

Pedagogy of Petroleum Engineering in Nigeria

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ABSTRACT

The petroleum industry in Nigeria contributes a huge percentage to the national revenue of the country, to the extent that budgets are being passed based on the oil price dynamics. With the importance the petroleum sector has attained in Nigeria, it is expected that the country's pedagogy will reflect the value it contributes to the national table. However, reviews, surveys, and works of literature have shown otherwise. As a result, this study emphasizes the importance of petroleum engineering pedagogy in-country as an oil-producing country, the university curriculum of petroleum engineering in Nigeria was also examined (with a particular focus on the impact of poor curriculum on national development), and the dynamics between the university, industry and government were critically discussed and recommended practices for improving petroleum engineering pedagogy were made. This study targets national development and control over its own resources through a knowledge economy and seamless dynamics of information within the oil and gas industry. The Nigerian government, through the Federal Ministry of Education, is further expected to capitalize on the outcomes of this research for curriculum review of petroleum engineering and related courses offered in-country to foster sustainability in a competing global society.

Keywords: Curriculum, Knowledge Economy, Local Content, Pedagogy, Petroleum Engineering, Petroleum Industry, PIA, Teaching, Triple Helix.

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I. INTRODUCTION

Nigeria is unique for its large oil and gas reserves and is one of the early regions within Africa to have discovered crude oil in its soil. These benefits have drawn foreign investors who want a piece of the oil revenues while also contributing to the development of the country's resources. Nigeria joined the Organization of Petroleum Exporting Countries (OPEC) in 1971 to strengthen its global oil trade alliance, and since then, OPEC has passed resolutions pressing its members to acquire a controlling interest in concessions owned by foreign companies (Fröhlich, 2020; Otiotio, 2020). Unlike some of her counterparts in the OPEC, Nigeria has not been able to control 100% of its oil and gas resource gains since its discovery in 1956. The Nigerian government has been involved in lots of joint ventures and production sharing contracts (Otiotio, 2020), but the question has always been asked "at what point will such heavy investments across over 90% of her proven reserves be done from the start to finish by local players". In time, technology is improving, and knowledge of its resource is spreading, but

the Nigerian petroleum engineers are still not major controllers of technical investment decisions and solutions to oil and gas challenges within the country. The assistance of foreign experts is still on the high side. This study has identified the nature of the Nigerian teaching and learning structure of petroleum engineering within her university and policies made by the federal government of Nigeria as the major cause of these shortfalls.

Drivers like the Petroleum Industry Act (PIA), Nigerian Petroleum Company Limited (NPDC), and Nigerian Content Development & Monitoring Board (NCDMB) have been put in place to encourage local participation (Amadi *et al.*, 2020; NCDMB, 2021; NNPC, 2021), but this study still finds the pedagogy of petroleum engineering in Nigeria as an issue that needs to be addressed in other for Nigerian experts to compete with global players within the oil and gas industry and gain more independence in technicalities surrounding exploration, drilling, completion, and production of Nigerian oil and gas.

Teaching petroleum engineering is both an art and science and involves humans (Sharma & Harris, 1992). It is essential,

especially in a country like Nigeria. Petroleum engineering students have often supported the art of effective teaching, especially using virtual reality (VR) and other forms of teaching that aid proper learning (Retnanto *et al.*, 2019). Because students are the future field engineers and policymakers, they can only contribute to social development to the amount that they have been taught or experienced through time. Effective teaching is essential for the present and future.

Pedagogy is perceived as the heart or the centre of teaching and learning and this is because it doesn't only rely on the transfer of knowledge but on how knowledge is transferred and what is learned (Peterson *et al.*, 2018). Teaching is very sacrosanct, and it's a major medium for transferring ideas and contents from one person to another. Knowing new approaches or improving on the existing methods are the best ways of ensuring a sustainable global future. Therefore, efficient student engagement or motivation improves with an enthusiastic tutorship, instruction style, interaction level, and industry-relevant tutorship (Aziz & Islam, 2022). It is further advised that learning should be problem-based, especially within the environment of instruction with global relevance. It also should be inquiry-based and transition with trends since researchers are constantly asking the question 'why' and looking for the best ways to unravel challenges (Aziz & Islam, 2022). Teachers should be able to disintegrate approaches into practices by understanding the mechanisms that explain how teaching practice can best achieve its effect (Peterson, 2016). The pedagogy of Petroleum Engineering in Nigeria should not be an exception. This study discusses the flaws in the teaching pattern of petroleum engineering in Nigeria and explores global best practices, upgrades, and causes of changes to help in recommending improvements in Nigeria's petroleum engineering tutorship for the purpose of producing petroleum engineers competent enough to match up against world players and improve in the petroleum industry local contents within Nigeria. The later parts of this study will discuss the petroleum engineering curriculum in Nigeria, the triple helix integration plan, and sustainability boosters for petroleum pedagogy in Nigeria.

II. NIGERIAN PETROLEUM ENGINEERING CURRICULUM

According to the structure and curriculum of the Department of Petroleum and Gas Engineering of the University of Port Harcourt, one of the foremost Nigerian institutions established by the Federal Government in the crude oil-rich city of Port Harcourt, Petroleum/Gas Engineering program requires five academic calendars of ten semesters, with nine of these semesters used for classroom studies (Chidinma, 2020). One semester is dedicated to the compulsory industrial training, and in the fifth-year students are assigned research project topics to execute. The bachelor's program in Petroleum/Gas Engineering of this institution is divided into two broad areas such as Basic Engineering Courses and Core Engineering Courses. The basic engineering courses are covered in the first two academic years and are expected to provide the students with the foundation they need in engineering before they then move to more complex courses. Courses in this category include common science, general studies, and elementary

engineering courses required for all engineering students. The core engineering courses are completed in years 3 – 5 and include more advanced professional courses within the faculty. These courses are not restricted to Petroleum or Gas Engineering alone. At the end of their year three, the students are expected to undergo a three-month industrial training, and by the second semester of their year four, a 6-month compulsory industrial training. In their final year, they are assigned research project topics and are expected to conduct necessary studies in that area (Oriji, 2019).

The Petroleum Engineering curriculum of the University of Calabar is very similar to that of the University of Port Harcourt (Udie, 2017). The University of Calabar, which is also in an oil-rich region of the Niger Delta has about 81 courses in its curriculum, with both basic engineering courses and core engineering courses. One very noticeable pattern in the curriculum is that the students are not taught petroleum engineering till their third year when they take on an introductory course to Petroleum engineering, petroleum geology, and drilling technology. This means that the students spend the first two years of their academic journey being taught other general or basic engineering courses. In addition, they are not introduced to Gas engineering till much later in their fifth year when they take on only a single course in Natural Gas Engineering (Udie, 2017).

The challenge facing the present-day Nigerian Petroleum Engineering Pedagogy is that the teachings in Petroleum Engineering schools do not reflect the exploration and production industry it serves. The present-day petroleum engineering pedagogy system in Nigeria is often outdated, and graduates are not equipped with the digital knowledge to immediately contribute when they join the industry. In addition, it also does not address the demands for sustainability, lower carbon intensity, and the need for radical productivity improvements, which are only feasible with the aid of artificial intelligence (AI) and machine learning which are the future (Feder, 2019).

III. SIGNIFICANCE OF PETROLEUM ENGINEERING PEDAGOGY

The world will always require energy, and Nigeria's economy has been predominantly centred on the petroleum industry since the late 1960s, accounting for roughly 90% of its gross earnings (Odularu, 2008). Petroleum engineering pedagogy in Nigeria should be fostered for Nigerian universities to provide world-class petroleum engineering education, research, and service. This will go a long way toward responsibly meeting the world's energy needs, as well as exceeding the evolving demands of petroleum and energy industry employers. It can be stated that the future of Nigeria's petroleum industry lies in the pedagogy of Petroleum Engineering to build the necessary infrastructure, sustain industry-leading expertise, as well as produce industrial, academic, and government leaders. The Group Managing Director of the Nigerian National Petroleum Corporation (NNPC), Malam Mele Kolo Kyari, in the Daily Trust Newspaper edition of August 27, 2021, stated that the country's infrastructural deficit remains a challenge in delivering gas to the domestic market, despite the corporation's efforts to make gas accessible to every Nigerian

within the next three years. In the light of this, according to the March 27, 2022, edition of This Day Newspaper, Nigeria's Minister of State for Petroleum Resources, Mr. Timipre Sylva, has stated that Nigeria is willing to serve as an alternate gas supplier to Europe. Sylva's call comes in the wake of Russia's war with Ukraine, which threatens to disrupt the Russian gas supply to the whole European continent. Nigeria, on the other hand, lacks the necessary infrastructure and investment to do so. Therefore, there is an urgent need to develop the necessary manpower to meet the challenges in this industry through Petroleum engineering pedagogy.

IV. CHALLENGES OF THE PRESENT NIGERIAN PETROLEUM ENGINEERING PEDAGOGY

Petroleum engineering students are at high risk if they are thought by lecturers that do not understand the curriculum goals and visions (Khoza, 2016) and this is basically what Nigeria faces. Tutors focus more on the grades of a course without emphasizing the learning outcomes and broadly ensuring the visions and goals of the curriculum are achieved. Every petroleum subject should have an aim, objective, and outcome, this promotes effective learning.

Lectures should be done in such a way that the tutor should perceive alternative possibilities of every study outcome to avoid creating a strict environment, petroleum engineers should be expressive to enable them to present inner thoughts that represent local contents. The contrary is the case in Nigeria as engineering students feel caged and respond singly to what is thought without considering broader views in some instances (Oloyede *et al.*, 2018; Subeno & Kerry, n.d.). Failure to identify the diversity of a subject and lack of motivation is also a challenge of pedagogy in petroleum engineering in Nigeria. The shortage of experienced skilled lecturers in a specific area of petroleum engineering in Nigeria cannot be overlooked as this is an issue in Nigeria, Sub-Saharan, and Africa as a whole (Jacob Ogunode & Gloria, 2020.; Mohamedbhai, 2015). Furthermore, inadequate funding, strike actions, brain drain, and inadequate classroom and lab equipment are critical challenges affecting pedagogy in Nigeria (Jacob Ogunode & Gloria, 2020).

In a study on achieving basic science and technology in Nigeria, it was discovered that kinaesthetic learning is a learning style that should be encouraged as it involves physical experiences such as practical, touching, drama, and holding (Afuwape & Olugbuyi, 2019; Njoku & Abdulhamid, 2016), although the Nigerian government tries to improve practical learning, there is a little cross-sectional improvement across the country.

In the Nigerian educational system, a lack of industry-based learning and research focus is also a key issue. Due to a lack of data, the research on real-life industry situations is inadequate (Afuwape & Olugbuyi, 2019). In Nigeria, there is a poor data-keeping tradition, and access to data is a rigorous practice. When teachers are unable to access basic information that will improve learning based on real-life industry practices unique to their environment (Afuwape & Olugbuyi, 2019), they will be unable to impact effectively, resulting in a paucity of knowledge among future petroleum engineers.

Poor inquiry-based learning: critical thinking and skill-

building are essential in teaching and learning, however, there is a severe gap in the Nigerian practice as students are being taught to fulfil basic grade point average (GPA) which is based on individual course output without a focus on how information from studies is being mixed to develop a skill in the course area. The entrepreneurial part of petroleum engineering is rarely assessed. Teachers are meant to arouse the minds of students, ponder around the “why’s”, build a unique skill over time, and point the student in the right direction while developing self-regulated learning habits for the optimum industry solution their skills could solve (Peterson *et al.*, 2018).

Poor University Lecturer training structure: Human capacity is critical; it is the foundation of petroleum engineering pedagogy (Dibiamaka & Olafinhan, 2019). Because there is no precise structure for training and growth, there is low human capacity development of petroleum engineering instructors in Nigeria. Furthermore, professional association membership, grant acquisition, industrial linkages, and global participation receive less emphasis. As a result, many skilled lecturers have left academia in search of a better feeling of belonging and greener pastures through training and funding (Dibiamaka & Olafinhan, 2019). Lastly, the challenge of improper placement for lecturers in courses they are weak at due to lack of manpower is a challenge hampering effective learning. A reservoir engineer might not be too efficient at production, and neither can a drilling engineer be too efficient at reservoir engineering. Proper placement requires tutors to teach in areas they have great interest and experience in, that way the pedagogy of petroleum engineering in Nigeria will be more efficient.

V. TRIPLE HELIX THEORY

The triple helix technique essentially applies to a series of interconnections between academia (University), the industry as well as the Government to promote the progress of a knowledge economy, and knowledge society as defined by notions like the cognitive market and spread of ideas (Carayannis & Campbell, 2010). Every section is depicted by a loop (helix) in the innovative circular structure concept featuring intersecting illustrating interconnections. The concept has progressed beyond different axis to depict greater complicated dynamics such as a cross duration. In the 90s Henry Etzkowitz and Leydesdorff published the “Triple Helix, college relationships”, which proposed the concept (Karabelas *et al.*, 2015).

The major goal of this study is to create a clear but also a meaningful link between the understanding of business and excellence in petroleum engineering education. Evidently, there is a significant link connecting tertiary institution expenditure and the development of an expertise population that is both independently innovative and competent. The majority of Nigerians are currently not wealthy in the knowledge of having the potential to develop fresh ideas which are critical for creativity (Suwandari, 2015). Primarily owing to a shortage of financing as well as support for petroleum engineering education, particularly at the higher education institutes (HEI's).

As a consequence, tertiary institutions in the area often struggled to develop enough personnel and political guidance

to assist the development of sustainable enterprises and encourage active management in the oil field (Syzdykov & Ozkan, 2019). To address this, issue the Nigerian authorities created the tertiary education trust fund (TETFund) to improve information development, distribution, and application of appropriate engineering skills.

This article will investigate the same applicability of initiatives and sequence to evaluate the effects of setting initiatives in reinforcing HEIs to end up driving the triple helix prototype in sequence to access the country's responsiveness to confront the novel global competition motivated by skills and science in the petroleum field (Bamiro, 2016).

As a result, lacking a proactive collaboration involving the authorities and HEIs cannot fulfil its breathing function in supporting the shift between an asset to an experience and understanding of society (Shamsudin *et al.*, 2015).

Realizing this will result in higher quality instruction in this discipline as well as a considerable rise in elevated studies having possibilities for copyrighted works and industrial relationships. Furthermore, this handful of learning and collaborations will inevitably spur creativity as well as support sensible plans both of which are necessary for establishing competitiveness in the hydrocarbon sector.

VI. SUSTAINABILITY PLAN

A. Petroleum Engineering Policy

Petroleum engineering policy entails the policy the government needs to put in place to ensure that petroleum engineering courses are sustained while its long-term impact in practice is felt on the economy. On July 19, 2017, Nigeria's Federal Executive Council approved the National Petroleum Policy (NPP or the Policy), which lays out a vision for the country to become a country "where hydrocarbons are utilized as a fuel for national economic growth rather than simply as a source of revenue" (KPMG, 2017). Policies formed need adequate technical capability for effective implementation. How well the host government defines and implements sector policies, institutional frameworks, legal and regulatory frameworks, contractual and fiscal regimes, and revenue sharing will influence how well petroleum resources are translated into social welfare improvements (Hurdeman & Rozhkova, 2019). Through the ministry of education, the government can implement policies that review the petroleum engineering curriculum to reflect the current happenings in the industry. Special industrial attachment slots for petroleum engineering students should be available in various companies within the value chain of the petroleum industry. Special funds for field visits and research & development (R&D) should be created and easily assessed by the students/faculty members so as to aid technology development and move the country to a high pedestal.

B. Energy Transition

Energy transition simply refers to the transformation of the global energy system from fossil-based to zero-carbon by the second half of this century (IRENA, 2022). The need to cut energy-related CO₂ emissions to limit climate change is at its core. The energy transition is a crucial enabler of sustainable development and climate resilience with IT, smart

technologies, market instruments, and policy frameworks being its enablers (United Nations, 2021). This transition is built around three all-encompassing key pillars which are power sector transformation knowledge, energy systems models and data, and energy planning support. Green energy is a crucial step toward achieving climate neutrality and a response to the difficulties of climate change. Renewable sources of energy generation play a key role in achieving carbon neutrality. It will be difficult to meet the Paris Agreement's 1.5-degree target without a global energy sector change (IRENA, 2021). The energy transition is part of a plan for a sustainable energy future, forward-thinking industrial development, social inclusion, and human wellbeing. This is crucial to achieving SDG 7 – affordable and clean energy i.e., to ensure that everyone has access to affordable, reliable, sustainable, and modern energy. Core to the teachings of petroleum engineering today is energy transition, and engineers in training should be open to alternative sources of fossil fuels for energy with the aim to achieve sustainability.

C. Software Development

Petroleum engineering in most oil corporations across the world focuses on maximizing cost-effective field production (LSBU, 2022). To achieve this, a variety of key software programs needs to be used to measure the effectiveness and efficiency of oil and gas production daily. In a study by (Elochukwu *et al.*, 2013), it was discovered that key areas of petroleum engineering where software skills are needed for effective teaching and learning in drilling engineering, production engineering, formation evaluation, and reservoir engineering. In existence for use are software such as HYSYS, PETREL, Eclipse, Prosper, GAP, etc. With the advent of smart technologies such as AI and rampant knowledge of programming language, petroleum engineering graduates through creativity and understanding of the petroleum technology system can build industry-relevant software to solve the daily challenge encountered in the field. It was opined that the development of such software should follow the Interactive Process Scheduler (IPS) model for an easy build as this will help to give relevance to the petroleum industry (Browning *et al.*, 1985). The core of the IPS model approach is to ensure reliability, maintainability, comprehensibility, and flexibility. The Nigerian petroleum engineering modules should be inculcated to include software development as this is one of the key futures of petroleum production and field assets management in Nigeria.

D. Patent-Produce-Publish (3Ps)

The production era of the current age we are in now is known as the knowledge economy (Unger, 2021) characterized by the possession of intellectual property. The knowledge economy is an economy in which knowledge is valued as a source of competitiveness, science, research, technology, and innovation are more important in knowledge creation, and computers and the internet are used to develop, exchange, and apply knowledge (De Souza *et al.*, 2008.). According to World Bank, the four pillars of the knowledge economy critical for the participation of any organization or country are education and training, innovation systems, information infrastructure, economic incentive & institutional regime (The World Bank, 2013). It is therefore important to protect such intellectual properties, and this can

be done through patenting. A patent is an exclusive right awarded for an invention, which is a product or a technique that offers a new technical solution to a problem or provides a new way of doing something in general (WIPO, 2022). When a new idea or process or method or product is developed, patenting helps to keep the knowledge exclusive to the patent owner in the event of commercial production except permission is sought from the patent owner. A patented idea should be published in a globally recognized and reputable journal to bring other the global community to the awareness of such inventions (Stellenbosch Business School, 2018). Other reasons include assurance that we leave a documented legacy of our discoveries and accomplishments for future generations (Peh & Ng, 2008), gain a reputation among our colleagues, and stay updated on the latest research (Monteiro *et al.*, 2012).

E. Local Content

The petroleum industry has seen substantial structural changes during the last 40 years (Kazzazi & Nouri, 2012). Changes range from technological advancement to an increase in the number of skilled workers, to environmental policies, and other policies of which local content development has been part. Local content has been a major game-changer with its objectives being to promote in-country value, retain more spending in the country, and get more locals involved (NCDMB, 2020b). Local content policies differ greatly from country to country (NRGI Reader, 2015). One of the pillars of local content in Nigeria is “Technical Capability Development which aims to extend and deepen in-country technical capability in the oil and gas industry (NCDMB, 2020a). This capacity building is dependent on the methodology of instructors teaching petroleum engineering and related courses to ensure that locals are trained to a level to be employed in high-value-added activities in the industry. In addition to the capacity building is a need for research and development that will drive local technology.

F. Virtual Learning

COVID -19 has changed the face of education in so many ways. As a result, education has undergone significant transformations, with the rise of e-learning, in which education is transmitted electronically and via digital platforms (Li & Lalani, 2020). The use of information and communications technology (ICT) to enhance and/or support learning in tertiary education is referred to as e-learning (OECD, 2005). This, however, encompasses a wide range of technologies, from students using e-mail and accessing coursework online while taking a course on campus to completely online programs. The future of education is virtual learning. With this, there is a need to think more carefully about a range of concerns, from design and quality to ethics and economics, because online courses have a real chance of becoming the dominating informative platforms of the future (Westbrook, 2007). Virtual learning is viewed as the catalyst that would propel learning; as a result, it should become an integrated part of tertiary education in Nigeria (Whyte & Tonye, 2020). The advantages of virtual learning are access to ever-expanding databases of e-texts, bibliographies, and links to important holdings in university libraries throughout the world, online courses have the potential to considerably boost the possibilities for affordable

and quick research (Westbrook, 2007). There is a low acceptance rate of virtual learning by students in tertiary institutions in Nigeria (Egielewa *et al.*, 2021). This is mainly due to a lack of access to power and internet connections. Thus, all tertiary institution is to install these two infrastructures (Electricity access and internet connection) and maintained them accordingly. By so doing, we are assured that the delivery of petroleum engineering classes will be seamless and all-encompassing.

VII. CONCLUSION

In conclusion, this study has highlighted the challenges of petroleum engineering pedagogy and teaching in general in Nigeria, and the reviews and findings have revealed that there are significant setbacks within the tertiary mix that hinder the production of expert petroleum engineers, one of which is the lack of adoption of the triple helix theory, incompetency of lecturers, lack of funding, lack of schemes designed to follow global trends, stunted learning cues that limit students from being more expressive, wrong curriculum structure, lack of training for lecturers, poor software development initiatives, struggling local content acceptance and most of all relevant law to influence a knowledgeable economy. The shortcomings should be recognized and addressed so that Nigeria develops adequate engineering capabilities to self-drive its resources in the future, similar to other oil-producing countries, to the point of exploring beyond its borders.

VIII. RECOMMENDATIONS

The Nigerian petroleum curriculum should be able to offer relevant courses in Engineering as well as introduce students to the Petroleum industry much earlier in their academic journey, instead of during their third academic year. In addition, relevant digital skills used in the industry should be taught in the classroom to ensure that students can immediately contribute when they join the industry.

Installation of key infrastructures such as electricity access means and internet connection be done on campus to ensure the efficiency of virtual learning.

Encourage all students to inform their faculty about a novel finding made during research, this is to ensure a fast track of the process of patent and publication.

Nigeria should apply the theory of the triple helix in promoting a knowledge economy within its society.

With a focused commitment to local content development and in-country addition, students/graduates of the petroleum engineering department can be taken on the key role of R&D in the industry and thus arouse their interest and have the possibility of producing a new idea that can be patented.

Petroleum engineering pedagogy indicates the importance of the educational process in preparing the next generation of engineers to meet the industry's needs.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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