NEW CURRICULA IN APPLIED SCIENCE BASED ON INTERDISCIPLINARY COLLABORATION AND UNIVERSITY-PRECOLLEGE-INDUSTRY IN DEVELOPING COUNTRY

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Abstract *- Education and training of civil servants and high-school teachers have been for a while, the main task of universities in developing countries such as Sénégal. Recently, insuch countries facing increased unemployment even of graduate students, attempt has been made to analyze the state of traditional science disciplines. The existing curricula have been found rather good for capacity building and basic knowledge acquisition, but not well suitable for solving the problem of education-employment adequacy. The necessity of designing new curricula closely coupled as well with the traditional disciplines as with the research and development activities is demonstrated. The formulation of such new curricula is then presented, focussing on modular approaches and science and technology integration. Moreover, the close relation between the traditional academic fields and our research and development activities in material science is pointed out. Some of our concrete results illustrate the pre-requisiteness of the vulgarisation of science with respect to the process of appropriation by the students of the essential concept of technology and skill acquisition through the application of scientific knowledge. In that respect, the aim of the present approach, while avoiding course-overload, is to give vocational competence in addition to the academic background. Finally, the new curricula are shown to be pertinent to the university-precollege-industry collaboration, through the recrudescence of dynamism and activity of the so-called ''Blocs d'Enseignement Scientifique et Technologique'' and the emphasis on dealing with real-life socio-economic problems.*

Index Terms – Science knowledge acquisition, technical training, work-oriented higher-education, apprenticeship of skill-workers, education with production.

I Introduction

I.1 Capacity building in the early stage of independence

From 1960 up to 1970, the main task of most of the newly independent states such as Senegal, has been to take over the education and administration system from the french government. Therefore, much attention has been given to the education and training of civil servant and high-school teachers. In the end of sixties and the early seventies, the need of socio-economic activity –oriented education has led to the creation of the so-called ''Institut Universitaire de Technologie''. However, besides the sector dedicated to business and management, a limited number of curricula (electrical, mechanical, civil-infrastructural, biochemical and agro-industrial engineering) has been considered in such engineering education system. It is only recently that informatics and communication science and technology have been introduced as curricula.

The appointment of well-qualified senegalese national to fill almost all the positions in the education and administration has been achieved between 1980 and 1985. Since then, the education system is continuously welcoming increased number of students while the number of available public office jobs is decreasing. Employment in the growing industrial sector would be beneficial to school leavers entering the labour market. However, the existing curricula rather good for capacity building and basic knowledge acquisition, need some improvement, particularly much more science and technology integration, closely related with the needs of the industry to foster education employment adequacy.

TABLE I :
The syllabuses of Mathematics and Physic curriculum

	Mathematics and Physic (MP)
1rst year	
Mathematics	i) algebra - linear algebra ii) calculus (vectorial, differential, integral) iii) analytical geometry
Physic	i) electricity, magnetism and AC circuit) ii) classical mechanic (kinematic, dynamic iii) optic (geometric, interference and diffraction)
2nd year	
Mathematics	i) algebra - linear algebra ii) calculus (series, integral,) iii) analytical geometry iv) probability.
Physic	i) electromagnetism and relativity (Maxwell equation, electromagnetic energy, wave propagation, reflection, refraction, standing wave and guided propagation) ii) Quantum Mechanic (duality wave-particle, photon in photoelectric and Compton effect, wave function and one dimension Schrodinger equation, particle in an infinite well - tunnel effect, atomic energy level, kinetic and magnetic (spin) particle momentum iii) thermodynamic and statistical physic (system, principles, variables, and functions, work and heat, transformations, gas statistic).
Mechanic	i) torque iii) kinematics - classical dynamic of point and solid iii) static of solid iv) analytical mechanic (Lagrangian, Hamiltonian)

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The aim of this paper is to discuss the formulation of the work-oriented new curricula starting from the advantages and limitations of the traditional science disciplines. The newly proposed curricula lean on the existing good-quality higher-education balanced however with the student preparation for entry into the modern labour market.

I.2 State of traditional science disciplines

The undergraduate syllabuses of the three main curricula, are Mathematics and Physic, Physic and Chemistry, Chemistry, Biology and Geology or Natural Sciences.

TABLE II

The syllabuses of Physic and Chemistry (PC)

	Physic and Chemistry
1rst year	
Mathematic	i) algebra ii) calculus (vectorial, differential, integral, numerical) iii) analytical geometry
physic	i) electricity, magnetism, AC circuit ii) classical mechanic, iii) optic (geometric,:interference diffraction)
chemistry	i) matter (bonds and structure) ii)chemical reaction (thermodynamic, kinetics)
2nd year	
Mathematic	Same as in MP
Physic	Same as in MP
Chemistry	i) mineral chemistry ii) organic chemistry (structure, properties, synthesis, reactions of functional compounds)
Bio-chemistry	i) lipids, glucides, proteins, nucleic acids ii) enzymatic catalysis

The tables 1 to 3 display a relatively detailed description of the traditional science disciplines, MP, PC and CBG or SN. The syllabuses and contents are well designed and comparable to the undergraduate course in the french system. This is attested by the ability of our students to continue their study in France or most of the industrialized countries with equivalent academic standard, showing the good quality of the senegalese higher educational system in science knowledge acquisition within a two-years course.

However, the shortage of practical training that is also not well diversified, not up-dated and not well related to the socio-economic net lead to the weakness of the student skills in technology although they have rather good basic scientific knowledge. For instance, they can handle elements of thermodynamic theory, solve equations and discuss diagrams without knowing the technical aspects behind a refrigerator. They master the theory of electricity, induction laws and electromagnetism ignoring the technology of transformers.

The framework of a widespread and organized apprenticeship in Senegal, is well known to strengthen the technical skills of the craftsmen and technicians. Such skillworkers are well qualified to repair and even assemble various kinds of machines (motors, refrigerator, transformer, etc) but on the other hand, they don't have any basic theoretical scientific background.

In conclusion, while skillworkers will be receiving formal theoretical scientific background education in vocational schools or training centers, our students will be practically much more trained especially in applied and technical field in our work-oriented new curricula.

II. Design of new curricula

In the new curricula, interdisciplinary topics that are identified as essential for development are laid out in addition to the traditional educational core. The three major problems to be dealt with are the identification of the relevant contents, the teaching level to be considered and the ways and means of teaching. Choice has been made to select students after the completion of the second year of undergraduate course because of the good basic scientific education they already received.

II.1 Modular approaches

The new curricula that are based on a modular approach, consist of a proportioning of a basic skeleton (science course, namely mathematic, physic and chemistry) and optional (technical course).

a) common basic skeleton

The basic skeleton of the new curricula is designed to additionally provide extended basic knowledge, stressing the close connection between several aspects of science and technology that are related to the traditional disciplines.

TABLE III

The syllabuses of Chemistry, Biology and.Geology CBG)

	Chemistry, Biology and.Geology CBG)
1rst year	
Mathematic	i) relations, applications, functions, graphs ii) calculus (series, integral,) iii) probability and statistics.
Physic	i) classical mechanic - vibrations - harmonic oscillations, gravitation ii) Thermodynamic and Statistical Physic: system, principles, variables, and functions, work and heat, reversible and irreversible transformations, gaz statistic iii) electricity, magnetism and AC circuit iv) Optic (vawes, polarisation, reflection, refraction, interferences) - Electromagnetism and Relativity (induction laws, Maxwell equations and electromagnetic wave - introduction to electronic functions v) introduction to quantum mechanic and nuclear physics - atom and nucleus, radioactivity vi) structure and properties of condensed matter - properties of fluids: viscosity, diffusion, osmosis vii) symmetry in physics
Chemistry	i) Physical chemistry (matter : bonds and structure) ii)chemical reaction (thermodynamic, kinetics) – catalysis iii) mineral chemistry
Biology	Cell biology (cell structure, functioning, reproduction, varaiations: gene permanence, mutation, reproduction, genetic recombination, metabolism regulation
geology	A) geodynamic i) introduction, ii) internal geodynamic :geophysical data, horizontal mobility of continent - earth'crust composition (geochemical data, rocks formation) - seismology and vulcanology iii) external geodynamic (marine geology, erosion and sediments – continental domain :role of alteration, wind, surface water and glacier –erosion - relief B) paleonthology i) fossiles, ii) ecology, iii) life, iv) paleonthological groups and environmental medium
2nd year	
Chemistry	i) organic chemistry (structure, properties, synthesis and reactions of organic compounds, multiple functions and complex heterocycles, stereochemistry, physico-chemistry determination of structures
Bio-chemistry	i) Proteins –enzyms: catalysis and kinetics ii) metabolism substrate and products iii) nucleic acid - biosynthesis
Biology	Cell biology :animal physiology (neuron structure - membrane : permeability, electrical phenomena and excitability - conduction of propagating potential - nerves : nature of the potential, message, synapsis transmission, muscle contraction
	Zoology and animal biology i) organism development (embryonic and organogenesis ii) morphogenesis (multiplication, organisation, comparative anatomy and physiology
	Vegetal physiology i) Nutrition and metabolism ii) growth, development and morphogenesis
geology	Petrography i) mineralogy ii) rocks (eruptive – metamorphic – sediments – alteration)
	Geomorphology i) definition and principles :erosion agents ii) lithology, st ructure - history iii) climate

b) work-oriented optional courses

Our approach [1] is comparable to the one nicely described by J. B. Holbrook [2], when analysing the technology education as a union of science and technical skills. Four different industry-related optional subjects have been considered, i) metals, semiconductors, superconductors, and alloys, ii) cristals, glasses, ceramics and composites, iii) dyes, pigments, fats and essential oils, iv) natural fibers, polymers and resins.

Option 1 :
metals, semiconductors, superconductors, alloys :
metallurgy, casting and other processes – structural, mechanical and physical properties – characterization techniques

Option 2 :
cristals, glasses, ceramics and composites : raw materials, structural, mechanical, physical and chemical properties – molding and characterization techniques

Option 3 :
dyes, pigments, fats and essential oils :
raw materials - extraction and transformation
structural, , physical and chemical properties and reactivity – characterization techniques

Option 4 :
natural fibers, polymers and resins :
anatomy and microchemistry of natural fibers – structure and elaboration of polymers and resins –physical, mechanical and thermomechanical properties - characterization techniques

Education and training in the above mentioned subjects include material extraction and processing from raw up to high value added products, material recycling, laser cutting or welding, etc..

For instance, the topics of the first option that are related to metallurgy and foundry will be stressing the importance of concept such as phase transition in diagram thermodynamic and alloy structure, miscibility and stability. The relation between polymer properties and some selected industrial applications like soft thermoplastic for packing bag to hard plastic for shoe industry, special plastic for kitchen tools.

The syllabuses include also the study of existing fabrication process and activities for the improvement of handicrafts. Finally, the curricula organisation illustrates in a concrete manner the efficient and appropriate fabrication of products.

II.2 Science and Technology integration

The first step of our approach concerning science and technology integration is the identification of flourishing or growing handcraft and industrial sectors as follow : i) casting and metallurgy, ii) building, sanitary, tiling and glassware, iii) painting, dyeing, soap, cosmetic and perfume, iv) textile, plastic, sponge and coating compounds.

The practical works of the experimental set-up have been selected closely related to the production and quality control sector. In addition, students should be going to partner industrial factories for a three months training every year.

As pointed out by Wim Hoppers [3], our curricula organisation that is based on a full integration of the work-oriented topics into the core, is essential for a valuable understanding of the structure and processes of work, its technologies, its relation to production or its economic, cultural and political context.

III Relationship between traditional academic field and our R&D in Material Science

In the framework of our research & development activities in material science, our students are also trained in several ongoing handcraft manufacture project. The production of various goods i) wax, dye.for coloured candles or shoe-polish ii) reinforced clay for hardening of ceramic and composite, iii) metal and glass recycling and laser or abrasive pressure processing, etc., is therefore an integral part of the learning process.

Such production activities showing the relationship between traditional academic field, technology development and handcraft manufacture, demonstrate the importance of education with production in this efficient educational innovation, as pointed out in early studies [3,4].

IV Vocational competence and academic background

The adequacy of the optional courses have been discussed in detailed with the experts and professionals from the industrial sectors. Well balanced curricula avoiding course-overload has been obtained taking into account the need of solving real industrial and socio-economic problems. Pertinent courses are being introduce by easy stages.

The financing method is on a sponsorship basis. As a matter of fact, industrial companies are requested i) to participate in the elaboration of several topics of the optional part of the curricula, ii) to provide fellowships for students that cover tuition fees and living expenses.

The advantages of such mixed financing model is to ensure a minimum funding for the running cost in addition to the equipment budget provided by the government, to prevent student strike and to promote steady involvement of the industrial sectors into the education affairs. Of course, paying students are unwilling to be disturbed by any strike perturbation.

REFERENCES

[1] Beye, A. C., Nouvelles filières en Sciences Appliquées et les possibilités de développement et de transfert de technologies vers des PME/PMI, Symposium of AFRISTECH 8 – 13 Décembre 1997, Dakar, Sénégal.

[2] Holbrook J. B., Technology Education: A Union of Science and Technical Skills, Education, Industry & Technology, Vol 3, edited by D. J. Waddington, 1987, pp. 85 - 95

[3] Hoppers W., Searching for relevance: the development of work orientation in basic education, UNESCO International Institute for Education Planning, Vol 52, 1996, pp. 1 – 114.

[4] Inbar Dan E., Planning for innovation in education, UNESCO International Institute for Education Planning, Vol 53, 1996, pp. 1 – 109.