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Telling Half a Story: A Mixed Methods Approach to Understanding Culturally Relevant Engineering Education in Nigeria and the U.S.

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Abstract

Nigerian students account for more than a quarter of all African students in the US, having just recently overtaken Mexico as the United States' 9th highest source of international students. These huge numbers, however, have not necessarily translated into seamless transitions for students who still have to cope with cases of systemic racism, discrimination, and microaggression. While schools boast of diversity and their promise of inclusion and equity continue to successfully attract these students, how might they deliver on these promises and actually create environments where these students feel prepped for success? I argue that the answer may lie not in the US, but in their home countries, by investigating the principles of culturally relevant pedagogy (CRP). This paper shares emerging insights from ongoing research investigating how engineering educators might provide culturally relevant engineering education to Nigerian and Nigerian International students. On the broader research project, a comparative case study using explanatory sequential mixed methods was designed surrounding engineering education in Nigeria and the US. This work-in-progress paper tells half of the story, focusing primarily on the emerging results in Nigeria. It contributes to the broader project by answering the following research questions: what are the conceptions of engineering educators in Nigeria and how do culturally relevant engineering educators support their engineering students in Nigeria? The paper leverages the socio-psychological teacher conceptions described by Gloria Ladson Billings' CRP framework (conceptions of knowledge, of social relations, and conceptions of the self and others). Schools located in all six of Nigeria's geopolitical zones and participants fluent in her three major spoken languages are represented in the study. The analyzed data for this study include surveys, in-person and virtual classroom observations, teacher reflection journals, classroom artifacts, school policy documents, and semi-structured interviews with 37 engineering faculty members, 2 provosts, 5 engineering college deans, and 2 students. The findings reveal a strong leaning for analogies and proverbs as analogical bridges engineering instructors in this context used when traditional experiments, classroom demonstrations, or local educational resources failed. Nuances of culturally-relevant teacher conceptions are discussed in light of CRP: using proverbs to build cognitive reasoning in Nigerian engineering classrooms; visual and auditory cues as a form of formative feedback; analogies as a pedagogical form; advocating for active and authentic learning through tutorials; leveraging the communal nature of the culture in the classroom; colonial antecedents responsible for certain school policies; manifestations of Ladson-Billings' conceptions in this context; peculiarities of the three CRP criteria in this context. To fit within the scope of this paper, only two themes are extensively discussed. The paper concludes with useful suggestions for instructors looking for culturally relevant ways of supporting students of Nigerian students in their engineering classrooms.

Introduction

In 2021, the United States maintained its reputation as a destination of choice for international students around the globe. Despite a decrease in the enrollment rate of new international students by 34% for undergraduates and 45% for graduates compared to 2019/2020, close to 1 million students still chose to come to the US for their education [1]. More than 80% of these students are pursuing advanced degrees in STEM [2]. Why has the US been able to attract so many international students into STEM for higher education? Several reasons have been suggested in the literature - the availability of state-of-the-art research labs, opportunities to embark on ground-breaking research, the presence of highly qualified researchers, and the benefits of working with intellectuals from other parts of the world [3]. It is humbling to observe from the literature that "inclusivity" and the "presence of better educators" are not commonly cited reasons why international students come to the US for higher education [4], [5].

The presence of international students is often described in terms of its socioeconomic benefits to the host countries [6], but this perspective often cloaks the associated nuances of studying abroad. One commonly cited statistic on this topic is that international students contributed more than $45 billion of revenue money to the United States within one calendar year [7]. Yet, other studies have attempted to expound on the benefits of developing interculturally competent graduates through the interactions between domestic American students and their international peers [8]. International student populations also serve as the bridges between host and home nations, fostering international relations, building social understanding and intercultural competence that could be the very difference between war and peace, employability and joblessness, open-mindedness, and misogyny. It stands to reason, therefore, that successfully attracting international students to the United States for higher education is only half the tale. I argue unequivocally that the commitment to diversify and attract international students to US institutions must be followed by a clear understanding of what it takes to support said students.

On a purely quantitative scale, Chinese and Indian International students far outnumber all other international students in the US at both undergraduate and graduate levels [9]. Justifiably, studies that attempt to understand and support "international students" have had more traction focusing on Chinese and Indian students, outnumbering studies involving students from other countries [10], [11]. While this work builds on previous studies to improve the likelihood of the success of international students in engineering in the US [12], [13], it also problematizes the generalization. Using a generic term like "international" glosses over the many subtle, complex, and varied differences that exist between and even within subclasses of international students. Consequently, this paper focuses on a subset of international students – it briefly discusses the literature surrounding the experiences of African international students, who, in addition to the many challenges faced by their domestic African American peers also struggle with language and culture shifts, conflicting worldviews, and value-based discriminations [14].

The presence of African internationals in the US presents a unique opportunity to uncover their academic experiences in the US relative to their home countries, particularly in a field like engineering that has such a huge potential for national development [15], [16]. A few studies have attempted to do so [17]. A recent collaborative autoethnography study involving nine diasporan African doctoral students and scholars in engineering education revealed several challenges that diasporan Africans experience while navigating their engineering education programs in the US [18]. Participants of the study discussed their experiences with social disconnectedness, uncertainty regarding residency/post-graduate employment, excessive workloads in the US compared to their home countries, differences in assessment philosophies, and a challenging work-

life balance. These findings are consistent with the literature surrounding the experiences of international students in the US [17], [19], [20].

Yet, the amount of work that remains undone is staggering. While acculturation studies have expanded the literature, there is still a lot of room for comparative cross-national studies. This paper calls for more nationally based comparative studies that consciously appraise the systemic factors associated with Western Engineering Education and African Engineering Education. This is a seldom researched area of study and is one of the motivations for this study. Highlighting how African teachers provide culturally relevant teaching to their students is intended to improve decolonized engineering education in Africa. Insights into how to support African students using culturally relevant pedagogy (CRP) will improve the likelihood of the academic success of these students and better inform their teachers in non-African contexts about how to support them. One could be forgiven for hoping that African students who travel outside the shores of their countries for education need not sacrifice their indigenous cultures on the proverbial altar of academic and professional legitimacy.

Positionality

Researcher positionality unveils the social, historical, and cultural views that researchers bring with them to their various research endeavors [21]. These factors are never fixed, are constantly evolving, ever-present in research, even if they are implicit or not easily discernible to others [22]. Rather than deny the existence of these factors, I invite the reader to consider mine from an experiential, developmental, and situational standpoint. My methodological framework for this study starting from my topic of interest, choice of culturally relevant pedagogy as a theoretical framework, comparative case study as the analytical framework, purposive selection of teachers and students as participants for my study, even the tenor of my voice on paper, have all been influenced by my experiences and worldview. These include my research and firsthand experiences as a Black, male, heterosexual African student studying in a predominantly white institution in the midwestern part of the continental US.

My educational experiences in Nigeria convinced me that regardless of the extenuating circumstances, exceptional educators find a way. Engaging in local capacity development projects in the US has further strengthened my conviction that research and teaching should always aim to be culturally sensitive. As an international student in the US, I have had to navigate multiple challenges on various philosophical axiological, ontological, and epistemological fronts. Thus, I actively push back against covert or overt attempts to view my culture as less than or as invaluable in my attempts to understand the world around me and solve the problems that matter to me. The choice of Nigeria as the context for this study also serves a utility function. Despite being one of over 50 countries on the African continent, recent statistics show that relative to the total population of African international students in the US, 1 out of every 4 African international students in the US is from Nigeria [1]. Thus, because of the possibility and availability of collecting data involving Nigerians and my personal educational experiences in both Nigeria and the US, this paper focuses primarily on African students of Nigerian descent.

Literature Review

This section illuminates a few foundational issues related to postcolonial education in sub-Saharan Africa. It introduces the works of Gloria Ladson Billing's theory of culturally relevant pedagogy discussing the premise that her work provides for this ongoing research. Recent articles that have

discussed CRP in engineering education are mentioned and a conclusion is provided concerning the gaps that exist and how this paper contributes to the literature.

The Argument for Decolonized Engineering Education for SSA

Since the early 1960s, Sub-Saharan African education has gone through multiple rounds of mass decolonization chronicled in national and sub-regional commitments to indigenous approaches to education in an era of postcolonialism [23]–[25]. Yet, certain scholars argue that the decades have only created a pseudo/neocolonial era rather than a truly postcolonial era [26], [27]. Consequently, one of the fundamental concerns that has remained over time is the concept of 'brain drain' [28], a term used to describe the immigration of exceptionally bright minds to the Western world at the expense of local development [29]. The concept has been used extensively, though not exclusively, to discuss geographical developmentalism as it relates to sub-Saharan Africa (SSA) and the Middle East and North Africa (MENA) [30]. Critiques argue that historical colonial influences have left a legacy in many African countries, disguised in the form of global education, introduced through western political ideologies, and cultivated by compensations in the form of aid for adopting the funders' worldviews [31].

Today, the seeds of neocolonialism have an additional source as several African countries continue to rack up debt and mortgage their national resources for the promise of Chinese support [32]. The actors might appear different but the neocolonial legacies are still the same –seeds planted through education, which, critiques argue, germinate in the minds of the African over time, who becomes more and more disenfranchised with their cultural heritage as they seek validation and acceptance from their funder [27]. Often, professional and academic legitimacy is demonstrated by the ability of the colonized to 'break out' of their own social and cultural realities; in their ability to speak the language of their colonialists, or act, dress, and interact like them [33]. However, as any proponent of the law of the conservation of mass and energy will rightly attest, nothing happens in isolation. "Breaking out" of one system also means "breaking into" another. Consequently, critiques of the ideology of brain drain argue that colonialism creates a feeder system that ships the best and brightest out of colonized countries often at the cost of local development to develop the economies of the colonialist countries [30], [34]. Conversely, neocolonialism also functions in the reverse direction, through an influx of expatriate workers to the Global South. Bereft of qualified workers with advanced skills, most African infrastructural development works (mostly involving engineering) are contracted to immigrant workers who deny local residents of opportunities for skill development [35].

For this reason, in 2013, The African Union unveiled 'Agenda 2063: The Africa We Want', a blueprint to transform the African continent into a powerhouse of the future in a series of five 10-year plans geared to improve the continent's socio-economic development [36]. The first of these five stage-plans involves identifying key priority areas, defining strategies and policy measures, providing actionable information to key stakeholders with measurable outcomes, and outlining strategies required to ensure the availability of resources to achieve set goals. There remains within sub-Saharan African countries, a strong interest in decolonizing education to serve their economic growth.

One solution that has been suggested has been indigenizing engineering education. With roots in anthropology, the term indigenous is often interpreted as the knowledge and practices of native Indians and aboriginals in white-settler regions of the world such as the US, Australia, or Canada. But indigenous is not exclusive to aboriginal Indians. To clarify, indigenous knowledge is from the root word "indigene", indigenous knowledge refers to knowledge that is discovered, nurtured,

preserved, and transmitted among local folk (indigenes to a place) [37]. African indigeneity has experimented with the notion of parables and storytelling as a theoretical framework [24], [38], local language as the conduit for epistemological training [25], and even served as the origin for apprenticeship as the model of education [39], [40]. Another solution that has been suggested in the literature is a focus on culturally relevant pedagogy.

A Conceptual Framework for Culturally Relevant Engineering Education

Originally developed through grounded theory from the practices of successful teachers of African American students in the US, culturally relevant pedagogy has become more than just a buzzword in many American classrooms. Between 1995 and 2022, more than 200 articles have discussed CRP use and application in the US [41], in other parts of the world [42], [43], within STEM classes [44]–[46], in teaching social sciences [47], etc. Surprisingly, the literature surrounding culturally relevant pedagogy in engineering education reveals a sparsity on the subject in higher education although there is a plethora of research on CRP at the secondary school level. Recently, scholars have taken a cue to examine what CRP would look like in engineering education [48], [49] including hosting faculty development workshops [50] and facilitating critical discussions through editorials [48], [51]. In some cases, the phrase culturally relevant has also been stamped on science and engineering curricula only to mean that end products are built or centered on or in a community [52]. Unsurprisingly, the theory is much more than an appendage that means "done in a community".

CRP framework suggests three defining criteria that can be interpreted as desirable student outcomes. The first is *academic achievement* which engineering educators model to their students by having high expectations of all of them, seeing them as capable of succeeding in engineering. Engineering students demonstrate the second criterion of *critical consciousness* by recognizing the historical and current roles of engineering in the world, consequences of decisions made as factors birthed by race, class, and gender biases in the world. Recognizing these social inequities is vital if they are to thoughtfully think through the active roles they play in reifying or challenging these inequities through their engineering/design decisions. Finally, students demonstrate *cultural competence* in their ability to approach authentic problem-solving while staying true to the culture of the communities they interact with. Likewise, they should be empowered to achieve these outcomes without necessarily sacrificing their own cultural heritage.

Three conceptual frames are also discussed in Gloria Ladson Billings' theoretical postulation: educators' conceptions of "the self and others", their conception of knowledge, and their conception of social relations. GLB refrained from imposing prescriptive qualities of "culturally relevant teachers". Her propositions, she insisted, were descriptive rather than prescriptive, fluid rather than fixed. Thus, she opined that regarding their conceptions of "self" and "others", culturally relevant teachers believed in all students' capabilities for academic success; saw pedagogy as art, unpredictable, always in the process of becoming; saw themselves as members of the community; saw teaching as a way to give back to the community; and believed in the Freirean notion of "teaching as mining" or pulling knowledge out. Likewise, culturally relevant teachers had the following conceptions of social relations: they maintained fluid student-teacher relationships; demonstrated a connectedness with all of their students, developed a community of learners, and encouraged students to learn collaboratively and be responsible for one another. Finally, culturally relevant teachers conceived knowledge as dynamic rather than static, shared rather than solely owned, and always being recycled and constructed; they believe that knowledge must be viewed critically; they are able to scaffold to facilitate learning; and they employ multifaceted multimodal assessments as evidence of learning.

Methodology

Context

The context of this paper is the Federal Republic of Nigeria, situated in the Western part of Africa. With an estimate of over 220 million people, Nigeria is the most populous country in Africa and the largest black nation in the world. The country boasts over 500 different spoken languages, and over 250 ethnic groups, each with their customs and cultural norms. The Federal Republic of Nigeria consists of 36 states and a federal capital territory, distributed among six (6) geopolitical zones. The three most commonly spoken indigenous languages are Hausa, Yoruba, and Igbo. Despite having such a diverse linguistic spread, as a result of British colonial influence, the official language of communication is English. However, most residents still speak their local languages and an increasingly large population speaks Nigerian Pidgin English.

This context is necessary to help readers appreciate how complex it is to do nationally representative research in Nigeria. It is not a homogenous nation with one commonly spoken language. Even the official language is not as commonly spoken as the local languages and the different ethnic groups have their own unique cultures and customs and shared histories with other ethnic groups. In order to achieve some representation at the linguistic and ethnic level, a sampling frame was created consisting of schools from each of Nigeria's 6 geopolitical zones with the three major indigenous languages spoken. The uniqueness of the cultural norms within these geopolitical zones are interesting considerations in this paper.

Education Pathway into Engineering in Nigeria

The pathway of the Nigerian child from early childhood into the field of engineering is varied (please see Appendix for reference [53]). English language is taught as a separate subject from nursery school through secondary school. Assessments of all subjects are also done using English as the medium of expression. After secondary school, the main pathway into engineering is a bachelor's degree attained from an accredited University or National and Higher National Diplomas attained from accredited monotechnics/polytechnics. The Federal Republic of Nigeria has federal institutions in each of its 36 states and federal capital territory as well as state institutions and privately owned and managed educational institutions. Federal institutions are public educational establishments funded by the Federal Government through the Ministry of Education and managed by the National Universities Commission (NUC). Students, teachers, and administrative staff are recruited through national pools through standardized recruitment practices, and 80% of all courses are prescribed through the NUC. Conversely, state-owned and managed institutions are funded by each of the 36 states and the federal capital territory that make up the country. Recruitments into these schools are done at the state level. Finally, private institutions are owned and managed by individuals, religious organizations, and affiliated groups.

The varied pathway of students into engineering in Nigeria is very important to consider because each pathway has its own unique characteristics, financial and academic requirements, duration of study, politically influenced decisions, and perceived local, national, and international prestige. While discussing the intricacies of each of these different pathways is beyond the scope of this paper, the consideration of the different pathways of students into engineering is also included in the sampling frame (Tables 1 and 2).

Sampling

The purpose of this work is to generate explanatory claims by thoroughly examining cases from the selected contexts. This is hinged on a clear rationale for the inclusion and exclusion criteria within the study [54]. Thus, each case was bounded as follows: semester-long teaching of an undergraduate engineering course in a federal, state, or private University. To be included in this study, participants were recruited using two-stage criterion sampling. Criterion sampling involves specifying criteria that participants must satisfy before being included in the study. Six engineering educators were purposively sampled from faculty mailing lists of engineering programs in Nigerian federal, state, and private universities located in its 6 geopolitical zones. The inclusion criteria in order of importance and justifications are provided in Tables 1 and 2.

Table 1. Criterion Sampling for School Selection

Zone	Institution	Location (State)	Type	Data Collection
North Central	University of Ilorin	Ilorin, Kwara	Federal University	Survey data
	Nile University	Abuja	Private University	Survey data
North-East	American University of Nigeria	Adamawa	Private University	Survey data
	Modibbo Adama University of Technology	Adamawa	Federal University	Survey data
North-West	Ahmadu Bello University (ACENPEE)	Zaria, Kaduna	World Bank Center of Excellence within a Federal University	Survey, Faculty & student interview
	Kebbi State University	Aliero, Kebbi	State University	Survey data
South-West	Covenant University	Otta, Ogun	Private University	Survey, Faculty & student interviews, Classroom observation[1]
	University of Lagos	Akoka, Lagos	Federal University	
	Afe Babalola University	Ado-Ekiti, Ekiti	Private University	
	Lagos State University	Ojo, Lagos	State University	
South-East	University of Nigeria	Nsukka, Enugu	Federal University	Survey data
	Federal University of Technology, Owerri	Owerri, Imo	Federal University	Survey data
	Imo State University	Imo	State University	Survey data
South-South	Akwa-Ibom State University	Uyo, Akwa-Ibom	State University	Survey data
	University of Port-Harcourt		Federal University	Survey data

[1] Colored cells represent schools that participated in both quantitative and qualitative studies

Table 2. Inclusion Criteria for the Participant Recruitment Protocol

Participants	Criterion	Criteria in order of alignment to research	Priority
Teachers	Teaching responsibilities	Actively teaching engineering in Fall 2022	1
	Target Class	Teaching an undergraduate class	2
	Class Demographics	Minimum of 5 Nigerian students in the class	3
	Familiarity with CRP	Level 1: Familiar with CRP Level 2: Participated in a CRP workshop/training Level 3: Read an article on CRP Level 4: Actively practicing CRP in the classroom Level 5: Published an article/editorial on CRP	4
	IRB Requirements	Available to sign a letter of collaboration	5
		Available to provide a memo of cultural appropriateness	6
	Data Collection	Available for short survey data collection Available for semi-structured interviews Willing to allow class observation	7
Students	Demographics	Identifies as Nigerian	1
	Data Collection	Available for semi-structured interviews Willing to have class observation	2

Method

Acculturation studies [55] and comparative studies are effective ways of revealing the factors, attitudes, resources, and practices that work in one context as a way to inform another [56], [57]. Although a comparative case study was designed to better understand the culturally relevant practices and conceptions surrounding engineering education in Nigeria and the US, this paper tells half of the story. It focuses primarily on the emerging results in Nigeria. Thus, each of the sites where data was collected was treated as a piece of a larger puzzle of a multi-site case study [58]. To address the research questions guiding this study, an explanatory sequential design was employed. An explanatory sequential design is a mixed-method approach that involves two stages of data collection – the first is a quantitative study that provides insights that are further investigated and/or explained in the second stage of qualitative research. However, it is crucial to point out that contrary to certain misconceptions that view research on a linear path, this research ended up being an iterative use of both quantitative and qualitative instruments. The analyzed data for this study include surveys, in-person and virtual classroom observations, teacher reflection journals, classroom artifacts, school policy documents, and semi-structured interviews with 37 engineering faculty members, 2 provosts, 5 engineering college deans, and 2 students.

IRB

This study is approved for study by the Purdue Institutional Review Board. This process was concluded by July 2022 through the IRB (Institutional Review Board) with approval number (IRB 2022-342). In July 2022, after receiving approval to conduct this study, electronic mails were sent to the deans and the provosts of the colleges of engineering in the six geopolitical zones of Nigeria.

Data Collection

The research question posed in this paper is as follows: what are the conceptions and practices of culturally relevant engineering educators supporting their engineering students in Nigeria? To answer this research question, an explanatory sequential design was employed. An explanatory sequential design is a mixed-method approach that involves two stages of data collection – the first is a quantitative survey that provides insights that are further investigated and explained in the second stage of qualitative research.

First, a survey instrument was sent out to engineering faculty members in the schools that had been criterion sampled in Nigeria (see Tables 1 and 2). The goal of the survey was to gain an exploratory insight into the practices, activities, impressions, and expectations of these faculty members about their students and the courses they teach. The survey instrument consisted of biographical descriptor items and validated items designed to elicit teachers' approaches to student-centered teaching, general pedagogical practices, impressions of culturally relevant pedagogy, and school climate (promotion and tenure metrics, and questions about the then-ongoing national academic union strike – see discussion section for more on ASUU strike in Nigeria). Although English is the official language spoken in academia in Nigeria, the survey was also translated into the local languages of Yoruba, Hausa, and Igbo in case respondents preferred them. In total, the survey was sent to 690 faculty members in Nigeria. Only 37 responses were collected and all responses were in English language.

The survey was also used to recruit participants who were interested in providing a deeper context for their responses and were available for semi-structured interviews or observations of their classrooms. 9 faculty members agreed to participate in this second stage of data collection. However, only 5 were contacted. This decision was based on an analysis of the responses to the survey and the availability of the respondents. Secondly, an interview protocol consisting of 20 questions that ask questions about teachers' perceptions, challenges, practices, and any biases they may have about teaching, assessment, and critical consciousness was designed to dig into the frames of mind, biases, and individualized approaches for recognizing or addressing their biases. Likewise, students being taught by the instructors were recruited for semi-structured interviews.

The third stage of data collection involved classroom observations using a modified version of the Culturally Responsive Instruction Observation Protocol (CRIOP) - a validated instrument that measures teachers' classroom instruction along key pillars: assessment practices, teacher dispositions, classroom climate, planned curriculum activities, instructional discourse, family collaboration and involvement, instructional strategies/pedagogy, and sociocultural perspectives [59], [60]. The instrument was modified to be consistent with the target class (being an undergrad class in a University). Likewise, the discourse dimension was excused from the instrument. Three (3) classes were observed for this study. Two were conducted in person and one was conducted online, as a consequence of the modifications of COVID-19. In order to triangulate the findings that emerged from the analysis, subsequent interviews were conducted with deans and provosts of the engineering colleges. Policy documents were also included in the analysis as well as artifacts and reflection notes from instructors.

Data collection in Nigeria began in August 2022. I sent out the survey questionnaires at the start of the study. First, I began by securing permission to conduct research in the Nigerian institutions by sending out emails to and contacting the deans and provosts of the various colleges of engineering by phone calls, text messages, and WhatsApp messages. Afterward, I traveled to Nigeria for 3 months to collect observation data, conduct interviews, and field surveys. The observation was conducted using a modified version of the Culturally Responsive Instruction Observation Protocol. The observation phase ended in October 2022.

While I initially planned to collect observation data before interviews, the realities of the situation in Nigeria caused me to change my plans. I discuss these in more detail in the discussion section. I opted to conduct interviews with certain instructors after they filled the surveys and others were interviewed after their classes were observed. Data transcription, cleaning, and analysis began in October 2022 and continued for 2 months until December 2022. In January 2023, after the first stage of data immersion and in-vivo coding was concluded, study participants were contacted again for member checking. The objective was to see how the study participants reacted to and what they thought about the observations, analyses, and emerging results.

Analysis

Analysis of the data collected from this study was through qualitative in-vivo coding, followed by thematic analysis using the identified situated learning theoretical framework and culturally relevant pedagogy. The analysis of the qualitative data from the survey responses and interview transcript followed an abductive approach [61]. To accomplish this goal, I used a modified version of the standard iterative process [62] to perform in-vivo coding of the data, thereby developing a codebook for the thematic analysis of the conversation and survey data for this study. Data analysis began with iterative immersions in the data, generating codes in vivo (inductively) relevant to the research interests. In the first pass, I coded the texts of the data and the codes emerged in vivo. In the second pass, I compiled similar codes into parent codes and thus develop the categories for defining them. In the third pass, I described the inclusion and exclusion criteria for the parent categories. These codes were then compared to the codes deductively generated from the literature surrounding situated learning and culturally relevant pedagogy to investigate fit and reliability.

For considerations of rigor, I subscribed to the concept of engaging crystallization in qualitative research [63]. To enhance the trustworthiness of the research findings and the procedure, participants of this study were contacted after the transcription and data analysis stages of this study to perform member checking [64]. Member checking involves returning data to participants to attest to or clarify the accuracy of the research findings and data collection with their experiences.

Findings and Discussion

The first research question in this paper asks what are the conceptions of engineering educators in Nigeria? Using the survey instrument, the results are presented using simple descriptive statistics. It is crucial to note that although the respondents come from all 6 geopolitical zones in Nigeria, the statistical power of this study is too low to infer generalizability across a single school, much less a geopolitical zone or the whole Federal republic of Nigeria. Fundamentally, the results of the survey only served as expositions into nuanced insights that were further introduced and discussed in the follow-up interviews.

Survey Results

Demographics

32% of the respondents of the survey identified as female, none of the respondents identified as non-binary. More than half of the respondents were aged between 41-50. All six geopolitical zones of the country had representation although there was a huge skew in the South West which accounted for more than 50% of the responses. 12 of the 15 sampled schools had respondents, most of whom (85%) had a very broad range of teaching experience (0-28 years).

School Climate & Administration

With respect to school climate and administration, close to 80% believed that there was a culture of shared responsibility among staff in their schools, staff were a big part of making decisions about the school although less than 38% believed that students was a part of the decision making. Interestingly, teachers more than 90% of the surveyed respondents believed that teachers were concerned for students' wellbeing and managed to get on well with them although a third of them did not take extra steps to find out what they had to say about the school or their teaching.

Promotion & Tenure

Unsurprisingly, in responding to questions about promotion and tenure more than 90% of the respondents affirmed that research and publications were the most important metrics for promotions, some restating the maxim they had heard so many times about academia in Nigeria being a 'Publish or Perish' field. When asked to clarify during follow-up interviews, some of the faculty members in the private institutions insisted that the publications had to be SCOPUS referenced in order to count toward promotion. Others insisted that they were required to publish in field-specific journals and conferences and not engineering education or education related fields. Service record within the school was another good metric for promotion and tenure. Perhaps the most surprising finding in this category of questions was that more than half of the respondents claimed to have never had their classes observed by anyone in the school i.e. the dean, head of department, university president, or provosts although these were the main actors who ultimately reviewed their research portfolios to approve or deny promotion.

Pedagogical Skills

The questions about pedagogical skills also revealed very interesting findings. A staggering 100% of respondents believed strongly or simply believed that they could vary their instructional strategies in the classroom if needed and/or provide multiple alternative explanations to their students whenever they were confused about an engineering concept. However, less than a third claimed to have never created surveys nor spent time getting to know their students' individual backgrounds. This also ended up becoming a major topic of discussion during the follow-up interviews.

Fostering an Environment of Cultural and Social Acceptance

When asked how they had managed to foster an environment of cultural and social acceptance in their classrooms, 60% of the respondents thought it was not their job to raise an awareness of cultural differences amongst their students. Additionally, more than half of the respondents claimed that they had never considered asking if, why, or how certain school policies may be biased against minority students in their schools. The term "minority" for most was not one that they were used to in this context. This finding also became an important discussion point in the follow-up interviews. 30% of the respondents thought it was not their responsibility to create an atmosphere where students respect one another. Surprisingly, more than 96% of the respondents thought that the curriculum and planned learning activities should incorporate opportunities to confront negative stereotypes and biases.

Criteria for Culturally Relevant Pedagogy

A dedicated section of the survey asks respondents about their impressions of the three criteria for CRP, viz academic achievement, cultural competence, and critical consciousness. The analysis revealed that 100% of respondents recognized they were responsible for teaching their students the jargon of engineering, all respondents claimed to always communicate high expectations of all their students and all respondents believed that their students were not lazy although they needed

the right academic and environmental conditions to help them succeed. All respondents also believed that what they taught in the classroom had to be contextualized with examples and applications in the students' daily lives, experiences, and abilities. When asked about assessments, 23% of the respondents were suspicious of assessments as accurate metrics of what students actually know. being accurate measures of student knowledge

In response to the items eliciting the respondents' cultural competencies, 87% believed that engineers have a professional way of looking, dressing, and acting and that they always tried to model this in the classroom. They were asked to clarify what they referred to as 'professional' and this question led to consultations with school policies. About 70% of the respondents claimed to go out of their way to find articles, textbooks, and other resources in the local language for their students engineering learning. Paradoxically, while 78% believed that students' guardians, parents, and caregivers had relevant input that could be included in their students' learning, they also had not taken any steps to invite them into the classroom.

The third criterion that was introduced in the survey concerned critical consciousness. This criterion was difficult to unpack in the study. 100% of the respondents thought that it was their job to help students connect the dots between the engineering concepts they taught and the sociopolitical consequences of their application. All the respondents also thought that students needed to recognize through the curriculum, the relevance of historical and current issues happening in the world outside the classroom. Furthermore, 78% thought that engineering should be mixed with sociopolitical issues. However, only 17% thought that this necessarily had to translate into students becoming activists of responsible, just, and inclusive engineering. This prompt was also discussed in the interviews but it also created an interesting segue into the final question asking about the state of education in Nigeria.

Regarding the 8-month Strike of the Nigerian Academic Staff Union of Universities (ASUU)

The final question in the survey concerned respondents' impressions of the then-ongoing ASUU strike, which had started 6 months prior on February 14th, 2022 and was responsible for the shutdown of all academic operations in Federal universities all over the country. Despite being a non-flattering aspect of the academic realities in Nigeria in 2022, this essay-type question had to be included in the survey for a couple of reasons. First, participants had expressed their frustration over the situation through personal communications prior to fielding the research instruments. Second, most agreed to participate in the survey because they believed the strike was necessary in getting the attention of the government although it was a critical deterrent to their professional practices. Thirdly, some respondents believed that this research could serve as one of the many avenues through which they could share with the international community some of the struggles that educators had to constantly navigate in their efforts to support their students in Nigeria.

More than half of the respondents provided short but elaborate essay replies to the question. The responses collected showed that all the respondents believed that the strike was having a severe negative impact on them and worse still on their students. One respondent bemoaned the fact that the prolonged strike only further worsened the apathy that certain students felt towards education in Nigeria currently, quoting the popular expression – *"education na scam"*. This expression, which was originally rendered in Pidgin English translates into "Education is a scam", an apathetic disposition that suggests that education is not a worthwhile investment and that Nigerian youth were better served following other paths. Some students, the respondent went on, could even refuse to return to school if they were able to find temporary jobs.

Another major impression that was discussed was the danger of dampening the spirits of students in Federal universities who were left at home as they had to watch their mates in the private

universities who were unaffected by the strikes graduate and move on with life ahead of them. The impact of the strikes on students' employability was also discussed as several respondents expressed concerns that firms would not wait for students' calendars in order to employ skilled labor in their companies. This impression was further corroborated by another respondent who felt that the prolonged strike was also negatively affecting the emotional and mental well-being of faculty and students. Another respondent stipulated that students who had experienced this break in their studies were unlikely to maintain their academic enthusiasm and would struggle upon returning.

Finally, several respondents lamented the exodus of seasoned lecturers from Nigerian Universities to 'greener pastures' which they said could either mean engineering companies within the country or academic and professional engineering positions outside the country due to the prolonged strikes. Two exceptional educators reached out during the research to say that they were no longer in the country, having just begun their academic and professional careers abroad. These stark realities were further expounded by the deans and provosts of the College of engineering who discussed how difficult it was to fill the entry-level positions of faculty in their engineering programs, most of whom, they claimed had decided to resign and continue their professional careers elsewhere.

Qualitative Analysis Results

The thematic analysis of the collected data revealed several results – using proverbs to build cognitive reasoning in Nigerian engineering classrooms; visual and auditory cues as a form of formative feedback; analogies as a pedagogical form; advocating for active and authentic learning through tutorials; leveraging the communal nature of the culture in the classroom through attendance taking; colonial antecedents responsible for certain school policies; manifestations of GLB's conceptions in this context; peculiarities of GLB's three CRP criteria in this context. To fit within the scope of this paper, only two of the themes are discussed.

Theme 1: Visual and Auditory Cues as Culturally Relevant Forms of Formative Assessment

The literature surrounding summative and formative assessment is extensive [65], [66]. In the classroom, formative assessment can serve as a cue to warrant further elaboration or verification of a stated concept, fact, or explained process [67]. Shute's literature review suggests that formative feedback should be nonevaluative, specific, timely, and supportive. In more heavily-resourced teaching environments, instructors are able to use clickers to perform formative assessments. Quick, instantaneous feedback is useful for instructors to assess whether their explanations of certain concepts or mathematical processes have been properly understood by their students. However, in contexts with fewer resources, how might teachers get useful and quick formative assessments of student understanding? In the Nigerian context, particularly as observed in this study, there was a huge reliance on visual and auditory stimuli as forms of formative assessment by all the observed instructors.

Although blatantly subjective, this cue was particularly effective in helping teachers navigate through the courses they taught. It became a matter of discussion during the follow-up interviews. I was particularly interested in understanding how instructors initiated them, how they interpreted these visual and auditory cues, and how they learned to move on after the verification or elaboration had concluded. One instructor suggested that it was not ideal, because it was not an objective test of understanding –

"but we have to make do with what we have, which is why I rely on my gifts of observation. Sight and sound. If everything else fails, go for the eyes, they never fail."(Petroleum & Gas Engineering Instructor)

This excerpt suggests that the instructor would have preferred to have tools that could enable him to get an objective representation of his students' understanding. However, failing that, he opted for visual and auditory cues: Did the students look slightly confused by what they had just said? Did the volume of their *yeses* reduce when they were asked if they understood? Were the students excited to volunteer and answer the question that he had just asked? Did the amplitude and velocity of their nods increase or decrease relative to what I have known from the time I taught less advanced concepts that day or in previous classes? Figure 1 provides a pictorial representation of the process.

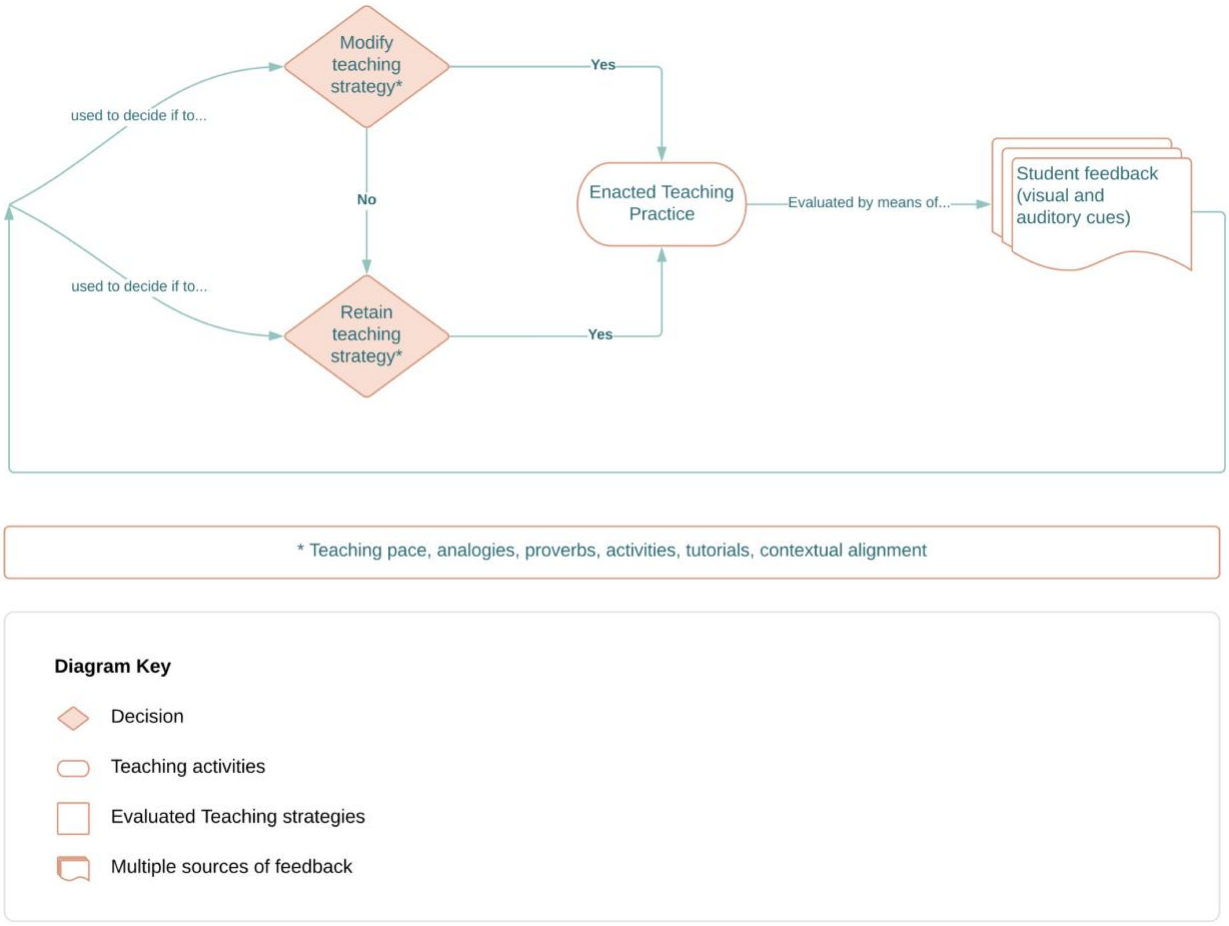

Figure 1. Visual and Auditory Cues as Formative Assessment

The image typifies the process by which engineering educators in the Nigerian context perform real-time modifications to their teaching practice by taking stock of student feedback through visual and auditory cues. These cues serve as input that either causes them to retain their teaching strategy or retain it. Elements of their teaching in this context could be their teaching pace, use of analogies, or other contextual pieces of evidence to support teaching. This important finding was thought-provoking. Rather than serve as an objective measure of understanding, it resonates with Gloria Ladson Billings's observation of the teachers in her study who saw teaching as an art, a way of becoming [68]. It demonstrates the use of *call and response* as an African cultural form of democratic participation. The notion of call and response has already been discussed in relation to music, hip-hop, African songs, and even in religious settings [69], [70]. Its proponents in the

Nigerian engineering classrooms only recognized the importance of students' auditory responses in the classrooms, but had no name for it.

Perhaps future studies might examine the quantitative analysis of auditory and visual cues like this as formative assessment tools. SOUND: In pop culture, sound meters are used to determine winners in games, dance competitions, rap, etc. The audience is left as the judge, capable of determining who won the game. While noise meters have been used in certain high school classes to coordinate classes, this finding suggests that there may be a culturally relevant way to leverage sound as a formative assessment tool rather than fear its capacity to disrupt. SIGHT: The findings of this study also suggest that future ergonomic and human factors analysts might benefit from observing students' reactions in the classroom. Although far-fetched because of the unique behavioral peculiarities of each individual, observing students' visual cues could prove useful in the future. Yet, it is more crucial to recognize that these formative assessment cues are an art form. Thus, they are best understood by an instructor, who has the opportunity to see students' reactions every time they have class. Rather than subject the cues to scientific scrutiny, perhaps the art of observation is a skill better nurtured than exploited.

Theme 2: Leveraging the Communal Nature of Culture through Attendance-taking

The modified CRIOP instrument used for this study showed that the dimension that instructors in this context excelled in more than any other was CLASSROOM RELATIONSHIPS. This dimension evaluates the frequency at which professors demonstrate an ethic of care in the form of equitable relationships and bonding, how often students are encouraged to work together, how the professor creates a learning atmosphere that engenders respect for one another and diverse populations, and how often the professor communicates high expectations for all students. In all the settings observed in this study, the instructors scored an unprecedented 16/16. Curious as to why this was the case, the follow-up interviews and analysis revealed why and how.

In the literature, the communal nature of African settings has been extensively discussed. But conflicting conclusions have also been drawn from other studies in the African context. Not all classrooms operate in a sense of community. Students are openly propped against other students as they vie for the instructor's attention or in their efforts to be on the upper end of curve-normalized grades. However, as the analysis revealed, whether by reason of the policies of the school or by the decisions of the instructors, there was a shared sense of community in the classes observed. Perhaps nowhere is this case clearer than in the class of a Petroleum engineering instructor.

Of the sixty-six (66) students who attended class on this day, the instructor called almost half by their first names during class time. He asked questions during class by assigning them to specific people. As he did so, an attendance sheet was being passed during class. At the end of the day's lecture, the instructor pulled out the attendance sheet and called out the names of all the students. Two keen observations were made during this exercise. First, he asked to see the faces of certain students whose names he had not memorized. Second, he observed and drew the attention of the class to the name of a student who was uncharacteristically absent. When he did, from no particular origin, students chorused that that student was not feeling fine, to which the instructor asked that the class rep should ensure they checked up on him. I asked the instructor a series of questions in a follow-up interview. I was curious to know how he had memorized so many names. I was surprised that he caught the incidence of the sick student and used it as an opportunity for the class to expend their social capital. I was especially curious if he required that all his students be present for every class.

The responses of the instructor serve in no way, shape, or form as prescriptions for other instructors. In his case, he replied:

"Memorizing my students' names is just my way of reminding them, 'maybe this guy is not so bad, after all. He actually cares. What was he saying, even? I better pay attention in case he asks a question again.'"

The instructor went on to suggest that sometimes he would even experiment with his own memory and catch the students off guard by calling them not by their first names, but by their middle names:

"It can be especially funny to see a student's face light up when you do that! The look they give you like – 'how did you know?' which is funny because it's right there in the attendance sheet. They provided it. It's unlikely that you will see a student tune off during class when they know you know them dele-dele"

"Dele-dele" is a Yoruba expression that means all the way to your home. It is an adverb used to describe the intimacy of knowing someone so much, you could practically guess what they call them at home. The instructor went on to share his strategy for memorizing students' names. The process, he explained, is easier if you're teaching a class more than once, as was the case here. But he also explained that it is a slow process that requires intentionally remembering something unique about each student. This was why he was looking to memorize the names of the students whose names he had not yet successfully committed to memory.

The question I was most curious about was the issue of classroom attendance. In response to the question about mandatory attendance, the instructor had an unpopular but remarkable comment. Rather than summarize his thoughts, I elected to share them verbatim in this paper:

"No, I don't necessarily require students to come to all my classes! In fact, I remember the case of one student who never showed up to my classes. I could tell from always seeing a fine unsigned line on my attendance sheet. And I was very concerned for him. I knew how much effort I put into class preparation to make sure my students understood concepts. I am not the kind of lecturer that will ask you questions in an exam that rely on your ability to cram (memorize). You need to really understand and be able to apply what I taught. So, yes, I was very concerned about this student because I had learned from his classmates that he was not sick. I was afraid he would fail and I didn't want him tarnishing my good records. His success mattered to me. On exam day, I saw him for the first time and all I could think of was 'how would he survive my questions?' He ended up passing…passing very well (muffled laughter) … which…honestly speaking, was humbling for me. Rather than berate him, I called him and congratulated him. In fact, I asked him for tips. Perhaps he knew something I didn't…some resource that was far better than mine. I wanted his peers, the other students, to get that help too. So, you see, it's not so much about them coming to my class, there's nothing special about my face. But I care about them passing…you can choose not to come to class, but please you better impress me by passing."

There is a lot to unpack from this instructor's views. Perhaps none more surprising than his reaction to a student who passed his course without attending his lectures. As the instructor explained, and as is common in the Nigerian system, 70% of a course grade is dependent on final exams [71]. This student had successfully passed the course by his performance in the final assessment. Yet, the instructor had not only been impressed, but reached out, expressed his congratulations, and asked for tips to share with his peers. This was not an act popular in the Nigerian context. Rather than see his months of teaching as unappreciated by this student, he decided to ask how the student may help his future students. Finally, the communal nature of the classroom was discussed. Tinto's

model of student retention suggests that several factors influence a student's decisions to conclude their programs. This study reveals the extent to which students can serve as a communal resource for one another in the classroom. The instructor had expected the class representative and the other students, some of whom were friends with the absent students to know why he was absent and to visit him after class.

Conclusion

This paper shares emerging insights from ongoing research investigating how engineering educators might provide culturally relevant engineering education to Nigerian and Nigerian International students. On the broader research project, a comparative case study using explanatory sequential mixed methods was designed surrounding engineering education in Nigeria and the US. This work-in-progress paper tells half of the story, focusing primarily on the emerging results in Nigeria. Here I investigate the conceptions of engineering educators in Nigeria and how culturally relevant engineering educators support their engineering students. Two findings are discussed in-depth in this paper: visual and auditory cues as culturally relevant forms of formative assessment for Nigerian students, and leveraging the communal nature of culture in the classroom through attendance-taking. Each theme is discussed with the support of proverbs as epistemological frameworks in the Nigerian context. The first theme reveals a practice that is embedded in many African cultures – the art of call and response, while the second presents the nuanced views of an exemplary teacher in Nigeria with respect to student attendance. These findings provide some empirical support for culturally relevant practices that may help instructors looking for culturally relevant ways of supporting students of Nigerian students in their engineering classrooms.

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APPENDIX

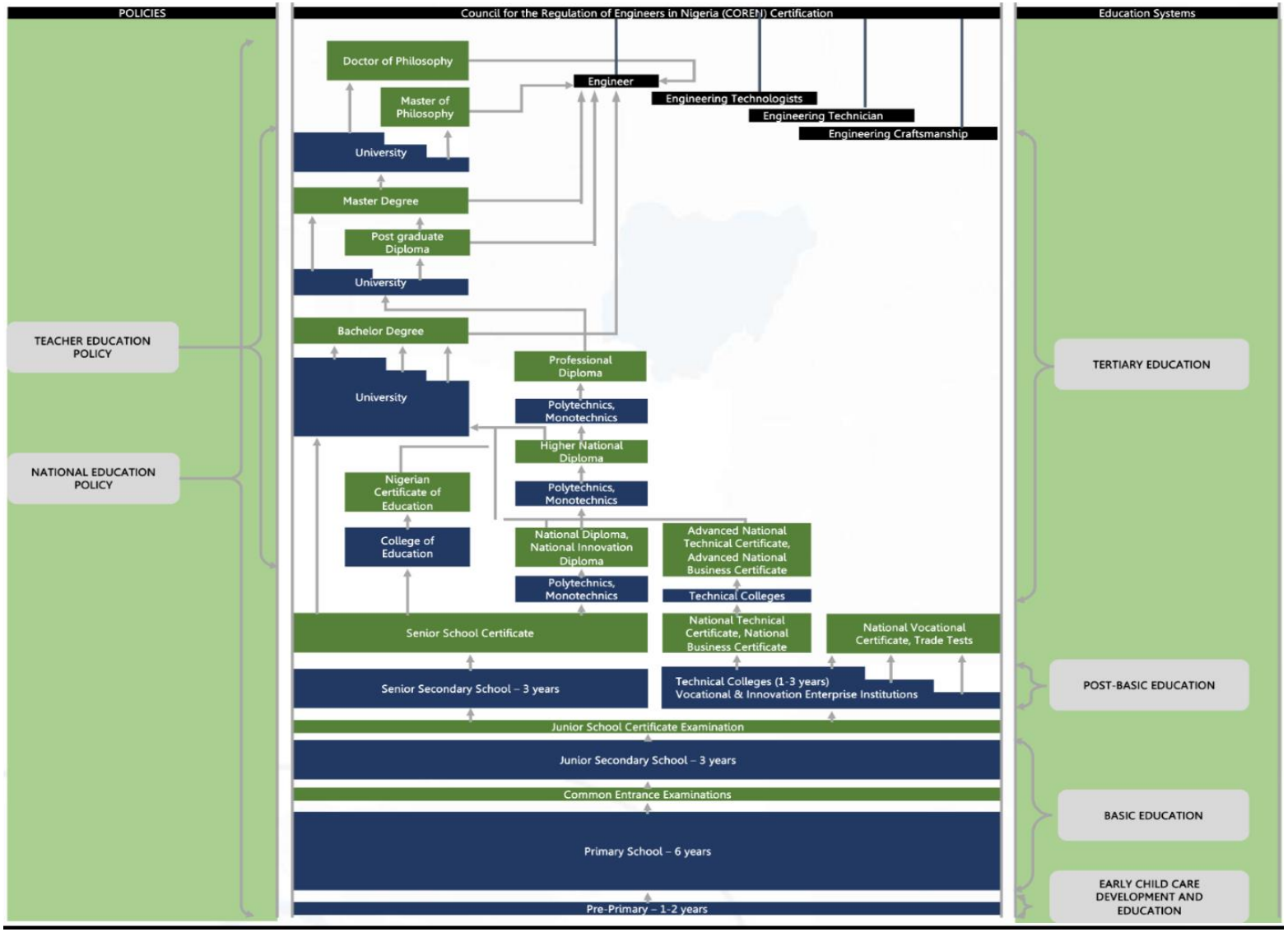

Figure 1. Engineering Pathways Within the Federal Republic of Nigeria (modified from WES website)