

3.1 The OcARI Gen-AI Class Minutes & Self Study

The OcARI Gen-AI Class Minutes powered by voice recognition and auto-recording system, so lecturers don't have to write on the whiteboard, and students don't have to write; they just have to pay attention to the lecturer's explanations. These recordings can be shared after the lesson is complete and can be reused by students through the self-study feature below.



https://ai.ocari.net/Kampus/UTM/AI/勉強/Minutes

Figure 6: The OcARI Gen-AI Class Minutes



https://ai.ocari.net/Kampus/UTM/AI/勉強/SelfStudy

Figure 7: The OcARI Gen-AI Self Study

3.1 The OcARI Gen-AI Lecturers & Assessment

The OcARI Gen-AI Lecturers & Assessment supported by a voice, text and image recognition system, so that learning and all student answers will be analyzed and assessed automatically by AI. The primary benefit for students is the ability to learn anytime, anywhere, and on any device.

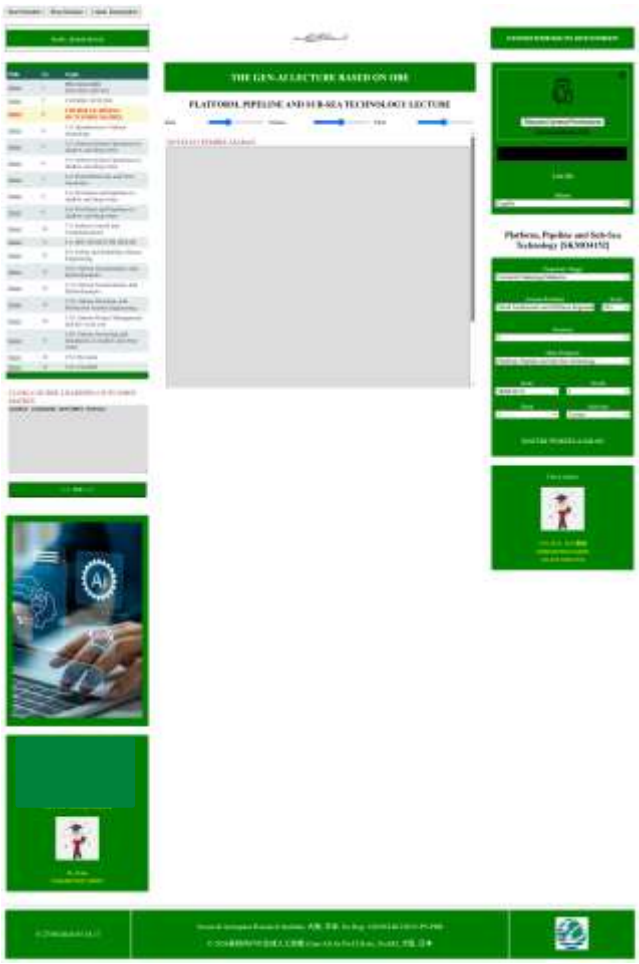

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Figure 8: The OcARI Gen-AI Lecturers

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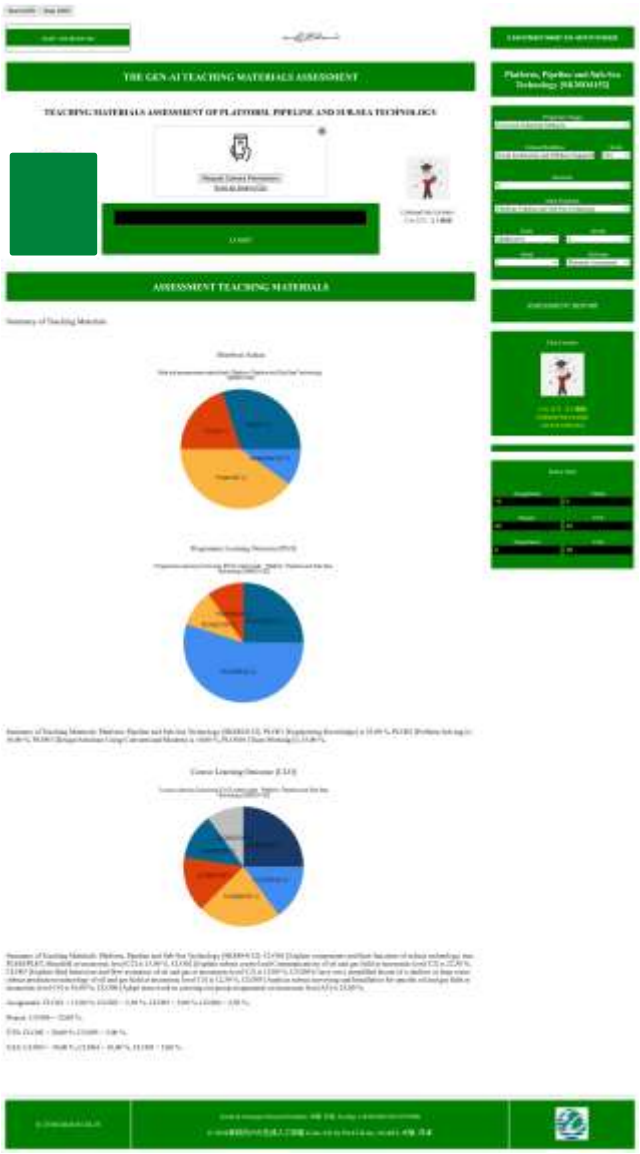
https://ai.ocari.net/Kampus/UTM/AI/勉強/Tugas

Figure 9: The OcARI Gen-AI an Assessment

3.1 The OcARI Gen-AI Teaching Materials Assessment

The OcARI Gen-AI supported by Teaching Materials Assessment based on OBE.



https://ai.ocari.net/Kampus/UTM/AI/勉強/Materials

Figure 10: The OcARI Gen-AI Teaching Materials Assessment

3.1 The OcARI Gen-AI Student Achievements

The OcARI Gen-AI supported by Student Achievements based on OBE.

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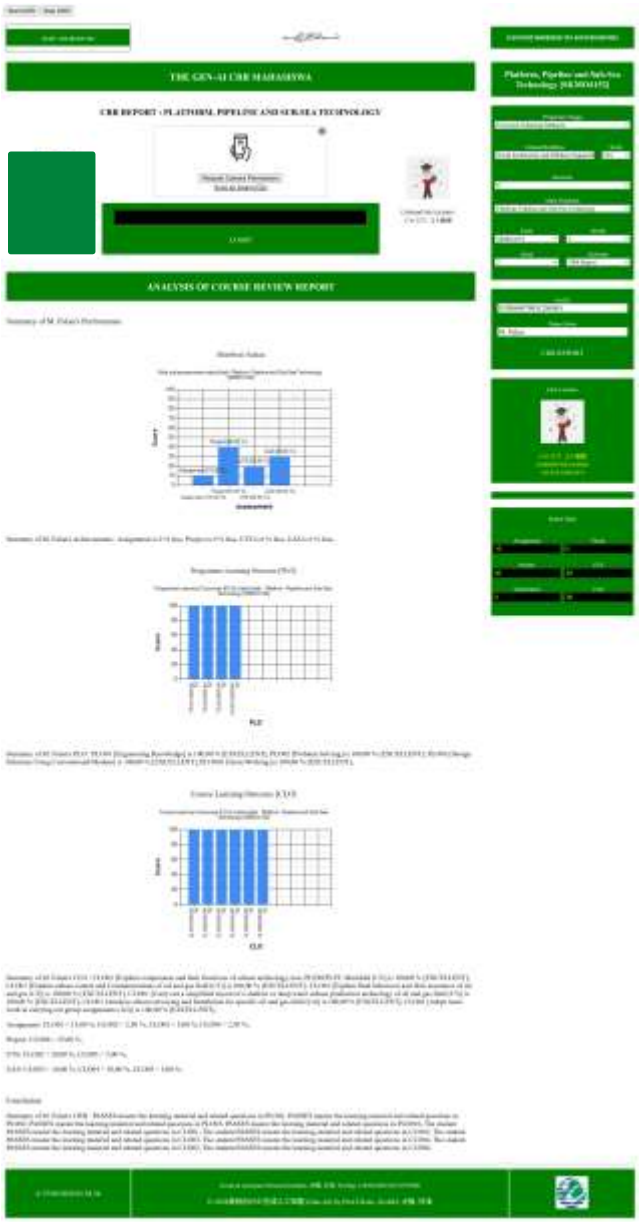
https://ai.ocari.net/Kampus/UTM/AI/勉強/Progress
Figure 11: The OcARI Gen-AI Teaching Materials Assessment

3.1 The OcARI Gen-AI Course Review Report

The OcARI Gen-AI supported by Course Review Report based on OBE.



https://ai.ocari.net/Kampus/UTM/AI/勉強/CRR
Figure 12: The OcARI Gen-AI Course Review Report

4.0 CONCLUSION

The teaching process in Indonesia faces various issues and challenges stemming from factors such as regional disparities—exacerbated by the country's vast maritime expanse and infrastructure conditions as well as low learning outcomes and the large size of the Generation Z population. However, the advent of Generative AI-based OBE such as The OcARI Gen-AI OBE has created new opportunities, positioning AI-driven teaching reform

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as a crucial solution. Through the implementation of Generative AI-based OBE as seen in the Subsea Engineering Course, personalized learning pathways enable instruction tailored to individual needs, intelligent assessment provides immediate feedback, and multidimensional evaluation systems ensure that competency assessments are conducted scientifically and rationally; this comprehensively optimizes both the teaching process and instructional practices within OBE-based programs.

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