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Research Article

STRATEGIES FOR EFFECTIVE PRACTICAL TRAINING IN NIGERIAN ELECTRICAL ENGINEERING EDUCATION

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Abstract

Electrical Engineering education worldwide has evolved to meet the demands of technological advancement, industrial automation, and digitalization, emphasizing experiential learning, project-based instruction, and strong university–industry collaboration. Such approaches enhance the translation of theoretical knowledge into practical competence, boosting graduate employability, innovation, and industrial productivity. However, in Nigeria, a persistent theory–practice gap undermines these outcomes. Despite producing a significant number of Electrical Engineering graduates annually, Nigerian institutions face challenges in equipping students with hands-on skills, problem-solving capabilities, and familiarity with modern engineering tools. This paper examines the underlying causes of this gap and explores strategies to bridge it, including curriculum modernization, enhanced laboratory and workshop exposure, and structured industry partnerships. By aligning academic instruction with practical requirements, Nigerian Electrical Engineering education can better prepare graduates for the demands of a rapidly evolving industry, contributing to national technological development and economic growth.

Keywords: Electrical Engineering, Theory-Practice Gap, Experiential Learning, Curriculum Development, Nigeria

Introduction

Globally, Electrical Engineering education has undergone significant transformation in response to rapid technological advancement, industrial automation, digitalization, and the growing demand for industry-ready graduates (Froyd et al., 2021; Graham, 2022). In advanced and emerging economies, engineering education increasingly emphasizes experiential learning, project-based instruction, strong university–industry collaboration and continuous curriculum renewal to ensure that theoretical knowledge is effectively translated into practical competence (Kolmos et al., 2020; Prince & Felder, 2021). Countries that have successfully linked theory and practice in engineering education record higher graduate employability, stronger innovation capacity and improved industrial productivity (OECD, 2023).

Despite these global best practices, many developing countries, including Nigeria, continue to struggle with a persistent gap between theoretical instruction and practical application in Electrical Engineering education (Akinwale & Adekunle, 2021; Okolie et al., 2020). While Nigerian universities and polytechnics produce a large number of Electrical Engineering graduates annually, employers frequently report deficiencies in hands-on skills, problem-solving ability, and familiarity with modern engineering tools (World Bank, 2022). This mismatch undermines graduate employability and limits the contribution of Electrical Engineering to national development, particularly in critical sectors such as power supply, telecommunications, manufacturing, and renewable energy. Although regulatory bodies such as the National Universities Commission (NUC), National Board for Technical Education (NBTE), and the Council for the Regulation of Engineering in Nigeria (COREN) emphasize practical

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competence in curriculum guidelines, implementation challenges persist (NUC, 2023; COREN, 2022). Inadequate laboratory facilities, weak industry linkages, limited industrial exposure, and an overemphasis on theoretical content continue to widen the theory–practice gap (UNESCO, 2022; Kolmos et al., 2020; Prince & Felder, 2021). Against this backdrop, there is a growing need for a comprehensive review that situates Nigeria's experience within the global discourse on engineering education reform.

The main objective of this study is to critically review existing literature on the linkage between theory and practice in Electrical Engineering education, with a particular focus on Nigeria within a global context.

The specific objectives are to:

i. Examine global perspectives of best practices on theory–practice integration in Electrical Engineering education.

ii. Review empirical evidence on the nature and causes of the theory–practice gap in Electrical Engineering education in Nigeria.

iii. Identify strategies for strengthening practical orientation and industry relevance in Nigerian Electrical Engineering programmes.

Therefore, the study is significant to multiple stakeholders. For policymakers and regulatory agencies, it provides evidence-based insights to support curriculum reform and effective implementation of practice-oriented standards in engineering education. For educators, the review highlights pedagogical approaches such as project-based and experiential learning that can enhance students' practical competence and problem-solving skills. For industry stakeholders, the study underscores the importance of sustained collaboration with academic institutions in producing job-ready Electrical Engineering graduates capable of addressing contemporary technological challenges. Ultimately, the study contributes to the broader discourse on engineering education reform and supports efforts to align Electrical Engineering education in Nigeria with global best practices and national development goals.

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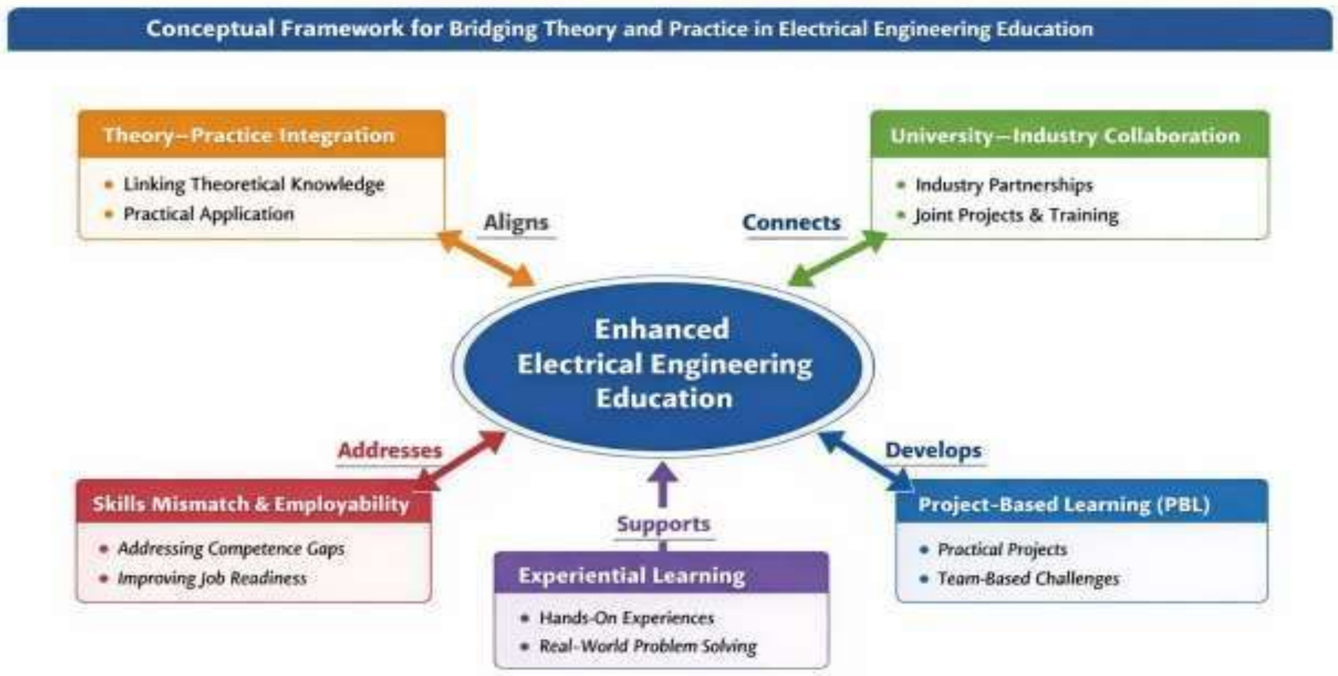
Conceptual Framework: Linking Theory and Practice in Electrical Engineering Education in Nigeria



Conceptual Review:

Theory–Practice Integration in Engineering Education

Scholars widely emphasize theory–practice integration as a core requirement for effective engineering education. According to Kolmos, Hadgraft, and Holgaard (2020), theory–practice integration refers to the deliberate alignment of abstract engineering principles with real-world problem-solving activities, ensuring that conceptual knowledge directly informs professional action. Similarly, Trevelyan (2021) defines it as a pedagogical process through which engineering theory is continuously tested, refined, and contextualized through practical engagement, particularly in industrial settings. From another perspective, Male, Bush, and Chapman (2022) view theory–practice integration as a curriculum strategy that bridges cognitive understanding and hands-on competence, enabling graduates to function effectively in complex engineering environments. Despite these perspectives, many engineering programmes especially in developing contexts continue to treat theory and practice as separate domains. Drawing from these views, theory–practice integration in this study is defined as a structured educational approach that systematically connects theoretical engineering knowledge with authentic practical experiences, enabling students to apply, adapt, and validate classroom learning within real industrial and societal contexts (Kolmos et al., 2020; Trevelyan, 2021; Male et al., 2022).

Experiential Learning

Experiential learning is commonly described as learning through direct experience and reflection. Kolb (2020) conceptualizes experiential learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation. In engineering education, Zainuddin et al. (2021) define experiential learning as instructional practices that immerse students in real or simulated engineering tasks to foster deeper conceptual understanding and skill acquisition. Likewise, Yardley, Teunissen, and Dornan (2022) emphasize that experiential learning enables learners to construct meaning by interacting with real-world professional environments rather than passively receiving knowledge.

These definitions highlight experience, reflection, and application as central elements. However, experiential learning becomes more impactful when aligned with disciplinary demands. In this study, experiential learning is defined as a learner-centered approach that promotes the acquisition of engineering knowledge and skills through structured real-life experiences, reflective practice, and continuous interaction with professional engineering contexts (Kolb, 2020; Zainuddin et al., 2021; Yardley et al., 2022).

Project-Based Learning (PBL)

Project-Based Learning (PBL) is widely adopted in engineering education as a means of linking theory and practice. Mills and Treagust (2020) define PBL as an instructional method in which students gain knowledge by working over an extended period to investigate and respond to complex, real-world problems. De Graaff and Kolmos (2021) describe PBL as a collaborative learning strategy that integrates multidisciplinary knowledge through student-led projects. Similarly, Guo et al. (2020) emphasize that PBL promotes active learning, critical thinking, and practical competence through problem-centered project work.

Across these perspectives, PBL is characterized by authenticity, collaboration, and problemsolving. Building on these views, project-based learning in this study is defined as a structured pedagogical approach that engages engineering students in collaborative, real-world projects requiring the application of theoretical concepts to practical engineering challenges (Guo et al., 2020; Mills & Treagust, 2020; De Graaff & Kolmos, 2021).

University–Industry Collaboration

University–industry collaboration is central to aligning engineering education with labour market needs. Ankrah and Al-Tabbaa (2020) define it as formal and informal partnerships between universities and industries aimed at knowledge exchange, innovation, and skills development. Perkmann et al. (2021) view such collaboration as a mechanism for integrating academic research and teaching with industrial practice. Similarly, Bellucci and Pennacchio (2022) argue that university–industry collaboration enhances curriculum relevance and graduate employability by exposing students to real engineering problems.

These views underline mutual benefit and skills alignment. In this study, university–industry collaboration is defined as a strategic partnership between higher education institutions and engineering industries that facilitates curriculum relevance, practical training, and the coproduction of industry-ready engineering graduates (Ankrah & Al-Tabbaa, 2020; Perkmann et al., 2021; Bellucci & Pennacchio, 2022).

Skills Mismatch and Graduate Employability

Skills mismatch refers to the gap between graduates' competencies and labour market expectations. McGuinness, Pouliakas, and Redmond (2020) define skills mismatch as a condition where workers' skills exceed or fall short of job requirements. In engineering contexts, Tomlinson et al. (2021) associate skills mismatch with inadequate practical training and weak industry exposure. Similarly, OECD (2022) links graduate employability to the alignment of educational outcomes with market-relevant skills.

Synthesizing these views, skills mismatch in this study is defined as the disparity between engineering graduates' acquired knowledge and practical competencies and the expectations of employers, while graduate employability refers to the capacity of engineering graduates to secure and sustain employment through relevant technical, practical, and transferable skills (McGuinness et al., 2020; Tomlinson et al., 2021; OECD, 2022).

Thematic Analysis Based on the Specific Objectives:

Objective I: Global Perspectives on Best Practices for Theory–Practice Integration in Electrical Engineering Education

The thematic analysis of global literature reveals integration-driven pedagogical reform as a dominant theme in Electrical Engineering education across developed and emerging economies. Studies from Europe, North America, and parts of Asia consistently emphasize experiential learning, project-based learning (PBL), and outcome-based education (OBE) as effective mechanisms for linking theory with practice (Kolmos et al., 2020; Graham, 2018). These approaches move beyond traditional lecture-dominated models by embedding real-world engineering problems into curricula, allowing students to apply theoretical principles in authentic contexts.

Another prominent theme is strong university–industry collaboration. Empirical evidence shows that countries with structured industry partnerships such as cooperative education programmes, industrial internships, and industry-led capstone projects produce graduates with higher employability and technical competence (OECD, 2023). Industry involvement in curriculum design ensures alignment with current technological trends, tools, and workplace expectations.

A third recurring theme is curriculum flexibility and continuous renewal. Global best practices demonstrate that Electrical Engineering curricula are frequently reviewed to accommodate emerging areas such as renewable energy, smart grids, automation, and artificial intelligence. This adaptability ensures that theoretical content remains relevant and practically applicable (UNESCO, 2022).

Finally, assessment reform emerges as a critical theme. Rather than relying solely on written examinations, global models emphasize performance-based assessment, laboratory work, design projects, and portfolios to evaluate practical competence (ABET, 2023). Overall, the findings suggest that successful theory–practice integration globally is systemic, involving pedagogy, curriculum, assessment, and industry engagement.

Objective II: Empirical Evidence on the Nature and Causes of the Theory–Practice Gap in Nigeria

Analysis of Nigerian-focused literature highlights structural and systemic deficiencies as the core themes explaining the theory–practice gap in Electrical Engineering education. One dominant theme is inadequate infrastructure, particularly poorly equipped laboratories, obsolete equipment, and limited access to modern engineering software. Studies indicate that many institutions rely heavily on theoretical instruction because practical facilities cannot support effective hands-on training (Akinwale & Aremo, 2021).

A second theme is weak industry linkage. Unlike global best practices, Nigerian institutions often lack sustained collaboration with engineering industries. Industrial Training (SIWES) is frequently poorly supervised, short in duration, or disconnected from academic learning outcomes, limiting its effectiveness in skill acquisition (Okolie et al., 2020).

The third theme concerns curriculum overload and theory bias. Empirical findings show that Electrical Engineering curricula in Nigeria are often content-heavy, prioritizing mathematical and theoretical depth at the expense of applied learning and problem-solving (Ogunleye et al., 2022). This imbalance results in graduates who possess conceptual knowledge but lack operational competence.

Another critical theme is capacity constraints among instructors. Limited opportunities for staff industrial exposure and professional development reduce lecturers' ability to integrate contemporary engineering practices into teaching. Collectively, these factors reinforce a persistent disconnect between academic training and industry expectations, contributing to graduate unemployment and underemployment.

Objective III: Strategies for Strengthening Practical Orientation and Industry Relevance in Nigeria

The thematic synthesis of reviewed concepts identifies multi-level intervention strategies as essential for strengthening practical orientation in Nigerian Electrical Engineering programmes. A key theme is curriculum re-engineering toward application-based learning. Scholars advocate the adoption of project-based learning, problem-based instruction, and design-focused courses that compel students to apply theory to practical challenges relevant to Nigeria's engineering context (Kolmos & de Graaff, 2021).

Another major theme is institutionalized industry collaboration. Findings emphasize the need for structured partnerships with power companies, manufacturing firms, telecom operators, and renewable energy providers. Such collaboration should include joint curriculum development, industry-supervised projects, extended internships, and guest lectures by practicing engineers (COREN, 2023).

Laboratory modernization and digital simulation also emerge as critical strategies. Where physical resources are limited, virtual laboratories, simulation tools, and blended learning environments can enhance practical exposure and bridge resource gaps (UNESCO, 2022). Additionally, strengthening SIWES through better monitoring, assessment integration, and longer industrial placement is widely recommended.

A final theme is capacity building for educators. Continuous professional development, industry sabbaticals, and certification in modern engineering tools can enhance lecturers' practical competence and teaching effectiveness. Together, these strategies point toward a holistic reform model capable of aligning Electrical Engineering education in Nigeria with global standards and national development needs.

Discussion

The thematic analysis of the reviewed literature reveals that the gap between theory and practice in Electrical Engineering education is a systemic and globally recognized challenge, though its intensity varies across contexts. One prominent theme that emerged is experiential and applicationdriven learning as the cornerstone of effective engineering education. Global studies consistently show that Electrical Engineering programmes that prioritize project-based learning, laboratoryintensive instruction, and real-world problem solving produce graduates with stronger technical competence and adaptability. These findings underscore the inadequacy of traditional lecturedominated models, which emphasize abstract theories without sufficient opportunities for practical application. In contrast, hands-on learning environments allow students to internalize theoretical principles through experimentation, design, and implementation.

A second dominant theme is the centrality of industry–academia collaboration in bridging the theory–practice divide. Globally, structured partnerships between universities and engineering industries ensure curriculum relevance, facilitate industrial exposure, and enhance graduate employability. However, in the Nigerian context, the absence of sustained and meaningful collaboration with industry significantly weakens the practical orientation of Electrical Engineering programmes. Although industrial training schemes exist, empirical evidence indicates that they are often poorly coordinated, weakly supervised, and insufficiently integrated into academic assessment. This disconnect limits students' exposure to contemporary engineering practices and workplace technologies.

The third theme revolves around resource and infrastructure constraints, which are particularly pronounced in Nigeria. Findings indicate that inadequate laboratory facilities, obsolete equipment, and limited access to modern simulation tools restrict the effective implementation of practical training. While global best practices increasingly combine physical laboratories with digital simulations and virtual labs, many Nigerian institutions struggle to adopt such innovations due to funding limitations. This resource gap reinforces an overreliance on theoretical instruction and constrains students' practical skill development.

Another emerging theme is curriculum imbalance and rigidity. The literature reveals that Electrical Engineering curricula in Nigeria remain heavily theory-oriented, with excessive emphasis on mathematical derivations and limited focus on applied problem-solving. In contrast, global models demonstrate the value of flexible, outcome-based curricula that are periodically reviewed to reflect technological advancement and labour market needs. The persistence of rigid curricula in Nigeria contributes to skills mismatch and graduate unemployment.

Finally, capacity development of educators emerges as a critical yet underemphasized theme. The effectiveness of theory–practice integration depends largely on instructors' practical competence and industry exposure. Findings indicate that limited opportunities for professional development and industrial engagement among lecturers weaken their ability to deliver practice-oriented instruction.

Above all, the discussion highlights that addressing the theory–practice gap in Nigerian Electrical Engineering education requires holistic reform, encompassing curriculum redesign, infrastructure development, industry collaboration, and staff capacity building. Aligning these elements with global best practices is essential for producing industry-relevant graduates capable of contributing meaningfully to Nigeria's technological and economic development.

Conclusion

This study reviewed literature on the persistent gap between theory and practice in Electrical Engineering education, with a focus on situating Nigeria within global best practices. Findings indicate that effective theory–practice integration globally relies on experiential learning, projectbased instruction, strong university–industry collaboration, and continuous curriculum review. These approaches enhance students' practical competence, problem-solving skills, and employability.

In contrast, Electrical Engineering programmes in Nigeria continue to face significant challenges, including inadequate laboratory facilities, obsolete equipment, weak industry linkages, and theoryheavy curricula. Although regulatory bodies and industrial training schemes exist, poor implementation and limited integration with academic learning outcomes reduce their effectiveness. The lack of sustained professional development and industrial exposure for educators further weakens the delivery of practice-oriented instruction.

The review concludes that addressing the theory–practice gap in Nigeria requires holistic reform. Key strategies include curriculum re-engineering toward application-based learning, modernization of laboratories through physical and digital resources, institutionalized industry partnerships, and continuous capacity building for academic staff. Aligning Electrical Engineering education with global standards while responding to Nigeria's contextual realities is essential for producing industry-relevant graduates capable of supporting technological advancement, employability, and national development.

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