Intelligent Higher Education Model Based on Competences and Architectures for the Colombian Post-Conflict ,m

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***Abstract*– In our Colombian institutions, we find educational and entrepreneurial leaders who are technophiles towards systems based on knowledge and others, and on the other way, we find leaders with the technophobia towards those systems, situation that could act like a sword of double edge: expensive errors, vs. the unwanted Accountability. This seems common in third world countries. Intelligent Knowledge based systems (IKBS) have to do with the creation of value from intangible intelligent assets, that are resurrected from amalgams of Artificial Intelligence, Knowledge Engineering (KE), BUSINESS PROCESS REENGINEERING (BPR), Cognitive Systems Engineering, Software Engineering, and Third Millennium organizations, among others.**

Intelligent behavior requires being able to acquire and manage information, data and knowledge to make effective decisions for organizations to function intelligently in crises. Requires intellectually demanding environments with more open minds.

The U. San Jose-FESSANJOSE has developed a supportive environment for decision-making in the complexity of higher education (HE), and a set of planning tools has been designed to deal with the crisis. These tools, are expected to help stakeholders develop and communicate understanding of high priority issues so that smart decisions can be made and implemented during crises in the case of Colombia. After 60 years of war confrontation (civil society, guerrilla, paramilitary) we are preparing toward a post-conflict situation; for labor re-qualification of thousands of victims a new education model based on integrating architectures and knowledge systems is proposed. The post-agreement implies greater social investment especially in education, towards the reconstruction of Peace and Equity that goes beyond social mobility (e.g. employment) with new educational models based on high quality and decentralization. Nowadays the Government of Colombia (GoC) signed an Agreement with the guerilla FARC after 6 years of talks. In the following days the Peace Nobel Prize was granted to the GoC President, Juan M. Santos. The following days new dialogues, with the minor and remaining guerilla ELN, was announced for starting soon in Ecuador. If succeed, the total peace will be warranted. The new educational model, involves:

- **Individual monitoring and evaluation,**
- **guided by ICT (information and communications technologies),**
- **competencies (supported by KE)**
- **asynchronous methodolyg,**
- **personal tutoring: teaching/automated online (including mobile devices usage),**
- **for the population of young and adult, victims of armed conflicts,**
- **for people preparation for the IV Industrial Revolution, and to face the transition to the Digital Transformation (to radically improve performance of institutions)**

Regarding the social situation, in our side we are preparing for a post-conflict situation; we have to prepare thousands of demobilized people and victims, requiring labor re-qualification. In addition, given the deficit of 100,000 ICT Engineers, and 300,000 Technologist (T) and Professional Technicians (PT), e.g. programmers; our proposal is intended as a disruptive innovation to address the post-war digital divide, and this country has based human talent mental rehabilitation, with training and labor requalification. We integrated our own experiences and proposed a new education model, based on the integration into an Intelligent Management Information System (iMIS), of 5 architectures that we previously have implemented in several higher education Institutions (HEI) in Colombia. Those architectures, supported by the convergence of Information, Software, and KE, with Artificial & Computational Intelligence, and guided by mathematical and computational models. iMIS integrates hybrid multilevel architectures with multilevel systems, in order to respond to the solution of HE-ME (middle education) problems, leading to face competitiveness and productivity, observing specifically how to include these technologies for evolving the university into modernity, bringing together the institution governability, the student and teacher productivity, and the High Quality Education (HQE). The paper characterizes an intelligent educational organization of the III millennium, defines post-conflict crises, and discusses a competency-based educational model as part of the alternatives to confront the national crisis with an educational crisis management framework. We are trying to consolidate numerous experiential learnings related to the complexity of HE such as student dropout, educational quality, productivity and competitiveness in an underdeveloped country like Colombia. Finally, the model includes the use of architectural tools already implemented

***Keywords*-- Competencies, Education Architectures, Intelligent Systems, High Quality, Competitiveness, Productivity.**

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I. PRELIMINARIES

The system offers alternatives to young people and adults who wish to make a career but with a significant readiness in semesters (coaching), skills and competencies Certification, e.g. ICT & On Line Government.

Ministry of National Education (MEN) and Ministry of ICT (MinICT) point other uses in Colombia, as follows:

- Women in Women in Teleworking National Program

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- Inmates in the Country's prisons Program
- Digital Literacy in Colombia

The strategic development of the Model, on social innovation and KE is based. The model main characteristics are:

1- Approach: Bio-psycho-socio-technical-scientific
2- High: Quality, Technology, ICT, and Articulation
3- On Line Learning
4- Knowledge and competence management
5- Social importance: Reduce ICT talent gap; and individual student improvement
6- Multiple Social Impacts: Secondary students, Post-conflict demobilized people and Victims, ICT job remediation
7- Business model

More than 5 million users have been estimated for this project, which will be under construction for the next five years.

The five architectures, are discussed in Section V.

II. Initiative Presentation

A. Education Sector Crisis

The recent Colombia Tertiary Education Law is exclusive for the TP and T education, which again separates it from the HE, leaving it as the poor relative. It was presented at the Congress of the Republic, to achieve MORE EQUITY in HE. Local graduates in a greater proportion are not competitive for the global society. Education and the promised EDUCATIONAL REVOLUTION, instead of being an ENGINE, as stated both in the development plans and in the aforementioned law, is an obstacle to social equity and income redistribution. [17] [18].

Although Government efforts have driven towards greater coverage of Education, there is evidence of little progress in Educational Quality and competitiveness.

On the other hand the Decennial Education Plan 2016-2026 does not tend to face the structural problems of the sector.

In the HE competitiveness, Colombia is one of the last WEF (World Economic Forum) places; only 34 of the high school students go to higher levels and only 9% of the poorest sectors manage to reach it. Very low resources have been assigned to the research in Education. Although it is true that the MinTIC has made significant progress in infrastructure, Internet and the popularization of ICT in this country, it presupposes that pedagogical models are magically provided by hardware, which is an aberrant methodological error, because these are not given, and research is urgently required in this.

The quality of HE and ME challenged among others by the results from the STEM (acronym that refers to the academic disciplines of science, technology, engineering and mathematics[1]) at the Trends in International Mathematics and Science Study (TIMSS), the Program for International Student Assessment (PISA), and many others. In HE less than 10% of the universities have quality accreditation, which is an indicator of low competitiveness. The problem of desertion in HE & ME, (as concerns ICT human resources), is dramatic: desertion reaches more than 50% in HE and is much higher than 65% in T and PT, a situation that involves a high volume of Government and family's resources, and is aggravated by the fall in number of applicants to study engineering and professions related to ICT at all levels worldwide.

B. The Collaborative Project

This initiative has been carried out with the San Jose[2] , and UNIMINUTO[3] universities.

An intelligent educational model, integrated with institutional software architectures, and competencies based, is offered, seeking training that links ME and HE. Consist of individualized technological tools (for student-teacher) that solidify the articulation of ME, with the ultimate aim of generating institutional technological management capabilities and improve productivity of students, teachers and institutions, towards competitiveness (e.g. results in PISA, and TIMSS).

The new system offers alternatives to young people and adults who are interested in employment requalification & re-training and don't want to make a long career (of years) but an important readiness in semesters (Coaching), skills and competencies certification, e. g. ICT & OLG (On Line Government). (See section III.A. Description)

As dual use, the system seeks to extend its application to retrain and rehabilitate disabled victims, demobilized and displaced people by the armed conflict, and their labor re-qualification, increasing the supply of ICT talent, reducing unemployment and digital divide and contributing to the construction and consolidation of Peace in Colombia, largely awaited.

C. Previous Research

The FESSANJOSE since the creation of its International Research Group San José EIDOS in 2008 has carried out numerous research projects, especially with the Ministry of National Education (MEN), with which it built the iCOACH learning prototype [6]. Thenceforth, dozens of papers were presented at world-class events (EDUCON, FIE, ISTEC), books and book chapters published, and intellectual software assets registered in the Copyright Office[4]. Several innovative constructs and mathematical and computational tools were developed; some of them were implemented in Colombian universities.

The ICOACH prototype is a knowledge based, skills driven architectural construct, powered by Artificial and Computational Intelligence (ACI). The student desertion

1 The term STEM, is used, when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development.

2 Fundación de Educación Superior San José, www.usanjose.edu.co

3 Corporación Universidad Minuto de Dios, www.uniminuto.edu

4 DNDA, National Directorate of Copyrights.

problem, national wide is very critical for its cultural, economic, familiar and institutional implications, in addition to the poor performance of Colombian students in PISA and TIMSS, where Colombia occupies the last places. Several HEI and the MEN have made studies, showing a recurrent and widespread problem which also contributes to the decline in enrollment of Engineering - worldwide.

In addition, other experiences are highlighted:

- Our institutional accomplishment with "Escuela Integral" at the municipality of Soacha, an adult education model for conflict victims (displaced people because of war for over 10 years), that has earned several national and international awards and reconnaissance to FESSANJOSE.
- The work of FESSANJOSE in the Colombian Bajo Cauca Antioqueño at the municipality of El Bagre (currently military conflict zone), for several years, where FESSANJOSE created and implemented different presence and online methodology HE programs, with the support of civil society, state agencies and the MEN.
- The multimedia know-how, developed by FESSANJOSE, with "CreameVirtual" in online education, making technology transfer: bringing this experiential learning to others HEI in Colombia. [21]. FESSANJOSE has been developed and registered in MEN, 50 academic programs with On Line methodology, including Qualified Register.

D. Impacts

- Empowerment, strengthening and building capabilities in order to improve Governability.
- Promoting a Culture of HQE, that is attainable, measurable, sustainable and controllable.
- OTHER EDUCATIONAL FOCUS: Asynchronous and by competences training, offering young people and adults opportunities to continue post-secondary studies.
- HIGH SOCIAL IMPACT: contribution to post-conflict, to durable, consolidated and inclusive peace, with sustainability

E. Products

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F. Products

- The Student Intervention Methodology, is included for the ME-HE articulation architecture. [4]
- The foregoing includes: knowledge bases for verification of cultivated skills and knowledge, and batteries of intelligent questions, with protocols for knowledge verification and questioning design; extensive use of international standards such as from IEEE (Software Engineering & Higher Education Standards) and QTI (Question, & Test Interoperability). Besides the documentation.

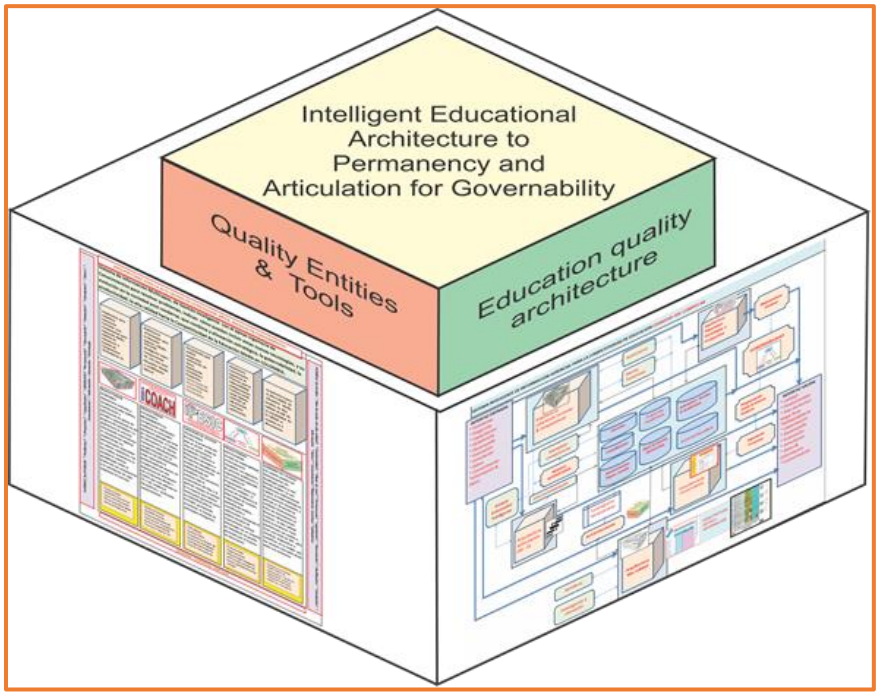

Figure 1 Educational Model

III. The New **ICT** Education System Model with Knowledge Engineering: Usanjose-Arke-Intell

As said, a new intelligent, competences-based educational model of institutional software architectures. See Figure 2

A previous advance [1] was submitted to EDUCON 2016. We have submitted and defended several projects to COLCIENCIAS, MINTIC, CINTEL. Convocations: 745,731 among others. We have also received partial financial support from MEN and FODESEP.

A. Description

A multidimensional approach was adopted. The first dimension is related to HQ [4]. The second is the dimension of the iMIS, as described in Section IV. The third, deals with the architectures described in Section V.

The strategic development on social innovation is based,with KE.

Intelligent Coaching contrasts the universe of thematic skills with the user-acquired skills, by checking concepts and expertise with intelligent, dosed, and classified questions, oriented to test knowledge and skills, with individual self-regulation and cognitive control. Remediation is done through online platform or optionally with an accompanying teacher, or a mixture thereof.

B. Characteristics [3][4]

- The deployed architecture illustrates an iMIS complex whose components articulate coherently and consistently, acting as an organized whole, to obtain new and better functionalities.
- The architectural approach has been analyzed and evaluated with large volume of academic and administrative information in a well-structured way, with 360° visualizations. We also allow to browse administrative and academic information from the university in upward and downward directions, and also over time (Prospective) for constructing future. The gathering of information at different levels of aggregation will reduce the complexity of the analysis and design.
- The strategic alignment of the different components has provided the ultimate aim: HQ. It has provided the harmonization of academic and administrative processes and the establishment of common references for the community in accordance with the International Organization for Standardization, ISO. Obviously we have also included the alignment of micro-competences with the target professional competences of academic programs.
- Continuous improvement plans will provide coherently leaning, mature, academic and management indicators as subsystem for inferences in strategic planning and prospective.
- The Self-Assessment as an organizational process, has been facilitated by metrics inside the linear programming with the Leontief Input-Output model, which extended its value for optimization purposes, towards governability. This governance is based on maintaining the maximized number of students in good performance, and also on controlling the number of students at risk of dropping, and recuperating the former deserter students. The Self-Assessment model for higher education is in accordance with the National Accreditation Council of Colombia (CNA), for which some tools to managing large volumes of data and visualization are used, through a multivariate Scale-gram: matrix with fuzzy value (qualitative) variables.
- The system follows an asynchronous methodology with competencies certification by levels, supplied by our University.

Our work has attempted to fill a gap and to be a response, in which we have worked with scientific rigor and discipline. Our implementations have proven to be useful for understanding the reality of the HE and for the transformation of the sector itself, which facilitates the entry into a knowledge economy

IV. Control Information with IMIS

We called this control information system USANJOSE-MIS-COMPES-KB, and is displayed on Figure 1 (at the end).

A. The System

In a previously developed iMIS [5] this paradigm is considered as the systematization of human intelligence, a substitute to human reasoning, and also as the foundation of intelligent reasoning in order to encapsulate solutions to difficult tasks and problem solving skills, to face the complexity of HE.

The iMIS integrates multi-hybrid system architectures as a space to meet the problem solving aimed at a competitive HE, specifically noting how they can include these new technologies for adaptation and evolution in the modern university, combining the governance, the teacher and the student productivity with quality education.

$$Y(MIS) = f\left\{\begin{array}{l}\text{Desertion, problems, coverage,}\\ \text{performanc e, technolog ical level,}\\ \text{management level, plan - user,}\\ \text{Trainining , Profiles, Subjects,}\\ \text{Knowledge}\end{array}\right\}$$

5. "Sistema de Información por Arquitecturas para la Educación Superior, Gestión Académica y Administrativa". Colombia National Directorate of Copyrights (DNDA): Registered software record Book 13 - Volume 40, Part 307. Bogotá, 2012

Y(MIS) represents the output or results of iMIS, such as quality metrics, management indicators, and values, defection, answers & plans, required knowledge, solutions, inferred plans, policies and continuous objects improvement for the sustainability of quality, the roadmap for Permanency, among others.

B. Interfaces

The Input Interface: is for the data, information and knowledge acquisition, where the attributes, parameters, values, problems (e.g. desertion) in active and dynamic structures, are obtained and recorded. The problem is expressed as the kind of decision making problems, i.e. the complexity of the desertion information needed: students trained in math skills, a survey about the system variables, and the ratio of decreasing levels between the actual excellence state and the current gap.

Databases and knowledge level (deductive databases): these are about the students at risk of dropping out and the possibility of identifying new knowledge from the deductive database, as e. g. characterization of student.

Coverage: involves functions at management level and/or academic abstraction (semester, program and area covered by iMIS), e. g.: Registration and control, Accounting, Finance, Human Resource, Stores, Educational Services Laboratories, Students, Parents, the MEN, and others involved.

Performance (Output Interface): refers to the inferred or explicit management skills in terms of quality and academia.

Decisional reasoning in several domains: organizational and/or academic information processes required for making decisions based on quality and user level. Involves MEN standards, and the determination of mathematical and non-mathematical instruments (e.g. econometrics, statistics and computer organizational culture of the institution).

- The levels to implement are:
- The I/O interfaces,
- Complex architectures,
- Models,
- Data and Knowledge bases, and
- Applications in the field of HE.

V. Architectures of USANJOSE-ARKE-INTELL

There are five architectures that we have implemented in several HEI, are:

1- Academic productivity for curricular analysis, management and optimization
2- Student productivity with intelligent coaching
3- Building management technology: construction of the future: roadmap for student permanence
4- Institutional productivity, process engineering for governability
5- Quality management, for HQE

A. Academic Productivity Architecture

This construct[6] is one of the previous work [5], one of the results of a research project, that has been implemented in several institutions in this country and duly inscribed in the DNDA. The curricular coherence architecture is a linear mathematical and analytical tool of academic information, enabling the curriculum making sense as a whole complex. Academic coherence refers to the logical-cognitive relations between parts of an educational system architecture. It's an analysis instrument which provides optimization for an engineering curriculum using propaedeutic cycles, and weaves the coherence and consistency, both internally and externally.

The curriculum and competencies architecture is for analysis, quantification and optimization of study plans and for monitoring student progress. The architecture establishes the specific knowledge (courses) relating them to the target competencies, establishing their implications. Incidence and relationships are expressed in qualitative values with academic credit metrics that enable measuring competencies production and the contribution of each curricular subject. Optimization enables especially the curriculum preparatory cycles. [23] [25]

ITEMS: Teacher Productivity, Edumatics Builder, Student Auto control, Data Mining, Deductive Data Bases.

B. Student Productivity

This is a construct based on knowledge, guided by competencies, and powered by ACI to train engineering students in mathematics, physics and literacy. The Architecture includes: Edumatics Builder of Tests and Examinations, Student Subsystem and Administration Sub-System. Several developments have preceded these efforts.

Improving individual skills through a smart coach is supported by a knowledge base construct we called USANJOSE ICOACH-PROTY for intelligent coach in mathematics, physics and literacy[7]. The Self Individualized Board and Early Warnings, supplemented with an intervention model, are supporting student productivity. This is complemented by a joint architecture for ME: iCOACH applied to ICT/OLG, and to verify the individual progress of each student in the relevant competences.

The Methodology aspects are mature and are worked with QTI & IEEE International Standards. [25]

The software construct USANJOSE ADVERTOR-HE-PRODUCTIVITY, "Student Productivity Driven with Early Warning"[8] is complementary of the architectures.

C. Capabilities of Technology Management

We have developed some tools and other complementary developments that have been implemented for several HEI in

6. "Intelligent Architecture of Curricular Knowledge and Competencies for optimizing a Curriculum in Higher Education". DNDA: Book 13 - Volume 45- Item 197 Bogotá, 2015

7 Colombia National Bureau of Copyright (DNDA) Registered Software Record: Book 13 - Volume 49 - Item 414 Bogotá, October 2015

8 Sistema de Alertas Tempranas". DNDA Registered Software Record: Book 13 - Volume 41 - Part 203

pursuing the student permanence rout map, i.e. action plan; especially complete tools for strategic planning coordinated with prospective, as well as a system for establishing curricular coherence with the competences, and optimization of a study plan; these tools were built with end-user computing (Excel).

They allow the generation of the action plan (roadmap) for student retention by strategic planning and forecasting, supported by a model of student individualized intervention. We called this construct USANJOSE-STRATEGIC-PROSPECT-PLAN, "Prospective and Strategic Planning for Student Permanence in Higher Education"[9]. It contains all the knowledge of the plan and allows the user to navigate in time and space through the management information for future construction, enabling scenarios management and intelligent management of strategies (i.e. with metadata and meta-knowledge). [22]

ITEMS: SWOT (strengths, weaknesses, opportunities, threats) Analysis, Prospective and Scenario Management; Smart Strategies, Roadmap to Permanence.

D. Corporate Productivity

Management Governance in Student Permanence for engineering academic and organizational processes is supported by Leontief Input-Output linear programming models with multiple objectives (3 levels of students), implemented through field work allowing the analysis, quantification and optimization, including the iterative analysis of continuous improvement that is also supported with a set of indicators generated by the iMIS. Process management is the architectural foundation. [24]

ITEMS: Input-Output Matrix; Intelligent Process Methodology; Governability Model.

E. Governability of Quality

It is structured by an analytical model of self-evaluation and graphical display; it is also based on a three-dimensional architecture: Quality, Governability of student retention, and the size of entities (instruments). Among the tools are: Institutional Continuous Improvement and High Quality Towards Excellence. These architectures help us to have a 360° to visualize, diagnose and quantify, to the extent that we are approaching now the academic superiority.

ITEMS: Quality Architecture; Self Chart Model; Continuous Improvement Model; Empowered Indicators; Academics and Management.

From our Business Model [15], our value propositions, are:

1- Innovative institutional architecture: Tools for methodologies in mathematics, computer and technology (innovative, knowledge-based), already built to handle the problem of student dropout, with 360° Action Plan for governance in the medium term, regarding HQ, Productivity, Competitiveness, Government cost, Family cost, and HEI cost.
2- Reduction of shortfall/deficit of professional technicians, technologists and Engineers.
3- Permanence Consolidation Policy.
4- Customized tool possibility for each HEI.

See Figure 3

V. CONCLUSIONS AND THE ROAD AHEAD

- The foregoing includes increasing large knowledge bases for verification of cultivated skills and knowledge, and batteries of intelligent questions, with protocol for designing and verification of knowledge questioning; extensive use of international standards such as of IEEE (Software Engineering & Higher Education Standards) and QTI (Question, & Test Interoperability).
- The experimental work with the model components and evaluations have generated numerous useful indicators that have allowed us to obtain valuable feedback. Some experiences have been cataloged by the MEN, CINTEL (Social Market Place) and FODESEP.
- Our work shows that is entirely feasible an ethos for research and knowledge in the technical and technology institutions. Likewise it is also seen that this policy based on propaedeutic cycles, far from being an utopia, really enables the democratic way to knowledge as proclaimed in the world summits on information society.
- Our work has attempted to fill a gap and to be a response in which we have worked with scientific rigor and discipline. As mentioned, our tools are being implemented in several HEI in this country, have proven to be useful for understanding the reality of higher education and the transformation itself of the sector, that facilitate the entry into a knowledge economy.
- Thus the mathematical and computational tools make it easy, in a way more than proportionately, the decision making and the definition of policies, building future prospected scenarios, both in the evolution of ICT, and from science itself.
- The system offers alternatives to young people and adults who wish to make a career but a significant readiness semesters (Coaching) skills and competencies certification, e. g. ICT & OLG. The strategic development is based on social innovation KE.
- In longer terms, the authors intend to do more in-depth continued work with major field-testing in order to improve the pedagogical and instructional systems, and especially with the tutorial and remediation strategies aspects.
- We are building a Knowledge and Competencies Manager construct as a teacher productivity tool for better definitions and designing of skills, , and generation of tests and examinations for the individual assessments via WEB. A Knowledge Base Administrator is included; and a mature statistical system is involved.
- FESSANJOSE, as an academic institution, is creating an environment to allow productivity improvement for students,

9. DNDA: Registered Software Record: Book 13 - Volume 45, Part 198 Bogotá, 2015.

lecturers and staff, which has been provided with our architectures. An English version of our systems is to be undertake for abroad implementation with UNIMINUTO.

- We will improve the methodological and software developments to achieve better versions with better usability characteristics, to be offered to all local and international academic community.
- It's not enough improving the quality of the Higher Education in this country!! Most important is to generate a national capacity for constructing knowledge. Also, to create an ETHOS for KNOWLEDGE inside our Universities.

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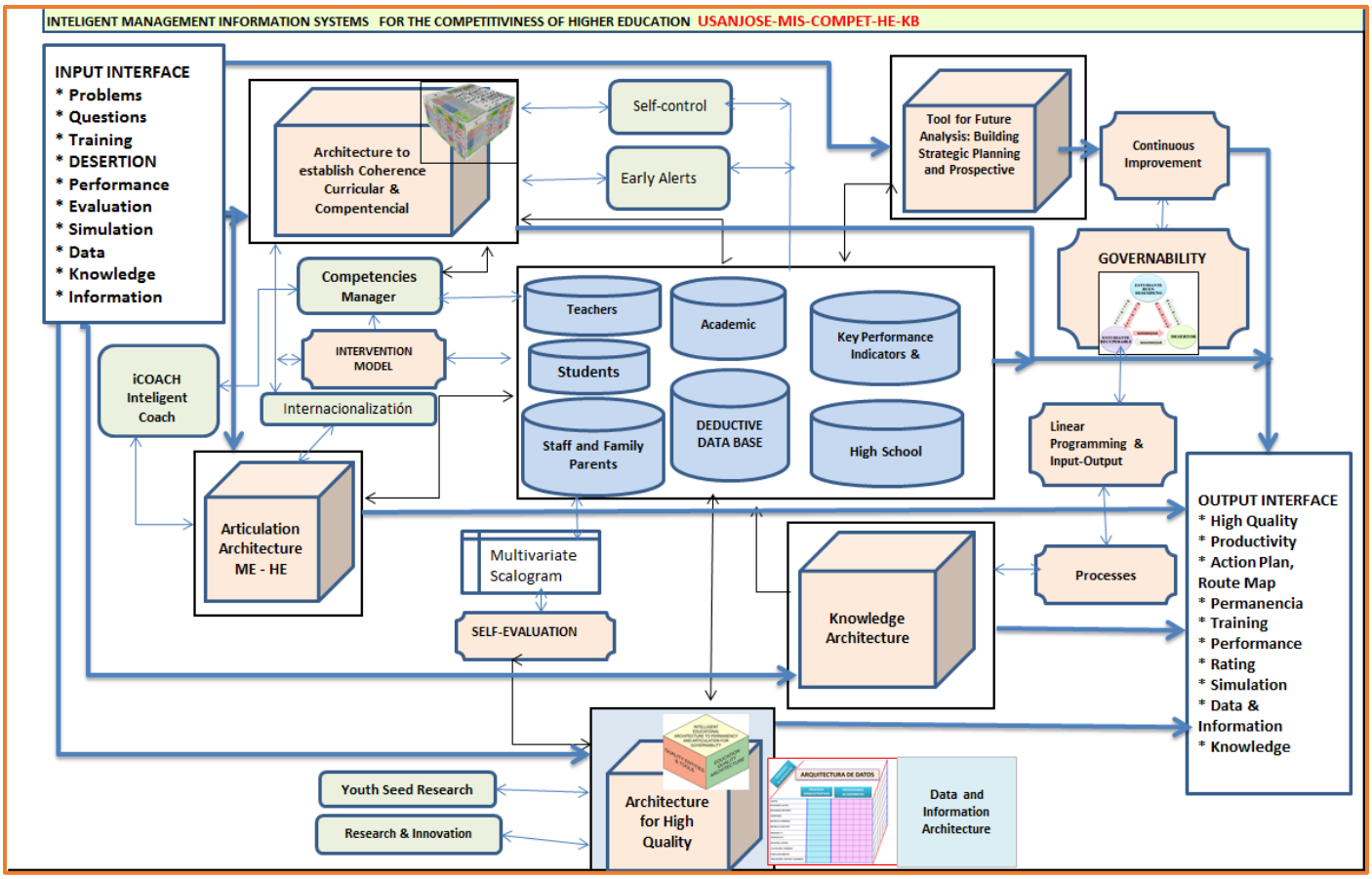

Figure 3 ICT Education System Model with Knowledge Engineering: Usanjose-Arke-Intell

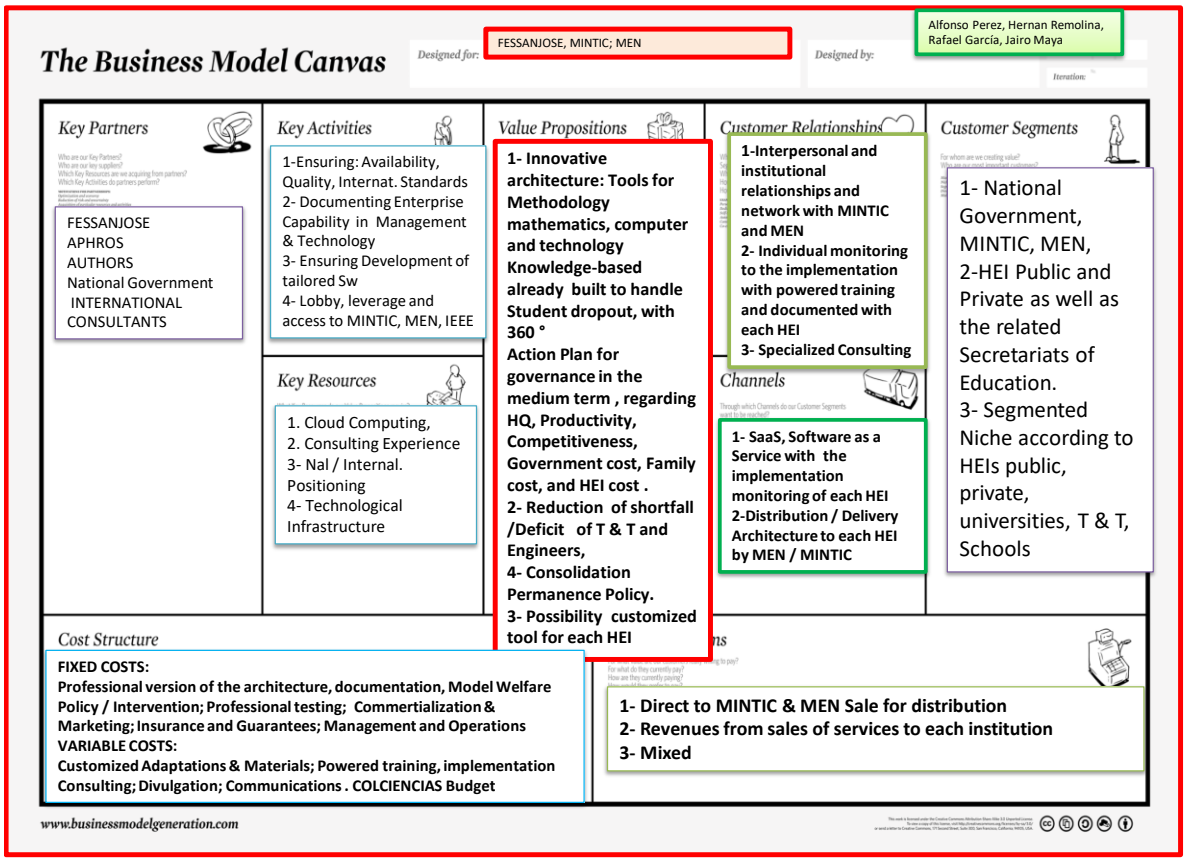

Figure 3 Business Model