Project-Based Learning With AI Tools: An Approach to Autotronic Skill Development among Students of Industrial Technical Education, School of Technical Education Epe Campus.

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ABSTRACT

The study examine Project-Based Learning with AI Tools: An Approach to Autotronic Skill Development among Students of Industrial Technical Education, School of Technical Education Epe. The objective of the study were to examine the technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program at the School of Technical Education, Epe Campus, to examine the real-world problem-solving skills required in modern autotronics careers , to design and implement a project-based learning model integrated with AI tools for teaching autotronic systems and to assess students' engagement, collaboration, and critical thinking in autotronic tasks when exposed to AI-supported PBL environments. The study was reviewed using local and international journals. Exploratory design method were adopted to investigate Project-Based Learning with AI Tools: An approach to autotronic Skill Development among Students of industrial Technical Education using convenience sampling method, the research question were analyzed using It was concluded that AI-supported PBL significantly improves students' engagement, promotes collaboration, and enhances real-world problem-solving abilities all of which are essential for success in modern autotronics careers. It was therefore recommended that Industrial Technical Education curriculum should be revised to include structured AI-supported project-based learning modules, especially in autotronics-related courses. These modules should focus on real-world diagnostic tasks, sensor integration, electronic control systems, and fault-finding activities.

INTRODUCTION

Background of the study

Technical education programs in Nigeria increasingly recognize autotronics the integration of automotive and electronic systems as essential to modern vocational training. Lindner et al. (2023). Yet, research indicates that curricula often lack robust content on this interdisciplinary skill set, leading to gaps in the preparedness of graduates for industry demands. De Beer, (2023). The Fourth Industrial Revolution (4IR), demands for advanced technical skills, particularly in fields like robotics and automation, has intensified. Autotronics, a multidisciplinary domain combining automotive technology and electronics, requires a robust educational framework to equip students with the necessary competencies. AUTO 4.0 Competency Framework. (2023). Traditional teaching methods often fall short in fostering the practical, problem-solving abilities essential for success in this field.

Project-Based Learning (PBL) has emerged as an effective pedagogical approach, emphasizing active student engagement through the completion of real-world projects. Fink, Koller, Gartner, Floh, & Harms (2020).This method not only enhances technical skills but also cultivates critical thinking, creativity, and collaboration collectively known as the 4Cs. Integrating Artificial Intelligence (AI) tools into PBL can further augment these outcomes by providing personalized learning experiences and facilitating complex problem-solving scenarios. Kaumba, (2023).

The Quadruple Helix model, which involves collaboration among academia, industry, government, and civil society, offers a comprehensive framework for innovation and knowledge exchange. Schweisfurth & Raasch

(2024). Applying this model to autotronic education can bridge the gap between theoretical knowledge and practical application, ensuring that students are well-prepared to meet industry demands in the field of automotive and electronic system in motor vehicle. Stapa, M. A., & Mohammad, N. (2019).

This study aims to explore the implementation of a PBL framework, enriched with AI tools, within a Quadruple Helix context to develop autotronic skills among students. Wagiran & Purnama (2021). By examining this integrated approach, the research seeks to identify Project-Based Learning with AI Tools: an approach to autotronic Skill Development among Students of of Industrial Technical Education, School of Technical Education Epe campus a strategies for enhancing technical education and fostering a workforce capable of thriving in the evolving landscape of 4IR technologies.

Statement of the Problem

Despite the emerging importance of autotronics, the fusion of automotive and electronic systems in today's industrial landscape, students within the Industrial Technical Education program at the School of Technical Education, Epe Campus, remain under-prepared for industry expectations. The current curriculum often emphasizes theoretical knowledge over hands-on-training and , industry-relevant skills, leading to a noticeable gap between training outcomes and workplace demands. This study seeks to fill the gaps of insufficient practical exposure and engagement; underutilization of AI tools in the learning process and mismatch between curriculum and industry needs. There is a lack of structured frameworks that integrate industry demands with educational curricula, through modes such as the Quadruple Helix approach (which involves academia, industry, government, and civil society).

Consequently, students at the Epe Campus are not fully equipped with the technical competence, adaptive learning strategies, and real-world problem-solving skills required in modern autotronics careers which the study examined

Objective of the study

The main objective of this study is to investigate how integrating Project-Based Learning (PBL) with Artificial Intelligence (AI) tools can enhance autotronic skill development among students of Industrial Technical Education.

Specific Objectives:

1. To examine the technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program at the School of Technical Education, Epe Campus.
2. To examine the real-world problem-solving skills required in modern autotronics careers
3. To design and implement a project-based learning model integrated with AI tools for teaching autotronic systems.
4. To assess students' engagement, collaboration, and critical thinking in autotronic tasks when exposed to AI-supported PBL environments.

Research Questions

This study seeks to answer the following research questions:

1. What is the current technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program at the School of Technical Education, Epe Campus?
2. What is the relationship between the real-world problem-solving skills and modern autotronics careers?
3. In what ways can AI tools be integrated into project-based learning to support autotronic skill acquisition?
4. What is the effect of AI-supported project-based learning on students' engagement, collaboration, and problem-solving abilities?

Justification of the study

The study is Discipline-specific technical/industrial skill focus (Autotronics). The study demonstrated how AI can be used in vocational/technical education for *autotronics*, not just in generic STEM or robotics maker tasks. It shows the impact on specific technical competencies in a field where hands-on skills are crucial by addressing implementation in a less-researched context (for example in Nigeria, or similar developing country contexts). It also identify challenges/solutions specific to that context (e.g. power, hardware, sensor parts, cost, teacher training) and how AI tools can help or need adaption. Possibly showing that students can acquire autotronic diagnostic and repair skills faster or more effectively than via traditional methods, or that they retain skills.

LITERATURE REVIEW

The focus of the literature is to discover the integration of the 4Cs: critical thinking, creativity, collaboration, and communication into service-learning pedagogy within the context of quadruple helix partnerships. Service-learning boosts student engagement and societal awareness by fusing classroom instruction with volunteer work. In the contemporary employment market, the 4Cs skills are essential for developing critical thinkers, boosting creativity, encouraging teamwork, and improving communication.

Autotronic Technical Competence

Autotronic technical competence refers to the knowledge, skills, and attitudes required to work effectively with the electronic and mechatronic systems in modern vehicles. It covers the ability to diagnose, repair, maintain, and optimize various automotive electronic control systems. Widyastuti, E., & Susiana. (2019).

Table 1: Components of Autotronic Competence

S/N	**Competence Area**	**Description**
1.	Engine Management Systems	Skills in sensors, actuators, ECUs, and engine control (e.g., fuel injection).
2.	Chassis Management	Understanding ABS, traction control, suspension control systems.
3.	Comfort/Safety/Infotainment	Working with climate control, airbags, infotainment, HUDs, ADAS.
4.	Vehicle Control Systems (VCS)	Advanced diagnostics of integrated vehicle networks (CAN, LIN, FlexRay).
5.	Diagnostics and Troubleshooting	Using diagnostic tools (e.g., OBD-II scanners), interpreting fault codes.
6.	Software and Networking	ECU programming, firmware updates, network communication protocols.
7.	Data Interpretation & Calibration	Reading sensor data, calibrating components (e.g., throttle position).
8.	Standards & Safety	Following ISO/SAE standards (e.g., ISO 26262), electrical safety practices

Source: https://www.ijera.com

Required Competence Areas

Electronics i.e soldering, testing circuits, using oscilloscopes.

Control Systems: Working with ECUs, real-time control of vehicle functions.

Communication Systems: CAN, LIN, FlexRay networks; analyzing network traffic.

Diagnostics: OBD-II tools, diagnostic flow charts, fault code interpretation.

Software Integration: Flashing firmware, updating modules, using OEM diagnostic software (e.g., Xentry).

Safety & Compliance: ISO 26262 for functional safety, ECE and SAE standards for vehicle electronics.

Table 2: Problem-Solving Skills in Autotronics & Relevant Evidence

S/N	Skills	What it involves in Practice	Supporting evidence
1.	**Fault diagnosis & troubleshooting**	Detecting, isolating, and resolving faults in vehicle control systems (engine, sensors, actuators, ECUs, networked electronics). Often involves interpreting scan-tool data, waveform analysis, and logical elimination.	Trainees were found below the desired competence in fault diagnosis of increasingly networked vehicle systems; the project deploys digitally supported simulation tools to develop diagnostic skills.
2.	**Systems thinking / holistic diagnostic view**	Understanding how subsystems (electrical, mechanical, software, networked sensors) interact; recognizing cascading effects; anticipating side-effects of interventions. Useful when changing one component affects others.	From "Essential Skills for the Future Automotive Electronics Engineer," engineers must adopt a systems thinking approach to handle interactions across subsystems in complex automobiles.
3.	**Proficiency with diagnostic tools & signal processing**	Using oscilloscopes, multimeters, diagnostic software (e.g. OBD-II, scan tools), interpreting waveforms; understanding communication protocols (CAN, LIN, FlexRay).	Globibo's blog on advanced diagnostic equipment training emphasizes *analytical skills*, sensor data interpretation, waveform patterns; familiarity with OBD-II, oscilloscopes, ADAS calibration equipment.
4.	**Adaptive learning and digital simulation**	Using simulations to replicate real faults; adjusting tasks to skill level; using modelling examples and self-explanation to improve strategy; remote diagnostics.	Project, diagnostic competence is developed via a vehicle computer simulation environment and adaptive learning tasks. Also, "CDMs in Vocational Education: Assessment and Usage of Diagnostic Problem-Solving Strategies in Car Mechatronics".
5.	**Critical thinking & decision-making under uncertainty skill**	Judging among possible diagnoses with incomplete or noisy data; deciding on next tests; risk assessment (e.g. safety implications of failure); balancing cost/time vs solution accuracy.	World Skills Occupational Standards for Mechatronics (2024) include "strategies for problem solving (fault-finding, optimization)" as essential in analysing, commissioning, maintenance tasks.
6.	**Communication & collaboration**	Communicating findings to colleagues, manufacturers, customers; writing reports; coordinating with software teams, mechanics, parts suppliers; listening to symptoms from users; teamwork.	Job postings (e.g., Bosch technical support specialist) list *communicate effectively with customers and teams* as a requirement, and bringing complex technical content to workshops/users.
7.	**Continuous learning & adaptation**	Keeping up with rapid technological change (EVs, ADAS, over-the-air updates); learning new diagnostic tools; adapting to software-defined components; integrating digital twins, IoT, networked systems.	The project emphasizes continuously updating training via digital tools because many trainees lag behind current vehicle complexity. Also "Essential Skills for Future Automotive Electronics Engineer" demands proficiency in simulation /modeling tools,

Source: International Journal of Vocational Education 2020

Project-Based Learning (PBL) Model integrated with AI tools aimed at teaching autotronic systems. It includes justification, components, possible AI tools, workflow, and evidence as support. Modern autotronic / automotive electronics systems are increasingly complex: embedded controllers, sensor networks, software,

diagnostics, predictive maintenance, connectivity (e.g. CAN/LIN/FlexRay, over-the-air updates). To teach these systems well, students need:

(i) Hands-on, realistic tasks (not just theory),
(ii) Adaptive feedback and personalized learning,
(iii) Skills in diagnosing, simulating, and optimizing systems,
(iv) Collaboration, critical thinking, and problem solving.

Project-Based Learning (PBL) is well suited: it gives students authentic problems to solve, often in teams, across multiple disciplines.

Integrating AI tools can add value via:

(i) Creating simulations/emulators with intelligent feedback,
(ii) Auto-grading & assessment,
(iii) Adaptive difficulty; personalizing learning paths,
(iv) Data-driven diagnostics, predictive models.

Components of an AI-Enabled PBL Model for Autotronics

A real or realistic autotronic challenge e.g. designing a subsystem (e.g. sensor network, diagnostic module), building or simulating a mini autonomous vehicle, ECU calibration, predictive maintenance for vehicle electronics. Students form teams; roles may include hardware engineer, diagnostics/software, data analyst, tester etc. Encourages collaboration.

Typical PBL phases: Define & Plan → Research & Design → Implementation / Prototyping → Testing and Feedback → Reflection & Presentation. Examples: simulation environments (virtual ECU / vehicle systems), AI-powered diagnostic tools, computer vision modules, generative AI for helping with code or documentation, adaptive tutors, perhaps reinforcement learning agents in simulation.

Use of both peer and instructor feedback; AI tools to provide automatic performance metrics (e.g. in simulations, misdiagnosis, latency, errors). Reflection phases. Since students may not have full mastery yet, teacher provides mini-lessons, resource libraries, example models. The AI tools scaffold: hints, diagnostics, error checking. Projects are not one-shot; allow revisions after feedback/testing. Students refine their design. Yasseri, Dar; et al. (2018).

The effects of AI-supported Project-Based Learning (PBL) on students' engagement, **collaboration**, and **problem-solving abilities.**

Engagement

A systematic review of AI-enhanced PBL in Autotronic technology acquisition found that AI-PBL frameworks (with elements like real-time feedback, adaptive learning, intelligent content generation) tend to foster higher motivation and engagement. *Implications* reports that teachers perceived that adding AI to PBL increased students' motivation and reduced anxiety, especially through adaptive feedback and self-assessment tools. PBL + AI at the elementary level improves student immersion in real-world problem situations and students' sense of achievement**,** which are components strongly related to engagement.

Collaboration

In Collaborative Uses of GenAI Tools in Project-Based Learning (2025), postgraduate students organized in small teams used generative AI (ChatGPT, Gemini, Copilot) in their PBL projects. The study found that students perceived benefits in communication**,** sharing ideas**,** and constructing knowledge together, especially when negotiating use of AI tools and resources. The Teachers in the "Role of Artificial Intelligence in PBL" study believe that AI can facilitate interaction among students and among students and teachers.

Problem-Solving Abilities

The AI-assisted POPBL (Problem Oriented Project-Based Learning) model in Malang, showed statistically significant improvement in students' critical thinking and communication skills compared both to traditional PBL and non-project-based learning, indicating that AI augmentation improves problem solving. The study (elementary students, AI convergence + PBL) found improvements across subdomains of creative problem-solving: knowledge, cognitive functions, divergent thinking, critical/logical thinking, motivational components. In The Effects of Generative AI on Collaborative Problem-Solving and Team Creativity Performance in Digital Story Creation (university students), those using generative AI tools via PBL methods significantly outperformed peers in collaborative problem solving (CPS) and team creativity performance.

Benefits of the Rapid Prototyping Model in Autotronic Education

(i) **Enhanced Engagement**: Students actively participate in the design and development process, leading to increased motivation and ownership of their learning.
(ii) **Real-World Relevance**: Projects are closely aligned with industry standards and challenges, preparing students for the workforce.
(iii) **Iterative Improvement**: Continuous feedback loops allow for the refinement of projects, ensuring high-quality outcomes.
(iv) **Collaborative Learning**: Working within the Quadruple Helix model fosters
(v) interdisciplinary collaboration, enriching the learning experience.

Challenges & Gaps

(a) Many vocational/autotronic curricula still do *not* cover all competencies needed in industry, especially newer software-oriented competencies.
(b) Diagnostic competence (identifying which faults, interpreting sensor data etc.) is often weak among trainees according to some studies; adaptive learning tools and simulations could help, but infrastructure & teacher training are barriers.
(c) There is often a mismatch between what is taught and what the industry requires, particularly for emerging/control electronics and networked systems.
(d) Evaluations of adaptive learning strategies in these technical domains are still somewhat limited in number and scope; more longitudinal studies are needed

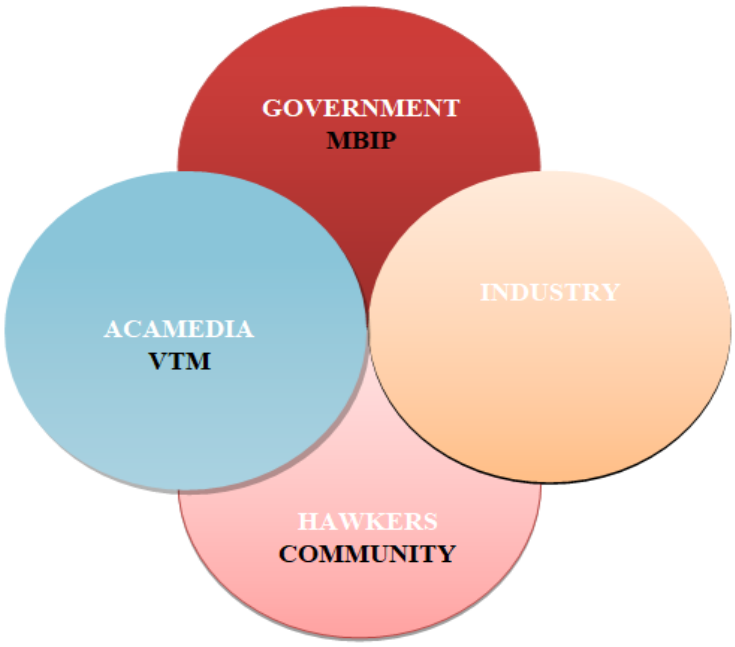

Fig: 1.0 Quadruple Helix Partnership

Source: Journal of Innovation and entrepreneurship 2012

Partnerships based on the Quadruple Helix model are important because collaboration is a major element. This ground-breaking framework involves the public sector and the general public (hawkers). The purpose of academia is to promote the spread of knowledge. To create a successful learning environment, UTM makes use of its pedagogical and project management capabilities. Faculty members keep an eye on the program's organisation and make sure that it adheres to educational goals.

A crucial layer of support is added by the government's involvement through MBIP. This partnership gives the programme credibility and guarantees the availability of materials and logistical support for smooth programme execution. Industry collaborators provide useful insights that fill the knowledge gap between theory and practise (Hasche et al., 2020). This first-hand experience enhances learning by presenting problems and answers that can be found in the actual world (Morawska-Jancelewicz, 2022). In actuality. the project's core is the hawker community. They actively participate and learn useful knowledge that helps them run their firms more effectively in the digital age. Integration of Service-Learning and the Quadruple Helix Model

In essence, this study develops students' fundamental skills and aids in the development of the neighbourhood by fusing theoretical knowledge with practical application and encouraging Quadruple Helix collaborations (Bellandi et al., 2021). The digital entrepreneur programme paves the path for a more linked and effective approach to education by demonstrating the value of collaboration between academia, government, industry, and the community. Thus, this endeavour indirectly addresses the important Sustainable Development Goals (SDGs). It first supports quality education (SDG 4), economic growth, and sustainable livelihoods while promoting digital literacy and hawking income, which is in line with the Sustainable Development Goal 8 (SDG 8) on decent work and economic growth. This is accomplished by tying theory and practise together and giving both students and hawkers useful skills. The formation of quadruple helix alliances then draws attention to alliances for the Goals (SDG 17), emphasising collaborative efforts across academia, government, industry, and the community that are crucial for attaining sustainable development

Application within a Quadruple Helix Framework

The Quadruple Helix Model involves collaboration among four key sectors: academia, industry, government, and civil society. Applying this model to autotronic skill development ensures that educational initiatives are aligned with industry needs, supported by governmental policies, and informed by societal expectations. Incorporating AI tools into this framework allows for the creation of adaptive learning environments that can respond to the evolving demands of the autotronics field.

Practical Role of Quadruple Helix in Innovation and Education

Quadruple helix contributes practically in areas like technical education, project-based learning, or AI-integrated programs:

1. Academia: It develops AI tools and technical content for education, runs PBL-based curricula focused on real-world problems and trains students in autotronic and engineering skills

2. Industry: It identifies needed skills (e.g., in vehicle electronics), provides internships, mentorship, or AI diagnostic tools and supplies data and feedback on graduate performance

3. Government: It funds education programs and innovation hubs, sets national vocational education standards and regulates AI use in education and data privacy (e.g., NDPR in Nigeria)

4. Civil Society: It helps align education with local community needs, ensures public understanding and trust in AI technologies, engages in participatory feedback (e.g., parents, community leaders) and raises ethical and cultural concerns (e.g., surveillance, equity)

Integration with Project-Based Learning (PBL)

In the context of Project-Based Learning (PBL)**,** the RP model facilitates the development of authentic, hands-on projects that mirror real-world challenges. This approach encourages students to engage deeply with the subject matter, promoting critical thinking, collaboration, and problem-solving skills. By incorporating AI tools, students can leverage advanced technologies to enhance their projects, leading to more innovative and effective solutions.

C's Skills (Critical Thinking, Creativity, Collaboration, Communication)

Critical thinking, creativity, teamwork, and communication are recognised as being essential for students' future success in the ever-changing educational context. Particular emphasis is placed on critical thinking due to its importance in making wise decision (Thornhill-Miller et al., 2023). According to Astuti et al., (2019), creativity is viewed as a skill that can be developed through education to promote inventive thinking. In a globalized environment where interpersonal contacts and teamwork are crucial, collaboration and communication skills are crucial.

METHODOLOGY

Research Design

This study is an exploratory study as it seeks to investigate. School of Technical Education Epe Campus. By focusing on a relatively small sample size Project-Based Learning with AI Tools: An approach to autotronic Skill Development among Students of Industrial Technical Education using convenience sampling method, the study aims to gather initial insights, explore key variables, and identify potential challenges in the application Project-Based Learning with AI Tools to autotronic Skill Development among Students of Industrial Technical Education. This preliminary investigation will allow researchers to adjust their methods and refine research questions for future studies. The flexibility of exploratory research is particularly beneficial when dealing with new or rapidly evolving technologies like AI, where unforeseen factors may emerge

Quantitative approach was selected as the primary design for this study and it was done at a School of Technical Education among Industrial Technical Education students across all level. Quantitative approaches were utilized in the study to capture the frequencies of each sub-category. Quantitative studies focus on numerical data and measurable outcomes . As this study aims to investigate the usefulness and the ease of use aspects in using AI in project-based learning, quantitative approach using survey is suitable. This study uses simulations to create diagnostic situations; they then assess diagnostic competencies (judgment accuracy, diagnostic argumentation etc.). Some of them use adaptive feedback in the simulations. They measure (pre/test, post/test) how well learners make diagnoses or judgments.

Participant

There were 62 students involved in this study. The participants were taking the same subject, Autotronic Technology. These students are Bachelor's degree students from 100 Level to 400 Level in Vocational Education department of the School of Technical Education Epe campus. They were selected as the research participants using convenience sampling as they were currently the students taking the subject. Instrument

A questionnaire was used in this study as the instrument for data collection. It was adapted from for learners' perceptions of project-based learning and for learners' perceived ease of use and usefulness. It was distributed to the students at the end of the project to get the general perception of use of AI technologies in project-based learning among students. The questionnaire consisted of four parts with 16 questions in total. The parts of the paper that are relevant to the study include PBL in Autotronic Technology classroom, usefulness, and ease of use. The six-point Likert scale is used in the questionnaire for higher reliability. The data collected from this study were analyzed using mean and standard deviation for answering the research questions.

Research Question 1

What is the current technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program at the School of Technical Education, Epe Campus?

Table 3 Project-Based Learning (PBL)

ITEM	SCALE (%)					
	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agreed	Strongly Agreed
I can confidently identifying and explaining the function of key sensors used in modern vehicles	0(0.00%)	0(0.00%)	2(3.22%)	5(8.08%)	20(32.25%)	35(56.45%)
I can confidently diagnose basic faults in automotive electronic systems	2(3.22%)	3(4.83%)	4(6.45%)	5(8.08%)	20(32.25%)	28(45.16%)
I have the ability to use diagnostic tools (e.g., OBD-II scanner) effectively	25(40.32%)	15(24.19%)	5(8.08%)	4(6.45%)	8(12.09%)	5(8.08%)
I can collaborate with peers to solve technical problems or practice together	0(0.00%)	0(0.00%)	0(0.00%)	4(6.45%)	30(48.38%)	28(45.16%)

Source: Field survey

Analysis in table 3 showed the current technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program. They included identifying and explaining the function of key sensors used in modern vehicles, confidence in diagnosing basic faults in automotive electronic systems, ability to use diagnostic tools (e.g., OBD-II scanner) effectively and collaborating with peers to solve technical problems or practice together.

Research Question 2

What is the relationship between the real-world problem-solving skills and modern autotronics careers?

Table 4

ITEM	SCALE (%)					
	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agreed	Strongly Agreed
My ability to solve real-world technical problems makes me more employable in the autotronics field.	6 (9.67%)	5 (8.06%)	23 (37.09%)	25 (40.32%)	2 (3.22%)	1 (1.61%)
Most autotronics tasks I've encountered require creative and adaptive problem-solving.	1 (1.61%)	2 (3.22%)	2 (3.22%)	3 (4.83%)	26 (41.93%)	28 (45.16%)
My education/training has adequately prepared me to handle real-world autotronic challenges.	0 (0.00%)	0 0.00%)	3 (4.83%)	4 (6.45%)	25 (40.32%)	30 (48.38%)
AI and automation in the automotive sector have increased the need for higher-order problem-solving skills.	0 (0.00%)	0 (0.00%)	2 (3.22%)	5 (8.06%)	27 (43.54%)	28 (45.16%)

Source: Field survey

Analysis in table 4 showed that relationship exists between the real-world problem-solving skills and modern autotronics careers. Respondents were indifferent in their ability to solve real-world technical problems makes me more employable in the autotronics field. However, respondents agreed that most autotronics tasks encountered require creative and adaptive problem-solving as well as education/training acquired has adequately prepared me to handle real-world autotronic challenges. AI and automation in the automotive sector have increased the need for higher-order problem-solving skills.

Research Question 3

In what ways can AI tools be integrated into project-based learning to support autotronic skill acquisition?

Table 5

ITEM	**SCALE (%)**					
	Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agreed**	**Strongly Agreed**
Integrating AI into PBL helps me better understand complex vehicle electronic systems.	0 (0.00%)	0 (0.00%)	2 (3.22%)	15 (24.19%)	20 (32.25%)	25 (40.32%)
Using AI tools during projects increases my motivation and interest in autotronics.	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (3.22%)	30 (48.38%)	30 (48.38%)
AI-powered simulators make it easier to practice and test autotronic systems without real hardware.	0 (0.00%)	0 (0.00%)	0 (0.00%)	20 (32.25%)	15 (24.19%)	25 (40.32%)
Generative AI tools (e.g., ChatGPT, Copilot) help me write or debug code used in autotronic systems.	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (3.22%)	30 (48.38%)	30 (48.38%)

Source: Field survey

Analysis in table 5 showed that AI tools be integrated into project-based learning to support autotronic skill acquisition which includes: complex vehicle electronic systems, AI tools during projects, AI-powered simulators make it easier to practice and test autotronic systems without real hardware and generative AI tools (e.g., ChatGPT, Copilot) to write or debug code used in autotronic systems

Research Question 4

What is the effect of AI-supported project-based learning on students' engagement, collaboration, and problem-solving abilities?

Table 6

ITEM	**SCALE (%)**					
	Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agreed**	**Strongly Agreed**
AI tools used in project-based learning make learning more engaging for me.	1 (1.61%)	2 (3.22%)	4 (6.45%)	10 (16.12%)	20 (32.25%)	25 (40.32%)
I find it easier to work with others on projects when we use AI tools to support our learning.	1 (1.61%)	2 (3.22%)	2 (3.22%)	3 (4.83%)	26 (41.93%)	28 (45.16%)
I am better able to think critically and solve problems when AI is used to support my learning.	0 (0.00%)	0 0.00%)	3 (4.83%)	4 (6.45%)	25 (40.32%)	30 (48.38%)

AI-supported project-based learning improves my ability to analyze and troubleshoot real-world issues.	0 (0.00%)	0 (0.00%)	2 (3.22%)	5 (8.06%)	27 (43.54%)	28 (45.16%)

Source: Field survey

Analysis in table 6 showed that the effect of AI-supported project-based learning on students' engagement, collaboration, and problem-solving abilities: complex vehicle electronic systems, AI tools used in project-based learning make learning more engaging, easier to work with others on projects when we use AI tools to support our learning, ability to think critically and solve problems when AI is used to support learning and AI-supported project-based learning improves my ability to analyze and troubleshoot real-world issues..

FINDINGS AND DISCUSSION

The present study explored the impact of integrating Artificial Intelligence (AI) tools within Project-Based Learning (PBL) environments on the development of autotronic skills among students in the Industrial Technical Education program at the School of Technical Education, Epe Campus.

Findings indicated that students exposed to AI-supported PBL demonstrated significant improvement in core autotronic competencies, including fault diagnosis, sensor integration, and system programming. Findings show that Fifty-five (55) students approximately 89% affirmed that AI-supported project-based learning on students' engagement, collaboration, and problem-solving abilities This aligns with recent studies (e.g., Kim, 2024; library.iated.org that emphasize AI's role in providing adaptive, hands-on learning environments that bridge theoretical concepts with practical applications. The use of AI-powered simulators and diagnostic tools enabled students to engage deeply with complex autotronic systems, fostering both skill acquisition and confidence. The integration of AI tools within PBL notably increased students' engagement levels. Survey responses showed heightened motivation and sustained interest during project activities involving AI tools such as intelligent tutoring systems and real-time feedback platforms. These findings correspond with research by MDPI, 2023. which highlighted that AI-enhanced learning environments reduce cognitive load and support personalized learning pacing, thus improving learner persistence and curiosity.

AI-supported projects encouraged better collaboration among students, as they facilitated task coordination and communication through AI-driven project management tools and shared digital workspaces. Participants reported clearer division of labor and improved knowledge sharing, echoing findings from a 2024 study on collaborative uses of generative AI in PBL (MDPI, 2024). This collaborative environment not only enhanced interpersonal skills but also promoted collective problem-solving, a crucial competency in modern autotronics careers. Students reported an increased ability to approach and solve real-world autotronic problems effectively when supported by AI tools. The adaptive feedback and diagnostic suggestions provided by AI aided in critical thinking and troubleshooting, as corroborated by findings from the Indonesian POPBL-AI model study (2023). The dynamic interaction with AI tools fostered higher-order thinking skills, enabling students to analyze complex system failures and devise innovative solutions a vital skill in the fast-evolving autotronics industry.

Despite the positive outcomes, some challenges emerged. A minority of students expressed initial difficulties in navigating AI tools, indicating a need for adequate training and scaffolding. Furthermore, reliance on AI could risk diminishing manual troubleshooting skills if not carefully balanced with traditional hands-on practice. These challenges are consistent with literature warnings about over-dependence on AI potentially reducing deep learning (Springer, 2025).

The findings suggest that incorporating AI-supported PBL into the Industrial Technical Education curriculum can substantially enhance autotronic skill development. However, successful implementation requires careful integration strategies that combine AI tools with effective pedagogy and teacher facilitation. Educators must ensure that AI acts as a cognitive scaffold rather than a replacement for critical thinking.

Ethical Considerations

This study involved the integration of AI tools within project-based learning for autotronic skill development. Ethical concerns addressed include informed consent for all student participants, anonymization of performance and interaction data, and compliance with NDPR for educational data collection. To mitigate over-reliance on AI, students were required to cross-validate AI-suggested diagnostic procedures using manual test equipment and real vehicle systems. AI outputs were critically evaluated, and students were trained to recognize potential biases and limitations of AI recommendations. Care was taken to ensure equitable access to AI tools, and alternative pathways were provided for students with limited digital literacy or connectivity. The study design emphasized hands-on competency assessment to preserve the integrity of practical skill development.

CONCLUSION AND RECOMMENDATIONS

This study investigated the integration of Artificial Intelligence (AI) tools into Project-Based Learning (PBL) as a method to enhance autotronic skill development among students of Industrial Technical Education at the School of Technical Education, Epe Campus. The findings revealed that AI-supported PBL significantly improves students' engagement, promotes collaboration, and enhances real-world problem-solving abilities all of which are essential for success in modern autotronics careers.

Students showed increased motivation and interest when working on AI-enhanced projects, especially those involving fault diagnostics, simulation, and real-time feedback. Collaboration also improved, as AI tools facilitated task distribution and teamwork. Most importantly, the study found that students using AI tools in PBL settings developed deeper problem-solving skills, allowing them to handle complex autotronic systems more confidently and effectively.

However, the study also identified some challenges, including students' initial unfamiliarity with AI tools and the need for more structured guidance from instructors. These limitations suggest that while AI tools are powerful aids, their successful use in PBL depends on thoughtful integration into the curriculum and proper teacher support.

Based on the findings of this study, the following recommendations are proposed:

(i) The Industrial Technical Education curriculum should be revised to include structured AI-supported project-based learning modules, especially in autotronics-related courses. These modules should focus on real-world diagnostic tasks, sensor integration, electronic control systems, and fault-finding activities.
(ii) Educators should receive professional development and hands-on training in AI tools relevant to autotronics and project-based learning methods.
(iii) Workshops and certifications in AI applications (e.g., diagnostic software, simulators, generative AI) should be encouraged.
(iv) The institution should invest in AI-based learning platforms such as automotive diagnostic simulators, smart learning environments, and adaptive feedback systems.
(v) Access to internet-connected tools like AI coding assistants (e.g., Copilot, ChatGPT) should be made available in technical laboratories.
(vi) Introduce AI tools gradually into PBL tasks, beginning with tutorials and guided exercises to build student confidence and competence. Encourage students to reflect on how they use AI during projects to develop self-regulation and metacognitive skills.
(vii) Establish clear metrics to track students' progress in autotronic skill development, engagement, collaboration, and problem-solving abilities.
(viii) Partner with automotive and AI technology companies to expose students to industry-grade tools and practices.

Questionnaire

Project-Based Learning With A1 Tools: An Approach To Autotronics Skill Development Among Students Of Industrial Technical Education School Of Technical Education, Epe Campus

Dear Respondent,

I am a conducting a research topic **"Project-Based Learning with AI Tools: An Approach to Autotronic Skill Development among Students of of Industrial Technical Education, School of Technical Education Epe campus".**

The study aims to explore how integrating project-based learning (PBL) methods alongside Artificial Intelligence (AI) tools can enhance students practical competence, problem-solving and adaptability in modern autotronic.

Please note that this research is purely for academic purpose and any information supplied will be treated with utmost confidentiality, also your anonymity is guaranteed.

Thanks in anticipation

Best Regards,

Obembe Oladimeji & Martins R. O

Researchers

Section A:

INSTRUCTION: Tick (✓) where appropriate in the boxes provided

1. Sex of respondent:

Male: [ ] Female: [ ]

2. Age of respondent:

17 – 20 [ ] 21 – 24 [ ] 25 – 28 [ ] 29 and above [ ]

3. Marital status of respondent

Single [ ] Married [ ]

4. Educational qualification of respondent

SSCE/NECO/GCE O/L [ ] ND [ ]

NCE [ ] HND [ ]

5. Year of study

100 Level [ ] 200 Level [ ]

300 Level [ ] 400 Level [ ]

Section B:

Instruction: Please tick (√) as appropriate response to each of the following questions. Strongly Disagree (SD), Disagree (D), Somewhat Disagree (SWD), Somewhat Agree (SWA), Agree (A), Strongly Agree (SA)

S/N		SD	D	SWD	SWA	A	SA
A.	**What is the current technical competence, adaptive learning strategies in autotronic skills possessed by students in the Industrial Technical Education program at the School of Technical Education, Epe Campus?**						
1.	I can confidently identifying and explaining the function of key sensors used in modern vehicles						
2	I can confidently diagnose basic faults in automotive electronic systems						
3	I have the ability to use diagnostic tools (e.g., OBD-II scanner) effectively						
4	I can collaborate with peers to solve technical problems or practice together						
	What is the relationship between the real-world problem-solving skills and modern autotronics careers ?						
5.	My ability to solve real-world technical problems makes me more employable in the autotronics field.						
6.	Most autotronics tasks I've encountered require creative and adaptive problem-solving.						
7.	My education/training has adequately prepared me to handle real-world autotronic challenges						
8.	AI and automation in the automotive sector have increased the need for higher-order problem-solving skills.						
	In what ways can AI tools be integrated into project-based learning to support autotronic skill acquisition?						
9.	Integrating AI into PBL helps me better understand complex vehicle electronic systems.						
10.	Using AI tools during projects increases my motivation and interest in autotronics.						
11.	AI-powered simulators make it easier to practice and test autotronic systems without real hardware.						
12.	Generative AI tools (e.g., ChatGPT, Copilot) help me write or debug code used in autotronic systems.						
	What is the effect of AI-supported project-based learning on **students' engagement, collaboration, and problem-solving abilities?**						
13	AI tools used in project-based learning make learning more engaging for me.						
14.	I find it easier to work with others on projects when we use AI tools to support our learning.						
15	I am better able to think critically and solve problems when AI is used to support my learning						
16	AI-supported project-based learning improves my ability to analyze and troubleshoot real-world issues.						

Thank you.

REFERENCES

1. Astuti, A. P., Aziz, A., Sumarti, S. S., & Bharati, D. A. L. (2019). Preparing 21st Century Teachers:Implementation of 4C Character's Pre-Service Teacher through Teaching Practice. Journal of Physics: Conference Series, 1233(1).
2. AUTO 4.0 Competency Framework. (2023). In: Learning Factory Approaches for Mechatronics and Autotronics. InTechOpen.

3. Bellandi, M., Donati, L., & Cataneo, A. (2021). Social innovation governance and the role of universities: Cases of quadruple helix partnerships in Italy. Technological Forecasting and Social Change, 164.
4. De Beer, J. (2023). Excursions as an Immersion Pedagogy to Enhance Self-Directed Learning in Pre-Service Teacher Education. Education Sciences, 13(9), 862.
5. Fink, M., Koller, M., Gartner, J., Floh, A., & Harms, R. (2020). Effective entrepreneurial marketing on Facebook – A longitudinal study. Journal of Business Research, 113, 149–157.
6. Hasche, N., Hoglund, L., & Linton, G. (2020). Quadruple helix as a network of relationships: creating value within a Swedish regional innovation system. Journal of Small Business and Entrepreneurship, 32(6), 523–544.
7. Kaumba, C. (2023). Learners' Reflections on Service Learning Pedagogy in the Teaching of Civic Education Lessons in Zambia. International Journal of Research and Innovation in Social Science, VII, 1134–1147.
8. Lindner et al. (2023). "Digital measurement of hands-on performance." Empirical Research in VET.
9. Morawska-Jancelewicz, J. (2022). The Role of Universities in Social Innovation Within Quadruple/Quintuple Helix Model: Practical Implications from Polish Experience. Journal of the Knowledge Economy, 13(3), 2230–2271.
10. Schweisfurth & Raasch (2024). "Software-defined vehicles and competence building." Industry and Innovation.
11. Stapa, M. A., & Mohammad, N. (2019). The Use Of Addie Model For Designing Blended Learning Application At Vocational Colleges In Malaysia. Asia-Pacific Journal of Information Technology and Multimedia, 8(1), 49–62.
12. Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois- Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. In Journal of Intelligence (Vol. 11, Issue 3). MDPI.
13. Wagiran & Purnama (2021). "The Relevance of Autotronic Engineering Competency in Vocational Education." Journal of Vocational Education.
Watson, D. (2008). The university in the modern world: Ten lessons of civic and community engagement. Education, Citizenship and Social Justice, 3(1), 43–55.
14. Widyastuti, E., & Susiana. (2019). Using the ADDIE model to develop learning material for actuarial mathematics. Journal of Physics: Conference Series, 1188(1).
15. Yasseri, Dar; Finley, Patrick M.; Mayfield, Blayne E.; Davis, David W.; Thompson, Penny; Vogler, Jane S. (2018). The hard work of soft skills: augmenting the project-based learning experience with interdisciplinary teamwork". Instructional Science. 46 (3): 457–488.