LOGICAL POSITIVISM IN MECHANICAL ENGINEERING EDUCATION IN NIGERIAN UNIVERSITIES

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Abstract

Engineering education in Nigerian universities is shaped by logical positivist assumptions that emphasise empiricism, objectivity, measurement, experimentation, and evidence based reasoning. While these principles have strengthened scientific rigour, standardised curricula, laboratory instruction, and the production of technically competent mechanical engineering graduates, they are increasingly inadequate for addressing contemporary socio technical challenges. This paper critically examines the influence of logical positivism on mechanical engineering education in Nigerian universities using a conceptual and philosophical analytical approach. It explores how positivist assumptions are embedded in curriculum design, laboratory practices, assessment systems, and research culture within mechanical engineering programmes, particularly under frameworks such as the Core Curriculum and Minimum Academic Standards of the National Universities Commission. Drawing on post positivist, pragmatic, critical realist, and pluralist perspectives in contemporary philosophy of science, the study highlights the limitations of an exclusively verificationist orientation in engineering education. It argues that while positivist foundations remain essential for scientific and technical rigour, they must be complemented by creativity, ethical reasoning, innovation, and contextual understanding. The paper concludes that a balanced epistemological framework is necessary for preparing mechanical engineering graduates capable of responding effectively to the developmental and technological needs of Nigeria.

Keywords: logical positivism; mechanical engineering education; philosophy of science; engineering pedagogy; epistemology; curriculum reform; socio technical systems

1. Introduction

Engineering education plays a central role in national development by providing the technical expertise required for industrialisation, technological innovation, infrastructure development, and economic growth. In Nigeria, universities are expected to produce engineering graduates capable of addressing complex societal challenges in areas such as energy systems, manufacturing, transportation, environmental sustainability, and technological advancement (Federal Republic of Nigeria, 2014; National Universities Commission, 2023). Consequently, the quality and relevance of engineering education remain central concerns for policymakers, accreditation bodies, and higher education institutions. The philosophical assumptions that underlie this enterprise, however, are rarely made explicit, and it is precisely these assumptions that this paper sets out to interrogate.

Within this context, mechanical engineering occupies a particularly important position because of its broad application in manufacturing systems, energy conversion, thermodynamics, machine design, robotics, and industrial innovation. Mechanical engineering programmes are therefore designed to develop scientific knowledge, technical competence, analytical reasoning, and problem solving abilities required for professional practice. In line with this orientation, the Core Curriculum and Minimum Academic Standards emphasise measurable competencies, laboratory based learning, innovation, and practical skill acquisition as essential outcomes of engineering education (National Universities Commission, 2023). Similarly, the National Policy on Education positions science and technology as critical instruments for national development and industrial transformation (Federal Republic of Nigeria, 2014).

Underlying these curricular and policy directions are deeper philosophical assumptions concerning the nature of knowledge and scientific inquiry. One of the most influential traditions shaping engineering education is logical positivism, which holds that meaningful knowledge must be empirically verifiable or logically demonstrable (Ayer, 2001; Carnap, 2003). This tradition emphasises observation, measurement, experimentation, objectivity, and verification as the foundations of scientific knowledge. In engineering education, these assumptions are reflected in laboratory instruction, quantitative analysis, mathematical modelling, and evidence based problem solving approaches (Prince and Felder, 2006).

Developments in contemporary philosophy of science have, however, significantly challenged the assumptions of classical positivism. Popper (2005) rejected verificationism in favour of falsification, while Kuhn (2012) demonstrated that scientific progress is shaped by paradigms and conceptual frameworks. Quine (1951) further questioned the strict separation between analytic and synthetic knowledge. More recent perspectives such as post positivism, critical realism, and pragmatism emphasise that scientific knowledge is theory laden, fallible, and socially situated (Bhaskar, 2008; Godfrey Smith, 2021; Phillips and Burbules, 2000). These developments suggest that scientific inquiry involves not only observation and measurement but also interpretation, judgment, and contextual understanding.

Despite these intellectual developments, mechanical engineering education in Nigerian universities continues to reflect strong positivist orientations. Curriculum structures, laboratory practices, assessment systems, and accreditation standards remain largely focused on measurable outcomes, quantitative analysis, experimentation, and standardised evaluation. While these approaches strengthen technical competence and scientific rigour, they may not fully address the multidimensional nature of contemporary engineering practice. Modern engineering challenges increasingly require competencies that extend beyond technical calculation. Engineers are expected to demonstrate creativity, innovation, ethical reasoning, communication skills, teamwork, and sustainability awareness. Engineering problems are rarely purely technical, since they are embedded within social, environmental, economic, and ethical contexts that demand interpretive judgment and contextual sensitivity.

Against this background, this paper critically examines the influence of logical positivism on mechanical engineering education in Nigerian universities. It explores its philosophical foundations, analyses its manifestations in curriculum and pedagogy, engages contemporary developments in the philosophy of science, and evaluates both its contributions and limitations. The paper ultimately argues for a reoriented framework that retains scientific rigour while integrating creativity, ethical reflection, innovation, and contextual understanding in order to better prepare engineering graduates for the complex developmental realities of Nigeria.

2. Methodological Approach

This study adopts a conceptual and philosophical research approach to examine the influence of positivist assumptions on mechanical engineering education in Nigerian universities. Conceptual research is concerned with the analysis, clarification, interpretation, and evaluation of concepts, theories, assumptions, and intellectual traditions that shape scholarly discourse and professional practice (Brinkmann, 2014). Unlike empirical studies that rely on the collection and analysis of observational data, conceptual inquiry seeks to investigate the meanings, coherence, implications, and practical significance of ideas within particular contexts. In educational research, conceptual and philosophical analyses are valuable for examining the assumptions that underpin curriculum development, pedagogical practice, assessment systems, and educational policy (Carr, 2003).

The study employs critical philosophical analysis as its principal analytical framework. Critical philosophical analysis involves the systematic examination of concepts, arguments, theories, and assumptions in order to evaluate their coherence, strengths, limitations, and implications for educational practice (Winch and Gingell, 2008). This approach is particularly suitable for the present study because the investigation centres on questions concerning the nature of knowledge, scientific inquiry, objectivity, evidence, and educational practice within mechanical engineering education.

Sources were selected purposively on the basis of their relevance to four interrelated areas, namely philosophy of science, engineering education, educational policy, and mechanical engineering curriculum studies. The philosophical component draws upon foundational works associated with logical positivism and its subsequent criticisms, including Ayer (2001), Carnap (2003), Popper (2005), Kuhn (2012), and Quine (1951). To address contemporary developments in the philosophy of science, the study also engages literature on post positivism, critical realism, pragmatism, and scientific pluralism, including the works of Phillips and Burbules (2000), Bhaskar (2008), Kellert, Longino, and Waters (2006), and Godfrey Smith (2021). These sources provide the theoretical basis for examining the evolution of scientific thought beyond classical positivism.

The educational component of the study draws on literature relating to engineering pedagogy, laboratory learning, outcome based education, competency based assessment, and professional engineering formation. Particular attention is given to studies that examine the role of experimentation, quantitative reasoning, design processes, practical instruction, and evidence based learning in engineering education (Crawley, Malmqvist, Ostlund, Brodeur, and Edstrom, 2014; Nikolic et al., 2024; Prince and Felder, 2006; Yuan, Wan, An, Lu, and Yuan, 2024). To ensure contextual relevance, the study also examines policy and curriculum documents that guide engineering education in Nigeria, particularly the National Policy on Education (Federal Republic of Nigeria, 2014) and the Core Curriculum and Minimum Academic Standards for Engineering and Technology (National Universities Commission, 2023).

The purpose of the study is not to determine empirically whether engineering educators explicitly subscribe to positivism as a philosophical doctrine. Rather, the analysis seeks to examine the extent to which assumptions traditionally associated with positivist thought, such as empiricism, objectivity, experimentation, measurement, standardisation, and evidence based reasoning, continue to influence curriculum design, teaching practices, assessment procedures, and research activities within mechanical engineering education. Through this critical examination, the study contributes to discussions on the philosophical foundations of engineering education and the need for approaches that combine scientific rigour with creativity, ethical awareness, contextual understanding, and innovation in preparing engineers for contemporary professional practice.

3. Logical Positivism and Engineering Knowledge

Logical positivism emerged in the early twentieth century through the work of the Vienna Circle, a group of philosophers and scientists who sought to establish a rigorous scientific foundation for knowledge. Influenced by advances in mathematics, logic, and the natural sciences, logical positivists argued that meaningful knowledge must either be empirically verifiable through observation and experimentation or analytically true by virtue of logic and mathematics (Ayer, 2001; Carnap, 2003). According to this perspective, scientific inquiry should be grounded in observable evidence, logical consistency, objectivity, and systematic verification, and claims that could not be subjected to empirical testing were regarded as lacking scientific meaning.

The verificationist commitment can be represented as a sequential progression in which observation and measurement supply the raw material of knowledge, experimentation subjects that material to controlled testing, and verification certifies the result as objective. Figure 1 depicts this progression as it is tacitly reproduced within engineering instruction, where a proposition earns the status of knowledge only after it has withstood measurable confirmation.

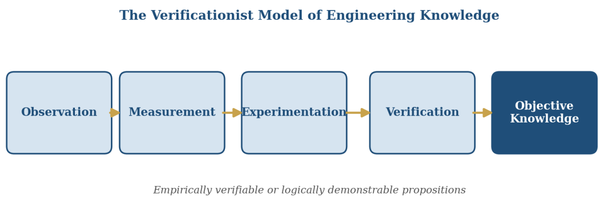

Figure 1: The verificationist model of engineering knowledge, tracing the positivist progression from observation to objective knowledge. *Source: Authors' conceptual synthesis.*

The influence of logical positivism extended far beyond philosophy and became deeply embedded within the scientific disciplines. Its emphasis on observation, measurement, experimentation, prediction, and verification contributed significantly to the development of modern scientific methodology and technical education. Engineering, as an applied scientific discipline, has historically relied on many of these principles, since engineering knowledge is expected to be evidence based, testable, measurable, and reproducible. Whether engineers are designing machines, analysing thermodynamic systems, evaluating material properties, or optimising manufacturing processes, decisions are typically justified through empirical data, mathematical modelling, and logical reasoning.

Within engineering education, the positivist orientation is reflected in the assumption that engineering competence can be developed through systematic instruction, laboratory experimentation, quantitative analysis, and objective assessment. Engineering students are trained to formulate hypotheses, collect and interpret data, verify theoretical principles, and develop solutions that can be evaluated against measurable criteria. Such practices align closely with the positivist belief that reliable knowledge emerges from empirical investigation guided by logical analysis (Prince and Felder, 2006). Mechanical engineering education provides a particularly clear illustration of this relationship, since core courses such as Engineering Mechanics, Thermodynamics, Fluid Mechanics, Heat Transfer, Materials Science, and Machine Design are grounded in scientific laws and mathematical relationships that can be tested, measured, and verified.

The contemporary emphasis on outcome based engineering education further demonstrates the continuing influence of positivist assumptions. Outcome based education focuses on clearly defined learning outcomes, measurable competencies, performance indicators, and systematic assessment procedures (Crawley et al., 2014). Engineering programmes are increasingly expected to demonstrate that graduates possess specific technical knowledge, analytical abilities, design competencies, and professional skills that can be objectively assessed and documented. Professional accreditation bodies similarly rely on standards, measurable indicators, and evidence based evaluation processes to determine programme quality and effectiveness. Nevertheless, the relationship between logical positivism and engineering education is not entirely unproblematic, because engineering practice also involves creativity, innovation, ethical judgment, sustainability considerations, teamwork, communication, and responsiveness to social needs that cannot be determined solely by empirical evidence or mathematical calculation.

4. Contemporary Philosophy of Science

The philosophy of science has evolved considerably since the emergence of the Vienna Circle and the early positivist tradition. While empirical observation, logical reasoning, and scientific rigour remain central to scientific inquiry, contemporary philosophers of science generally recognise that knowledge production is more complex than earlier verificationist accounts suggested. As a result, scientific inquiry is now commonly understood as involving not only observation and measurement but also theoretical interpretation, historical context, professional judgment, creativity, and social influences (Godfrey Smith, 2021).

The trajectory of twentieth century philosophy of science can be read as a gradual loosening of the demand for certainty in favour of an appreciation of contextual plurality. Figure 2 arranges the principal traditions along this continuum, situating each school by its distinctive criterion of scientific adequacy, so that the movement from verification to workability becomes visually legible.

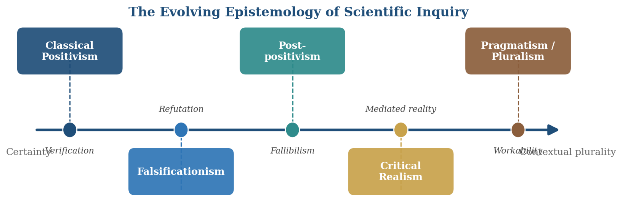

Figure 2: The evolving epistemology of scientific inquiry, from classical positivism through falsificationism and post positivism to critical realism and pluralism. *Source: Authors' conceptual synthesis.*

One of the most influential developments in twentieth century philosophy of science was the criticism of verificationism advanced by Karl Popper. Popper (2005) argued that scientific theories cannot be conclusively verified because future observations may always contradict current conclusions, and he proposed falsifiability as the distinguishing characteristic of scientific knowledge. According to this view, scientific theories gain credibility not because they have been verified but because they have survived rigorous attempts at refutation. This perspective shifted attention from the accumulation of confirming evidence to the critical testing of scientific claims and remains influential in scientific and engineering research. Thomas Kuhn further transformed understandings of scientific development by emphasising the role of paradigms in shaping inquiry, arguing that scientists operate within shared conceptual frameworks that determine which questions are asked, which methods are considered legitimate, and how evidence is interpreted (Kuhn, 2012).

Additional criticism emerged from the rejection by Quine (1951) of the strict distinction between analytic and synthetic propositions. Quine argued that scientific statements are interconnected within broader systems of belief and cannot be tested independently of the theoretical frameworks in which they are embedded. This perspective reinforced the idea that scientific inquiry involves interpretation and conceptual judgment alongside empirical observation. These criticisms contributed to the emergence of post positivism, which accepts the importance of empirical evidence while recognising that complete objectivity and certainty are unattainable. Post positivists maintain that knowledge is provisional, fallible, and subject to revision in the light of new evidence and improved explanations (Phillips and Burbules, 2000).

Contemporary discussions have also been influenced by critical realism. Bhaskar (2008) argues that although an objective reality exists independently of human perception, knowledge of that reality is always mediated by theoretical, historical, and social factors. Critical realism therefore seeks to reconcile scientific rigour with an appreciation of complexity, context, and underlying causal mechanisms, a stance that has become increasingly relevant in educational research because it allows scholars to examine both observable outcomes and the deeper structures that shape them (Danermark, Ekstrom, Jakobsen, and Karlsson, 2019). Pragmatism offers a further influential perspective, since rather than focusing exclusively on questions of verification or falsification, pragmatists emphasise the practical consequences and usefulness of knowledge in addressing real world problems (Biesta and Burbules, 2003). Such a perspective resonates strongly with professional fields such as engineering, where the ultimate value of knowledge often lies in its capacity to generate workable solutions.

Recent scholarship has further emphasised scientific pluralism, which recognises that complex problems frequently require multiple methods, forms of evidence, and theoretical perspectives (Kellert et al., 2006). Contemporary scientific inquiry therefore increasingly accommodates interdisciplinary collaboration, diverse methodological approaches, and contextual understanding. This development is particularly important in addressing complex global challenges such as climate change, sustainable energy systems, environmental degradation, and technological innovation. For mechanical engineering education in Nigerian universities, these philosophical developments suggest that scientific inquiry should remain a central component of professional preparation while being integrated with approaches that foster innovation, critical thinking, ethical responsibility, and contextual awareness.

5. Positivism in Mechanical Engineering Education

The influence of logical positivism on mechanical engineering education is evident in the philosophical assumptions that underpin curriculum design, teaching methods, laboratory instruction, assessment practices, accreditation standards, and engineering research. Although contemporary engineering educators rarely identify themselves explicitly as logical positivists, many educational practices within engineering continue to reflect positivist assumptions concerning the nature of knowledge and the means through which valid knowledge is generated and evaluated. These principles correspond closely with the scientific and technical foundations of engineering, which rely heavily on observation, experimentation, measurement, prediction, and evidence based decision making.

The pervasiveness of positivist assumptions is not uniform across the curriculum but varies by domain. Figure 3 offers an analytical estimation of this salience, indicating that laboratory instruction and quantitative modelling exhibit the strongest positivist imprint, while accreditation standards, though still measurement oriented, admit slightly greater scope for professional and contextual judgment.

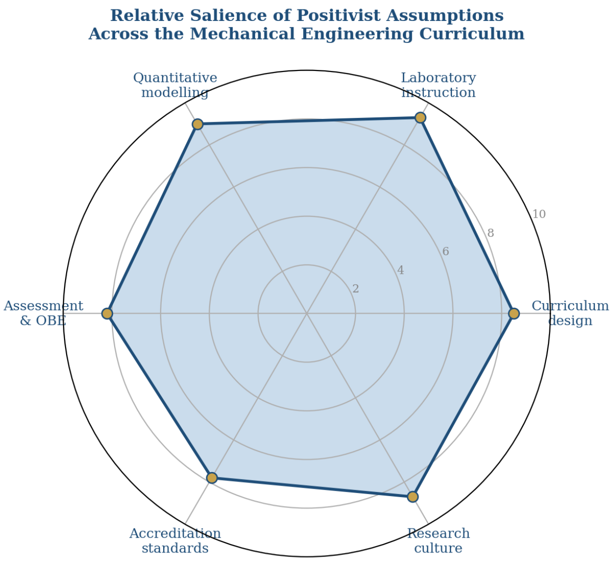

Figure 3: Relative salience of positivist assumptions across six domains of the mechanical engineering curriculum. *Source: Authors' analytical estimation based on curriculum and policy review.*

The persistence of positivist assumptions within Nigerian mechanical engineering education is observable in national educational policies and curriculum frameworks. The Federal Republic of Nigeria (2014), through the National Policy on Education, identifies science, technology, innovation, and manpower development as central objectives of higher education, and the policy emphasises the production of highly skilled personnel capable of contributing to national development through scientific inquiry, technological advancement, and problem solving. Similarly, the National Universities Commission (2023), through the Core Curriculum and Minimum Academic Standards for Engineering and Technology, requires engineering programmes to emphasise measurable competencies, practical skills acquisition, innovation, quality assurance, and professional preparedness. The focus on observable learning outcomes, competency based training, and systematic programme evaluation demonstrates the continued relevance of positivist assumptions in curriculum development and educational planning.

Within mechanical engineering programmes, laboratory instruction provides one of the clearest manifestations of logical positivism. Mechanical engineering students are required to undertake laboratory activities in courses such as Thermodynamics, Fluid Mechanics, Heat Transfer, Strength of Materials, Manufacturing Processes, and Machine Design. These laboratory experiences are designed to enable students to verify theoretical principles through experimentation, collect and analyse quantitative data, and draw conclusions based on observable evidence. According to Nikolic et al. (2024), laboratory learning remains a fundamental component of engineering education because it promotes technical competence, experimental reasoning, and evidence based judgment. Similarly, Prince and Felder (2006) argue that engineering learning is strengthened when students actively engage in the investigation and validation of concepts through practical experience. The emphasis on observation, measurement, and verification within engineering laboratories reflects the positivist conviction that reliable knowledge emerges through systematic empirical inquiry.

Logical positivism is also evident in the prominence of quantitative problem solving and mathematical modelling within mechanical engineering education. Core courses such as Engineering Mechanics, Dynamics, Thermodynamics, Fluid Mechanics, Machine Design, and Control Systems require students to analyse engineering phenomena using mathematical equations, computational tools, simulations, and statistical procedures. Engineering decisions relating to material selection, system design, machine performance, and operational efficiency are generally justified through measurable evidence and logical calculation rather than subjective opinion. The increasing integration of computer aided design, finite element analysis, computational fluid dynamics, and simulation technologies into engineering education further reinforces the importance of quantification, prediction, and objective analysis in contemporary practice.

Assessment practices within mechanical engineering programmes also reveal significant positivist influences. Student achievement is commonly evaluated through examinations, laboratory reports, design calculations, practical projects, and performance assessments that rely on observable and measurable indicators of learning. The growing adoption of outcome based education has strengthened this emphasis on measurable achievement and evidence based evaluation. Crawley et al. (2014) note that contemporary engineering education increasingly focuses on clearly defined learning outcomes, performance indicators, and systematic assessment procedures designed to demonstrate competency attainment, while Yuan et al. (2024) found that outcome based educational reforms encourage institutions to employ measurable indicators of student learning and programme effectiveness. The influence of logical positivism extends beyond teaching and assessment to engineering design and research activities, in which students are trained to identify problems, formulate hypotheses, gather data, test alternatives, evaluate outcomes, and select solutions based on empirical evidence.

Nevertheless, contemporary engineering education has increasingly recognised the limitations of an exclusively positivist orientation. Engineering practice today requires competencies that extend beyond technical expertise and empirical analysis, since engineers are expected to demonstrate creativity, innovation, communication skills, teamwork, ethical reasoning, sustainability consciousness, and sensitivity to social and cultural contexts. Prince and Felder (2006) argue that effective engineering education should promote higher order thinking, problem solving, and active engagement rather than reliance solely on traditional transmission models of instruction, while Crawley et al. (2014) emphasise that graduates must possess interpersonal, professional, and contextual competencies in addition to technical knowledge. These developments suggest that engineering education cannot be adequately understood through a purely positivist framework, because many aspects of engineering practice involve judgment, values, stakeholder interests, and contextual considerations that resist complete quantification.

6. Critique of Positivist Orientations

Positivist orientations have made important contributions to mechanical engineering education through their emphasis on empirical investigation, experimentation, objectivity, measurement, and evidence based reasoning. These principles have strengthened scientific rigour, promoted technical competence, and supported the development of professional standards within engineering education. The continued reliance on laboratory instruction, quantitative analysis, performance testing, and outcome based assessment demonstrates the enduring relevance of these principles to the preparation of engineering graduates (Crawley et al., 2014; National Universities Commission, 2023). A balanced critique must therefore begin by acknowledging that the positivist inheritance is not an obstacle to be discarded but a foundation to be extended.

Nevertheless, contemporary engineering practice reveals limitations in relying exclusively on positivist assumptions. Mechanical engineering increasingly operates within complex social, environmental, economic, and technological contexts that require more than empirical measurement and technical analysis. Engineering problems frequently involve ethical considerations, sustainability concerns, stakeholder interests, and contextual factors that cannot be adequately addressed through objective data alone (Godfrey Smith, 2021). A major limitation of positivist orientations is their tendency to privilege technical knowledge over creativity and innovation, since engineering design often requires imagination, judgment, and the exploration of multiple solutions under conditions of uncertainty. Such processes extend beyond the verification of established principles and involve forms of reasoning that are not easily captured through quantitative methods alone (Prince and Felder, 2006), so that excessive emphasis on standardisation and measurable performance may constrain opportunities for innovative thinking.

Positivist approaches have also been criticised for insufficient attention to the social and ethical dimensions of engineering practice. Contemporary engineers are expected to consider issues relating to environmental sustainability, public safety, social responsibility, and professional ethics, and while empirical evidence remains essential for informed decision making, scientific data alone cannot determine the moral or social implications of engineering actions. Engineering education must therefore incorporate opportunities for ethical reflection and contextual understanding alongside technical training (Crawley et al., 2014). Developments in contemporary philosophy of science further challenge the assumption that knowledge is entirely objective and free from interpretation, since scholars such as Kuhn (2012), Phillips and Burbules (2000), and Bhaskar (2008) have demonstrated that scientific inquiry is influenced by theoretical frameworks, historical conditions, and social contexts. These perspectives suggest that engineering students should be encouraged not only to apply scientific knowledge but also to critically examine its assumptions, limitations, and implications.

The constructive response to these limitations is not to displace positivism but to pair it with the interpretive and evaluative capacities that professional practice demands. Figure 4 renders this argument as a convergence of two pillars, in which empirical rigour and complementary competencies meet in the formation of an engineer equipped for socio technical practice.

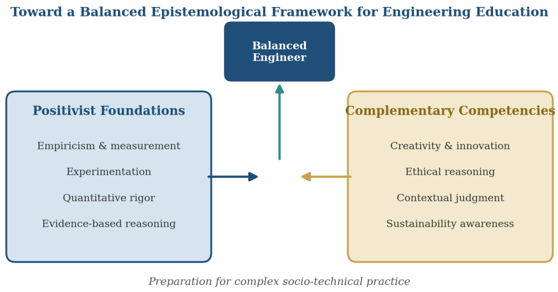

Figure 4: Toward a balanced epistemological framework in which positivist foundations and complementary competencies converge in the formation of the engineer. *Source: Authors' conceptual synthesis.*

For Nigerian universities, the challenge is therefore not to abandon positivist principles but to balance them with broader educational perspectives capable of fostering creativity, ethical responsibility, critical thinking, innovation, and contextual responsiveness. Such an approach would preserve the strengths of scientific rigour while addressing the increasingly complex demands of contemporary engineering practice. A reoriented curriculum would retain the laboratory, the model, and the measured result as indispensable instruments of formation, while embedding them within design studios, ethics seminars, sustainability projects, and interdisciplinary collaborations that cultivate the judgment on which responsible engineering ultimately depends.

7. Conclusion

This paper examined the influence of positivist orientations on the teaching and learning of mechanical engineering subjects in Nigerian university education. Drawing on philosophical and educational literature, the study demonstrated that principles associated with empiricism, objectivity, experimentation, measurement, and evidence based reasoning continue to shape engineering curricula, laboratory instruction, assessment practices, and research activities. These orientations have contributed significantly to the development of scientific rigour, technical competence, professional standards, and problem solving capabilities that are essential for engineering education and practice.

The analysis further showed that the influence of positivist thought remains evident in the objectives of engineering education articulated in national policy documents and curriculum frameworks, including the National Policy on Education and the Core Curriculum and Minimum Academic Standards for Engineering and Technology. Through their emphasis on measurable competencies, practical training, and scientific inquiry, these frameworks reflect the enduring relevance of evidence based approaches to engineering formation. However, the paper also argued that contemporary engineering practice presents challenges that extend beyond the scope of traditional positivist assumptions, and that the increasing importance of creativity, innovation, ethical responsibility, sustainability, interdisciplinary collaboration, and contextual problem solving highlights the need for broader educational perspectives.

The paper therefore concludes that positivist orientations should not be discarded, since they provide an essential foundation for scientific and technical education. Rather, their strengths should be complemented by educational approaches that recognise the human, ethical, creative, and contextual dimensions of engineering practice. Such a balanced orientation is likely to enhance the capacity of mechanical engineering education in Nigerian universities to produce graduates who are not only technically competent but also innovative, socially responsible, and capable of responding effectively to the complex challenges of contemporary society.

8. Recommendations

On the basis of the foregoing analysis, the following recommendations are proposed. First, mechanical engineering curricula in Nigerian universities should maintain strong foundations in scientific inquiry, experimentation, and evidence based reasoning while incorporating learning experiences that promote creativity, innovation, and critical thinking. Second, engineering educators should adopt pedagogical approaches such as project based learning, design thinking, collaborative learning, and problem based learning to complement traditional laboratory and lecture methods.

Third, greater attention should be given to ethics, sustainability, entrepreneurship, and societal responsibility within mechanical engineering programmes in order to prepare graduates for contemporary professional challenges. Fourth, curriculum implementation should align with the objectives of the National Policy on Education and the Core Curriculum and Minimum Academic Standards framework while encouraging interdisciplinary engagement and contextual problem solving. Fifth, engineering education should embrace insights from contemporary philosophy of science, particularly post positivist and pragmatic perspectives, in order to promote a more comprehensive understanding of knowledge and professional practice.

Declarations

Conflict of Interest Statement

The authors declare that no conflicting interests exist.

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Author Contributions Statement

The authors were involved in the conception and design of the study, the drafting of the paper, revising it critically for intellectual content, and the final approval of the version to be published, and they agreed to be accountable for all aspects of the work.

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Ethical Approval

No ethical approval was required, as this is a conceptual paper in which there are no human participants for primary data collection.

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