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## ENHANCING NIGERIAN EDUCATIONAL CURRICULUM DEVELOPMENT FOR DATA SCIENCE AND ANALYTICS: CHALLENGES AND PROSPECTS

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### ABSTRACT

*The rate at which data science education is increasing requires curriculum frameworks that reconcile technical rigor with pedagogical effectiveness within Nigeria's unique educational and socio-economic context. This article incorporates findings from structured reviews, empirical studies, and institutional case samples from Nigerian universities, government programmes, and industry partnerships published between 2020 and 2025. Analysing TPACK, Cognitive Apprenticeship, and project-based learning models, it identifies main dimensions of effective curriculum design which include: authentic, process-oriented learning; vertical alignment from secondary to postgraduate study; ethical reasoning; and industry collaboration. Findings reveal that while Nigerian institutions have demonstrated innovation through early-year coding programmes, innovation hubs, and large-scale upskilling initiatives, like the 3MTT, significant gaps still exist in empirical research on pedagogy, assessment methodologies, teacher preparation, and infrastructure. The study concludes with evidence-based recommendations for curriculum designers, researchers, and policymakers to further data science education as a coherent, context-responsive discipline in Nigeria.*

**Keywords:** Data science education, curriculum development, Nigerian higher education, project-based learning, workforce readiness, assessment strategies

## INTRODUCTION

Data science, according to National University (2025) is "an interdisciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from structured and unstructured data. It integrates statistics, computer science, and information science to analyze and interpret complex data." By implication, data science does not belong to any particular genre of science, rather it is more of a hybrid or applied interdisciplinary science which combines the Mathematical sciences (statistics, probability, mathematical modeling), Computational **sciences** (programming, algorithms, machine learning, big data platforms) and Information sciences (data management, databases, information systems).

Data science has emerged as a transformative academic and professional field, integrating statistics, computer science, and domain-specific applications to extract knowledge from structured and unstructured data (Donoho, 2017). In Nigeria, there is the high demand for data-literate professionals, driven by glaring digital transformation in the banking, telecommunications, health, agriculture, and e-commerce, subsectors. Consequently, many Nigerian universities and polytechnics have begun to introduce data science programmes, certificates, and other embedded analytics courses.

Globally, there is an increase in undergraduate data science majors, and Nigeria inclusive. For instance, the adoption of data science in Nigerian tertiary institutions is evidenced in following among others:

- i. the global rise in undergraduate data science majors, mirrored in Nigeria;
- ii. NUC's encouragement of STEM curricula, leading to new data science, AI, and cybersecurity departments (Pulse Nigeria, 2025); and
- iii. empirical evidence from Daya et al. (2025) on predicting at-risk students at CAMTECH Potiskum
- iv. Anierobi & Jisieike (2025) on AI integration challenges and prospects – both of which provide convincing support for adopting data analytics across Nigerian polytechnics.

STEM education is gaining grounds rapidly in Nigeria. Many schools have already incorporated more science labs, computer rooms, and robotics classes, etc., with organizations like EduFun Technik are complementing their efforts by creating special STEM programs for students. While emphasizing on its important, former Minister of Science and Technology, Dr. Ogbonnaya Onu, cited in Edufun Technik (n.d., para. 8), *"Our nation cannot develop without proper education in science and technology. STEM education is the foundation upon which Nigeria will build its technological future."*

Avila-Garzon and Bacca-Acosta (2025) observed that "data science education is an interdisciplinary and multidisciplinary field, with curricula continually evolving to meet societal needs" (p. 2). In Nigeria, this evolution is further shaped by the need to address local content – including indigenous languages, agricultural data, public health surveillance, and fintech innovation – with the mindset of preparing graduates for global competitiveness. The major challenge before Nigerian curriculum designers is to synthesize international best

practices with local realities, producing graduates who can think critically about data, understand end-to-end workflows, and steer ethical consequences.

### **Problem Statement**

Despite growing interest, Nigerian data science curricula remain disjointed and often introduced from Western contexts without adequate adaptation to local realities. In the same vein, there is no national consensus on foundational competencies, pedagogical frameworks, or assessment methodologies (De Veaux et al., 2017). More so, many programmes rely on theoretical lectures with limited hands-on projects, resulting in a “process deficit” (Brattin, 2025, p. 1130) where students learn fragmented technical skills but cannot apply them within structured, real-world situations.

Other problems include:

- i. Infrastructure deficits: Insufficient computers, licensed software, and stable internet.
- ii. Teacher preparation: Most lecturers in Nigerian tertiary institutions lack formal training in data science pedagogy or modern analytics tools.
- iii. Industry-academia gap: Few formal partnerships with the growing tech ecosystem (e.g., Andela, Flutterwave, Paystack) to provide internships, project supervision, or equipment.
- iv. Outdated curricula: Slow curriculum review processes that cannot keep pace with rapid technological change.

These problems if left unaddressed will broaden the skills gap, leaving Nigerian graduates underprepared for both local and global data-driven economies.

### **Objectives of the Study**

The main objective of this study is to enhance understanding of how educational curriculum development for data science and analytics can be improved within the Nigerian context, while maintaining rigor, relevance, and pedagogical effectiveness. In specific, the study aims :

- i. To bridge theoretical frameworks with practical implementation in data science curriculum design for Nigerian institutions.
- ii. To identify transferable best practices from within Nigeria and, where relevant, from other African contexts, that can inform local curriculum development.
- iii. To highlight Nigeria-specific adaptations addressing local languages, resource constraints, and societal challenges (e.g., agriculture, health, finance).
- iv. To provide actionable insights for curriculum designers, educational researchers, and policymakers working in Nigeria’s varied socio-economic and cultural settings.

### **Research Questions**

The general question we intend to answer in this study is: How can educational curriculum development for data science and analytics be enhanced to meet the needs of diverse Nigerian learners while maintaining rigor, relevance, and pedagogical effectiveness? We intend to achieve this by proffering answers to the following:

- i. What pedagogical frameworks are currently applied in data science education within Nigerian institutions, and how can they be strengthened?
- ii. How do curriculum development approaches differ across Nigeria’s secondary, undergraduate, and graduate levels, and what can be learned from these differences?
- iii. What persistent challenges and knowledge gaps exist in Nigerian data science curriculum development – particularly regarding infrastructure, teacher preparation, and industry alignment?

- iv. What evidence-based recommendations can be formulated for Nigerian curriculum designers, researchers, and policymakers?

### **Significance and Scope**

This study contributes to the growing scholarship on data science education by focusing exclusively on Nigeria which still is under-represented in curriculum development literature, especially in data science and other novel areas of global knowledge. The scope covers formal educational settings from secondary (senior secondary schools, polytechnics and universities). It also involves professional training initiatives such as the 3MTT (3 Million Technical Talent) programme and private sector bootcamps.

### **Methodology**

This study adopts a narrative synthesis approach, integrating findings from systematic literature reviews, empirical studies, theoretical papers, and institutional case samples from Nigerian universities (e.g., University of Lagos, Obafemi Awolowo University, Federal University of Technology Minna, Covenant University), government initiatives (NUC, NBTE, 3MTT), and industry reports published between 2020 and 2025. Sources were identified through searches of academic databases (ERIC, Scopus, Google Scholar) and Nigerian institutional repositories using keywords such as “data science education Nigeria,” “curriculum development in Nigeria,” “pedagogical frameworks,” “Nigerian higher education system,” and “STEM education in Nigeria.” Additional sources include news reports from *Pulse Nigeria*, *The Guardian Nigeria*, and *Daily Nigerian* that document innovative practices in Nigerian educational subsector.

### **Defining Data Science as a Disciplinary Field**

Donoho (2017) identified six foundational divisions of data science which include: data exploration and preparation, representation and transformation, computing with data, modeling, visualization, and meta-science. In the Nigerian context, these divisions must be taught with attention to locally relevant datasets (e.g., agricultural yields, mobile money transactions, disease surveillance) and limited computational resources. Rosenberg (2025) noted the fragmentation of data science education literature into undergraduate, K-12, and computational approaches – a fragmentation that also appears in Nigeria, where data science is often housed in computer science or statistics departments without integrated curricula.

### **Evolution of Data Science Curricula in Nigeria**

Avila-Garzon and Bacca-Acosta (2025) documented global growth of data science programmes. In Nigeria, the evolution has been driven by the National Universities Commission’s Benchmark Minimum Academic Standards (BMAS) for computer science, which now include data analytics and machine learning components. However, many institutions still rely on foreign textbooks and case studies that do not reflect the realities of the Nigerian data environments. Thus, the main challenges remain: “creation of up-to-date and competitive curricula, integrating data science training at early educational stages, leveraging data-driven technologies, and defining the profile of a data scientist” (Avila-Garzon & Bacca-Acosta, 2025, p. 3).

### **Competency Frameworks and Nigerian Context**

According to ACM (2021) competency framework and the National Academies (2018) six competencies provide useful reference points. However, Brattin’s (2025) critique of the “process deficit” (lack of structured workflows) is particularly related in Nigeria, where many graduates know Python or R but have never completed a full CRISP-DM cycle on a real

organisational problem. Hence, Nigerian curriculum designers need to integrate process-oriented frameworks like CRISP-DM alongside technical competencies.

### **Edagogical frameworks for data science education in Nigerian**

#### **Tpack framework**

Memarian and Doleck (2024) applying the Technological Pedagogical Content Knowledge (TPACK) framework to data science education, observed that it is seldom used. In Nigeria, TPACK is principally valuable because while lecturers often have strong content knowledge (statistics/computing), they have weak technological knowledge (modern cloud tools, version control) and pedagogical knowledge for active learning. Hence, curriculum development must include training lecturers to integrate technology profoundly.

#### **Cognitive Apprenticeship and Authentic Learning**

Cognitive Apprenticeship (Collins, Brown, & Newman, 1989) emphasises modelling, coaching, scaffolding, and reflection. Nigerian programmes that adopt this model – like those that have industry mentors and project-based capstones – have shown better products. Students mostly learn by working on real problems (e.g., predicting customer churn for a telecom, optimising fertiliser distribution). This approach no doubt, directly addresses the theory-practice gap.

#### **Project-Based Learning Models**

The ADAPT model (NC State Data Science and AI Academy, 2025a, 2025b) provides a structured milestone approach. Nigerian institutions can adapt this by using locally hosted platforms (e.g., JupyterHub on university servers) and offline-capable tools. Milestones such as data selection, exploration, analysis plan, and storytelling mirror typical industry workflows.

#### **Connected Learning and Local Relevance**

Herro, Adisa, and Abimbade (2025) showed that connected learning – linking curricula to student interests and local realities – improves engagement. In Nigeria, this means using datasets from the National Bureau of Statistics, NITDA, or health records (with privacy safeguards). For example, students can analyse traffic accident data from Lagos or agricultural price fluctuations from the Nigeria Commodity Exchange. Such relevance fosters deeper learning and societal impact.

## **CURRICULUM DEVELOPMENT ACROSS EDUCATIONAL LEVELS IN NIGERIA**

### **Secondary School Data Science Education**

Rafiepour and Fadaee (2025) noted that data science changes should target mathematics, statistics, and computer science. In Nigeria, initiatives like the University of Nairobi's Data Club (a model) could be replicated. However, most secondary schools lack computers and trained teachers. The government's digital skills programmes (e.g., NITDA's National Digital Literacy Framework) are starting to address this, but curriculum integration remains weak.

### **Undergraduate Data Science Education in Nigeria**

Nigerian universities have shown significant innovation. According to Pulse Nigeria (2025):

- University of Lagos requires all first-year students to complete a Python and electronics fundamentals course.
- University of Ibadan offers mandatory IoT prototyping workshops.
- Federal University of Technology Minna and Covenant University have launched dedicated schools of data and cybersecurity.

- Obafemi Awolowo University's Centre for Embedded Systems Development provides weekly mentorship clinics.
- Afe Babalola University hosts hackathons at its innovation centre.
- Pan-Atlantic University's Lagos Business School runs executive bootcamps with global fintech partners.

These examples demonstrate that undergraduate curriculum enhancement is possible, but scaling these efforts to all 170+ Nigerian universities remains a challenge.

### **Graduate and Professional Education Initiatives**

The government-led 3 Million Technical Talent (3MTT) programme, in collaboration with Data Science Nigeria and Google.org, launched the DeepTech\_Ready Upskilling programme (January 2025). It aims to train 20,000 Nigerians in Advanced Data Analysis, Machine Learning, Data Architecture, Geospatial Data Science, Computer Vision, NLP, and Mathematics. The 6-month curriculum includes self-paced learning, on-site support, project immersion, and job placement (Federal Ministry of Communications, Innovation and Digital Economy, 2025). Dr. 'Bosun Tijani called it "a tangible realization of our collective vision to position Nigeria at the forefront of the global digital economy" (p. 2).

In the private sector, the National Digitisation Initiative by NCDMB, Seplat Energy, and 3logy Limited targets youth in Northern Nigeria, equipping them with digital and data analytics skills for the oil and gas sector and broader digital economy (Daily Nigerian, 2025). Managing Partner Nasiruddeen Yakubu noted that "Northern Nigeria has an abundance of talent" and the programme aims to unlock that potential.

### **Teacher Education and Professional Development**

Herro et al. (2023, cited in Herro et al., 2025) found that co-design professional development increases teacher self-efficacy. In Nigeria, The Sanguine Academy's Data Analysis Masterclass at the University of Ibadan provided practical instruction on research data analysis, digital tools for academic work, and analytics in business and education (The Guardian Nigeria, 2025). Academy founder Adewale Stephen Olabamiji emphasised that "students and young professionals must see data as a language of innovation" (p. 2). However, such masterclasses are sporadic; systematic, ongoing teacher training is lacking.

### **Addressing the Theory-Practice Gap in Nigeria**

#### **The Process Deficit**

Brattin (2025) identified that academic frameworks over-emphasise technical skills while neglecting structured workflows. Nigerian students may learn to use scikit-learn but not how to frame a business problem, clean messy data, collaborate on Git, deploy a model, or monitor it in production. Curriculum designers must embed process-oriented learning (e.g., CRISP-DM, TDSP) throughout.

### **Work-Integrated Learning and Employer Partnerships**

Nigerian institutions are building partnerships: Federal University of Technology Owerri with Siemens, Pan-Atlantic University with global fintech firms, and the 3MTT programme with industry for internships and projects (Pulse Nigeria, 2025; Federal Ministry of Communications, Innovation and Digital Economy, 2025). These partnerships expose students to authentic workflows and keep curricula current.

### **Capstone Experiences**

Capstone projects using real-world Nigerian datasets (e.g., from the Nigeria Living Standards Survey or open data portals) are essential. Data Science Africa's summer school model – hands-on projects with real datasets – should be adopted by Nigerian universities. The ADAPT milestone approach can be implemented even with limited infrastructure by using collaborative notebooks (Google Colab, Kaggle) or local Jupyter.

### **Pedagogical Tools and Technological Knowledge**

Memarian and Doleck (2024) noted that most studies fail to explain how students learn to use tools proficiently. In Nigeria, curriculum must explicitly teach tool usage: Python, R, SQL, Git, Docker, cloud basics (AWS/Azure free tiers), and data visualisation (Tableau/Power BI). Assessment should include practical examinations where students complete milestones using these tools.

### **Context-Appropriate Tool Selection**

Given infrastructure constraints, Nigerian educators should select tools that work offline or with low bandwidth. Options include RStudio (local), Jupyter Notebook (local), SQLite, and offline-first platforms. Data Science Africa's focus on "deploying AI in resource-constrained environments" (Data Science Africa, 2025, p. 2) is directly relevant. The University of Nairobi's Data Club model of providing specialised resources and mentorship can be replicated with support from Nigerian tech hubs.

### **Assessment Strategies**

Traditional exams are insufficient. Nigerian programmes should adopt milestone-based rubrics (ADAPT model) that assess data selection, cleaning, analysis, visualisation, and communication. Formative assessment through regular code reviews and peer feedback is critical. The Sanguine Academy's emphasis on practical application (The Guardian Nigeria, 2025) should become standard.

### **Diversity and Inclusion**

Nigeria has significant gender and regional disparities in technology education. Lagos State University runs a "recruit-and-train scheme for female engineers" (Pulse Nigeria, 2025, p. 4). The National Digitisation Initiative targets Northern youth, addressing regional exclusion (Daily Nigerian, 2025). Curriculum designers should deliberately include diverse case studies, ensure accessible learning materials, and promote female participation through scholarships and mentorship.

### **Challenges, Gaps, and Future Directions in Nigeria**

The integration of STEM in the curriculum is aimed at providing foundational knowledge and also to foster relevant skills such as problem solving, creativity and computational thinking (Tan et al. 2023), Shahbazloo and Mirzaie 2023; Wang et al. 2024). Yet, unlike well-funded European or North American organizations, Nigerian educators face unique challenges: unreliable electricity and internet connectivity, limited access to modern computing infrastructure, large class sizes, and a significant gap between academic curricula and industry needs.

Similarly, Anierobi and Jisieike (2025), seven major challenges that the integration of artificial intelligence (AI) into Nigeria's polytechnic education sector faces. They are:

- i. inadequate digital infrastructure (outdated labs, poor internet, unreliable power);

- ii. low digital literacy among staff and students (fewer than 30% of lecturers have formal AI training);
- iii. severe funding constraints;
- iv. absence of a comprehensive policy framework and accreditation standards;
- v. resistance to change due to fears of job displacement;
- vi. cybersecurity and data privacy risks;
- vii. and inequitable access that widens the digital divide

### **The Need for Empirical Research**

Johnson et al. (2025) found that much data science education literature lacks empirical rigour. In Nigeria, there are near no published empirical studies on the efficacy of a particular pedagogical method (e.g., project-based learning vs. traditional lectures) in local institutions. There is the urgent need to fill this gap through funded educational research.

### **Teacher Preparation and Professional Development**

The co-design model (Herro et al., 2025) is encouraging but needs scaling. Nigeria requires a national programme to train data science and other related tertiary educators in TPACK, active learning, and modern data science tools. The 3MTT programme could be also extended to incorporate “train-the-trainer” components to reach out to a larger number of people.

### **Future Directions for Nigeria**

- i. National Data Science Curriculum Framework: NUC and the NBTE should develop flexible, competency-based frameworks that could allow institutions to adapt to local industry needs while upholding core standards.
- ii. Investment in Infrastructure: Government and private sector (e.g., telecoms) should subsidise computer labs, offline learning resources, and solar-powered internet to make them more affordable.
- iii. Industry-Academic Exchange: Mandate paid internships for final-year students in Nigerian universities and polytechnics and adjunct industry lecturers.
- iv. Ethics and Local Content: Include compulsory modules on Nigerian data protection, indigenous language processing, and culturally conscious AI.
- v. Assessment Reform: Adopt portfolio-based and milestone-based assessment across all data science programmes.
- vi. Teacher Fellowships: Establish a Data Science Education Fellowship for lecturers of data science to spend one year in industry or advanced training.

### **CONCLUSION**

Enhancing Nigerian educational curriculum development for data science and analytics requires a multi-dimensional approach: adopting pedagogical frameworks that support authentic, project-based learning; aligning academic preparation with industry workflows; addressing the full educational spectrum from secondary to postgraduate; selecting context-appropriate tools with explicit training; and embedding ethics, diversity, and social responsibility.

Nigerian institutions have already demonstrated innovation – from first-year Python at UNILAG to the 3MTT national upskilling programme. However, significant gaps remain. For instance, empirical research on pedagogy is almost non-existent, there is inadequate teacher preparation, lack of infrastructure, and persistent process deficit. These challenges are not insuperable. What is just needed is a collaboration among educators, researchers, industry

partners (e.g., Andela, MTN Nigeria, Paystack), and policymakers (NUC, NBTE, NCCE, NITDA). Investment in teacher training, research, and equitable access will no doubt ensure that Nigerian students are not merely consumers of data science tools but creators of solutions for local and global challenges. As data science and AI continue to advance, Nigerian curricula must remain dynamic, evidence-based, and deeply rooted in the nation's diverse realities.

## Recommendations

To adequately enhance data science curriculum development in Nigeria, the following steps are recommended across different stakeholder:

- i. Curriculum designers should combine a process-oriented frameworks (e.g., CRISP-DM) with technical skills; design progressive, milestone-based technology skill development; use locally relevant, real-world datasets (e.g., NBS, health, agriculture); set in ethics and Nigerian data protection principles across all courses; create modular curricula that allow annual updates; formalise partnerships with Nigerian tech companies for projects and mentoring; and address regional.
- ii. Educational researchers such as Institutional Based research (IBR) should focus on conducting empirical studies aimed at comparing pedagogical approaches in Nigerian classrooms; develop and validate context-appropriate assessment tools (e.g., offline rubrics); examine technological learning paths under resource-constrained conditions; investigate scalable models for teacher professional development; and publish findings in open-access journals to inform policy.
- iii. Policymakers (NUC, NBTE, Ministry of Education, NITDA) should launch a national Data Science Pedagogy Training Programme for teacher preparation; provide fund for data science education research through TETFund and other agencies; offer tax incentives to companies that host interns or donate equipment; promote equity with scholarships for female and rural students and support for disadvantaged universities; establish comprehensible pathways from secondary data literacy to postgraduate study level; and recognise data science as an interdisciplinary field in accreditation and funding.

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