NEED-DRIVEN MANPOWER DEVELOPMENT FOR THE METALLURGICAL AND MATERIALS INDUSTRY BY ENGINEERING CURRICULUM RESTRUCTURING.

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ABSTRACT

Development and enhancement of innovative engineering curriculum is a vital exercise in producing well grounded graduates that can perform in today's world. In this paper, two existing models on developing metallurgical engineering curriculum were outlined: The Russian model where there is early specialization to meet national interest and the Western model where there is emphasis on acquiring basic engineering principles with some form of introduction to specializations in the senior year. The merits and/or demerits of the two models were discussed. In developing undergraduate metallurgical engineering curriculum, it was adjudged best to strike a balance between the future of the student (academics and job), the needs of the employer and the nation for reasons of academic progression, job safety and global relevance.

Keywords: undergraduate, curriculum, development, metallurgical engineering.

1.0 INTRODUCTION

Engineering curriculum development is an arduous task. Its importance is seen by the myriads of curriculum development and reviews across the world in higher institutions of learning[1-6].It has to take care of many aspects such as students career prospects, employers interests, national interests and academic content cannot be jeopardized as well. Material content to be included in curriculum will depend on all of these factors. Also, the curriculum must satisfy the Engineering registration body of individual countries. Two main models have been competing over the years; the Union of Soviet Socialist Republics (USSR) model called 'Russian model' due to the disintegration of the Republic and the 'Western model'. In recent years, developing democracies have woken up to the fact that enhancement of the western model will suit them best. In this country, there is some degree of foresightedness in the enhancement of the engineering curriculum by one - semester Students Industrial Work Experience Scheme (SIWES) and recent introduction of entrepreneurship courses. SIWES is an experience which aids the choice of specialized courses in addition to the core courses by the students. In the Eastern democracies like Malaysia and India, there are different structures in place to aid industrial training [5]. Here, curricula are being developed that make the engineering graduate compete in terms of knowledge base, interpersonal and entrepreneurial skills. With this, the graduate can fit into industry, design, research or academics. Adopting the middle – of- the- road approach between the Russian and the Western models, the graduate can contribute to society and have a sense of fulfillment. In this case, he is not straight jacketed into a mould whose non-existence leads to irrelevance. This is the trust for this paper.

2.0 THE TWO MODELS

2.1 The Russian Model

Russian curriculum for metallurgical engineering is based on specialization in different areas of the discipline such as iron making, steel making, foundry, rolling mills and mineral processing. In this model, emphasis is laid on the graduate fitting into State –run - business. The State in this case is the employer and the students graduate directly into this business.

Table 1: Metallurgical Engineering Curriculum of Saint-Petersburg State polytechnic University [7]

Departments	Bachelor (4 years) (code and designation of branch)
Department: "Steels and alloys"	150100 Metallurgy
Department: "Physics-chemistry of castable alloys and processes"	150100 Metallurgy
Department: "Investigation of structure and properties of materials"	150100 Metallurgy 150600 Material science and new materials technology
Department: "Plastic metal working"	150100 Metallurgy
Department: "Welding and laser technologies"	150100 Metallurgy
Department: "Electronic engineering materials technology"	210602 Nanomaterials (speciality) 240306 Chemical technology of monocrystals, materials and articles of electronic engineering (speciality)

2.1.1 Merits and Demerits of the Russian Model

The merit of the Russian model is that there is very high skill specialization and men appear like tools in a business jig-saw. The advantage of this is obvious in that early specialization enhances proficiency. The best can come out of individuals especially when dealing with complex systems as we have in the iron blast furnace that requires minute details.

However, there is lack of business entrepreneurship capability when manpower production is more than available spaces in State - run enterprises. Also, in cases where State - run enterprises are no longer the main employers of labor as it is turning out in recent time in Russia, graduates will find it difficult to fit in to other business outfits. A graduate who has come out with a

foundry degree will find it difficult to be employed in a plastics industry which would have been possible had he/she come out with a materials engineering degree. It must be noted that all counties that practiced the Russian model have a very strict socialist system till date and many of their graduate find it increasingly difficult to be competitive in the post USSR era. This is definitely not the way forward in a global village, a free enterprise system and a democratic world. Thus, the demerits of the Russian model preponderate over the merits especially for developing nation like Nigeria. Even then, the Western model can not be adopted hook, line and sinker.

2.2 The Western Model

In the Western model, emphasis is laid on acquisition of basic science, mathematical and engineering principles which are foundational to the practice of engineering and research. Some form of introduction into specializations is introduced at the senior level where some technical courses are taken like optical materials, nuclear materials, refractory technology and nonferrous materials [9]. At graduate (postgraduate) level, deeper insight into different specializations can be made such as physical metallurgy, chemical metallurgy, mineral processing or mechanical metallurgy but the graduate will still have a Masters degree in metallurgical and/or materials engineering. This system feeds the graduate into any organization whose production fall under any of the specializations. A graduate who specialized in mechanical metallurgy finds it easy to fit into a rolling mill, machining or manufacturing organization where forging and welding are the basic production processes. At the University of Tucson, Arizona, for example, undergraduates have opportunities at engaging in research and utilization of industrial level equipment for electron microscopy, spectroscopy and other materials characterization purposes [8].

Table 2: Metallurgical Engineering Curriculum of University of Arizona, Tucson [8]

Curriculum

Freshman - First Semester			Freshman - Second Semester		
Class	Title	Units	Class	Title	Unit
CHEM 151	General Chemistry I	3	ENGL 102	1st Year Composition	3
ENGL 101	First Year Composition	3	MATH 129	Calculus II	3
ENGR 102	Introduction to Engineering	3	PHYS 141	Intro to Mechanics	4
MATH 124/125	Calculus with Applications	5/3	MSE 110	Solid State Chemistry	4
Tier I	INDV*	3	Tier I	TRAD	3
Sophomore - First Semester			**Sophomore - Second Semester**		
MATH 223	Vector Calculus	4	MATH 254	Ordinary Differential Equations	3
PHYS 241	Intro to Electricity and Magnetism	4	MSE 365	Structure and Prop. of Materials I	4
MSE 222	Introduction to Material Science	3	MSE 223L	Materials Processing Lab	2
MSE 345	Thermodynamics	4	MSE 223R	Intro. to Materials Science & Engr. II	3
			Tier 1	INDV*	3
Junior - First Semester			**Junior - Second Semester**		
MSE Tech.	MSE Technical elective**	3	MSE 360L	Materials lab	1
MATH Elec.	Math elective course***	3	MSE Tech.	MSE Technical elective**	3
MSE 350	Numerical Methods in MSE	3	MSE 480	Exp. Methods Microstruct. Analysis	3
ECE 207	Elements of Electrical Engineering	3	MSE 415	Transport/Kinetics	4
Tier I	TRAD*	3	Sci. Elective	Advanced Basic Science Elective.	3
Senior - First Semester			**Senior - Second Semester**		
ENGR 498A	Cross Discipline Design	3	ENGR 498B	Cross Discipline Design	3
MSE Tech.	MSE Technical Elective**	3	MSE Tech.	MSE Technical Elective**	3
TECH Elec.	Technical Elective**	3	TECH Elec.	Technical Elective**	6
TECH Elec.	Technical Elective**	3	Tier 2	Arts or Humanities*	3
Tier II	INDV	3			

* One course focusing on a non-western culture or on race, gender, class or ethnicity is required.
**Electives should be chosen with the 42 upper division unit requirement in mind (300 & 400 level courses).
***Students are required to take a course such as statistics, linear algebra, or advanced calculus. A statistics course, such as SIE 305, is highly recommended.

2.4 Merits of the Western Model

The Western model is a more advantageous system than the Russian model where the graduate comes out with a specialized degree say, Masters in rolling mills. The leeway created by the Western curriculum structure takes the long-term interest of the student into consideration while providing a good foundation for either an academic or industrial career. Continuous development make the Western graduate more fulfilled career wise and better rounded. He is better adapted to vagaries on the job market and for purposes of entrepreneurship.

Table 3: Metallurgical Engineering Curriculum of (IIT), Kanpur [9]

STRUCTURE OF THE B.TECH. PROGRAMME

SEM. II	SEM. III	SEM. IV	SEM. V	SEM. VI	SEM. VII	SEM. VIII
MME 100	MME 200	MME 210 MME 250 HSS II	MME 310 MME 320 MME 330 E1	MME 331 MME 340 MME 350 MME 370 MME 390 E II	MME 410 MME 415 MME 470 DE I	MME 480 MME 499 E III DE II DE III

2.6.2 Brazil; Case Study- University of São Carlos [10].

Brazil's curriculum system is just like the USA system with specializations at the senior level. Industrial sociology is also included.

Table 4: Metallurgical Engineering Curriculum: University of São Carlos [10]

Semester 1

Discipline	**Credit**	**Status**
Introduction to computation	4	**Basic**
General experimental Chemistry	4	**Basic**
Analytical Geometry	4	**Basic**
Calculus1	4	**Basic**
Ecology	4	**Basic**
Introduction to the science and Engineering of Materials	2	**Professional**
Engineering Mechanics	4	**Basic**
Total	26	

Semester 2

Discipline	**Credit**	**Status**
General Chemistry2	4	**Basic**
Inorganic Chemistry	4	**Basic**
Physics Experiment A	4	**Basic**
Calculus2	4	**Basic**
Physics 2	4	**Basic**
General Economics	4	**Basic**
Common Materials	2	**Basic**
Total	26	

Semester 3

Discipline	Credit	Status
Chemical Thermodynamics	4	Basic
Organic Chemistry	4	Basic
Experimental Physics B	4	Basic
Calculus3	4	Basic
Physics 3	4	Basic
Mechanical Applications 1	2	Basic
Materials Science	4	Professional
Total	26	

Semester 4

Discipline	Credit	Status
Series and Differential Equations	4	Basic
Experimental Analytical Chemistry	4	Basic
Solid Mechanics 1	4	Basic
Thermodynamics of Solids	4	Professional
Physics 4	4	Basic
Materials Science 2	4	Professional
Total	24	

Semester 5

Discipline	Credit	Status
Numerical Methods	4	Basic
Transport Phenomena	4	Basic
Ceramic Materials	6	Professional
Polymeric Materials	6	Professional
Metals	6	Professional
Fundamentals of Rheology	2	Professional
Total	28	

Semester 6

Discipline	Credit	Status
Methods of Mathematical Application	4	Basic
Experimental Transport Phenomena	2	Basic
Electrotechnics	4	Basic
Business Economics	2	Basic
Processing of Metals	4	Professional
Processing of Ceramic Materials	4	Professional
Processing of Polymeric Materials	4	Professional
Composite of Ceramic Matrix	2	Specific(Ceramics)
Fundamentals of Extractive Metallurgy	2	Specific(Metals)
Sintering of Polymers	4	Specific(Polymers)
OPTIONS		
Total(Polymers)	28	
Total(Ceramics and Metals)	26	

Semester 7

Discipline	Credit	Status
Introduction to metrology and statistics in Experimentation	4	Basic
Investment Analysis	2	Basic
Industrial Sociology	4	Basic
Materials Characterisation	4	Professional
Processing of Metals	4	Professional
Experimental Ceramics Processing	4	Specific(Ceramics)
Kinetics and Equilibrium of Ceramic Materials	4	Specific(Ceramics)
Mechanical Metallurgy	4	Specific(Metals)
Physical Metallurgy	4	Specific(Metals)
Extrusion and Properties of Polymers	4	Specific(Polymers)
Materials Engineering Project1	2	Professional
Total(Polymers)	26	
Total(Ceramics and Metals)	28	

Semesters 8 and 9

Discipline	Credit	Status
Theory of Organization	4	Basic
Materials Selection	4	Basic
Heat Treatment	4	Basic
Mechanical and Thermomechanical Properties of Ceramic Materials	4	Professional
Processing of Thermoplastics	[illegible]	[illegible]
Materials Engineering Project 2	2	Specific(Ceramics)
Professional Courses	24	Professional
OPTIONS: Total	24	Professional
Total	14 specialty area	

Semester 10

Discipline	Credit	Status
Quality Assessments	4	Basic
Foundry	4	Specific(Metals)
Mechanical Testing	4	Specific(Metals)
Polymer Engineering	4	Specific(Polymers)
Processing of Elastomers	4	Specific(Polymers)
Functional Properties and Application of Ceramics	2	Specific(Ceramics)
Ceramic Refractories	4	Professional
Final Year Thesis	8	
Total	20 specialty areas	

2.6.3 Nigeria; Case Study-Obafemi Awolowo University[11]

The Nigerian engineering undergraduate curriculum system looks developed. It has incorporated courses in entrepreneurship, one - semester industrial work experience program carried out in industry and specializations at the senior year. However, the Nigerian system is too theoretical and the government policies are not helping. With proper teaching, workshop practice, laboratory work and industry-university linkage it promises to be one of the best curricula for producing well grounded graduates for the metallurgical and materials engineering industry

Table 5: Metallurgical Engineering Curriculum: Obafemi Awolowo University [11]

Part1 MTH 101: Elementary Mathematics I PHY 101: General Physics I PHY 107 :Experimental Physics IA CHM 101: Introductory Chemistry I TPD 101 :Engineers in Society SE Special Elective	**PART 1: RAIN SEMESTER** MTH 102: Elementary Mathematics II MTH 104 :Vectors PHY 102 :General Physics II PHY 108 :Experimental Physics IB CHM 102: Introductory Chemistry II SE Special Elective
PART 2: HARMATTAN SEMESTER MTH 201 Mathematical Methods I CHE 201 Introduction to Thermodynamics CSC 201 Computer Programming *ME 201 Elements of Engineering Materials MEE 203 Engineering Drawing I MEE 205 Engineering Mechanics I EEE 201 Applied Electricity I EEE 291 Applied Electricity Lab. I SE Special Elective	**PART 2: RAIN SEMESTER** MTH 202 Mathematical Methods II AGE 202 Workshop Practice CSC 208 Computer Technology CVE 202 Strength of Materials MEE 204 Engineering Drawing II MEE 206 Engineering Mechanics II EEE 202 Applied Electricity II EEE 292 Applied Electricity Lab. II MME 202 Introduction to Materials Engineering SE Special Elective
	LONG VACATION MME 200 Student Work Experience Programme (SWEP)
PART 3: HARMATTAN SEMESTER CHM 207 Physical and In CHE 305 Engineering An MME 301 Foundry Techn MME 303 Heat and Mass Transfer MME 305 Mechanics of Materials MME 307 Metallurgical Thermodynamics MME 309 Materials Laboratory I SE Special Elective	**PART 3: RAIN SEMESTER** 02 Statistics for Engineers 306 Engineering Analysis II 302 Introduction to Crystallography MME 304 Fuels, Refractories and Furnace Technology MME 306 Materials Testing MME 308 Mineral Processing MME 310 Phase Diagrams MME 312 Physical Metallurgy I SE Special Elective
	LONG VACATION *MME 300 Student Industrial Work Experience Scheme I (SIWES I)
PART 4: HARMATTAN SEMESTER CVE 401 Technical Report Writing MME 401 Powder Metallurgy MME 403 Electrochemistry and Chemical Kinetics MME 405 Experimental Techniques MME 407 Fracture Mechanics MME 409 Heat Treatment of Metals MME 411 Fundamentals of Production Processes MME 413 Materials Laboratory II SE Special Elective	**PART 4: RAIN SEMESTER AND LONG VACATION** MME 200 Student Work Experience Programme (SWEP) MME 300 Student Industrial Work Experience Scheme I (SIWES I) MME 400 Student Industrial Work Experience Scheme II (SIWES II)
PART 5:Option A:Materials HARMATTAN SEMESTER TPD 501 Industrial Economics TPD 503 Industrial Law and Management MME 501 Materials Failure Analysis	RAIN SEMESTER TPD 502 Technology Policy MME 502 Materials Selection and Economics MME 504 Materials Process and Plant Design MME 506 Materials and Tribology MME 508 Wood MME 510 Composite Materials

MME 503 Ceramics and Glasses MME 505 Electrical, Magnetic and Optical Properties of Materials MME 507 Materials Production Processes MME 509 Polymers MME 529 Final Year Project I	MME 530 Final Year Project II
Option B:Metallurgical HARMATTAN SEMESTER TPD 501 Industrial Economics TPD 503 Industrial Law and Management MME 501 Materials Failure Analysis MME 511 Production Metallurgy MME 513 Non-Ferrous Extraction Metallurgy MME 515 Physical Metallurgy II MME 517 Principles of Metal Deformation MME 529 Final Year Project I	RAIN SEMESTER TPD 502 Technology Policy MME 502 Materials Selection and Economics MME 504 Materials Process and Plant Design MME 512 Foundry Technology II MME 514 Hydrometallurgy MME 516 Ferrous Extraction Metallurgy MME 530 Final Year Project II
Option C: Corrosion HARMATTAN SEMESTER TPD 501 Industrial Economics TPD 503 Industrial Law and Management MME 501 Materials Failure Analysis MME 519 Corrosion and Environments MME 521 Corrosion Monitoring and Inspection MME 523 High Temperature Oxidation MME 525 Surface Phenomena MME 529 Final Year Project I	RAIN SEMESTER TPD 502 Technology Policy MME 502 Materials Selection and Economics MME 504 Materials Process and Plant Design MME 506 Materials and Tribology MME 518 Design and Economic Aspects of Corrosion MME 520 Prevention and Protection Against Corrosion MME 530 Final Year Project II

3.0 CONCLUSION

In this paper, undergraduate engineering curriculum restructuring relevant to the needs of stakeholders-stu dustr the ional community has been discussed. Ma opted the western model have enhanced their curriculum structures to cater for different stakeholders. However, the Nigerian oo theoretical and the government policies are not helping. With proper teaching, worksh practice, laboratory work and industry-university linkage it promises to be one of the best curricula for producing well grounded graduates for the metallurgical nd materials engineering industry.

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