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Analytical Models for Tertiary Education by Propaedeutic Cycles Applying Knowledge Engineering and Knowledge Management

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1. Introduction

A Knowledge based system model to face the new methodological strategy on Higher Education in Colombia by propaedeutic cycles. A great challenge is presented to Superior Education Institutions: to establish the link between traditional cycles: professional-technical, technology and university ones with the secondary, basic and media levels. Our solution is presented linking each phase with a propedaeutic component discussed in a model. The model is dialogically integrated by cognitive an informational components.

Leontief III Millenium: we present the problem resituation from the Inter-industry Economy Model, to the new Knowledge and Information Economy, by recontextualizing 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 General Systems Theory in order to face the most critical problems in Superior Education in Colombia. A structural system to determine and analyze the cohesion and coherence of the propedaeutic cycles between competences and the curriculum knowledge. This construct enables curricular knowledge management inside the media and higher education. Several types of matrices are developed; firstly regarding columns: the longitudinal one in time (semesters); secondly the cross one grouped by curriculum subjects, (additionally each cell of them can be expressed by fuzzy values); thirdly regarding the structure: the input/output for optimization purposes.

Also an individualized model of student productivity to be integrated to counteract the stereotypes which considers the technical and technological cycles as relegated careers in higher education. This model is an intelligent knowledge based one which was validated with a software prototype just implemented in the FESSAJOSE. This construct has as its mission the guarantee of quality assurance of student's propaedeutic cycles.

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 the four main problems frequently found in third world countries:

* FESSANJOSE is a Technology Institution of Superior Education redefined by Propaedeutic cycles as a social project with student coming from lower economic strata at Bogota: www.fessanjose.edu.co.

- Student desertion in tertiary education which represent USD$300 million looses yearly in Colombia, by 2009
- The propaedeutic cycle's methodology for Higher Education in this country
- The academic governability for universities and the sustainability
- The low productivity in students and teachers with serious consequences in the competitiveness national wide.

Our response rests on 3 dimensional worlds with the mathematical and computational model: the Real world, the Virtual world and the Student and Lecturers world

- Firstly with a set of analytical-mathematical tools that enables the curricular knowledge management: FESSJ-PROP Model, which is a structural system to analyze and structure and cohesion and coherence between the propaedeutic cycles, supported in knowledge engineering, knowledge management, Artificial intelligence, Process Engineering and Fuzzy Systems.
- Secondly with a intelligent coaching systems called iCOACH to improve Student and lecturers productivity. It contains an individualized Student Model to address the dropout, and improve productivity in the process of articulation from the Secondary Education to the Professional one with additional propaedeutic complements.
- Thirdly with several Leontief Model extensibilities by Linear Programming, LP and Input-Output I/O, which analyses the dropout complexity and the other problems mentioned above. The LP Objective Function has 3 student levels
- They are integrated with a multidimensional flexibility system, which enables management of the complex and heterogeneous environment.

Several parts of the model we present in this chapter have been submitted in several international conferences showing the progress in our research. Also it was included by the Colombia Education Ministry as one of the BEST PRACTICES in Superior Education in Colombia†.

In Section 1 we introduced the higher education sector analysis presenting several problems currently affects this sector. In following section we present the FESSJ-PROP Model for curricular analysis through the Coherence Matrix. The third section we present to initiative leading to develop the education software architecture facing student desertion. Next section the integration Linear Programming an Leontief model for the study of education sector problems like student desertion costs, academic governability, sustainability and the intellectual capital and the knowledge activities. Finally we present the methodology issues we developed to undertake these projects.

2. Preliminary

2.1 Research development rationale

The higher education system model by propaedeutic cycles that has been named FESSJ-PROP is a complex curricular architecture for implementation and analysis in all Higher Education Institutions in Colombia. A great challenge is presented to Superior Education Institutions: to establish the link between traditional cycles: technical, technology and professional ones with the secondary, basic and media levels. This Architecture is integrated to the Plan of Studies coherent of the three Propaedeutic Cycles; Professional Technical, Technology, and Professional. The model is supported on several dialogical components;

† National Bank of Significant Higher Education Experiences: www.colombiaaprende.edu.co

structural components or matrix model for curriculum coherence verification and knowledge management, the management system of flexibility, and the student's productivity formation. The tests and validation of the model were initially supported on the rational on the use of the mathematical and computational instruments and, then, on the approach of the system measurement, the same rationale of the study theoretical frames, contrasting then, with the real application of the curriculum coherence matrix during the inspection on quality conditions of the Academic Peers for testing in Bogotá (March and April 2009) in all verified programs; additional a computer simulation model was designed and implemented for complementary validation. The consistence and the prediction power of the model was demonstrated along with the development of other information construct called iCOACH as a learning prototype , which is working to an experiential learning ; iCOACH is an intelligent system based on knowledge used as a student's individual productivity tool.

2.2 Student desertion and repetition issues

Student dropout is a phenomenon cultural and Socioeconomics. Several studies in Colombia have found statistics and figures in excess of 50% that significantly affect the efforts made for increasing the coverage and quality education. Similarly close to one of every two students entering the Systems do not completes successfully or do in times higher than expected. Some determinants of the phenomenon have been analyzed using Statistical and Sociological techniques. Important factors that are the following:

- Economic impact of more than 1/4 part of them.
- Academic with almost half of the students highlighting that most of the student population of the institution FESSANJOSE belongs to lower income strata: 1, 2 and 3 of Bogota. Also it is shown that the 1/3 of the deserters is first semester students who entered in 2007 at the Institution.
- Academic and psychological aspects represent a marked influence on desertion inside institutions, within the academic aspects we can emphasize: low academic performance, non-compliance with the expectations of students and poor vocational preparation from high school, which is demotivation and causes deviation of the students admitted their personal goals and objectives, forcing the student voluntarily to remain in academic conditionality and / or outside the program or even outside the university.
- The psychological aspects as the lack of screenning personnel and professional, the failure to adapt to the college environment and learning environment are significant and are presented in the students since the start of their studies and can be identified from their income the institution; It is directly linked to academics, because they affect the student's academic performance.

It requires among other: Virtual systems for verification of concepts and deepening of meaningful learning, monitoring progress of individual students and motivation Programs, counseling, vocational guidance reinforced through academic tutoring, life project. In the Section 5 we deal with methodology aspects related to these problems. However it is important to point out that the problem is worsened by increasing educational coverage and the global crisis: every time we have more students, larger classes, less contact with them, increasing the teaching load and higher costs that many students spend more time on making any income economy.

2.3 Tertiary education quality and competitiviness

The educational work has been understood as reconstructive science of the knowledge. That we want to motivate student from which the challenge for educators in the emerging Knowledge Society motivation lies in the appropriation of knowledge that encourages students to generate new knowledge as a way to confront the serious problems of backwardness and dependency of our own countries.

To understand the new role of lecturers is necessary to clarify what is the model that will go to rationalize and legitimize the claim to educational practices and especially the role of the teacher in the order produced by modernity and post-modernity in the informatics context; what is clear is that the traditional pedagogy of the lecturer seems to have fulfilled their life cycle. Education with information and knowledge technology based (EDUMATICS, COGNIMATICS) is an option of the lecturer from the standpoint of pedagogy which is due to its characteristic modifier for the training of future generations of engineers.

The theoretical framework of our project is also supported on models and systems including: Model of software engineering and architecture education, computational model of pedagogy, instructional model, System focused on Innovation and Learning System of thinking processes. This theoretical and conceptual framework is documented in a number of publications.

2.4 Governability & sustainability problems

It is a concept that goes beyond what administration is and is associated with the conditions of the institutional capacity to deliver the educational goods and services, the ease for decision making, the management of the new intellectual capital and related, to meet the needs of government, business and society in general. It is affected by the overload of demands and social requirements and also by factors such as the trust, the participation and the consensus building.

University Governance and Sustainability are closely associated. And as it is not a matter exclusively of educators, the sustainability is not a purely financial issue, but financially it is a strategic component of the strength of educational institutions. A model of corporate governance is the composition consistent, coherent, concerted, committed, participatory and assumed by the set of systems and actors, about ways of thinking, decision taking, acting and learning that shows an institution in the different dimensions of its strategy. In Section 4 we present the I/O model to quantitatively analyze these problems involved.

2.5 A hybrid system to face superior education sector problems: A computational and mathematical model

FESSJ-PROP and iCOACH integrate the model. Firstly, the structural system to determine and analyze cohesion and coherence of the propaedeutic cycles, between competences and the curriculum knowledge. This construct enables curricular knowledge management inside the media and higher education. Several types of matrices are developed; firstly regarding columns: the longitudinal one in time (semesters); secondly the cross one grouped by curriculum subjects, (additionally each cell of them can be expressed by fuzzy values); thirdly regarding the structure: the input/output for optimization purposes. Secondly an individualized model of student productivity to be integrated to counteract the stereotypes which considers the technical and technological cycles as relegated careers in higher education. This hybrid model is an intelligent knowledge based one which was validated with a software prototype just implemented. This construct has as its mission, the guarantee of quality assurance of student's propaedeutic cycles.

2.6 The propaedeutic cycles in higher education for the knowledge society

Formation through the propaedeutic cycles is a strategy responding to new dynamics of knowledge society, and the pace of the labor market. It is characterized by developing and organizing in a flexible, sequential and complementary curriculum programs of the university. There are three levels of postsecondary education: first, the professional technician, and second, technology, and third, the university, where each level is preceded by a previous preparatory cycle. Perez Gama Alfonso et al.(2010)

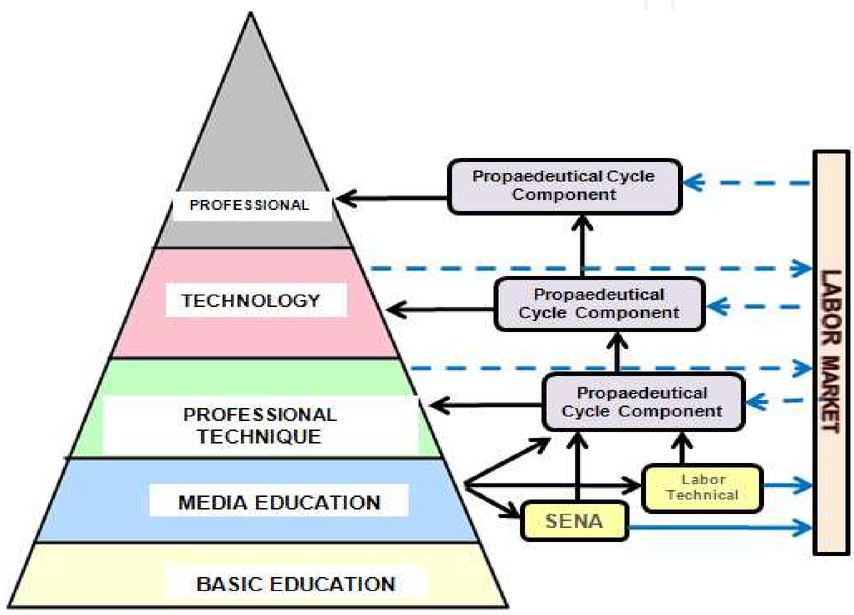

Fig. 1. Education System Pyramid with articulation: flexible, sequential and complementary

This means that a person must be able, in parallel with secondary education, starting in the tenth grade their technical training. Upon completion of this first level with the skills acquired will have access to employment. But also, if he or she has successfully completed high school and professional technical program, will be able to carry out technology studies: the second formation cycle.

According to the regulations mentioned in cycles propaedeutic formation becomes a model for access to higher and more complex levels of professional competitiveness, and a response to the need to adapt the educational supply of the continually changing and expanding labor market coverage as a manifestation of the right to knowledge. Education turns its gaze towards the productive sector to inquire about their new occupational demand and to offer from a scientific and technological training, responses and solutions to their problems and needs, using new skills.

A propaedeutic cycle is an intermediate step in a sequence that allows the student to progress in their education based on their interests and capabilities; each level carries a preparatory component which enables continuity of skills throughout their training. Propaedeutic cycles form a system that follows the principles of lifelong education is related to labor market trends (local and global) in terms of adaptability to new and diverse occupational and professional opportunities, and also mobility-mediated joint and possibilities of completing a cycle that provides the foundation for subsequent cycles continue, taking account among others:

- It is characterized by the relationship between theory and practice in matters directly related to the world of production, technological innovation and job performance ratings, allowing alternating study and work;
- It is projected as a strategy for expanding coverage, and provides answers to a country where professional training by levels and shorter periods, helping to reduce high dropout rates.
- Academic rigidity promoted by the Colombia Act 30, and forcing the student to a route inflexible, monolithic and binding, represents high economic and social costs to him or her for the institution and the educational system in general. It becomes more obvious in cases of desertion, death or change of career. In general the curriculum so far is a reflection of the academic organization of subject areas in schools and often distantly related to each other, in order to study phenomena or concepts from single disciplinary approach.

2.7 Required flexibility per propaedeutic cycles

A flexible curriculum could be defined as an alternative response to the linear and inflexible studies in higher education, which breaks with the system of serial and mandatory courses. To deal with rigidities it is required a comprehensive system of flexibility as the antithesis to the same. The high repetition and dropout rates are economic and cultural phenomena that have affected the higher education system in general.

As mentioned before the actual Education System is rigid, hard and forces the student to reentry as contrasting with propaedeutic cycles in which the flexibility is mandatory. The curriculum is defined as the set of criteria, study programs, methodology and processes contributing to the integral formation and to the national identify construction, including aids the scholar human resources to put into practice the policy to carry out the PEI (Institutional Educational Project acronym). The flexibility refers to the curricular, academic, pedagogical and administrative ones, that is, the use of the university autonomy to manage knowledge as well as the study plan for whom do not accomplish with the requirements to come up to higher cycles, and besides to relocate learning contexts supported by ICT. We describe them bellow

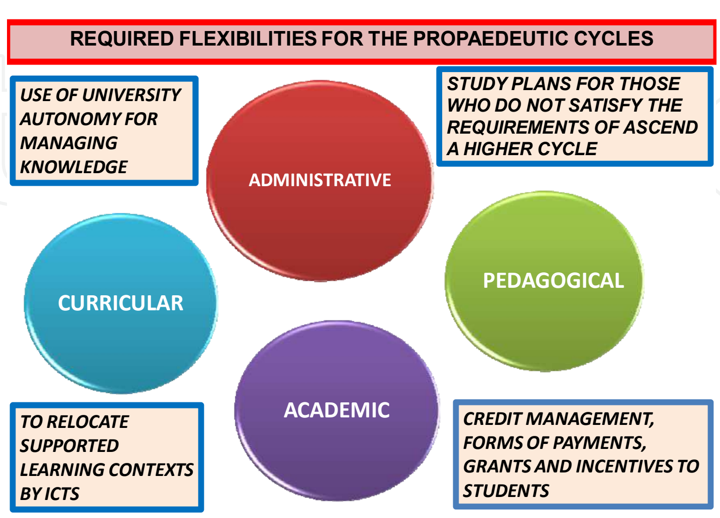

Fig. 2. Flexibility Required

Curricular flexibility is the structure defined as the content organization, methodologies, and selected vocational training to develop study plans of school programs in which the contents are selected according to their importance, pertinence, appropriateness, technological, scientific, social and economic impact on account of the competences wanted to be cultivated and developed in the technician-professional, technologist, and engineer. The structure has been provided with a solid common nucleus in each cycle and elective subjects which will consult the stage of this art. The broad experience of in the first cycle consolidates the possibilities of this flexibility.

Academic flexibility is an open and dynamical organized system which intends to transform the rigid structures which are uncoupled as it corresponds, wherein prevails the integrated work in the application and search of knowledge, defining the professional area. An open system promotes self management and self regulation. The strategic alignment of an institution is an imperative: PEI (Institution Educative Project).

Pedagogical flexibility that applies the educational strategy as a coherent unified, and integrated framework of school decisions promoted by the educational model, underlies the mentioned self-regulation and self-control by a student in his learning enabled by the ICTs, which allows him to enter to diverse learning spaces and environments tending to new educational communicative and interaction forms and also knowledge access In the same way the controls on the student about how to reach knowledge are implemented via electronic, information, and cognitive micro-worlds cultivating the competences which were already explicated as well as the involved strategies in the educational model that:

- Considers the integration of Academic Credit units of each engineering aspect.
- Creates educational mastery linking education, research, and social projection as pointed by, and
- Entails to new virtual spaces and contexts of personal autonomy in the students' learning, besides admitting that they perform an integrated project of each propaedeutic cycle.

Administratively, the flexibility supposes a range of possibilities to the educational offer within the culture of educational service to the research, the academic units which compose a outstanding institution as from the policies which assigns it for relevant, important, and appropriate making-decisions according to the FESSANJOSE Development Plan 2008-2015. This flexibility entails to the necessary reengineering of the administrative processes for its ISO certification.

To change, if required, the policies and flexible strategies, that is, it is necessary to state the actions in different university forms for the adjustment to the organizational change that implies to manage the Technician- Professional cycle to a broader level the Technology and the Engineering level. The earlier requires thinking over the sense, purpose of the Management Model, the curricular and scholar systems, which are coherent, appropriate, and suitable to the as a Higher Education Institution. It is required: flexible policies and strategies for change, i.e. the actions must be posed in different instances, in this case the University, to adapt to organizational change that involves the passage of Cycle Professional Technician to a much wider: the cycle of technology and the University cycle. This call requires reflection on the meaning and purpose of models of management and academic systems and curriculum, seeking to be consistent, relevant and proper for the Institution of Higher Education.

The formation by propaedeutical cycles in all the areas of competence of the systems engineering, will facilitate the relevance of professionals of the knowledge that will work in the global society and on behalf of a growing country where the intellectual capital should be distinguished for its formation in architectures and engineering of software, the capacity of investigation, development of intelligent systems, under the paradigms of government of the ICT and of the management information systems, taking care of the environment and in defense of the values and life.

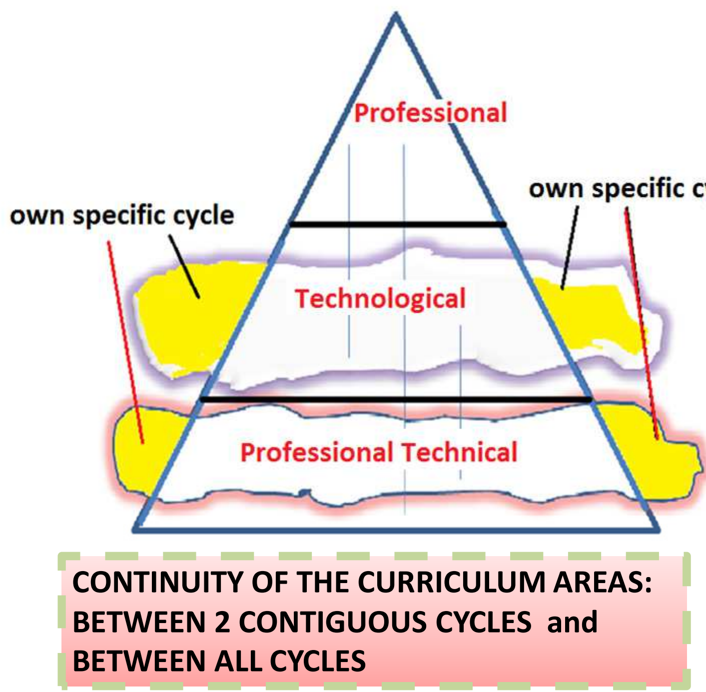

Fig. 3. Continuity cycle: flexible, sequential and complementary

This Figure 3, emphasizes that propaedeutic cycle education is more robust than the traditional model: an *all terrain professional*.

2.8 Section I syntehsis

We have presented a scope of the superior education sector mentioning some critical problems we have faced in our research which is presented in the following section.

3. Curricular and coherence matrix

One of the most important work we have developed and have been submitted to different international scenarios of high technical and scientific, is discussed in this section

3.1 Leontief input output model innovation

Leontief III Millenium: we present the problem resituation from the Interindustry Economy Model, to the new Knowledge and Information Economy, by recontextualizing 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 General Systems Theory in order to face the most critical problems in Superior Education in Colombia mentioned in the previous Section I. A structural system to determine and analyze the cohesion and coherence of the propedaeutic cycles between competences and the curriculum knowledge. This construct enables curricular knowledge management inside the media and higher education. One example of several types of matrices is presented bellow.

3.1.1 Objetives of FESSJ-PROP model

The Leontief innovation started by changing the monetary unit by the academic credit as usual in education. The concept of industry at macro-economic level we changed at university micro-economic level and changing by education process: knowledge (of the study plan) and competences as it is illustrated in Figure 4 bellow. It is searches:

- To reduce the high complexity of the propaedeutic cycle harmonization which are facing the Colombian Universities undertaking these projects
- To offer major clarity to the educational community
- To contribute to the democratization of the involved knowledge within this methodological strategic.
- To articulate efforts within the policy of the Government of Colombia that seeks to increase the educational supply to a major access of the marginalized social population and of those of lower income in order to fulfill the right to information and to the democratization of knowledge executed by the National Constitution.
- To improve the prospective scope as a tool for constructing future in institutions.

3.1.2 Specific objectives

- To enable the curriculum analysis in time power, by periods, and in the knowledge power by areas and assignments. This analysis includes all propaedeutic cycles in higher education.
- To quantify the university production in knowledge development for the student by propaedeutic cycle.
- To apply the new tendencies of engineering which are approached by models: model driven engineering, showing the good applicability of the model by propaedeutic cycles
- To enable the comprehension and management of the methodological strategic by propaedeutic cycles.
- To face accurately, the complexity involved in multiple dimensions leading to the optimization of a study plan in terms of balancing efforts, definitions, scope and projections of subjects and competences/expertise.
- To demonstrate that the student productivity and higher education quality run hand in hand in each propaedeutic cycle.

3.2 Relationships description and architecture

It refers the logical-cognitive relationships among the architecture parts of an educational system. It is as much an analysis instrument as a linear mathematical structure that communicates (all communication action is a pedagogical one), enabling the justification of a study plan and giving it as an organized and complex totality interlinking the interior and external coherency and consistency. Among the objectives are:

- To manage knowledge enabling a morphologic analysis to a study plan on higher education.
- To eliminate inconsistencies and make viable the curriculum optimization of the PEI.

- To improve the prospective scope of the PEI.
- To quantify the production of the universities in the development of knowledge in students (competence culture) by propaedeutic cycles to redesign the expertise areas in each cycle as well as the know-how.
- To give priority to and classify the competence areas.
- To contribute to develop a curriculum without errors and ambiguities.
- To construct the input/out matrix or as a foundation of the optimization and structural analyses.

The curriculum coherence is the strategic alignment between a study plans with its objectives, justification, given the purpose and view, duly articulated with the PEI:

- Non-complex comprehension of the methodology strategy by propaedeutic cycles.
- Optimization of university resources.
- The curricular coherence model is expressed as a matrix which is as much an instrument analysis as a lineal mathematical structure, enabling the justification of a study plan, which gives a sense as an organized and complex totality.

The external coherence refers to the alignment of the educational style of FESSANJOSE to the professional profiles and intellectual capital which demand the industry, the government, science, and technology in a global society. The model based on educational processes according to the curriculum study plan, where an assignment (including classes, workshops, tutorials, laboratories etc.) is associated to an expertise unit. The matrix method is of morphological type to obtain a system contradictions free without the unwanted entropy. The coherence also implies harmony, and articulation between teaching and apprenticeship, alignment, and synchronization.

The system diagram of the matrix model is expressed as follows: rows representing expertise of each level against columns in which the corresponding curricula subjects is arranged (See the whole Matrix Figure 4).

The link is expressed as a propaedeutic component formed by the intelligent iCOACH in order to increase the student productivity in each cycle and also some assignments of connecting in order to meet the prerequisites of each cycle. It is suggested to have both a terminal cycle with their corresponding competences with and the cycle for following higher levels. We did the design for Systems Engineering and it was presented to obtain the Qualified Register of the program.

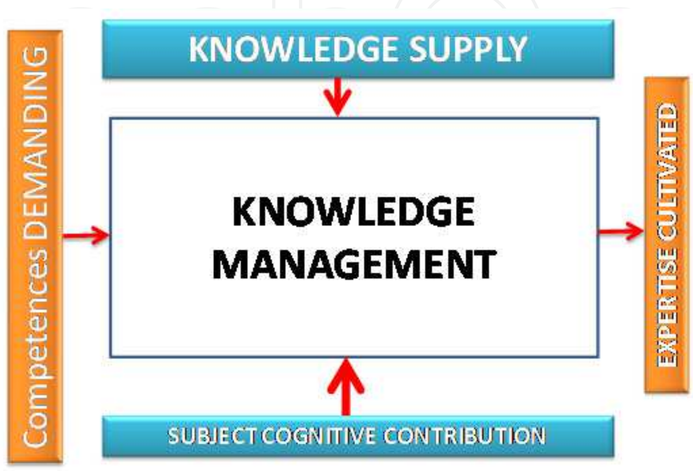

Fig. 4. Matrix model system schema

The *COHERENCE* additionally implies: It has the characteristic of holistic and integral view i.e. the entire complexity of the curricular system transcends knowledge in all its conceptual administrative, methodological, educational, normative dimensions. The academy management is coherent with the PEI when the difference between the achieved in face to the wanted is null, curricular coherence. The PEI is the expression of the proper philosophical comprehension of the educational task and it acts as definition of identity, exercising the university autonomy, recognized by the Constitution and Law.

3.3 Matrix and sub-matrix applications in curriculum analysis

In this subsection we discuss the Curricular Coherence Matrix which is an arrangement between Competences of the study plan and the knowledge involved in the courses and subjects involved.

3.3.1 Background: Mathematical Leontief model for systems analysis

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, larger.

3.3.2 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.

$$Y = AX \qquad t = T_0 \tag{1}$$

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

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

$$[a_{i,j}] = \{\text{yes, not}\} \text{ (black, white), or}$$

$$[a_{i,j}] = \{\text{null, medium, high}\} \text{ (white, red, and blue for a dashboard chart).}$$

See Figure 5.
Next figure we show the whole curricular coherence matrix for Systems Engineering career at the FESSANJOSE with the strategy of the propaedeutical cycles, namely: The Professional Technician in Software Development as the 1st level, the Technology in Software

Architectures as the 2nd cycle and the University cycle in Systems Engineering. All of them rightly articulated by the corresponding Propaedeutical component.

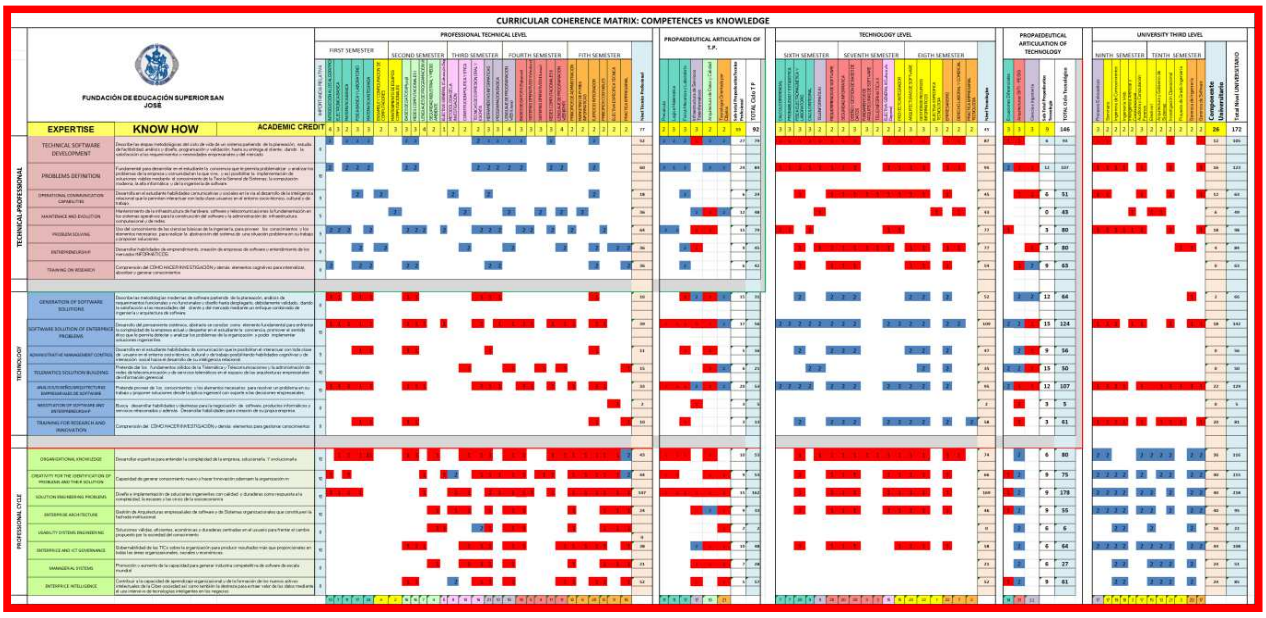

Fig. 5. Systems Engineering Curriculum Coherence Matrix

3.4 Quantitation of curricular knowledge curriculum

Another chart shows the metric for how well the systmens courses and subjects within each propaedeutic cycle features are integrated to provide specific expertise of the skills deployed in the cross-coherence curricular matrix consistency: from the quantified matrix can be obtain for each cycle the productions in systems, namely in terms of compuational expertise cultivated by the engineering educational process. This type of Matrix can be of several classes, i.e. grouped by areas of knowledge (basics, professional specific, professional, etc), organized in time (by academic semesters of the study plan) and also presented by each propaedeutic cycle with/without articulation. Bellow is presented a way (metaphor) to express a space for the several matrices with fuzzy values just specified earlier.

Fig. 6. Curricular Coherence Matrix hyperspace

In this work we present the re-contextualized linear model as did Buckley (1992) 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.

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 the Sub-Section 4.5.1, the Table 1. The analysis is based on academic governance system flexibilities of FESSANJOSE as discussed in the sub-section 1.7 and quantified by the equation (1), to observe endogenous or exogenous changes in either the skills or the same knowledge, equation (2)

$$\Delta Y = \Delta A X \tag{3}$$

3.4.1 Curricular quantification from the matrix: Cognitive contribution

The cognitive contribution of the j^a subject is obtained by the following relation:

$$\sum_i a_{i,j} n_j = d_j \tag{4}$$

Where n_j is the corresponding subject credits d_j is the cognitive contribution of the j^a subject for each propaedeutic cycle (columns). Bellow contribution in the last row present the cognitive for the first level, Professional Technician on Software Development corresponding to the Systems engineering matrix depicted in Figure 5.

Semester	IMPORTANCIA RELATIVA		
FIRST SEMESTER	INTRODUCCION A LOS ALGORITMOS	4	13
	ELECTRONICA BASICA	3	7
	MATEMATICA BASICA	2	11
	FISICA BASICA Y LABORATORIO	3	17
	MATEMATICA INTEGRADA	3	24
	ENSAMBLE Y CONFIGURACION DE COMPUTADORES	2	4
SECOND SEMESTER	MANTENIMIENTO DE EQUIPOS COMPUTACIONALES	3	2
	BASES DE DATOS I(Mysql)	3	16
	REDES COMPUTACIONALES I	3	16
	LENGUAJES DE PROGRAMACION VIS	4	7
	SEGURIDAD INDUSTRIAL Y MEDIO AMBIENTE	2	4
	ELECTIVA GENERAL (Cultura y/o Dep	1	5
THIRD SEMESTER	METODOLOGIA DE LA INVESTIGACION	2	8
	CONSTITUCION POLITICA Y ETICA	2	10
	TECNICAS DE EXPRESION ORAL Y ESCRITA	2	16
	HERRAMIENTAS INFORMATICAS	3	21
	PROGRAMACION BASICA	3	13
FOURTH SEMESTER	LENGUAJE DE PROGRAMACION WEB I (Java)	4	18
	BASES DE DATOS II (Sqlserver)	3	14
	SISTEMAS OPERATIVOS I (Windows)	3	5
	SISTEMAS OPERATIVOS II (Linux)	3	4
	REDES COMPUTACIONALES II	3	11
	LENGUAJE DE PROGRAMACION WEB II(PHP)	4	11
FITH SEMESTER	PRINCIPIOS DE ADMINISTRACION	2	12
	MARKETING DE PYMES INFORMATICAS	2	6
	EJERCICIO INTEGRADOR	2	20
	PRINCIPIOS CONTABLES	2	12
	ELECTIVA ESPECIFICA TECNICA	2	9
	PRACTICA EMPRESARIAL	2	16
	PROFESSIONAL TECHNICIAN LEVEL	77	

Fig. 7. Software Development Professional Technician Subjects Contribution

Similarly for the Technology level of Software Architecture, the cognitive contribution is presented jointly with the propaedeutical component of the 1st level, Professional Technician, as shown in Figure 7.

For the 3rd Cycle, Professional on Systems Engineering similarly is shown in Figure 9 with the propaedeutical component correspondent of the previous Technology level.

PROFESSIONAL TECHNICIAN							
PROPAEDEUTIC ARTICULATION							
Precalculo	Logica Matematica	Fisica Mecanica y Laboratorio	Infraestructura de Servicios Teleinformaticos	Arquitectura de Datos y Calidad	Tecnologia Orientada por Objetos	PROPAEDEUTIC OF PROFESSIONAL TECHNICIAN	TOTAL OF PROFESSIONAL TECHNICIAN CYCLE
2	3	3	3	2	2	15	92
11	11	17	17	18	21		

TECHNOLOGY																		
SIXTH SEMESTER						SEVENTH SEMESTER						EIGTH SEMESTER						
CALCULO DIFERENCIAL	PROBABILIDAD Y ESTADISTICA	FISICA ELECTROMAGNETICA Y LABORATORIO	CALULO INTEGRAL	TELEINFORMATICA I	REQUERIMIENOS DE SOFTWARE	SEGURIDAD INFORMATICA	DISEÑO Y GESTION DE BASES DE DATOS	FUNDAMENTOS DE ARQUITECURAS DE SOFTWARE	TELEINFORMATICA II	ELECTIVA GENERAL II (Cultura y/o Deporte)	PROYECTO INTEGRADOR	ARQUITECTURAS DE SOFTWARE	GESTION DE RECURSOS INFORMATICOS	ELECTIVA ESPECIFICA TECNOLOGIA	EMPRESARISMO	DERECHO LABORAL Y COMERCIAL	PRACTICA EMPRESARIAL TECNOLOGIA	Techology Level
3	3	3	3	2	2	2	3	3	2	2	2	3	3	3	2	2	2	45
7	7	20	9	9	20	20	20	3	3	15	15	20	22	1	22	7	2	

PROPAEDEUTIC ARTICULATION				
Ecuaciones Diferenciales	Arquitecturas SI/TI - PESIG	Ciencia e Ingeniería	Sub-total of Technology Propedeutic	TOTAL OF TECHNOLGY CYCLE
3	3	3	9	146
14	31	11		

Fig. 8. SoftwareArchitecture Technology Subjects Contribution: TP articulated

Technology PROPAEDEUTICAL ARTICULATION				
Ecuaciones Diferenciales	Arquitecturas SI/TI - PESIG	Ciencia e Ingeniería	Sub-Total Propedeutico Tecnologia	TOTAL Ciclo Tecnológico
3	3	3	9	146
14	31	11		

UNIVERSITY THIRD CYCLE													
NINTH SEMESTER						TENTH SEMESTER							
Procesos Estocasticos	Seminario	Ingenieía de Conocimientos	Ingeniería Web	Inteligencia Artificial y Computacional	Auditoria y Computación Forence	Electiva I	Arquitectura y Gobierno de Sistemas	Investigación Operacional	Proyecto de Grado Ingeniería	Gerencia de Ingeniería	Gerencia de Software	Componente Universitario	Total Nivel UNIVERSITARIO
3	2	2	2	2	3	2	2	2	2	2	2	26	172
17	17	19	18	3	17	15	13	21	3	20	17		

Fig. 9. 3rd cycle Professional on Systems Engineering Subjects Contribution technology articulated

These values (added by subjects) for each subject to compare the cognitive contribution per semester and also allows:
To identify orphan subjects which have not been established or are too weak implications.
To identify any overestimation
The above would require a review by the Curriculum Expert Group.

3.5 Other metrics obtained from the matrix: Production

The cultivated expertise is given by the production i as follows:

$$\sum_j a_{i,j} n_j = b_i \tag{5}$$

Where b_i is the i^a production, expressed as cultivated expertise for each competence unit (rows). For each cycle see bellow the corresponding values obtained.

The Figure 10 bellow shows the values of Expertise cultivated in the student for each cycle, by the competences of the 1st cycle of Technician-Professional.
The Figure 11 expresses the same by the competences of the Technology cycle. The Figure 13 the same for the University cycle.

		TECHNICAL-PROFESSIONAL Level	Propedeutical of TP	TOTAL TP Cycle	Technology Level	Propedeutical of Technology	TOTAL Ciclo Tecnológico	University Component	Total of University Component
	ACADEMIC CREDITS	77	15	92	45	9	##	26	172
TECHNICAL-PROFESSIONAL COMPETENCES	TECHNICAL SOFTWARE DEVELOPMENT	52	27	79	87	6	93	12	105
	PROBLEMS DEFINITION	60	24	84	95	12	107	16	123
	OPERATIONAL COMMUNICATION	18	6	24	45	6	51	12	63
	MAINTENACE AND EVOLUTION	36	12	48	43	0	43	6	49
	PROBLEM SOLVING	64	15	79	77	3	80	18	98
	ENTREPRENEURSHIP	36	9	45	77	3	80	4	84
	TRAINING ON RESEARCH	36	6	42	54	9	63	0	63

Fig. 10. Expertise cultivated in the student for each cycle, by the competences of the 1st cycle

3.5.1 Systems engineering skills by cycles, expertise and know-how

In the diagram of the Figure 5 it can be seen how they develop skills throughout student academic life. It is noted that development of basic skills is permanent or continuous Salthouse (1991) backed by numerous studies in which skill or expertise has a behavior of someone who continually learns, throughout his life: a Normal Distribution. This may be associated with the occupational skills of the three cycles preliminary in Systems Engineering.

The Systems Professional expertise requires the definition of specialized skills or outstanding tasks i. e. SUPERIOR PERFORMANCE or represented in a domain that are described as KNOW HOW. The cognitive processes associated with learning mechanisms are of more complex.
EXPERTISE approach involves the development of skills as a dynamic continuum and is associated with learning processes throughout life that are affected by change and social practices, industry behavior, science and technology. As a result, the structure of competence is variable in itself, change usually associated with a requirement of living space in which it is used. In concluding synthesis:

	FUNDACIÓN DE EDUCACIÓN SUPERIOR SAN JOSÉ	IMPORTANCIA RELATIVA	PROFESSIONAL TECHNICIAN LEVEL	PROPAEDEUTICAL OF PROFESSIONAL TECHNICIAN	TOTAL OF PROFESSIONAL TECHNICIAN CYCLE	Techology Level	Sub-total of Technology Propedeutical	TOTAL OF TECHNOLOGY CYCLE	Third Level	Total UNIVERSITY CYCLE
	EXPERTISE		77	15	92	45	9	146	22	168
TECHNOLOGY	GENERATION OF SOFTWARE SOLUTIONS	8	16	15	31	52	12	64	0	64
	SOFTWARE SOLUTION OF ENTERPRICE PROBLEMS	10	39	17	56	109	15	124	14	138
	ADMINISTRATIVE MANAGEMENT CONTROL	9	11	5	16	47	9	56	0	56
	TELEMATICS SOLUTION BUILDING	10	15	6	21	35	15	50	0	50
	ANALYSIS & DESIGN OF SOFTWARE ENTERPRICE ARCHITECTURES	10	33	20	53	95	12	107	18	125
	NEGOTIATION OF SOFTWARE AND ENTERPRENEURSHIP	8	2	3	5	2	3	5	0	5
	TRAINING FOR RESEARCH AND INNOVATION	8	10	3	13	58	3	61	18	79

Fig. 11. Competences cultivated in the student for each cycle, by the competences of the 2nd cycle

		TECHNICAL-PROFESSIONAL Level	Propedeutical of TP	TOTAL TP Cycle	Technology Level	Propedeutical of Technology	TOTAL Ciclo Tecnológico	University Component	Total of University Component
	ACADEMIC CREDITS	77	15	92	45	9	146	26	172
PROFESSIONAL CYCLE COMPETENCES	ORGANIZATIONAL KNOWLEDGE	43	10	53	74	6	80	36	116
	CREATIVITY FOR THE IDENTIFICATION OF PROBLEMS AND THEIR SOLUTION	44	9	53	66	9	75	40	115
	SOLUTION ENGINEERING PROBLEMS	147	15	162	169	9	178	40	218
	ENTERPRISE ARCHITECTURE	24	9	33	46	9	55	40	95
	USABILITY SYSTEMS ENGINEERING	0	2	2	0	6	6	16	22
	ENTERPRICE AND ICT GOVERNANCE	38	10	48	58	6	64	44	108
	MANAGERIAL SYSTEMS	21	7	28	21	6	27	24	51
	ENTERPRICE INTELLIGENCE	52	5	57	52	9	61	24	85

Fig. 12. Expertise cultivated in the student for each cycle, by the competences of the 3rd cycle

- The ability of generalization, abstraction, conception, analysis (decomposition), integration, design and composition (synthesis).
- Ability to apply high-level knowledge in exercise and professional practices.
- Ability to organize and plan the implementation time and wise use of resources entrusted him/her to social responsibility and civic commitment.
- Ability to communicate orally and in writing and to develop methods and techniques geared to the user, i.e. usability or user oriented, because the systems demand, apart from the machine communication, working with people is required.

- Ability to define problems: the creativity needed to identify problems and also the creativity needed to solve complex technical problems in order to face the turbulence of the global Millennium III: this is the imperative of our research.

The imperative demands of ICT and its domain expertise in different environments as enshrined in the Colombia National Plan of ICT, but the recent ICT Law passed by the local Government.

3.5.2 Inputs skills / expertise in systems engineering

For each of the cycles shows the quantification of the lecturing services, extension, research, mentoring, support, laboratories, experiment, practice and other which is acquired by every competence in the cognitive process of each student.
In these plots, the row number refers to the number of credits each course feeding the competence offered in this cycle: Professional Technician on Software Development.
Each value allows us to visualize the relative importance of a subject. If zero or very low one, tells us that is isolated or de-contextualized and deserves a critical review.
The model of the first cycle of the FESSANJOSE provides five semesters, has been successful in the national context, obtaining several years in the top ECAES (professional examinations of official national wide). The technology cycle visualize the design possibilities and advantages of this cycle. Applying the formulas (1) and (2) we obtain the corresponding values for competences cultivated for each propaedeutic cycle and the valued added of the courses. See Figures 10, 11 and 12.

3.6 Input / otput matrix

In this matrix each cell is expressed as follows:

$$\tilde{a}_{i,j} = \frac{d_j}{b_i} \tag{6}$$

Technical Coeficient: input fraction by production unit: Where each $a_{i,j}$ 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, 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 of the sub-section 4.1.4.
The Systems Engineering curriculum design based in propedeutical cycles and also in EXPERTISE have cognitive and structural features distinctive, the first of which is an academic structure articulated, sequential, complementary and flexible, whose cornerstone is the development of professional and occupational engineering skills. This assumption allows defining: Firstly the **Feedback sub-matrix** corresponding to the cycle objective, which can be quantified knowledge articulation, processes subsequent courses to strengthen the competencies implied. See Figure 13 bellow.
The **Feedforward sub-matrix,** to quantify the knowledge articulation of the processes of the current cycle and feeding skills training for senior cycle (upper).
There are many possibilities for analysis, to meet the socio-economics demands in terms of such competences.
Are they balanced?
Is there bias?

What if a new competence is included due to the Systems, Software and related industries demand?
What is the effect of restructuring a subject or a course or a subset of them in missionary terms?
Can you explain the lower/higher values?
Is it necessary to revise a subject content regarding the competence impact?
Is it necessary to redefine the scope and the limitation of a competence?
Is it a group of subjects of the study plan, biased or underestimated?
Is it necessary to recalculate the number of credits assigned to each subject initially proposed, after changes?

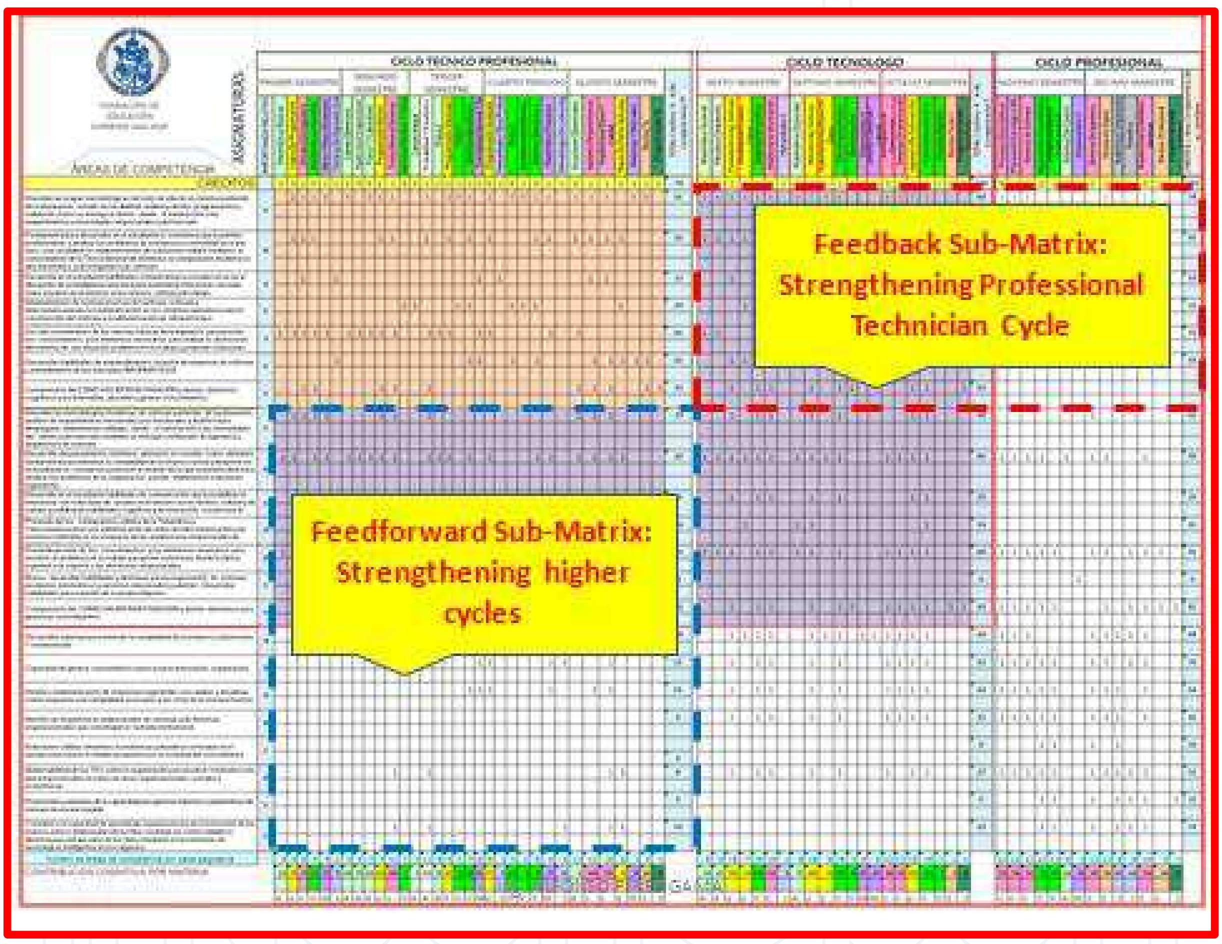

Fig. 13. Feedback and Feedforward Matrices

4. Education software architecture: Facing student desertion in Colombia higher education

The Student Desertion National wide problem is very critical by its cultural, economics and family impact. Several IES (Superior Education Institutions) have performed studies leading to point out this problem as a recurrent and prevalent one. The design and implementation of iCOACH which is an intelligent tool knowledge based is presented here as a instrument of high computing to follow up each student in the academic first terms of the engineering faculty at the FESSANJOSE, The software architecture have 3 main parts: Edumatic builder (as a tool for Professor), the Student Model, and the third one is the Knowledge Base for concept verification and security. Several previous works have preceded this project so our methodology and related are very experienced. A prototype was built to demonstrate the iCOACH validity and applicability and also as an instrument of academic productivity. This effort is part of a greater system called FESSJ-PROP which is an analytical model for Propedeutical Cycles Higher Education Strategy in Colombia. Perez Gama Alfonso et al.(2010).

4.1 Diagnosis and justification

Student dropout is a phenomenon cultural and Socioeconomics. Several studies in Colombia have found statistics and figures in excess of 50% that significantly affect the efforts made for increasing the coverage and quality education. Similarly close to one of every two students entering the Systems do not completes successfully or do in times higher than expected. Some determinants of the phenomenon have been analyzed using Statistical and Sociological techniques. Important factors that are the following:

- Economic impact of more than 1/4 part of them.
- Academic with almost half of the students highlighting that most of the student population of the institution FES belongs to strata 1, 2 and 3 of Bogota. Also it is shown that the 1/3 of the deserters is first semester students who entered in 2007 at the Institution.
- Academic and psychological aspects represent a marked influence on desertion inside institutions, within the academic aspects we can emphasize: low academic performance, non-compliance with the expectations of students and poor vocational preparation from high school, which is demotivation and causes deviation of the students admitted their personal goals and objectives, forcing the student voluntarily to remain in academic conditionality and / or outside the program or even outside the university.
- The psychological aspects as the lack of screening personnel and professional, the failure to adapt to the college environment and learning environment are significant and are presented in the students since the start of their studies and can be identified from their income the institution; It is directly linked to academics, because they affect the student's academic performance.

It requires among other: Virtual systems for verification of concepts and deepening of meaningful learning, monitoring progress of individual students and motivation programs, counseling, vocational guidance reinforced through academic tutoring, life project.
The problem is worsened by increasing educational coverage and the global crisis: every time we have more students, larger classes, less contact with them, increasing the teaching load and higher costs that many students spend more time on making any income Economy.

4.2 Anti-drop methodology

A program within the university by intelligent monitoring provide assistance ranging from the process of adaptation to university life to the completion of their studies, aiming to drop the risk is minimal, plus academics critical cases in the work is more specialized towards the student remained in college, monitoring for first semester students will be using our system: Intelligent Coach, we used to call iCOACH, to identify and strengthen weaknesses of students in those subjects where students show academic deficiencies, in this institution that the problems start from the basic courses. Individual causes are: Age, gender and civil status, home calamities, college change, life project and disease. Academic causes: High school deficiencies, Poor performance, No flexibilities (pedagogical and administrative). External causes: social Stratum, personal and parent's employment, household costs, city residence change. We conducted inside FESSJ, a survey and choose the following factors: Economic Difficulties, Life Project, Semester deferral, Academic performance, Career Change, City residence Change, family problems, disease, or working.

4.3 General objective problem for solving with iCOACH

Reduce the student's academic mortality index in first terms of each university program and also improve quality performance. The first goal is to develop an intelligent and computational system for monitoring student progress and also for be able for academic reinforcement to the student, way virtual tutoring and intensive courses in his college life. This intelligent tool is able student training and concepts verification with wide knowledge base of questions and testing previous to the taking examinations with the final purpose of entrenchment theirs mental and cognitive abilities for significant learning in his/her career. The second one is to evaluate academic and socioeconomic factors related to the student drop out using statistical metrics which are generated by the own intelligent tool, for quantification purposes. So with this to design emergent strategies more suited. The last one is to formulate complementary actions or programs leading to reduce. The most final goal of the Project is to improve academic student's quality.

4.4 Computational project description

Recent advances in ICT and hypermedia are offering opportunities with no precedent to comply with new student need or unsolved ones for all level. Actually the education sector in Colombia which is one of the most of the 4 axis in the ICT National Planning supported by web wide networks face several problems, as:

- Poor pedagogical services in which are attempted manage the student free time within the concept of ACADEMIC CREDIT. Regarding 18 articles of the 2566 Decree and the 1188 Education ACT an academic credit is "the estimated time of student academic activities as a function of academic expertise's which an academic program is expected to develop ". Its more essential , definition the term allows: to incorporate within the concept, not only the presence hours with/or without the lecture direct accompanying but also is being taking account the independent student work for preparation and practice. The later implies the managerial of the student free time way personnel autonomy in his learning under student control.
- The inadequacy of evaluative models for cognitive progress student as a countermeasure the desertion in Higher education.
- Failing protuberant in the feedback quality information and monitoring of the student progress.
- Few educational answers with based ICT technology to the increasing educational requirements, for all level.
- Few support to the Scientific and Technology sector, given the few opportunities for financial resources of continued researches which are involved in the relevant knowledge generation.
- Also huge considerations regarding Intelligent Computer Education and all digital technology are marginal options in process and darkness that the same education has to be re-contextualized (adequacy of a curriculum), redefined and resituated.

4.4.1 Antidesertion computational problem formulation

It was precede an intensive work in several research projects, something like EIDOS at the National University of Colombia and FESSANJOSE, in such areas as artificial Intelligence and cognimatics computing education and related, undergraduate and M Sc thesis as well as subjects as virtual and distance education. In several universities as The National of Colombia, District City University, and many others and also studying several international edumatics experiences in presence and virtual learning methodologies giving that an unusual interest in continuing these concerns exploring the electronics book production leading to a virtual library exploring related areas. It is required:

Firstly, of having good student models with feedback and forward monitoring leading to the user cognitive evaluation and individualized following up to each subject. Secondly to have lecturer tools (edumatics builders) in order to design tests intelligent wise, sure, and consistent, based in random and structured selection form knowledge bases. Thirdly, the new lecturer with the characteristics and new player roll of having the possibility for concreting the pedagogy as knowledge rebuilder for recontextualisation of all education materials for one user who will be alone doing his/her learning under his control and autonomy. To build a system for verification of student's concepts , it was undertaken the project within the edumatics and software engineering to establish the planning, analysis, identification of pedagogical training requirements and software to specify the design of a edumatics intelligent system, systemic and cognitive with assessment with the students to virtual mode. The system specified included the following: An edumatics builder, wich is the test and examination generator for students, which is a lecturer tool and cognitive evaluator of students for verification of concepts, controlled by an intelligent tutoring agent and a virtual knowledge base of questions and tests with a fully re-organized structure. It also identified the need for a comprehensive systems or basic models: Model of the System, functional model, data model and the student model, which included general information on knowledge bases to be used. On the other hand the market is demanding educational products, packages and systems to which the person learns what they want, anytime and anywhere, it also costs have to be attractive, as is being displayed in the electronic marketplace.

4.4.2 Theoretical context

The educational work has been understood as reconstructive science knowledge. That we want to motivate student from which the challenge for educators in the emerging Knowledge Society motivation lies in the appropriation of knowledge that encourages students to generate new knowledge as a way to confront the serious problems of backwardness and dependency of our own countries. To understand the new role of lecturers is necessary to clarify what is the model that will go to rationalize and legitimize the claim to educational practices and especially the role of the teacher in the order produced by modernity and postmodernity in the informatics context; what is clear is that the traditional pedagogy of the lecturer seems to have fulfilled their life cycle. Education with information and knowledge technology based (EDUMATICs, COGNIMATICS) is an option of the lecturer from the standpoint of pedagogy which is due to its characteristic modifier for the training of future generations of engineers. The theoretical framework of our project is also supported on models and systems including: Model of software engineering and architecture education, computational model of pedagogy, instructional model, System focused on Innovation and Learning System of thinking processes. This theoretical and conceptual framework is documented in a number of publications. The following is a brief description. The theoretical framework of our project is also supported on models and systems including: Model of software educational engineering, computational model of pedagogy, instructional model, System Focused on Innovation and Learning System of thinking processes. This theoretical and conceptual framework is documented in a number of publications.

4.4.3 Developing model of educational architecture

The model was developed, presented and discussed in many venues nationally and internationally. Taxonomically includes several models for students seeking a formal specification for use in modern software engineering practice and also in the architecture of educational software. The above mentioned is complemented by other models: the cognitive, conceptual or syllabus, and the Instructional Tutorial Planning. This software engineering education has been used to enable the stimulation of intelligence and the extension of the knowledge based on personal autonomy in learning supported by technology. The theme is very suggestive.

The rationale of the educational activities is focused on motivating higher mental abilities: this is a major challenge in research. ¿Why is the reason to have a computer model approach? Without going into a taxonomic discussion, we emphasize the approach of computational models to establish a differentiation primarily with mathematical models, which can closed express structures and behaviors, among others in addition to explicitly recognize the complexity of "model" as regards cognition. ¿How support the student personal autonomy in his/her learning? It considers learning as an essential part of the educational problem is even more true in regard to a new build of Educational Computing education - with the support of a knowledge-enabling staff carrying autonomous student learning in the field of robotics have shown significant progress in artificial learning.

One aspect of innovation in education is to understand that intelligence is a skill that can be educated: Learned (act of the individual) and education (opportunity for the teacher). We point out numerous scientific researches and the teaching practice and show intelligence as a result of thought. The correctly thinking is not a function of the innate intelligence nor education. Phenomenologically associated power of some subjects in the curriculum, to develop thinking (eg mathematics of all the ways to teach thinking is basically another way of addressing the educational problems throughout the area: kindergarten to higher education. If we start from the assumption of the modifiability of cognition, how much can be done more intelligently to people with or without the support of information technology in a meaningful and lasting? Regarding the educability of the intelligence is so intelligent behavior must be considered as a goal of educational activities, pari passu with other aspects such as emotional and psychomotor; also that the construction of data objects, so tecnofactum or mentefactum/ cerebrofactum (mental/brain artifacts) to extend their cognitive potential of the student. In summary, we propose an electronic and computer environment for learning, as dual use: machine or artificial learning (machine learning) to evolve the knowledge base and development of higher mental abilities by the student.

4.4.4 Software architecture and engineering methodology

Our methodology involves the use of multiple paradigms, ranging from engineering information, to modern software engineering/architecture with artificial intelligence and obviously web engineering. It includes evolutionary prototyping method.

4.4.5 Outcome
The products to obtain:

- Construction of an intelligent agent for monitoring student progress towards the verification of concept learned.
- Construction of an intelligent for the generation of tests and examinations and the presentation of individualized assessments, via the Internet. Includes a knowledge base manager of problems, a response handler for results and a statistical system. The intelligent evaluation using international standards. Repository or knowledge bases tested educational content on specific subjects, including a system of meta-cognition, e. g. conceptual or cognitive maps (digital maps).
- Generation of statistics for monitoring student progress in real time
- A management system safe and secure on the Internet for communication with the student to allow access 24 hours a day, 7 days a week, both the systems evaluated to establish electronic communication.
- With a website to see e. g. frequently asked questions and answers, news and more.
- Simulation Model for iCOACH and the full implementation.

4.5 Computer constructor of tests & exmination for knowledge verification
The software platform is designed as a tool for educational to be used by managers, tutors and learners, to facilitate the construction of tests for testing concepts and the generation of an intellectually demanding action space, allowing interaction of the various actor involved in the process. The constructor in with the general functional model of the project, through the following agents: Professor: individual or object that provides the system of disciplinary knowledge, ponders the complexity of knowledge, design tests with which to assess learning, provides the answers and lead the process of cognitive apprenticeship. Student: Is the person on which rests the teaching institution and who is responsible for the quantity and quality of knowledge acquired. The system serve as coach potentiates cognitive skills, accredited skills and explore their results critically. Manager: individual or object that performs the monitoring and feedback of student progress, uses statistical information on academic performance, monitors the implementation of curriculum plans and ensures compliance with the institutional offer.

4.5.1 Operationality
The system must control access to the authorized players through verification of the validity of a login and a password and only allows access to certain information service in accordance with the privileges of that user as a certain level it. In the same vein should give special attention to the process designed to protect from an unauthorized access over the network and safeguarding the integrity and confidentially of information.

4.5.2 Security
The system must control access to the players authorized through verification of the validity of a login and password and only allows access to certain information services in accordance with the privileges of that user as a certain level it. In the same vein should give special attention to the processes designed to protect from unauthorized access over the network and safeguarding the integrity and confidentiality of information.

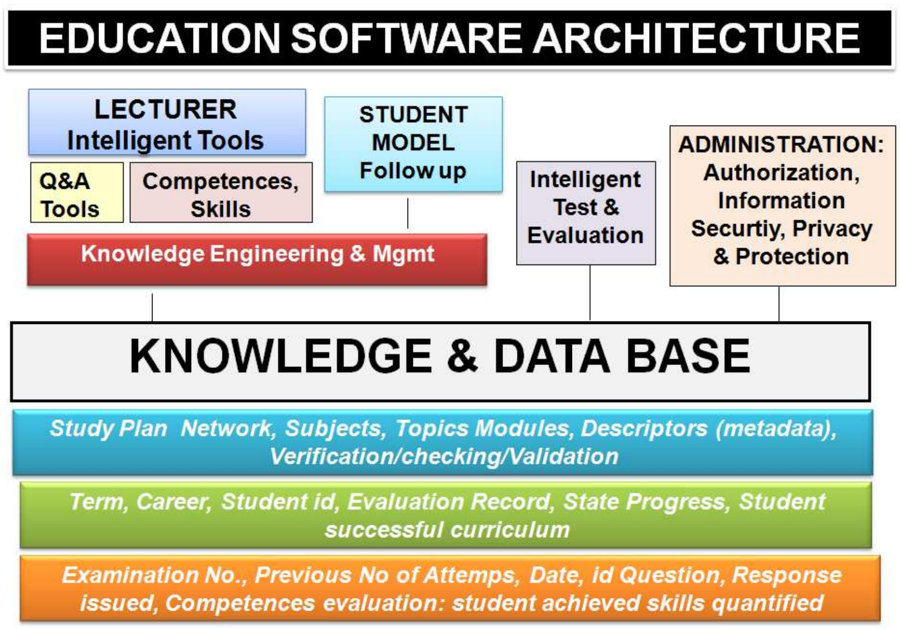

Fig. 14. iCOACH Architecture

4.5.3 Architecture

Functional components interact independently of the builder, so in most cases the transfer of parameters is absent or reduced to a minimum. Each function corresponds to a visual interface for easy operation, flexibility and self significantly.

4.5.4 Conclusions and future work

iCOACH allows to design strategies by monitoring individual student progress, to identify deserters and perform follow up of them with the additional support of the FESSANJOSE Welfare Department. The system implementation of flexibilisation: the administrative (i.e. payment by quotes, the pedagogical (i.e. transfers. ICT strategies) and related. iCOACH is also a management tool to the student surplus time for their learning controlled by him/herself. Other major conclusion of this effort is to have obtained the design specifications and the requirements for the professional software development for iCOACH: the maturity model.
The future work: is to extend iCOACH to all academic programs inside FESSANJOSE and to offer coaching services to all academic community in Colombia using SOA (Services Oriented Architecture). The iCOACH Professor-side is to extend the Knowledge base developing parameterized and intelligent queries/questions for knowledge verification with natural language processing in order to have a knowledge base fully re-organizing and intelligent one.

5. Integration of input-output model and linear programming: Linear programming with leontief input output model

5.1 Background: Mathematical Leontief model for systems analysis

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, extended. The first part of this modelwas presented in Section and we illustrated with several matrices. Perez Gama Alfonso et al. (2011).

5.1.1 Mathematical Leontief model for economic analysis

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

$\mathbf{X}_j$: 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 ∊ Rn 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:

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

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?

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

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.

5.1.2 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

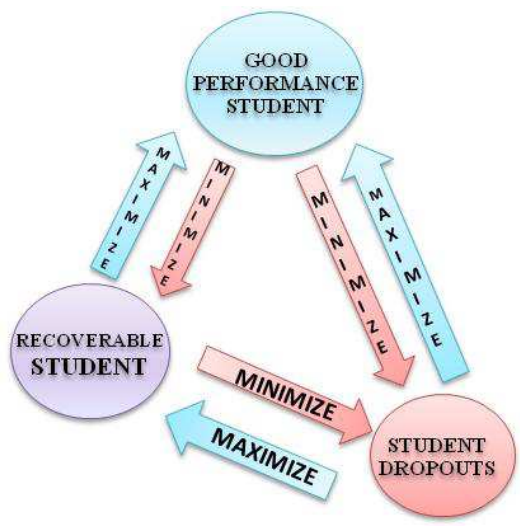

Fig. 15. Student Levels Flows for Optimization

5.1.3 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) Ortegón Edgar et al.(1973). The following 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 Figure 15.

5.1.4 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 and 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. 15, which shows the levels of students in higher education mentioned above.

FUNDACIÓN DE EDUCACIÓN SUPERIOR SAN JOSÉ	*Multisectorial Model: Linear Programming & Leontief Input-Output for Higher Education*			Higher Education											Rest of Final Demand				
		Primary	Manufacture Industry	Basic Sciences	Professional Basics	Socio-Humanistic	Communications	Found. Scientific Technical	Social Projectn & Research	Rest of Commerce & Services	Households	Government	Exports	Imports	Physical Capital	Intelectual Capital	Others		RHS
Industry & Knowledge ECONOMY	Primary Sector																	=	0
	Manufacture Industry																	=	0
Higher Education	Basic Sciences															k1		=	0
	Professional Basics															k2		=	0
	Socio-Humanistic					(I - A)					-H	-G	-1X	-1M	-df1	k3		=	0
	Communications															k4		=	0
	Found. Scientific Technical															k5		=	0
	Social Projection & Research															k6		=	0
	Rest of Commerce, Services & TICs															k7		=	0
	Remunerations	f1	f2	f3	f4	f5	f6	F7	f8	f9	-1							=	0
	Government	t1	t2	t3	t4	t5	t6	t7	t8	t9		-1						=	0
	Exports	ex1	ex2	ex3	ex4	ex5	ex6	ex7	ex8	ex9			-1					=	0
	Imports	m1	m2	m3	m4	m5	m6	m7	m8	m9				-1				=	0
	Rest Added Value	r1	r2	r3	r4	r5	r6	r7	r8	r8							-1	=	0
	Restrictions and Thresholds																		
FIT	Seats			q1	q2	q3	q4	q5	q6									≤	b1
	Human Resource			l1	l2	l3	l4	l5	l6									≤	b2
	Capacity			v1	v2	v3	v4	v5	v6									≤	b3
	Minimun Coverage			j1	j2	j3	j4	j5	j6									≥	b4
	Multiple Objective Functions																		Z
CRITERIA	STUDENT LEVEL			q1	q2	q3	q4	q5	q6									=	Opt
	Student repetition Avoided			l1	l2	l3	l4	l5	l6									=	Max
	Desertion Avoided			v1	v2	v3	v4	v5	v6									=	Max
	Gross benefits			j1	j2	j3	j4	j5	j6									=	Max

Table 1. Linear Programming with Leontief & Input-Output Model: Knowledge Architecture

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

$$f(X, D_{f)} = 0 \quad (8)$$

D_fIs the final demand: Households, Inversion, Government, Δ Inventories, Rest of the world…
Political function issues:
Max

$$Z= f(\Delta Students\ Level) \quad (9)$$

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

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

5.1.5 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?*
- *How much does it cost for an institution to improve 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?*

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.

5.2 Some conclusions and future work

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. At the same time the model allowed us to analyze the problems of Academic Governance and Financial Sustainability of Higher Education Institutions.

- The Model architecture shows a model suitable for the knowledge society as displayed in Table 1
- International Peers in evaluating our work have acknowledged that the literature is very scarce in this educational purpose. Also our mathematical system for analyzing the

desertion, curricular coherence consistency for the propaedeutic cycles 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 Higher Education in this country.
- Substantial rescue of the propaedeutic cycles, in particular: major industrial and social credibility of the TP-T education is expected.
- Major preference of young people, for education by propaedeutic cycles, due to the possibility of achieving better long-term career, prospected as a project life.
- Best potential for high quality accreditation by the TP-T institutions.
- Finally once we have our completed model it is verified, tested, validated and accepted, we make it serve the all country's academic community in Colombia.

6. Methodology issues

The problems presented was faced with multiple paradigm methods which are required to implement several complementary actions.

We have of a complex information system, called SIFES which involves the education software architecture with which we have historical information of the student cohorts, period to period. We have implemented the mentioned architecture shown in (See Figure 14) order to obtain information in real-time student and the student record the information including all incidents and risk factors. It is included:

- Student Communication System In Real-Time: is an additional module of the student web portal that allows each student to write their concerns, problems and suggestions so that the Welfare Department of the FESSANJOSE may consult such information once the student has registered, to be analyzed in order to determine the trouble spots by career or journey and also make direct intervention with students and thus further mitigating the chances of dropping out.
- Individualized Follow Up in Real-Time of the student of the FESSANJOSE, allowing the generation of new information from the SIFES database.
- SIFES As mentioned above, is a system of academic information FESSANJOSE is a system developed with high standards of engineering and advanced security controls, which have the academic record and financial participants such as teacher education project and students. Regarding students can consult their resume, medical exams, schedules, materials recorded, self-assessment results and institutional and historical grades of the semester, approvals, assistance, educational aid, and payments recorded. Front SIFES teachers have information on their resume, studies, time availability, results of teacher evaluation, contracts, schedules, attendance records, typed notes. SIFES generates reports for various agencies, report early warning dropout prevention such as low results in more than one material, appropriate controls on payments and attendances.
- BOARD OF CONTROL: This system allows monitoring the possible state of desertion based on variables such as attendance, grades and financial commitments and compliance with these indicators can be set for each student, using a mathematical model to determine the probability of dropping further with each student so they can make appropriate interventions as may be evidenced in the variables that make up the information and decrease the probability of a given student. Virtual and includes tutoring

with an emphasis for students with deficiencies and low performance, the implementation of training workshops to promote student retention, teachers, managers and administrative (use of technological support and also includes Parent Involvement).

6.1 Fieldwork survey methodology

The variables of the model are enriched with the national SPADIES (Prevention and Analysis System of the Attrition in Higher Education Institutions) that offers the National Education Ministry which allows us to compare the figures of dropout, repetition, retention, and others. One problem is reconciling the concepts in determining how to understand the dropout, how many academic periods without registering, if it is included students graduating from each program who have not received and others.
Institutionally implemented a system of engineering of organizational processes with dual-use ISO certifying institution and feed the model discussed in this chapter for quantified architecture model that includes obviously the intellectual assets.

6.2 Knowledge engineering methodology: Towards a knowledge engineering methodology: An attempt to its formalization

Our research effort represents ongoing work with several University projects and unpublished graduate works and also consulting works for institutions in Colombia. In the FESSANJOSE the model has evolved to our proposal of social innovation Leontief Model that incorporate the knowledge sector.
The Knowledge Engineering Methodology presented in this paper is an attempt for reducing the complexity involved: is part of that effort and has not obeyed to a large-scale project with good funding. They have been serene developments that we want to share with the academic community. We describe an attempt to formalize a KE methodology in 8 steps which are presented in detail, the mix of ideas coming from both Engineering and Management we tried to integrate in this construct. Also we discuss briefly our understanding between knowledge engineering and knowledge management.

6.2.1 Background of the method

For several years we have been involved in building expert systems, intelligent systems and courseware development in areas such Strategic Planning, Information Systems Architectures based on knowledge and building intelligent tools for Superior Education Sector, which has resulted in an empirical study we have gradually put on several congresses.
In particular we have faced the problem of Higher Education in Colombia for Propaedeutical Cycles, which faces many serious problems of student dropout and mainly the lack of competitiveness of the sector. The foregoing led us to rethink the matrix of input/ output in terms of curricular knowledge and competences to be cultivated in students to submit papers in several international conferences. In recent years we have redefined the architecture of the Leontief model by introducing the sector of knowledge and applied to our university, FESSANJOSE. The Knowledge Engineering Methodology presented in this paper is an attempt for reducing the complexity involved: is part of that effort and has not obeyed to a large-scale project with good funding. They have been serene developments that we want to share with the academic community. Our work has been developed with academic rigor, disciplined and continued: the documentation of the project is a key part of the methodology

we use to formalize and enrich our research ideas and innovation. They are subjected to the contrasting, in international meetings, world class, and obviously by systematizing the feedback provided by international pairs of very high scientific level.

6.2.2 Proposals towards a knowledge engineering methodology

Knowledge engineering (KE) is considered as the systemization of intelligence and relies on the work of organization, representation and knowledge management as a substitute for human reasoning and reasonable basis to encapsulate solutions to hard problems and difficult tasks, also serves to identify the layers of knowledge of an information system. In itself, the KE, is the technology for building expert systems and intelligent agents. Clearly the maturity of the KE requires a disciplined work and treatment of problems, analysis and solutions, supported by knowledge.

6.2.3 Some implications of intelligent engineering solution

We found that extensive knowledge in the subject or study target, informal or explicit is one of the consequences. Also, the use of knowledge representation with a model of expertise and the application of search techniques in the appropriate information structure. It is required the support for heuristics analysis or for the same creativity. Finally the main competences required are: the ability to infer knowledge, the ability to reason or symbolic processing and the ability to apply an appropriate logic of the problem. In e-Commerce, the increase in business intelligence (BI) is impressive, supported by ES (expert systems) and intelligent systems. An ES is seeking a satisfactory solution, good enough for the job, although not optimal. The output of an ES depends on the amount of knowledge and depth of analysis is made on the knowledge of experts.

6.3 Engineering of the knowledge

This construct refers to the techniques of obtaining knowledge, representing, building and using it appropriately to assemble and explain reasoning of the knowledge based system, creating a product which tries to solve the involved problem. The following defined steps were indentified: The following describes graphically the proposed methodology of Knowledge Engineering.

The two phases is related to the problem Definition and Determination, namely:

- Cognitive Planning: defining the system (structure and components), model (behavior), detailed specification of the problem, selecting methods and techniques, user requirements and interface, identifying the data types and objects and solution quality.
- Learning: Acquisition of knowledge or machine learning process: acquisition of knowledge required by the system, in a systematic or automatic or with help from the experts. This knowledge can be specific when the problem domain and solution procedures are the same, or may be general knowledge, i.e. knowledge across an enterprise.

The subsequent 3 phases are related to the development of the intelligent system:

- Ontology, representation and organization of knowledge: how it is distributed, classified, organized, developed the map of knowledge and is represented by some formalism or structured information or objects in the KB, to enable computer use.
- Knowledge Acquisition Methods
- Problem Solving Design alternatives and selection of the solution.

The final 3 phase are related to the system construction.

- Prototype Construction.
- Verification, validation, contrasting and legitimacy: the methodology used successfully for the problem? Verify sources of knowledge. Legitimate and check that the knowledge is represented in the KB, is correct. To demonstrate that the solution and conclusions are expected. The inference is based on the design of software, which allows the computer to infer on the knowledge represented in the BC. This includes: Explanation and justification.
- Obtaining the Final System and Evolution.

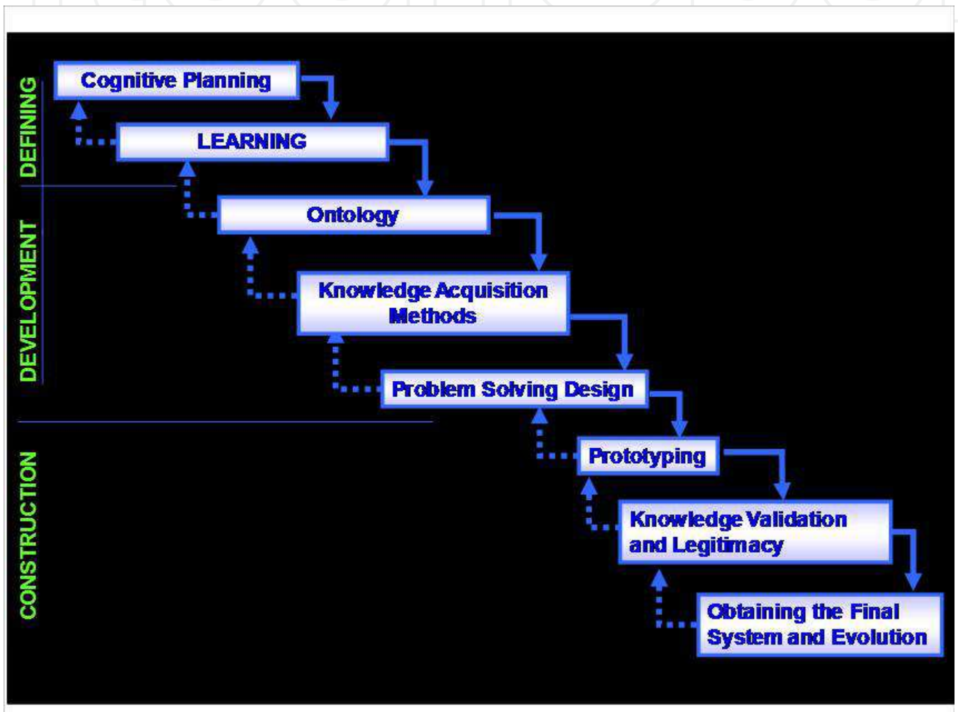

Fig. 16. Knowledge Engineering Life cycle

In the following sections we develop each of the mentioned phases.

6.3.1 KE cognitive planning

We begin by establishing the commitment of senior management and stakeholders and also the involvement of the group of domain experts. Preliminary meetings are held with this group, which reviews the key issues to consider in connection with the layers of knowledge to add. Planning is also made as to form and means to acquire such skills.

6.3.1.1 System determination

It refers to the identification of its *structure, the architecture, the model i.e. behavior and components (knowledge objects)*. Also includes the specification of the problem with its domain, computational requirements, scenarios, construction of an example of a user session, decision on the methods and techniques, user requirements and interface, identifying objects and data types and quality of the solution. It is very important to assess cost / benefit and identification and definition of dictionaries and concepts represented in the KB with the knowledge to select the really relevant.

6.3.1.2 Determination of the subsystem to incorporate knowledge

The analysis of the results of the application of the requirements engineering is included. Also, for purposes of choosing the corresponding subsystem, in order to recompose the architecture of the involved knowledge.

6.3.1.3 Determination of the specific module

Once chosen the subsystem, is analyzed functionally and, according to the priority of the modules and the requirements of users choose one of them for adding layers of knowledge.

6.3.1.4 Phase outcomes

Classes of knowledge.
The identification of the layers of the knowledge of the company (knowledge architecture).
Determination of intellectual assets.
The specification of the methodology, tools and techniques.
A portfolio of the intelligent subsystems.
The Intellectual capital resources.
Scheduling and Time table.
Quality Assurance Plan.

6.3.2 Knowledge acquisition phase: Learning

Taking the problem and its modular decomposition, followed by the conceptualization of relevant knowledge, must define its scope. When knowledge has been collected, must be analyzed, coded and documented so that these activities take place according to the chosen acquisition technique. It also should be prioritized to represent in the KB. Later must be formalized to determine the method of acquisition. The acquisition stage can be difficult to the extent that knowledge is extracted directly from human experts. Once the execution is carried out, it should be the implementation, which includes programming and coding of knowledge in the computer, designing a prototype that allows refining and contrasting the results. Finally, the knowledge engineer test at the KB by means of examples (cases) and compares the results with experts to examine the validity of knowledge.

6.3.2.1 Phase outcomes

Knowledge Recovery
Knowledge Bases
Repositories
Conceptual Map of the Knowledge or Syllabus
Knowledge Structures.

6.3.3 Knowledge representation phase: Ontology

The representation of knowledge involves the consistent use of mathematical logic and information structures. The KE theories fall into two categories: mechanisms and content. Ontologies are content theories about classes of objects, their properties and their interrelationships, which allow the specification in the domain of knowledge. The representation has several roles:

- As a substitute for human reasoning for knowledge automation
- As an ontological agreement to reason about the world
- As a component or part of intelligent reasoning

- As a means to achieve high computational efficiency
- As a means of the human expression to express things, about the world.

6.3.3.1 Phase outcomes

Knowledge Bases with fully reorganization
Internal and External Networks
Portfolio Capabilities: Assimilation, Strategic Technology and Innovation

6.3.4 Knowledge acquisition methods

Working with KE involves a trans-disciplinary team, in which the engineer is the intermediary between the KB and the Experts, refining and representing the KB. There are at least three types of methods for the acquisition of knowledge such as: manual, semi-computer based and automatic: artificial or machine learning.

SELECTING THE APPROPRIATE METHOD

- Applicability to a wide margin in the domain of problems, adequate both to the company and the system in question.
- Tutorial Capabilities, online help or learning environment, to reduce the need for a exhausting training expert and have less dependence on software manufacturer or distributor. It is a condition to motivate the user.
- Ability to work in parallel to analysis with the detection of flaws and inconsistencies in the reasoning process.
- Ability to incorporate multiple sources of knowledge.
- Analysis of the available tools

6.3.4.1 Phase outcomes

Assessed and appropriate method
Determination of appropriate computational resources
Tutorial Online Help
Determination of alternative sources of knowledge

6.3.5 Problem solving solutions design

The design of responses to problems or needs raised to be knowledge based is presented in several steps which are described as follows.

6.3.5.1 Defining of potential solutions

The first step, the knowledge domain organization related to the selected module, is to list all possible solutions, inputs, outputs, responses, alternatives and recommendations. It should identify the precise outputs to be presented to the user on the computer screen. The aim of this step is that the KB provides advice at the time required and not suddenly, a conclusion based on momentary must know every possible answer across time.

6.3.5.2 Determining the knowledge related to the relevant parts of the module

Knowledge Layers to be introduced should be raised at different levels of the organization. At this point is to be determined the operational knowledge, i.e. what is related to the application or specific system´s functionalities.

Domain knowledge module: determines the knowledge that the user needs to perform properly in the company.
Inferred knowledge: knowledge which is needed that can be inferred through the use of AI which supports the user.
Knowledge of processes and tasks of the module: identify the knowledge required for the development of system tasks, and relates to the basis of plans. These layers also serve as support for strategic planning and tactical levels, and are used in the plan generation and plan recognition.

6.3.5.3 Determining of knowledge related for problem solving

Layers of knowledge that are introduced should also support the management at the tactical and operational level, so should determine the knowledge that supports the resolution of problems.
Knowledge of **management skills**: includes the reasoning and decision-making DSS (Decision Support System), taking into account the user's management style in order to identify the subspace and data-information required by the executive for making their decisions in each application that contains the specific module. These layers of knowledge must be determined according to the administrative level support, i.e., differentiating strategic as tactical. Knowledge of **user interface**: where should the user's knowledge representation and should be considered cognitive style and managerial. In this respect it pursues a natural language interface to work with the system databases

6.3.5.4 Tasks decomposition

Tasks are evaluated regardless of the user model. At this point should answer:
¿What tasks can be decomposed?
¿Is there any difference between the user's perspective and that of the expert?
The second question is useful for determining if it is necessary to analyze and develop a comprehensive plan to draw conclusions. The tasks that are discussed are related to the tasks performed by the experts to solve their problems and do their job. These tasks should be decomposed into subtasks or sub-functions according to the natural order in which they develop.
To analyze the order of tasks: It should be a state diagram of the tasks previously listed, considering their order. With this diagram, it should do an analysis to determine if the order is correct, any extra work, or can be rearranged for performance optimizing.
Construction of the model: The model of a KB is useful to the extent as it constitutes a pattern of knowledge, easily interpretable, which determines how it will solve the problem in the KB. This model must be designed by determining the knowledge islands and regions.
Designing the architecture of the KB: Should design the hardware architecture of the KB, in which represents the different components and their relationships to have a "map" (e.g. semantic network or cognitive map) of the KB and facilitate construction. The conceptual design of the map gives the main idea or structure of meta-knowledge on the KB and the way they are going to solve problems. Should exhibit the capabilities and the interfaces with other MIS.

6.3.5.5 Identifying of production rules

To determine the rules of the tasks and subtasks is important to consider the solutions, inputs, outputs, responses, alternatives and recommendations that were identified previously, considering the following aspects:

- Need to identify questions to collect the necessary data from the IF portion to trigger rules lead to the conclusion.
- Should list all required data system called "facts" (or symptoms) the user will enter the system.
- Each conclusion should be in the THEN portion of the rule.
- A decision tree is a good help if the elements of knowledge can be arranged quickly in a tree format. If so, proceed directly to the construction of a tree from them. Some of them are so large that KB may require a decision tree for the entire domain; however, to simplify the work, you can build decision trees for subsets of the domain.
- Define rules for each output.

6.3.5.6 Identifying of meta-rules and frameworks

Once have determined the rules concerning the problem domain defined those who exercise control over the other and the process of inference.
By identifying, the frames: Select the objects on which the knowledge requires modeling.
By determining meta-knowledge: Control over knowledge, or "knowledge of knowledge" must be determined to have domain information and the inference process.

6.3.5.7 Phase outcome

Selected Method for solving the problems identified.
Problem solution domain.
Meta-cognition.
Specifications accomplished.

6.3.6 Prototipyng

The first objective is to build a small prototype, for which selects a subset of the KB and carries to the KE tool, which must be done quickly. The result is a prototype which can quickly verify the implementation and testing and verifying ideas. In this sub-step is the representation of knowledge with the tool by means of a prototype, since this technique to identify weaknesses and strengths of the model developed, by which you can refine the results to get quality. A prototype is also a good way to test the concepts before investing in a larger program. With the use of a shell can quickly assemble a small prototype to determine if you are on the right track. It allows for demonstrations, as its assessment will also be important in determining the quality of the result.

6.3.6.1 Graphical representation of knowledge layers

When rules and frameworks have led to the KB by using the tool must be plotted to assess the concatenation rules, relationships and inheritance between frames, i.e. to determine if the model is represented which really needs.
Elaboration of the rules diagram. There is a network diagram of the rules and actions for each of the layers of knowledge, which will have a broad overview of the KB and make the adjustments necessary to refine the model.
Elaboration of the diagram of the frames. There are graphically represented all the objects, taking into account the inheritance and relationships between them.

6.3.6.2 Inference proof

From the KB, the inference process is made to assess the results based on the reasoning process was implemented.

6.3.6.3 Phase outcome

Verified operational prototype and with quality assurance
Documentation of software testing and prototype
Effective and proven outcomes
Prototype of Dual-Use: as a Professional Tool and for Powered Training Tutorial

6.3.7 Knowledge validation and legitimacy

A used specific case to test the quality of the KB is acceptable, verifying that the source of knowledge is accurate.

6.3.7.1 Validation and contrasting of results with the experts

A workshop is held with experts in order to present the results obtained with the KB, for analysis and give their opinions. The main criterion should be used for the tests, is the opinion of domain experts, as they can tell if the results are satisfactory or not. Potential users can also serve as judges, with criteria regarding the usability, the interface and the clarity of the explanations.

6.3.7.2 Refinement

Based on the different opinions of experts, an analysis of BC and, as if the knowledge engineer finds it necessary, the redesign or restatement is realized.

6.3.7.3 Assessment

There is a close relationship between evaluation and refinements of the ES as the evaluation may reveal cases handled by the rules of the system and as a result, we add new rules or modify old ones, such changes can have unexpected negative effects on some parts of the system.

6.3.7.3.1 Verifying

The purpose of this evaluation is to check if the system implements its specifications and there are good logical consistency (i.e. the problem of verifying that the method is correct) for this purpose is the assessment obtained, taking into account actual performance levels. The prototype and system upgrades should be tested for performance in the laboratory and in the field. The initial evaluation is conducted in a simulated environment, the system is exposed to test problems (e.g., case histories or suggested by users.).

It also examines whether the system can be used efficiently and if it is cost-effective. The assessment should consider the quality of the messages presented, i.e., design and programming of the explanatory power of the BC to determine to what extent they meet the proposed objectives.

6.3.7.3.2 Validation

Should test the system and application performance, which makes comparison with expert, to establish that the system built to solve the problem is correct and will perform at an acceptable level of accuracy. The decrease in response time and quality of the conclusions may be a good initial approach to evaluate an ES.

For this purpose we used the modified Turing test, with which they are presented to potential users or administrators are two solutions to one problem: the first is the result of expert opinion and the other the result of IMIS (Intelligent Management Information

Systems). Without knowing the source, are asked to compare the solutions. With the results of the comparison determines how valid the results of IMIS are. To use this approach should consider potential disagreement between the criteria of the evaluators, since the problems can be so complex that occur disagreements over its interpretation and solution.
Other requirements to be considered in validating the final system are:

- Should meet a recognized and important business needs or assistance, counseling, tutoring.
- The processing speed of the system must be very high.
- The system must be able to increase the skills of the user: dual learning, man-machine.
- Error correction should be easy to perform.
- The system must be able to answer simple questions.
- The system should ask questions for additional information.
- Knowledge should be easily modified (allow add, delete and modify rules.)
- Make the user feel the control system to encourage its use.
- It must be reasonable degree of physical and mental effort of a novice user.
- Must be clear requirements in terms of data entry and should be simple to obtain.

6.3.7.4 Phase outcome

Correct source of knowledge.
Methodology used properly
The solutions checked and conclusions as expected.
Refined knowledge System.

6.3.8 Obtaining the final system and evolution

One advantage of rule-based systems is that they are modular, so can build subdivisions of large systems and then test them step by step, which is made possible with prototypes.
One approach is using the evolutionary prototyping, where a prototype is enhanced until obtaining the final system, which can be built gradually by adding pieces, parts or modular components. This is a cyclical process, which is an advantage that can improve the result and get the best approach to user requirements and needs of knowledge of IMIS.
If each subsection is evaluated and approved separately, the final system will most likely work the first time.
In this sub-step is performed integration of subsystems that is, if KB is created different or heterogeneous in terms of sources, we must take into account the need to create interfaces between them, allowing optimal operation and communication between the system and users.

6.3.8.1 Phase outcome

Integrated, Robust intelligent System
Populated Knowledge Bases
Institutional Learning System
Intellectual Assets
Institutional Memory
Tutorial Intelligent Engineering Knowledge

6.3.9 Section summary and work ahead

This proposal is an attempt in the way to formalize a methodology that allows the intelligence of information systems within the business, adding layers of knowledge. It provides methods that reduce the complexity of knowledge management which are required to enterprises of the Third Millennium. We have relied on experiential learning working primarily with our students for several years and also with external projects. We are aware that more empirical work is required complementary and many theoretical efforts.
The research has resulted in a tool that has allowed us to quantify our goals, to make viable and to face the serious problems of the Colombia Higher Education Sector for which we have innovated the Inter-industry model I/O W. Leontief incorporating the knowledge as a sub-sector of the economy, by the identification of a model architecture.
In Colombia there is an unusual demand for seminars and postgraduate courses in KM but little or no mention of the KE; it is imperative to migrate in this direction, especially when the economy demands more knowledge-based systems that require more rigorous engineering to improve competitiveness. This requires people, processes and methods and not only technology.
The world has become more complex, enterprise application development requires new engineering approaches and architectural approaches. Similarly, more specialized cognitive abilities around the working groups.
It takes audacity KE alternatives, systems architecture and design, taking into account the systemic qualities and cost-benefit to the organization.

6.3.9.1 Synthesis: Knowledge engineering vs. knowledge management

KE	KM
Tend to use technology low level	**Work at high level**
Application design & development	**Govern of ICT/IMIS**
Low Level Programming	**User´s View**
Workshop with experts	**Logistic management**
Knowledge Base Design and Implementation	**Strategy alignment of the Corporate Plan**
Resources Optimization	**Best Practices**
Requirements Engineering	**User´s Requirements**

6.3.9.2 Prospect work

Our models are implemented at institutional at FESSANJOSE but we want to undertake to the design and implementation national wide as a national purpose to face several higher education problems mentioned above as student desertion and the academic governability in which knowledge based systems are the key support.
In other hand we want to develop a knowledge a more complex architecture to support the knowledge engineering efforts which includes the knowledge model.

6.4 Chapter conclusions

It is very import to point out that literature related to the propaedeutic cycles in Superior Education is very scarce. Most of our works discussed in this chapter has been considered as a pioneering effort in order to face most of problems in Tertiary Education. In the first

section we introduced the higher education sector analysis with theirs several problems currently affects this sector. In following section we present the FESSJ-PROP Model for curricular analysis through the Coherence Matrix. The third section we have presented our initiative iCOACH, leading to develop the education software architecture facing student desertion. Next section as a complementary of the previous Section we presented the integration linear programming an Leontief model for the study of education sector problems like student desertion costs, academic governability, sustainability and the intellectual capital and the knowledge activities. Finally we present the methodology issues we developed to undertake these projects.
As future work we have undertaken the development of intelligent authoring tools for digital 3D interactive contents leading to the promotion of a knowledge industry in this country but mainly to increase the teachers productivity regarding his/her own cognitive style, the student style and the knowledge characteristics.

7. Acknowledgment

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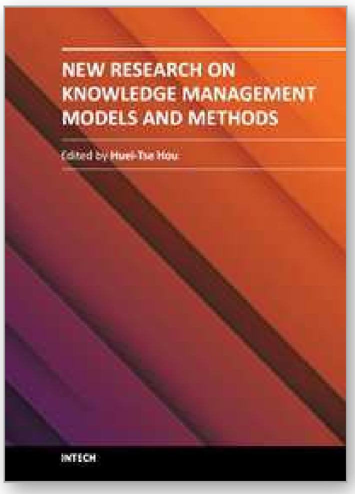

New Research on Knowledge Management Models and Methods

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Due to the development of mobile and Web 2.0 technology, knowledge transfer, storage and retrieval have become much more rapid. In recent years, there have been more and more new and interesting findings in the research field of knowledge management. This book aims to introduce readers to the recent research topics, it is titled "New Research on Knowledge Management Models and Methods" and includes 19 chapters. Its focus is on the exploration of methods and models, covering the innovations of all knowledge management models and methods as well as deeper discussion. It is expected that this book provides relevant information about new research trends in comprehensive and novel knowledge management studies, and that it serves as an important resource for researchers, teachers and students, and for the development of practices in the knowledge management field.

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