

# Minimum Curriculum and Course Specifications for Geological Engineering Technologists in Nigeria

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**Abstract:** *In view of the vital role of mineral, petroleum and other earth resources in national development and economic growth, adequate development of quality technical professionals is critical for geological exploration and evaluation of the resources. This paper presents an overview of recent reviews of education programmes for geological engineering technologists. The geological programmes are traditionally offered at Higher National Diploma (HND) levels alongside mining, petroleum, and mineral engineering in several Nigerian polytechnics, and are supervised by the National Board for Technical Education. The HND programmes are preceded by a common-based National Diploma (ND) in Mineral and Petroleum Resources Engineering. The entry requirements for candidates are similar to those for university degrees in engineering, but the curriculum structure and course contents give stronger emphasis to practical and industrial orientation, with a minimum ratio of 60:40 respectively, in the professional course units. The products of the ND and HND are employable as technicians and technologists respectively, in numerous engineering aspects of earth resources exploration, evaluation, exploitation, and construction. The strong blend of geological and engineering courses in their curriculum prepares the geological engineering technologists for a productive career in exploration and mining geology, mining, petroleum, civil and construction, military, chemical, and environmental sectors. It is recommended that the government should derive more benefits from its technical capacity by removing all existing derogatory impediments, and allowing technologists to pursue more effective postgraduate studies and professional development along the path of practical orientation.*

**Keywords:** diploma, engineering, postgraduate, professional, technical education.

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## INTRODUCTION

Mineral resources are vital to the development of any nation. The level at which a country consumes mineral products may be used as a gauge to how developed that nation is. Developing countries, in general, do not consume all the minerals they produce but sell the greater proportion to developed nations that consume more.

In the developing countries, therefore, there is a need for adequate training of professionals who would be able to effectively explore and exploit such resources. In designing curricula for training the personnel who could exploit these sources of wealth, the tendency in developing countries has often been to adopt the curricula of advanced countries, rather than adapting them to the local level of development and technological environment. For any form of training to be meaningful it must be relevant and realistic. In advanced countries, training in the field of mineral resources engineering, like any other facets of knowledge and development, has undergone very rapid changes and modification in recent years. Developing countries must therefore also update and modify their curricula to respond to local and international needs.

In Nigeria, the training of "mineral scientists" started with the training of geologists in the Geological Survey of Nigeria as a kind of apprenticeship, while a formal Geology Department was set up at the University of Ibadan in 1961 (Amoka et al, 2023). Jos School of Mines was later set up to produce personnel in the field of "Mining Technology" with an aim to feed the mine fields in Jos and environs with technicians to occupy middle level supervisory roles. The Jos School of Mines has been recently upgraded to Nigerian Institute of Mining and Geosciences, now offering professional postgraduate programmes in mineral exploration, mining, and mineral engineering. Several universities also later started geology degree programmes, but for a long time there was no degree programme in mining, geology, or related technology. In early 1980s, the Federal University of Technology Akure introduced a degree programme in Mining Engineering. More recently, mining engineering degrees have started in University of Jos, and Ahmadu Bello University Zaria.

In the 1970s, a few Polytechnics initiated the challenge to develop a suitable curriculum for technical training of mining and related engineers in Nigeria. This was pioneered by Kwara State Polytechnic, Kaduna Polytechnic, and Federal Polytechnic Ado-Ekiti. The training started with the one-tier Nigerian National Diploma (NND) syllabus, which was later split into the National Diploma (ND) and Higher National Diploma (HND) syllabi. Later the Council of Heads of Technological Institutions (COHEADS) and the National Board for Technical Education (NBTE) co-ordinated the development of national standards for all Polytechnic programmes, which included Mining Engineering. Between 1989 and 1990, NBTE co-ordinated a national critique workshop on the mining programme. This resulted in an expansion and harmonization to include other mineral related engineering programmes. The present structure involves a broad-based National Diploma known as Mineral and Petroleum Resources

Engineering, while the Higher National Diploma is offered in Geological Engineering, Mining Engineering, Minerals Engineering, and Petroleum Engineering. Table 1 shows Nigerian institutions that offer geological and mineral-related engineering programmes. Geological Engineering is presently offered at degree levels in 8 Canadian universities, 13 American universities, and several other countries (Wikipedia, 2022).

**Table 1. Mineral related engineering programmes in Nigeria and some foreign institutions**

Institution	Geological Engineering	Mining Engineering	Minerals Engineering	Petroleum Engineering	Qualifications
Ado-Ekiti Polytechnic	#	#	#		HND
Federal Polytechnic Kaduna	#	#	#		HND
Kogi State Polytechnic	#	#	#		HND
Kwara State Polytechnic	#	#	#		HND
Petroleum Training Institute Effurun	#	#	#	#	HND
University of Ibadan				#	BEng
Federal University of Technology Akure		#			BEng
University of PortHarcourt				#	BEng

## MATERIALS AND METHODS

The study was conducted by content analysis involving survey of curriculums and course specifications of various local and foreign institutions, with particular reference to standards prescribed by Nigeria's National Board for Technical Education. Institutions reviewed include polytechnics and universities. Reference was also drawn from authors' teaching experiences in the institutions, field exposures at related industries, as well as regulatory and professional bodies.

## RESULTS AND DISCUSSION

### ND Mineral and Petroleum Resources Engineering Technology

ND Mineral and Petroleum Resources Engineering Technology is designed to produce technicians who should be able to carry out basic functions in prospecting, mining, mineral processing, oil exploration and exploitation, and geotechnical engineering. They are also

expected to be able to collate and present relevant data meaningfully and to operate and maintain simple equipment used in minerals and related industries (NBTE, 2013a). The objectives of the four HND programmes are to produce technologists who can apply engineering principles involved in such activities as analysis, design, operations, processing, and production in the mineral industry.

The term "mining" was historically known and accepted to encompass all aspects of technology related to the exploration, extraction, and processing of mineral resources, including petroleum technology and quarrying. With development and diversification, however, major areas of mining have sprung up as separate disciplines.

Thus, now, in several mining institutions, Petroleum Engineering, Mineral Processing, and Metallurgical Engineering are offered as separate degree programmes. Mining is now applied mainly to the training programme concerned with the actual development and winning of mineral deposits from the earth's crust and sea bed.

This advancement has therefore necessitated a new nomenclature for an umbrella under which all mineral related programmes of training may be described. In many parts of the world, former Departments of Mining are now changing to the nomenclature of "mineral resources engineering" to describe all engineering training programmes that are related to the prospecting, exploiting, and processing of mineral resources. Examples include University of Nottingham and Royal School of Mines in Britain, and Nigerian Polytechnics offering Mining Engineering (Amoka *et al.*, 2023).

The programmes in Nigerian Polytechnics provide for a broad-based National Diploma (ND) in Mineral and Petroleum Resources Engineering Technology and four separate programmes at the Higher National Diploma (HND) level, namely, Mining Engineering Technology, Geological Engineering Technology, Mineral Engineering Technology, and Petroleum Engineering Technology (NBTE, 2013a). Figure 1 shows the general structure of the ND and HND programmes, and the admission requirements.

### **HND Geological Engineering Technology**

Geological engineering may be defined as the joint application of engineering and geological principles to the problem of analysis and design in the engineering activities directly related to the earth, its materials, structure, and forces (Amoka *et al.*, 2023). The increasing rate of depletion of shallow and mineral-rich deposits and the complexities of geological environment pose an ever-increasing challenge on the search for and evaluation of new mineral deposits. Geological engineers have the duty of exploring for minerals, petroleum and groundwater, and to obtain and analyze exploration data, and quantitatively assess economic prospects which will lead to feasibility studies for their exploitation. They are also expected to work competently with instrumentation engineers on the design, fabrication, and analysis of exploration equipment and to carry out routine testing and maintenance on this equipment.

In view of increasing demand on varieties and sophistication of geological equipment and earth structures, the challenges for the geological engineer are enormous. This is of particular

relevance in developing countries with great and urgent need for adequate supply of minerals, energy and potable water. Also of fundamental importance is the geological engineer's task of recognising and understanding geological conditions and their influence on engineering designs and the environment. The geological engineer therefore basically combines engineering tasks of information, instrumentation, structural, and environmental analysis and design, and provides specialist service to mining, mineral processing, petroleum, civil, construction, agricultural and environmental engineers. In mineral exploitation and other earth resources production and construction projects, the work of the geological engineer is to locate resource anomalies, and carry out tactical and detailed appraisal and evaluation of prospects. This culminates in preparation of a feasibility report that accepts or rejects the mineral deposit under study.

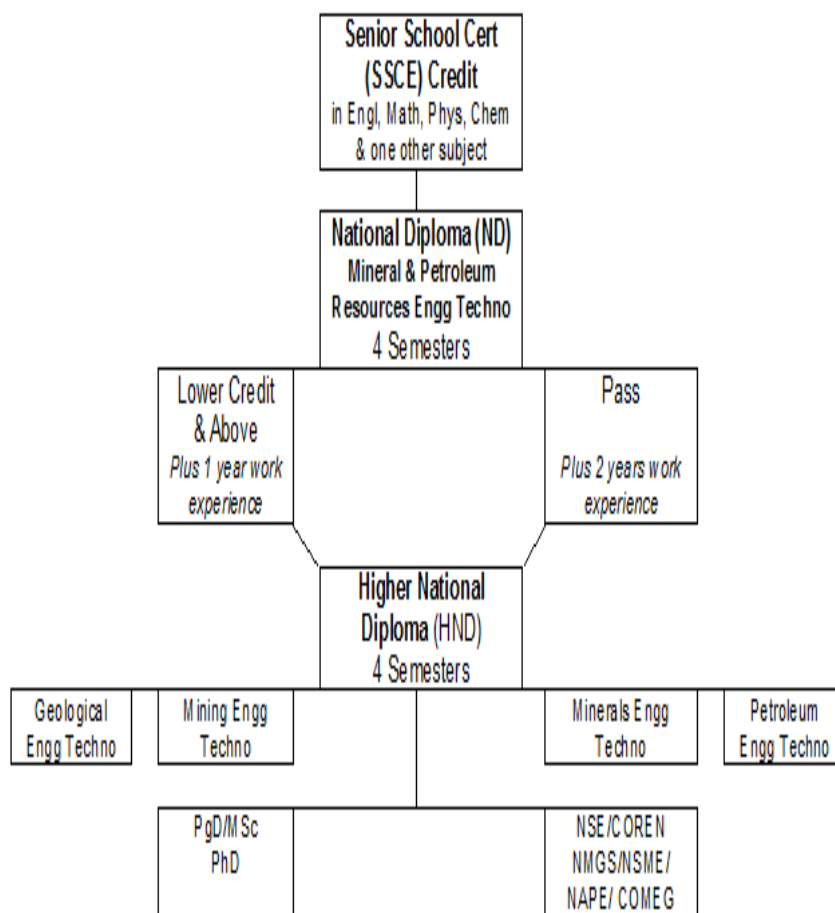


Figure1. General structure for mineral and petroleum resources engineering Programmes

## Entry Requirements

Candidates for admission into the programme are required to have a minimum of Senior Secondary School Certificate (SSSC), with credit level passes in five subjects at most two sittings which must include English Language, Mathematics, Physics, Chemistry, and one other subject from Biology, Agricultural science, Additional mathematics, Economics, Statistics, Technical drawing, Auto-mechanics, Geography, Basic electronics/Basic electricity, and Metal work. Equivalent qualifications for admission include GCE 'O' Level, WAEC, NECO, Teachers Grade II, National Technical Certificate (NTC). In any case, candidates must have credit level passes in five relevant subjects specified. In addition, each candidate must pass the Unified Tertiary Matriculation Examination (UTME) of Joint Admissions and Matriculation Board (JAMB), with the required cut-off mark and subject combination of English Language, Mathematics, Physics and Chemistry (NBTE, 2013a).

The general entry requirements for the HND programme include (NBTE, 2013b, 2013c, 2013d, 2013e):

- (1) All the requirements for admission into the ND programme in Mineral and Petroleum Resources Engineering.
- (2) Minimum of Lower Credit Pass in the ND examination in Mineral Resources Engineering Technology; and
- (3) A minimum of One year cognate work experience.

## Curriculum Structure

Every programme is accredited by the National Board for Technical Education before the graduates can be awarded the National Diploma or Higher National Diploma. The various areas of specialisation and specific components of each programme are designed in conformity with NBTE's new policy aimed at discouraging early specialisation and rather providing a broad base that would produce versatile diplomates at the Technician level. This enhances the employment opportunities of the diplomates. Table 2 summarizes the main components of the ND and HND syllabi. All the syllabi are designed in a course unit system spread over a minimum duration of four semesters at each level.

**Table 2. Main components of Mineral Resources Engineering Technology**

<i>Component</i>	<i>Main courses</i>
General Studies	English Language, Communication Skills, Sociology and Engineer-in-Society, etc.
Foundation courses	Mathematics, Computer Programming, Geometric and Technical Drawing, Pure and Engineering sciences.
Professional courses	<b><i>ND Mineral &amp; Petroleum Resources Engineering:</i></b> Elements of Geology, Mining, Mineral Processing and Petroleum Production courses <b><i>HND Geological Engineering:</i></b> Mineral Exploration, Hydrogeology, Geotechnics, etc.

	<p><b>HND Mining Engineering:</b> Mine Design, Mine Ventilation, Rock Mechanics, Mine Valuation, etc.</p> <p><b>HND Minerals Engineering:</b> Mineral Beneficiation, Mill Design Extractive Metallurgy, etc.</p> <p><b>HND Petroleum Engineering:</b> Reservoir Engineering, Petroleum Drilling and Production, Petroleum Economics</p>
Final Year Project	ND and HND
Field work & Laboratories	ND and HND
SIWES	ND only (Students' Industrial Work Experience Scheme)

Table 3. Practical-Theory Ratio for Mineral and Petroleum Resources Engineering Technology

Programme	Lecture/ Tutorial	Practical	Credit Hours	Practical %
ND MPRE	59	66	125	52.8
HND GLE	66	60	126	47.6
HND MNE	66	53	119	44.5
HND MLE	68	40	108	37.0
HND PTE	60	53	113	46.9

### Professional association and regulation

Table 4 shows major career prospects for engineering technicians and technologists in geological and other earth resources disciplines. The present declining state of Nigeria's minerals industry points to the great challenges and prospects that abound for mineral and petroleum resources technicians and technologists. Nigeria is blessed with abundant reserves of mineral and petroleum resources, which have not been sufficiently explored or exploited and the development of the industry is still at a very low-level. There is an urgent need to explore the indicated resources in sufficient detail to provide quantified information leading to reliable feasibility studies. Appropriate technologies also need to be developed for the economic and effective exploitation of reserves that have been adequately quantified. The industry however lacks, at present, modern exploration and mining equipment and spare parts.

It is necessary for personnel who are adequately trained to fill the industry needs. The current trend of the Nigerian economy also points to the necessity to encourage small-scale mining. This will provide more opportunities for self-employment in addition to careers in government

and large mining and related organizations. Table 4 outlines important career opportunities in Nigeria for geological engineers and other earth resources engineers.

Table 4. Career Prospects for Geological and Earth Resources Engineers

Industry	Expected functions	GLE	MNE	MLE	PTE
Geological Survey/ Raw Materials Agencies	Resources exploration and evaluation	F	V	V	V
Mines & Quarries	Mineral production, processing: quarrying	F	F	F	F
Petroleum & energy	Oil and gas exploration and production				
Steel/Metallurgical plants	Raw materials, Process/plant	V	F	F	V
Chemical/materials	Raw materials: assessment/supply, process/ plant	V	F	F	F
Water resources	Groundwater exploration: yield/quality evaluation, borehole drilling	F	V	V	V
Civil/construction	Geotechnics: site investigation, soil surveys, rock mechanics, construction material assessment/ supply	F	F	F	F
Agriculture	Soil identification and analyses; water analyses; Fertilisers	V	V	V	V
Military	Geological mapping: landforms (military tactics); geotechnics: subsurface installations; water supply: groundwater investigations	V	V	V	V
Ministries/ Agencies	Mines/ Petroleum inspectorates;	F	F	F	F
Environment Pollution	Environment Pollution assessment, earthquake, erosion, soil/rock stabilization	F	F	F	F
Teaching and Research	Resources exploration, evaluation and feasibility and consultancy: soil/rock identification and analyses	F	F	F	F

**Note:**

*GLE = Geological Engineering*

*MNE = Mining Engineering*



*MLE = Mineral Processing Engineering*

*PTE = Petroleum Engineering*

*F = Principal Function/Contribution ;*

*V = Vital Service/Supply*

The broad structure and scope of the ND curricula makes it possible for the professionals to have a wide range of employment opportunities. It is therefore expected that the ND graduate will find employment as technicians in exploration, mining (surface and underground), quarrying, mineral processing, extractive metallurgy, petroleum, natural gas, mines surveying, water resources, chemical, construction and banking industries. The HND graduates in the various disciplines can fill positions as technologists in appropriate ministries and industries. Opportunities also exist in closely related fields such as civil engineering, chemical and agro-allied industries (Amoka *et al.*, 2023).

Several Nigerian and foreign institutions recognize the broad-base nature of mineral related programmes and accept graduates of the Higher National Diploma to proceed for postgraduate studies. HND holders are registrable with relevant professional association bodies such as Nigerian Society of Mining Engineers (NSME), Nigerian Mining and Geosciences Society (NMGS), and Nigerian Society of Engineers (NSE). The graduates are suitably qualified for professional licensing by regulatory bodies like the Council for Mining Engineers and Geoscientists (COMEG) and the Council for Regulation of Engineers in Nigeria (COREN). Figure 1 illustrates the educational paths and contents for the production of engineering technologists, which is comparable to those of the engineers.

## **CONCLUSIONS AND RECOMMENDATIONS**

The importance of evolving and sustaining uniform national guidelines for technical manpower development cannot be over-emphasized. This ensures that the needs of the nation are duly taken into consideration while international standards are maintained. This trend should be upheld in developing nations especially in the field of mineral and petroleum resources engineering. This way, personnel are adequately trained to meet immediate national needs in resources development. The broad-based design of the curricula prepares the diplomats for growing career opportunities. It is recommended that Nigeria should derive greater developmental benefits from graduates of technical education by giving unhindered recognition and opportunities to HND holders to engage in higher studies and professional progression. The society should respect and utilize the complementary roles of technologists and engineers and thus remove all unnecessary discrimination against technologists.

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