THE INTERNATIONAL ACCREDITATION OF THE ENGINEERING THROUGH THE USE OF PROPAEDEUTIC CYCLES

Abstract

The Internationalization of Engineering by propaedeutic cycles is a new method to increase both quality and competitiveness of the engineering fields in tertiary education. Recently the IEEE Region 9 has shown an special interest in developing a task force to support global accreditation inside its member countries. To face the many challenges that international accreditation presents we propose some analytic instruments, of mathematical and computational type, using an innovated Leontief Model, which is based on the rationalization and optimization of resources required (included knowledge industry), because the international competitiveness and global accreditation in engineering education, are issues that are closely related, and very they are expensive for institutions in less developed countries.

Keywords

Intellectual Assets, Engineering by Propaedeutic Cycles, Higher Education, Internationalization, Competitiveness, Accreditation Tools, Resource Mobility

Summary

The Internationalization seeks further movement (mobility) of knowledge, Intellectual Assets, human and other resources. It is also intended to promote quality trans-boundary HE (higher Education), developing programs and giving them more competitiveness as an worldwide dimension, promoting international qualifications, language skills and multicultural understanding in the process as well as through the high training of lecturers for knowledge transfer competitiveness with global vision. Very important is the international mutual recognition before the smoothing of the engineering curriculum.

We present firstly, some reflections about the internationalization and global accreditation including the IEEE role in less development countries, in the way of competitiveness.

Secondly, the strategy of the Higher Education through the use of propaedeutic cycles, HEbPC, which are integrated for 3 levels or phases: Technician Engineering (known as Technician-Professional, TP), Technology Engineering (Technologist, T) and Professional on Engineering (Engineer). Each one has a propaedeutic component in order to establish the coherence, articulation and the consistency between knowledge and competences in the superior cycle leading to graduate professional of high competitiveness.

Thirdly we present some tools built by re-contextualizing the W. LEONTIEF Model from the Industrial Society to the Knowledge Society, and by innovating it, with the Process and Knowledge Engineering, Artificial and Computational Intelligence, Fuzzy Logic and others in order to face the most critical problems in HE in Colombia. A structural system designed to determine and analyze the cohesion and coherence of the propaedeutic cycles, PC between competences and the curriculum knowledge. These initiatives are focused on Research, Development, Innovation and Experimentation with application of knowledge and ICT architectures. They are synthesized with a model designed and implemented to confront some of the main problems frequently found in third world countries:

1- The low productivity of students and teachers with serious consequences in the competitiveness national wide.

2- The process of internationalization for HEI (Higher Education Institutions) results in mobility and circulation of intellectual assets, people, knowledge, goods and services including pedagogical, ideas and values cultivated for abroad institutions.

3- The Study Plan optimization.

The Higher Education Institutions, HEI are the natural space where the ethos of knowledge can be developed and the Intellectual Capital (IK) can be accumulated and also mobilized. It's no secret the inadequacy of the Management Information Systems, MIS to incorporate knowledge. In fact is shared by many authors that well over half the market value is explained by the IK in companies of the Third Millennium. Traditional systems do not account for the IK and only estimate the Book values vs. Market values when selling focused on negotiation processes. On the other hand, there are already quite a few financial models of the knowledge economy that considers the IK. For the universities is a critical issue in the way of the Competitiveness of Higher Education.

We conclude that the international accreditation is a known and perceived necessity, especially in countries as Colombia in which no quality condition appears in the Qualified Registration, in connection with the internationalization and the competitiveness of the HE.

The formalization of accounting for assets and liabilities of IK with endpoints is required and it is also required the reengineering of business processes to identify which of them generate value and advantage competitive and decide which of them have to be outsourced but fundamentally require investments in building capacities of knowledge within the company.

I. HIGHER EDUCATION

A *About the Fundacion Superior San Jose, FESSANJOSE*

FESSANJOSE is an Institution of Higher Education of technological nature, redefined by Propaedeutic cycles, non-profit making, public utility, and private one, is a social project for promoting the improvement of the intellectual, technical, technological, scientific, industrial for children, youth and adults. It was founded in 1984. It was legally constituted and has the official approval of the MEN.

We enable access to HE to a fringe population, located in the most depressed (lower income), with no access to state education coverage, which by their level of income cannot enroll in a private institution. We currently have 3500 students. One of the analytical models presenting here, was recognized by the MEN as a successful case and was included in the Colombia National Bank of Significant Experiences in HE. Our Research Team was recognized by Colciencias, (National Institution STI). Next section V and in section III, B we discuss other contributions.

B *Education Sector Brief Analysis*

The tertiary student desertion is a national wide problem that is very critical by its cultural, economic and households impact. Several SEI´s have performed partial studies leading to point out this problem as a recurrent and prevalent one. Other problem is related with academic governability in order to face additional demands from the environment, including the financial sustainability. Colombia by HE student abandonment loses annually a value close to USD $300.000.000 in which the corresponding rate is more than 0.50 by 2010.

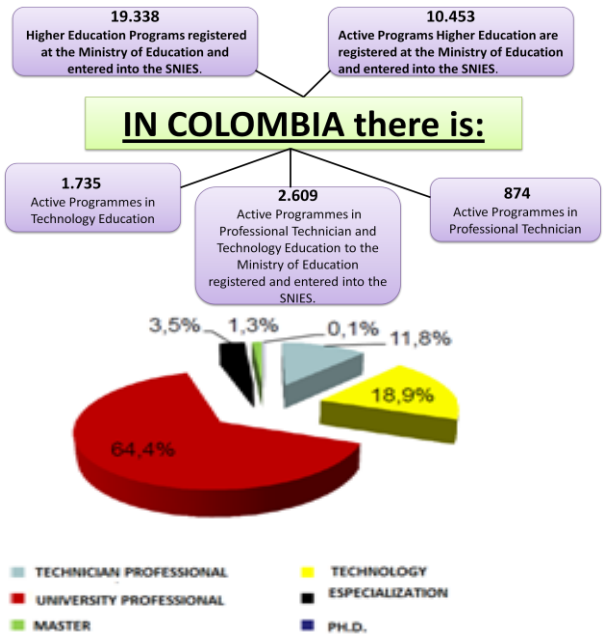

Figure 1: Colombia Higher Education

The figure above shows us, most educational problems related to the high offer and student´s most preference for university careers rather than Technologists and Professional Technicians, T/T with hard consequence in the pyramids of the work force. It shows that T/T figures are dangerous reduced.

Regarding official data of the MEN in LATIN AMERICA & CARIBEAN (2008), the mean HE student coverage is 38% in Colombia is 35.4% which is very low regarding neighbors: Ecuador: 42.4%, Chile: 54.8%, Uruguay: 64.9%, Panamá:45.1%, and Cuba: 121.5%.

In summary the HE sector suffers from the low competitiveness, nationally and internationally which together with the significant gaps in quality and demands require more drastic solutions.

C *Our Answer*

Our initiatives are focused on Research, Development, Innovation and Experimentation with application of knowledge and ICT (Information and Communication Technologies) architectures since 2005. They rest on an analytical model for the governance and the academic and financial sustainability, facing the student's dropout and social exclusion problems in order to move up to educational competitiveness. These efforts are concreted out with a system designed and partially implemented to confront the PC´s strategy; a blended system: virtual microworld called iCOACH for concept and knowledge verification for students and teachers productivity and the FESSJ-PROP a set of analytical-mathematical tools that enable the curricular knowledge management and governability; it is a structural system to analyze the structure, the cohesion and the coherence between the PC. Several Leontief Model extensibilities by Linear Programming and Input-Output, which analyses the dropout complexity, are included. We think our model be an academic response to the whole T/T Educational problem in this country. [2], [4]. The mathematical tools presented in Sections IV and V can be used and apply for quantification purposes of the transborder mobility of resources including knowledge.

II PROPAEDEUTICS CYCLES: THE INNOVATION OF HIGHER EDUCATION

The HEbPC is characterized by designing and organizing a flexible, sequential and complementary curriculum of the university education programs: three levels and three cycles in postsecondary education: first, the professional technician, second, the technological and third, the professional, preceded by an articulation PC, from the Media Education, the third cycles is preceded by an articulation set; the articulation sets, are the guaranty the continuity of the competences of the whole system. The methodological strategy is answering to the requirements of the knowledge society and the labor market. It is a system composed of three subsystems or interdependent cycles, as mentioned

This Research Project has been co-sponsored by the Colombia Ministry of National Education with *The National Mentoring Program for Institutional Capacity Building in Internationalization*. Special mention the support of FODESEP, Development Fund for Higher Education, of Colombia

before. These cycles are nested: the first is a subsystem of the second. The second is a third subsystem integrating the robust system: the measurable competencies as continuous variables have their own metric as fuzzy or numeric values (in academic credits). Nesting expresses membership in a large group or metasystem is also evidence that they are not isolated to the object: they are interdependent with the correspondent competencies which are articulated

A. Propaedeutic Basics

The model HEbPC is complex curriculum architecture to be used, analyzed and implemented in institutions of HE. A PC is an intermediate stage in a sequence that allows the student to progress in their formation according to their interests and possibilities. The PC forms a system that follows the principles of continuous and permanent education; is related to labor market trends (local and global) in terms of adaptability to new and diverse occupational and professional opportunities, and also student mobility mediated by the joint and chances of completing a cycle that provides the foundation for subsequent cycles continue as follows:
(1) It is characterized by the relationship between theory and practice in matters directly related to the world of the production, technological innovation and job performance ratings, allowing alternating study and work.
(2) It is projected as a strategy for expanding student coverage, and provides answers to the country in training professionals in shorter periods, helping to reduce high dropout rates and to enhance the student permanence rates.
(3) The architecture is integrated with the three levels professional technician, technology and professional: is supported by the dialogic components: the curricular coherence matrix, flexibility and student productivity.

B. The propaedeutic articulation assures:

- The connection of the knowledge and of the competencies between each cycle
- The transmission of the knowledge dynamics
- The curriculum flexibility.
- The integrity and consistency to the completeness of the larger system
- Each subsystem responds with the knowledge and the skills, required for its specific task.
- The new vision for promoting Engineering Education using the propaedeutic cycles, resulting in a more attractive strategy and expanding the student coverage

C *Advantages of the Propaedeutic Cycles*

- The higher education system by cycles is larger in knowledge, time, contents and competencies.
- The intermediate degree enriches the professional achievement and the expertise which qualifies the new formed workforce.
- Each level warrants professional skills formation in front to the traditional monolithic of the HE.
- Each cycle receive feedback from superior cycles.
- The intermediate cycle's degree involves the integration of knowledge which better cognitive development and extended learning.
- At the end, the cultivated expertise and the know-how acquired are more significant in front of the monolithic current traditional HE system.
- Each level provides training in specific professional competencies compared to traditional monolithic system.
- Each cycle receives feedback from the upper levels and in turn provides feedforward to others cycles.
- The Intermediate Degree involves the integration of the knowledge and the competencies which enables better cognitive development.
- The student possibility of entering into the productive sector alternately with the academic sector empowers and extends the experiential learning as learning scenarios.
- At the end of the professional cycle, the integrated and cultivated skills in the student, cannot be achieved with the current monolithic system.
- If a student for any reason must leave the university before completing the professional course, with an intermediate degree, he/she is able to demonstrate their competencies in the technical or technology work arena.
- The student who takes a first degree TP, has greater opportunities to improve their personal income and to return for continuing their training university process.
- The student, who has the opportunity to put their knowledge into practice, is gaining the necessary experience to perform more efficiently and professionally their project life.
- The student has the opportunity to receive professional education within the academic demands of the HE and which provides to him/her greater coordination and continuity between the professional training and work.
- The HEbPC aims for a more flexible education system which contributes to democratic equity. The first expression of the flexibilities refers to the organization, offering training as a sequence of cumulative levels, each with identity, goals and qualifications.
- The continuity and mobility is facilitated from one cycle to another within the same institution and between other institutions.
- It facilitates international mobility of students by demonstrating the quality conditions at each level, which is relevant to the FESSANJOSE. The MEN has been supported by the National Capacity Building of Internationalization, which is the strategic driver of the National Development Plan for Colombia 2010-14.

III INTERNATIONALIZATION AND ACCREDITATION

Accreditation of engineering programs has proven around the world, to be an excellent system to promote

the continuous improvement and the enhancement of quality of engineering programs. In some countries like the USA it has been in operation for over 75 years; however the history of accreditation of engineering programs in Latin America is more recent. The accreditation systems in this region have been developed independently by each country based in their philosophies, educational systems and governmental regulations and therefore are compatible; however there are important efforts made like the sub-regional Accreditation that is being done within the MercoSur countries (Argentina, Brazil, Paraguay, Uruguay, Venezuela, Chile, Colombia, Ecuador y Peru); this body of the sub-regional accreditation is called ARCUSUR and on the other an important effort being made by several accrediting agencies in Latin America to have a mutual recognition agreement of their accreditations to allow mobility and transparency.

A *The role of the IEEE*

The IEEE has been active in accreditation in the U.S. since 1932 and is a founding member of Accreditation Board of Engineering and Technology (ABET) in which approximately 400 helpers from voluntaries of the IEEE were involved in accreditation activities. IEEE activities outside the United States focused primarily on publicizing the different systems of accreditation with Accreditation Workshops in Europe, Asia and Latin America. But the IEEE philosophy changed after 2005, including with the publication of the document that defined the position of IEEE with respect to accreditation (IEEE White Paper on Accreditation). [10].

See´http://www.ieee.org/education_careers/education/eab/position_statements.html

Emphasis was placed on the creation of local accreditation bodies that meet the needs of the country, recommending IEEE members organize themselves to create local accrediting agencies. Also the IEEE supported to accreditation bodies as: IEEE CACEI of Mexico, ICACIT of Peru. CACET of English-speaking countries situated in the Caribbean and CAST of Chinese Association of Science and Technology and The Volunteers in the Gulf Region.

In April 2011 during the meeting of the IEEE R9 (Latin America) in Brazil has created an advisory board[1] whose main function was to advise and support the efforts of continuous improvement of existing accreditation bodies in Region 9. This function was carried out by establishing a close relationship with accreditation bodies in the region through local branches of IEEE and personal contacts of members of the Council. The functions are to promote and facilitate dialogue and cooperation for accreditation in the region, including:

- Support the organization of events aimed at creating mutual recognition agreements between accreditation bodies of engineering programs in the R9
- Promote continuous improvement of accreditation bodies in the region through the exchange of ideas and best practices in accreditation activities.
- Help find program evaluators or academic peers, participating in another country when it is important to have external evaluators.
- Training of assessors and academic peers through consolidated accrediting agencies in the Region
- Support the creation of accreditation agencies national engineering programs in countries that do not have an R9 in operation, working closely with local IEEE Section.

The activities identified by the IEEE are to support the creation of accreditation national agencies engineering programs in countries that do not have an R9 in operation, working closely with local IEEE Section [10].

Recently by November 18 a meeting was held with IEEE authorities, in New Brunswick, NJ where it was agreed: move forward in the formation of the Advisory Council on Accreditation for R9 that report both to Council and to the EAB R9. Full motion with all by-laws will be presented to EAB and R9 and its next meeting in February and March 2012 respectively for formal approval

In Colombia there is a national accreditation body in by the Ministry of National Education: one called CONACES which grants the Register-Qualified: it is compulsory for all the Higher Education Institutions, regarding the Act 1188, ranging from Technician-Professional, Technology and Professional, Specialization, Master and Doctorate. The other called CNA (National Council for Accreditation) also of type governmental: which grants High Quality Accreditation Certification; it is of voluntary type, for the Institutions at different HE level. [8]

The practice of the International Accreditation is of very few elite Universities in this country, none of the T/T. The Organization of the American States OAS is leading a project with several engineering faculties in this region called EftA (Engineering for the Americas) [7]

B *Internationalization In House*

In FESSANJOSE we started this process several years ago. Nowadays we have the support and accompaniment of the MEN, Colombia National Education Ministry with the most important universities. La Salle, Rosario. Also recently we have the visit of representatives of University of Yale and Kentucky State University inside the program of International Mentoring, provided by the MEN.

[1] This committee were coordinated by Dr Teofilo Ramos

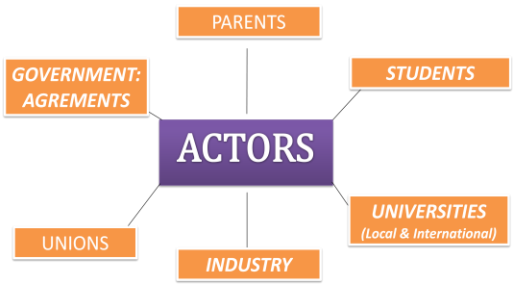

Figure 2: Internationalization players

The categorization of agents of this process, include family parents, students who are the kernel, the universities, the professional unions and the government.

- Research of the most serious problems of HE in Colombia: in searching solutions with intelligent systems and computational analysis of the student attrition, permanence, repetition and the integral accompaniment.
- Our role to the Best Case Studies as one of the significant experiences in Higher Education.
- Contributions to the International Visibility with our participation in world class events of the IEEE, ACM, ISTEC and SISOFT.
- Contribution to the theory of the PC accompanied tools for Curriculum Management and Optimization: There's a knowledge-based system with appropriate metrics. It offers a model pioneered in Colombia and the world to design and analyze the PC, with knowledge management curriculum. The curricular coherence matrix, in the space (competencies-skills vs. study plan-curriculum by cycles).
- Contribution of Knowledge Engineering methodology submitted to the international peers reviewing.

IV NEEDS FOR HE INTERNATIONALIZATION

As mentioned before, internationalization is a strategy for economic development under the Government of Colombia Plan 2010-2014. According to UNESCO the SEI´s worldwide have social responsibility to assist in the breaking of the gap in terms of development between countries, by increasing the transfer of knowledge across borders, especially towards developing countries. Moreover one of the problems of these countries is the brain drain or the so-called South-North transfer that advanced countries have not invested in the training of human resources are favored in hiring these graduates at zero cost. Internationalization seeks the movement (mobility) of these brains.

A Internationalization issues

Internationalization has developed rapidly, under the changes of the current complex and changing world stage. It not only responds to the simple globalization and an open education. Should not remain as a fashionable word or a set of institutional desires because it is a transcendental imperative which requires a model of academic governance, financial sustainability and a lot of flexibility that involves participation and commitment at all levels. It requires concrete answers. It is a condition, which is not exclusive of the quality and excellence of large universities as evidenced in the mentioned above call of the Colombia MEN. Should be articulated, on the basis of the academic collaboration, regional the integration and the partnership in the institutional action plans with a progressive process with metrics.

B Objective of the public policy for internationalisation

It seeks to consolidate the international projection of STI (science, technology and innovation) facilitating access to Colombia groups for research and technological development of the country to both intellectual and financial resources at the regional and international levels to of STI Colombian international networks. According to Colciencias (Colombia Institution of STI) "Internationalization is a process that prepares the community for successful participation in a globalized to encourage the integration and interdependent world requires the development of collaborative skills and work in a multicultural world which forces us to think globally and act big." The otherwise would be the isolation and disconnection of the advanced world.

It also seeks to promote the quality Trans-boundary HE, developing the most competitive programs and giving them an international dimension, promoting international qualifications, language skills and multicultural understanding in the process, as well as through training of teachers for knowledge transfer competitive with an international vision.

C. Requirements

A process of Internationalization for SEI´s results in mobility and circulation of people, knowledge, goods and pedagogical services, ideas and values for trans-boundary institutions.

- Academic Mobility: This is to provide opportunities to study abroad and expertise for the entire university community, primarily through inter-university academic exchange agreements. It implies also the option to develop missions and exchange of best practices for students, teachers, researchers and administrative staff are required to actively promote international training programs and scholarship opportunities and the establishment of financial aid to encourage the academic mobility. Many SEI´s begin to include in the curriculum courses with international component: the traditional philosophical ideal prevails that knowledge must be transmitted beyond the borders based, for example, on the export of high-level educational services.
- International Student Mobility: the participation of Students at a university in academic activities such

as short internships and research. Undergraduate academic exchanges, academic practices abroad, foreign language courses. Today's market requires a workforce that is modern and global, which exerts great influence on the internationalization of higher education. It may involve students in campus.

- Mobility of Lecturers (A lecturer of a SEI conducts courses, seminars and research fellowships of long-term joint project in a different organization and outside the country). Includes short courses, lectures international visits as invited lecturer and visiting foreign professors, research internships and is not a simple high-level training.
- Mobility of Researchers: the trend towards research and development projects set to participate internationally with new technologies: it is the case of the European Union with 7 Framework Program, SALA 3D and others.
- Mobility of Graduates: the internationalization is characterized as a process of transformation in which the activity areas of an institution are consistently appropriate (strategic housing) to operate in an international, transnational market conditions and career guidance international level. It also implies access to the benefits of knowledge society. International education facilitates the way for further integration, at least in regard to regional and sub-regional level as it is a double degree and joint programs. Obviously requires the implementation of the system of academic credits and a high flexible curriculum.

IV BACKGROUND: MATHEMATICAL LEONTIEF MODEL FOR ACCREDITATION PURPOSES

The linear model focused on curricular coherence matrix is both an instrument of analysis as a linear mathematical structure, enabling the justification of curriculum and making sense as an organized and complex. The re-contextualization and re-situation Leontief Model Analysis enables Governance and Sustainability with the extension of the matrix A of technical coefficients.

A. Generation of a Hyperspace Matrix for analysis

The curricular coherence matrix in a linear arrangement between the knowledge represented in a curriculum and competencies that are expected to develop in students during their student life.

$$Y = AX \qquad t = T_0 \qquad (1)$$

$$X = A^{-1}Y \qquad t = T_1 \qquad (2)$$

Where Y is the vector of endogenous (1) and vice versa in (2)
Vector X is the independent or exogenous (1) educational processes related to each subject and vice versa (2).
The matrix A is M x N where:

The M rows represent levels of competence / expertise of the curricular organization of an academic program.
The N columns represent the unit and functional areas (educational processes involving classes, workshops, tutorials, laboratories, workshops, etc.) knowledge of the Plan.

Figure 3: Curricular Coherence Matrix hyperspace

This cell may contain other qualitative values (fuzzy logic or ambiguity). Each value represents the incidence between the subject and skills.

$[a_{i,j}]$ = {yes, not} (black, white), or
$[\boldsymbol{a_{i,j}}]$ = {null, medium, high} (white, red, and blue for a dashboard chart**)**. See Figure 2.

This type of matrices can be of two classes: the longitudinal in time (i.e. by academic semesters of the study plan and the transversal knowledge, where the curriculum knowledge of the subject is grouped as mentioned above.

In this model we present the re-contextualized linear model as did Buckley [3] of the open model of input-output technical coefficients which are expressed by fuzzy numbers. There are some basic assumptions: A process or unit of knowledge can feed one or more competencies. On the other hand provides the linearity between the skills and knowledge. Furthermore the constancy of the technical coefficients of the matrix A is supposed in the medium term. Unlike the Leontief model in which the unit of measure is of monetary type in our unit of measurement is the Academic Credit is properly normalized in this country.

Our proposed model makes better use of academic information available. The Leontief model associates industries with academic units in cluster. The corresponding architecture is represented in Table 1, which is discussed later.

The analysis is based on academic governance system flexibilities of FESSANJOSE and quantified by the equation (1), to observe endogenous or exogenous changes in the skills or the same knowledge, equation (2)

$$\Delta Y = \Delta AX \qquad (3)$$

B. Curricular quantification from the matrix: cognitive contribution

The cognitive contribution of the j subject is obtained by the following matrix:

$$\sum_i a_{i,j} n_j = d_j \qquad (4)$$

Where n_j is the corresponding subject credits d_j is the cognitive contribution of the j[a] subject for each propaedeutic cycle (columns).

C. Other metrics obtained from the matrix: production

The cultivated expertise is given by the production $\boldsymbol{i}^a$ as follows:

$$\sum_j a_{i,j} n_j = b_i \qquad (5)$$

Where b_i is the i^a production mentioned, expressed as cultivated expertise for each competence unit (rows).

D. Input / Output Matrix

In this matrix each cell is expressed as follows:

$$\tilde{a}_{i.j} = \frac{d_j}{b_i} \qquad (6)$$

Technical Coeficient: input fraction by production unit: Where each $\boldsymbol{a_{i,j}}$ coefficient is the ratio of cognitive inputs by unit of cultivated competence production.

With this matrix (called of the technical coefficients), it can be performed the OPTIMIZATION analysis, by adding quality objectives, capacity restrictions as costs, academic objectives, scholars population, lecturers, university resources and many others related. Also this matrix can be extended to complete the Leontief I/O matrix with the remaining sectors as shown in the Table 1.

E. Mathematical Leontief Model for knowledge and economic analysis.

The model defines the main characteristics of sectored performance of a country's economic system interacting industries. [1].

$\mathbf{X_j}$: It is considered in the model increases or decreases linearly to changes in the gross value of production.

Although the model usually assumed that cutting the input current flows in each sector are proportional to the level of output in that sector, in the case of inter-industry flows this assumption is not appropriate.

Economic activities are grouped into n sectors or industries, where X (vector of production), Y (vector of final demand. X, Y $\in R_n$ values represent the vectors of gross production and final demand, respectively. The matrix technical coefficients is denoted by A = $[a_{i,j}]$, are transactions between industries i and j per unit industrial output j.

With the above matrix can perform optimization analysis of institutional, with the addition of objective functions, capacity constraints, unit costs for credit, the target student population, limited resources and many other related university items as mentioned above.

Production is assumed that X is distributed to some intermediate consumption and the rest to the final consumer. Whereas the vector of exogenous final demand, the solution vector is obtained by clearing the gross value of production:

$$X = (I - A)^{-1}Y, \qquad (7)$$

Where **I** is the identity matrix

Leontief matrix, which describes the total needs of direct and indirect inputs, such that its diagonal elements must be greater than or equal to 1, which means that to produce one additional unit to meet the net final demand of social production, is necessary to increase the production of each academic unit at least one unit. Among other questions asked in this analysis, would include:

¿ How much should increase the production of the P_i process to meet the increase of one unit of competence demanded further of that process and how much to increase the production of other processes?

$$\Delta X = (I - A)^{-1}\Delta Y \qquad (8)$$

This equation allows us to quantify and predict the output **X** and other institutional variables: cost, value added etc. of university academics in different periods.

This model generates a lot of information in such a way that enables us to analyze the financial sustainability and enriches the PEI (institutional Educational Project) planning process and specially favors the strategy formation process.

F. other considerations on the Leontief Matrix

The main underlying causes of the alteration of the coefficients over time are:

- Technological change in academic production e.g. by introducing ICT and Virtualization.
- The knowledge change in the state of the art
- The increase in the benefits arising from economies of scale e.g. content generation for personal independent learning.
- Substantial increases in student cognitive productivity through the use of intelligent virtual tutors as our prototype iCOACH.
- The changes in relative prices (as Leontief coefficients arising from a monetary valuation.)
- Changes in patterns of exchange (purchase of books and knowledge contents generated by lecturer-authors, etc.).

Final Demand at the institutional level is represented by all the activities of Social Projection, University Extension Services and Consulting, Research Projects. The changes in the final demand composition may result from the:

- Requirements of the Higher Education legislation

- ❖ Need to meet national and international standards of the Curriculum.
- ❖ Changes in the scientific production and new knowledge.
- ❖ Demand for Consulting by the company and the government in this country.
- ❖ Generation of new knowledge as a result of research and innovation processes

V LINEAR PROGRAMMING WITH LEONTIEF INPUT OUTPUT MODEL

One application of process engineering is the application of the Leontief model combined with linear programming, as many authors assert, and we have shown by applying these models in the Health Sector in Colombia (National Department of Planning) [5], [6].

The Table 1 shows the model architecture. Construction of these matrices requires a significant budget to develop the study field for several months within FESSANJOSE.

The Linear Programming with Leontief Input Output Model involves 3 Student levels: Good Performance, Recoverable and the Dropout; see the Figure 4, bellow:

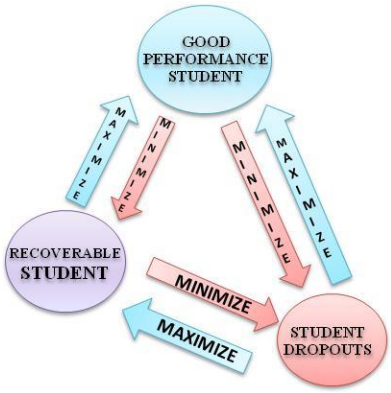

Figure 4. Student Levels

A MOP: Multiobjective Optimization

The Optimization problems involve more than one objective. The functions that is very common, yet difficult problems in the field of Science, Engineering, Business Management and Education. If Non-conflicting objectives: a single optimal solution can be achieved, which satisfies all objectives simultaneously SOPs (See Figure 4); however the competing objectives: cannot be optimized simultaneously. In this case the MOP– find a set of "acceptable"– maybe only suboptimal for one objective– solutions is our goal.

Why MOPs? In real-life environments we always strive to optimize a number of goals/objectives in a design and these parameters are usually highly correlated. Hence, some tradeoff between the criteria is needed to ensure a satisfactory design. For examples: The HE Student Desertion, Student Permanence, HE Quality, Governability and related.

B Mathematical knowledge architecture

The architecture presented in Table No. 1 comprises the matrix of Leontief Input-Output in a system either at the micro level (i.e. a program of study) or a higher level of an institution or country. This architecture has 3 components:

The inter-sector subset

The restriction and threshold values

The multiple objective functions.

The model was integrated with linear programming to analyze together the services of Education in the Tertiary Sector of the economy (trade and services), with the primary sector and the manufacturer sector.

The optimization criteria are shown schematically in Figure No. 3, which shows the levels of students in higher education mentioned above.

The flows within these levels of students are outlined and quantified in the multiple objective functions.

$$f(X, D_f) = 0 \qquad (8)$$

D_f Is the final demand: Households, Inversion, Government, Δ Inventories, Rest of the world…

Political function issues:

$$\text{Max Z} = f(\Delta Students\ Level) \qquad (9)$$

$$(I - A)X - D_f = 0 \qquad (10)$$

$$\text{F (resources)} \leq b_i \text{ availability} \qquad (11)$$

C STRATEGIES ANALYSIS

Among the questions that can be analyzed and quantified would be:

What would the cost of changing a student from one level to another?

What would be the opportunity cost of losing a student from a higher to a lower level?

What management strategies of type economic, academic or pedagogic, respond better in order to maximize the number of students who leave school?

Which strategy is more responsive to the maximization of repetition avoided?

How an institution responds to the demands facing in improving the quality and competitiveness economic and curricular without breaking?

How much does it cost for an institution to improve its quality and competitiveness?

How is the cost of the Internationalization process?

How much does it cost for an institution to improve global competitiveness?

What additional financial and technological resources an institution needs to maintain good government?

What is the value of intellectual capital accumulated in a university?

What is the new cost of an academic credit, after optimization?

How many credits are assigned to a subject?

How much does it cost a university program through the use of the propaedeutic cycles?

Many other questions can be done to this model giving possibilities for simulations running. As can be seen this mathematical tool, allow analyzing and quantifying a variety of strategies ranging from economic to academic and pedagogical, to reach optimum levels in terms of dropout, repetition and improvement in student performance and in general better IES governability.

VI. SOME CONCLUSIONS AND FUTURE WORK

We have showed that quality and poverty can go hand in hand: we intend to give high stratum education for the lowest stratum socioeconomic students.

We believe that internationalization is a pre-required path to the high quality certification but not enough to a global accreditation, one of our goals in coming years.

We think that internationalization process is necessary for the HE competitiveness. This process is more related to knowledge and Intelectual Assets mobility than resources mobility.

The global accreditation and the internationalization process are closely related and are required for competitiveness of the HE Sector.

This study has indicated the Leontief Model re-situation towards social sector: academic world of knowledge, and from the inter-industry economy to the new knowledge industry, is a way to analyze knowledge and large volume of information coherently. At the same time the model allowed us to analyze the problems of Academic Governance and Financial Sustainability of Higher Education Institutions.

International Peers in evaluating our work have acknowledged that the literature is very scarce in this educational purpose of the HEbPC. Also our mathematical system for analyzing the desertion, curricular coherence consistency for the PC and many other educational issues has been emphasized as a social innovation and pioneer in the international arena.

The integrated model for the knowledge society promises to be a tool for analyzing and quantifying the Competitiveness of Superior Education in this country.

Substantial rescue of the PC´s, in particular: major industrial and social credibility of the T/T education is expected.

We expect the major preferences for the HEbPC by Colombian young students, due to the possibility of achieving better long-term career that can be prospected as a student project life.

Best potential for high quality accreditation by the T/T institutions.

Finally once we have our model it is verified, tested, validated and accepted, we make it serve the all country's academic community in Colombia. In fact some SEI, are using various of our tools.

ACKNOWLEDGEMENT

Our gratitude to Dr. Jean Silk (U of Yale) and to Dr. Cornell Menking (Kentucky State University), for the support with the Internationalization Mentoring. Also to Dr. Carlos E Navarro and Dr. Giovanni Anzola, (U of La Salle) for the local Accompaniment provided. Special thanks to Dr. Natalia Jaramillo, of the National Education Ministry of Colombia. To "Fundacion de Educacion Superior de San Jose", to Lecturers and Officers, especially to ***the SAN JOSE EIDOS International & Research Team*** including Carlos F. Pareja, Guillermo Hoyos, Alexis Mena, Byron Perez Gutierrez, Ingrid V. Huertas, Andrey Alvarez, Leyini Parra, to all of them, our debt of gratitude.

REFERENCES

[1] Leontief, Wassily, (1975): Análisis económico: Input-output. Barcelona: Ariel.

[2] Perez Gama Alfonso, Guillermo Hoyos G., Byron Alfonso Perez Gutierrez: .Knowledge for the Society: Social Inclusion to the Superior Education High Competetiviness: A Knowledge-Based Governability Model for The Higher Education In Colombia by Propaedeutic Cycles; IEEE EDUCON 2011 Annual GLOBAL CONFERENCE ENGINEERING EDUCATION – AMAAN JORDAN APRIL4-6 2011. ISBN is: 978-1-61284-641-5

[3] Buckley J.J. (1992). Solving fuzzy equations in economics and finance Fuzzy Sets and Systems 48. North-Holland , pp. 289-296 15th International Conference on Input Output Techniques. Renmin University of China Beijing 2005.

[4] Perez Gama Alfonso, Ing. Guillermo Hoyos, Ing. Alexis Mena Mena; . Byron Alfonso Pérez Gutiérrez:;A Knowledge Based Analytical Model Of Propaedeutic Cycles: Linking Media Education To Higher Education In Colombia; IEEE EDUCON 2010 Annual Global Engineering Education Conference; Madrid España Abril 2010. Conference Book ISBN 978-84-96737-70-9. CD ROM IEEE CATALOG CFP10 EDU-CDR ISBN 978-1-4244-6569-9.

[5] Ortegón Edgar, Alfonso Pérez Gama y Gina Ballera "Aplicaciones de la Programación Lineal en la Planeación del Sector Salud" Revista de Planeación y Desarrollo Volumen V No. 3 ISSN 0034-8686 (Depto Nacional de Planeación) Septiembre 1973; Also published by the AID Sector Analysis Series: "Linear Programming Uses for Health Planning"; Bureau for LatinAmerica Agency for International Development # 17 USAID WASHINGTON January 1974 USA.

[6] Pérez Gama Alfonso: "Uso de Modelos Multisectoriales de Programación Lineal en Ciencias Sociales"; Revista TEMAS ADMINISTRATIVOS - 1978 U. EAFIT # 33 Medellín, Colombia.

[7] Lerner Norman: "Engineering for the Americas: Preparing Tomorrow's Engineers Today"; III Panel Educativo; Engineering Global Accreditation Conference 2011, Bogota Colombia.

[8] CNA: "Estrategia de Internacionalización del Consejo Nacional de Acreditación (CNA) de Colombia"; Septiembre del 2007 www.cna.gov.co

[9] PEREZ GAMA Alfonso: Analytical Models for Tertiary Education by Propaedeutic Cycles Applying Knowledge Engineering and Knowledge Management, in "New Research on Knowledge Management Models and Methods", InTech - Open Access Publisher; ISBN 979-953-307-226-4, 2011.

[10] Ramos Teofilo: "Accreditation of Engineering Programs in Latin America: Present and Future" ; III Panel Educativo; Engineering Global Accreditation Conference 2011, Bogota Colombia

[11] Ramirez R Octavio: "La Entidad: Capital Intelectual y Financiero" 1st vol. ISBN 978-958-99270-3-8, Corporacion Univ. Remington, 2011. Medellín, Colombia.

TABLE I MATHEMATICAL AND KNOWLEDGE ARCHITECTURE

The mathematical model to formulate the optimization problem between Student Desertion and Permanence:

Design Variables: decision and objective **Vector: RHS (right hand side)**
Constraints: equality and inequality; Greater-than-equal-to inequality constraint can be converted to less-than-equal-to constraint by multiplying -1
Objective Function: maximization can be converted to minimization due to the *duality principle*

$$\max f(x) = \min(-f(x))$$

As the problem ***Min Desertion***, an involved problem appears: ***-Max Permanence*** for a more complete analysis