Intelligent Educational Dual Architecture for University Digital Transformation

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Abstract Digital Transformation Inside Universities, a dual approach: On the way to the IV Industry Revolution companies of all kinds, are focused on the massive and optimal use of ICT in different organizational plans including human talent, organizational structures, processes, inputs, products, services and obviously the business model. Nowadays, 70% of the top companies have robust digital transformation (DT) teams, and 40% of them are being driven by high ICT and Artificial and Computational Intelligence. In other hand, very few Colombian universities have tackled the problem of competitiveness in higher education (HE), much less they have made the transition to the IV Industrial Revolution by taking the leap, thus receiving a tremendous blow due to academic obsolescence. In the recent ANDICOM (ICT International Congress, numerous national cases of domestic DT were presented from companies, but, unfortunately, not a single case of HE. Will the case of computerization in Colombia, be replicated, which was left to the discretion of transnational computer elites? The University DT implies necessarily the cognimatics (the informatics for the Knowledge Society) of all the companies, and their social insertion in this country. Why knowledge), of the digital university transformation. It is a dual DT model: curricular digitalization and institutional digitalization, i.e. knowledge and data. The pillars of the architecture are Funding, Research, Entrepreneurship and Social Projection, recognizing from the start, that Knowledge has its ethos in the University; they correspond to: 1- Productive Ecosystem of the transformation. 2- DT that enhance the knowledge and innovation in the universities for the habilitation of the digital capacities. 3- A new economy that requires transformation, also supported on entrepreneurship. 4- New DT human talent required by the new industry of knowledge and intelligence. The student hyper-personalization by competences and skills is required. We discuss the basic, conceptual aspects, and methodology for the DT, applying some intelligent constructs that we University Architecture: Enterprise Architecture (EA): Architecting implies the organization of subsystems or components to obtain better and/or new functionalities. If any component is knowledge-based, an intelligent behavior is obtained. The architecture-multilayer approach is a system of systems (SoS) one, that ensures compliance with government policies, rules and standards, in a highly complex social institution with intellectual assets and knowledge processes, which is a usual situation in a university institution; this approach describes the subsystems at a higher level, where a system is made-up, and with the protocols by which they communicate. EA and Business Architecture constitute a conceptual tool that helps the organizations to understand their own structure and the approach by which they work. It provides a business 360° vision map, and planning frame for business and technological changes. EA is presented like a system overall configuration of subsystems or components organized in layers, where each one describes an ordered congregation of structures and common functionalities grouped by a purposeful criterion inside the business. Our Proposal: We present a succinct outline of our architectural dual model (data-
have developed and documented in the last 10 years leading the DT in Postsecondary Education (PSEd)

Keywords: Digital Transformation, Postsecondary Education, Digital Talent, ICT, Artificial Intelligence, Fuzzy Dashboard Matrix, DT Ecosystem, DT Methodology

I. University Digital Transformation

On the way to the imminent IV Industrial Revolution companies of all kinds are focused on the massive and optimal use of ICT in different organizational plans including human talent, organizational structures, processes, inputs, products, services and obviously the business model. Nowadays, 70% of the top companies have robust digital transformation (DT) teams, and 40% of them

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are being driven by high ICT and artificial and computational intelligence. In other hand, very few Colombian universities have tackled the problem of competitiveness in higher education (HE), and much less have made the transition to the IV Industrial Revolution by taking the leap, thus, receiving a tremendous blow due to academic obsolescence.

The universities (Us) should play an important role in the reduction of the ***digital divide***, and even more, they must design new programs that face the formation of the digital talent required by this new paradigm; or we will be late again to change.

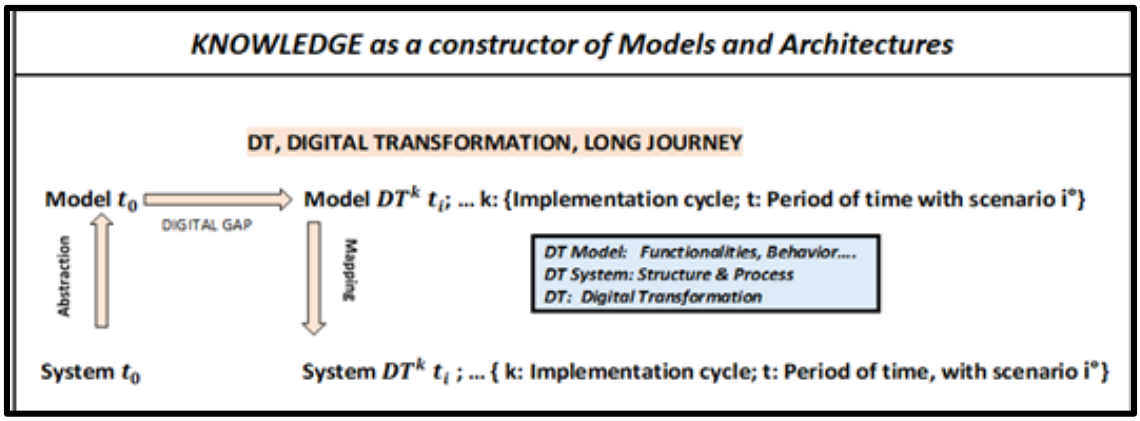

Figure 1. Digital GAP

The gap represented in Figure 1 is the difference between today and the future, in terms, mainly of:

Technology, Digital Culture and Human Talent, University Organization, Organizational model, Educational Model, Productivity, Competitiveness, High quality, Institutional Performance

The engine is the KNOWLEDGE as the CONSTRUCTOR of Models and Architectures, which evolve with the DT, which is not a goal of arrival, but a station of passage, in this long journey towards progress

II TRANSFORMATION INSIDE PSED:

DT seeks to significantly improve the *productivity*, *competitiveness*, and *quality* of PSEd institutions. DT is an accelerated evolution. It is also revolution because of its radical and structural implications for people as for infrastructure, that also demands new educational and business models. It requires accepting that the potential of DT is so aggressive: there is no time for an institution to take the position of "wait to see what will happen"; in fact, e.g., you can still work with outdated technologies, but it does not means getting rid of all the systems to buy them from new. *Digital competences* are no longer the plus for an institution: *they are an imperative*. It is the set of DT strategies, what constitutes the governance of its components' digital activities, driving the excellence in digital operationalization.

The **visioning** process is based on the assumption that figures of the future lead actors present behaviours, guide choices and influence decisions. Vision comprises players, stakeholders, values, wishes, behaviours. Vision is an framework of the DT future shared by a ICT community; and that the vision is adaptable into reality

Our DT MODEL is presented with several visions, namely:

1- The **Ecosystem** of the DT (Section 1.2
2- The **Structural** vision, or (a) the pillars of the University DT: Research, Entrepreneurship, Digital Talent, Budget and especially the Social Projection of the Institution. (Section 1.4.1). (b) The DT Sustainability (Section 1.4.2) Dual space Academy vs Organization)
3- **Strategic Map** of the DT showing scenarios, actors and vision-mission (not included)
5- **The architectural components for DT**: the eights architectures developed and implemented for our DT model: applying some intelligent constructs that we have developed and documented in the last 10 years at FESSANJOSE , leading the DT in Postsecondary Education (PSEd). (not included)
6- **Digital architecture 360** ° of DT: LOCUS Academy and Administration: This architecture is the Digital Portfolio implies the organization of the subsystems to obtain better and / or new functionalities based on knowledge to obtain an intelligent behavior. The

architecture-multilayer approach is a system of systems (SoS), which ensures compliance with government policies, norms and standards, in a highly complex social institution with digital assets; This approach describes the subsystems at a higher level, where a system is composed and with the protocols by which they communicate. It provides a 360 ° business vision map and a planning framework for commercial and technological changes. (not included)

7- **The computational-mathematical perspective of DT**, identifying endogenous, exogenous variables and interrelations. (not included)

8- The synthesis: **Matrix of Media-Ends** that summarizes: Where we are? And where can we go? DT. (not included)

9- **The Matrix MIR**: DT Objectives, Impacts-Indicators and Results to be obtained with the DT. (not included)

10- The **dynamic model of the DT** system based on Computational Intelligence, representing the control system of all its components to achieve the completion of DT. It is an iMIS,: Intelligent Management Information System for PSEd that shows the dynamics of DT control integrating several multilevel, system hybrid architectures, as a space to respond to the solution of HE problems, tending to their Competitiveness, specifically pointing out the way these modern technologies can be included for their adaptation and evolution in PSEd in post-modernity, making Governability, Teaching and Student Productivity compatible with educational high quality, the purpose of DT . (not included)

The interface of the Results of the iMIS, such as:

High Quality Metrics, Indicators and Values of Management, Desertion, Answers and Plans. These results can be decisions, information (e.g. Permanence), knowledge required, solutions, inferred plans, policies and objects of Continuous Improvement for the sustainability of the transformation and quality among others.

The input interface such as:

Data, information and knowledge acquisition: where the attributes, parameters, values, problems (e.g., desertion) are registered that actively and dynamically obtain and structure. The problem: it is expressed as the type of decision to be made e.g. in the complexity of the Student Dropout, the need for information: students trained in mathematical competences, a prospecting of system variables, e. g. rate of decrease of the gap Excellence-Current State.

III PSEd Ecosystem of the DT

A. DEFINITION

The *PSEd ecosystem* is defined as a network of HEI (Higher education Institutions) agents, accredited or not accredited, that are articulated around the DT from the needs of the country that respond to the PSEd contexts' characteristics in order to increase the student, educational, academic and institutional productivities to finally make the transfer of knowledge in function of the substantial improvement of the *HE competitiveness* that integrates all the PSEd's levels without exclusions, for the social and productive development of the country.

Also, it is composed of research programs, experimental development, technological development and/or innovation, that encourage the generation, transfer and appropriation of knowledge in collaborative work with international and national peer entities.

The digital ecosystem is understood as the set of benefits and requirements of diverse nature that are provided from and through telecommunications networks, the set of infrastructures and associated services that enable the provision of such services, as well as the interaction between the providers of services of a different nature that constitute the extended value chain of Internet services.

As the set of infrastructures and means associated with the provision of content and services through the internet, constitutes a new a subject of fundamental analysis from which public policies must be considered for definition, in areas as diverse as the digitalization of productive processes and the protection of users' privacy, which has already begun to be addressed recently by various entities and international organizations.

The concept of digital ecosystem defines a new industrial context and economic and social impact resulting from the massive adoption of digital technologies.

The study of the digital ecosystem involves three Locus or dimensions: new modes of information production, knowledge and content, different social behaviors related to the use and consumption of goods, and a more important economic and social impact than information and communication technologies considered in isolation.

B. ECOSYSTEM COMPONENTS

According to the scope of the DT, in terms of competitiveness, the PSEd ecosystem must be consistent with the academic and administrative processes with ***international*** reach of its new models (institutional, curricular, pedagogical and educational) as it is possible to appreciate the following Figure bellow, where these constituents are looked:

- Structurally they are:

1- Locus of culture and human resources: a university's approach to digitally driven innovation, and how it

empowers employees (teachers, staff) and students with digital technology.

2- Organizational Locus: how a university is aligned to support the digital strategy, governance and execution.

3- Technological Locus: the use and adoption of a new technology that is emerging and also new infrastructure and platforms.

- Functionally the DT governability is intended on different layers:
  1. Empowered users, with their Perspectives on DT,
  2. Application layer
  3. Layer of services on Social Projection and the
  4. Infrastructure layer
- Coherently the ecosystem architecture for the PSEd, it is understood that it should guide us towards dual productivity (institutional and academic), competitiveness and high quality

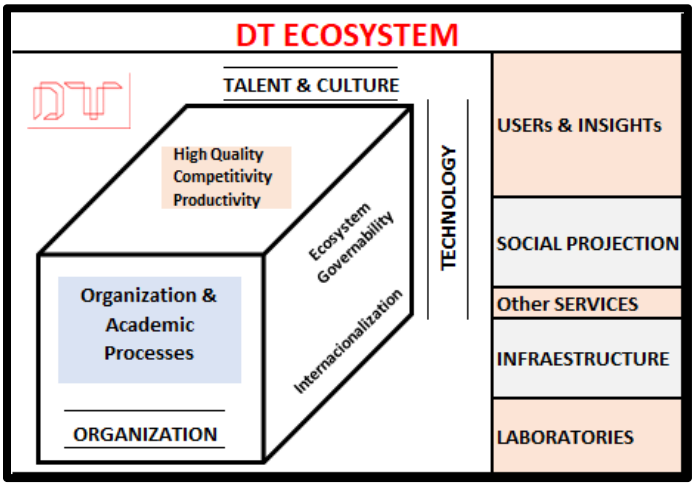

Figure 2. DT Ecosystem: scenarios, components and dimensions

C. PSEd Ecosystem Locus

In the dynamics of the DT's performance, the LOCUS are: the *organization*, the *culture and digital talent*, and also the *technology*.

D. Culturally

It is the digitally driven innovation and how to empower employees with digital technology. The competitive strategy depends on digital technology. The directives and top executives support the digital strategy. There is: an investment in targeted digital education and training at all levels of the organization; A clear communication of the digital vision both internally and externally; and taking of measured risks to allow innovation.

E. Organizationally

Certain concerns must be answered, including: How aligned is it to support digital strategy, governance and execution? Does the organization prioritize user experiences on functional silos (data storage towers)? Do we dedicate the required resources? Is the organizational model collaborative? Do our suppliers offer value that improves our digital skills? Do we have clear and quantifiable objectives to measure the success of our digital strategy? Do we measure the functionality of the channels together, to achieve the desired result? Does the user's perspective guide our digital strategy experientially? The user experience allows us to infer about elements of design and digital development. [5]

E. Technologically

Is our budget for technology practical to allow flexibility of priorities and strategies? Do we take advantage of modern architectures (API, cloud, big data, IOT, IA, robotization of processes, etc.) to promote speed and flexibility? Do we use digital tools to promote innovation, collaboration and employee mobility?

F. Constituents

The following table shows the different components of the DT Ecosystems

Table 1. **DT ECOSYSTEMS COMPONENTS**

	USERS	APPLICATIONS	SERVICES	INFRAESTRUCTURE
INSIGHT	TEACHERS	TEACHING	SOCIAL PROJECTION	ICT-DIGITAL
	PARENTS GOVERNMENT INDUSTRY	RESEARCH EXTENSION		UNIVERSITY PHYSICAL
	STUDENTS			

IV DT Structural Model

The DT in a HEI that has its ethos in a complex system, has numerous determinations and edges of problems.

We presented in Sections 1.4.1 and 1.4.2 different architectural views for the DT.

A. Functional Architecture of the University Digital Transformation

The architecture has dual functional aspects: academy and organization of the Intelligent Educational Architecture in terms of its pillars and sustainability components.

According to the previous definitions, the DT is located in the space of the institutions' productivities, the agents, the organizational processes and the users; equally, according to the Ecosystem.

In the case of the PSEd, the DT has 2 dimension spaces:

- **the curricular and**
- **the administrative.**

The agents or actors are: the students, the teachers and the staff. The stakeholders are: the parents, the CIO of the institution (superior council), and the government, and related.

The fundamental pillars of the DT Model are:

- The enterprise, taking into account that the DT promotes the re-invention of the institution
- The research, combined with innovation, for the generation of *intellectual-digital assets*
- Digital talent, endowed with digital expertise to promote, implement and maintain the system towards the IV Industrial Revolution
- The required budget, given the effort needed to get rid of the past and adopt new and extreme technologies, and
- The social projection of the institution both inside and outside, for the transfer of knowledge and technologies that promote the productivity and competitiveness of the country.

The model architecture (Figure 3) is integrated by 3 essential components:

- Portfolio analysis of produced digital and intellectual assets
- The analysis of the relevance of research policies and guidelines
- The Self-Assessment, evaluated in different relevant dimensions.

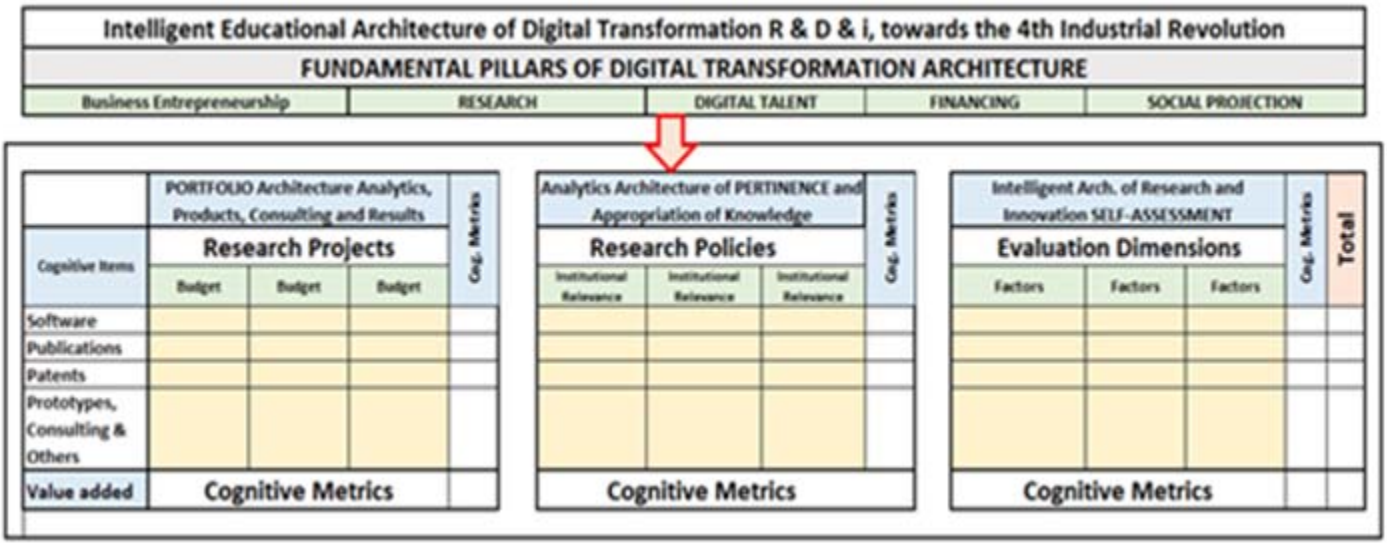

Figure 3. Pillars of the DT Model

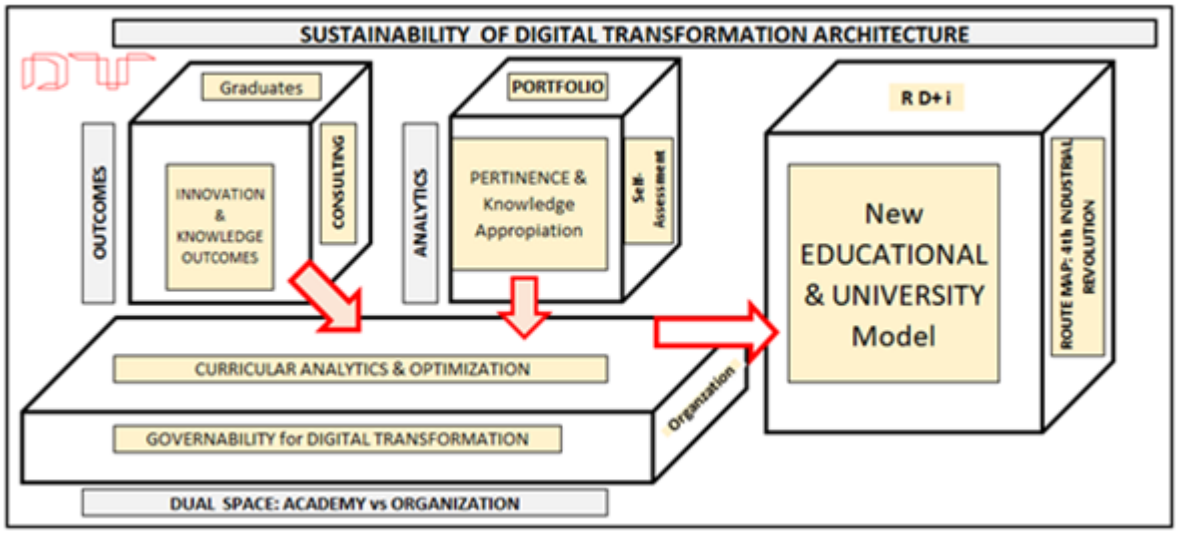

Figure 4. Sustainability of DT

Table 2 Specific Objetives
1) Digitize all the curricula in terms of its competences-objectives, measuring their impact on the universal knowledge of each subject with its academic credits and its micro-competencies.
2) Make the self-assessment of the institution's products as one of the instruments for migration and continuous improvement towards high educational quality that allows defining strategies for the reduction of operational costs.
3) Quantitatively analyze the product portfolio as impact of the research projects and of other activities on their social projection. In the same way, analyze the portfolio relevance in respect to the research lines and the results of the academic and administrative management. These analytical and deductive efforts should enrich all efforts towards high quality education.
4) Align the corporate strategies, the institutional educational project and the digital transformation strategies, taking into account the different normative and non-normative scenarios.
5) Develop an intelligent reengineering of processes towards their robotization.
6) Design and implement smart models focused on the students to improve their cognitive and academic productivity to reduce costs.
7) Design and implement intelligent models focused on the teachers to improve their productivity in teaching and in the development of knowledge verification methods.
8) Decrease the social gap in the human talent offer, for the world-class DT with *social innovation*.
9) Infer an institutional architecture with 360° vision that integrates all the efforts in productivity and quality, towards the *competitiveness* model objective, that consolidates the DT.

B. The Sustainability of the DT

The DT sustainability model was presented in Figure 4, where it is clearly shown the duality *academic space* vs *administrative space*, whose characteristics are: [7]

1) The generation of new knowledge translates into publications of scientific-technical papers, properly indexed books, patents, vegetable variety, software or new animal breed, etc.

2) The technical-scientific development and innovation, is characterized by: Prototypes, industrial

C. Intents and Purposes

Among the purposes it is worth mentioning:

1) Reach the new educational model based on competencies, micro-competences and high quality in the face of the new needs of the IV Industrial Revolution, with new services and new capacities for generating knowledge and innovations.
2) Get the Mature Digital Marketing Model.
3) Repower the Model of Academic and Administrative Governability.

Redesign the Academic-Administrative and Enterprise Model of the Institution.

V. DT METHODOLOGY: DT development process based on models, architectures, systems, information, data and knowledge

A. METHODOLOGY – Preliminary stages

They are related to the identification of functional and non-functional requirements within the academic and administrative systems that wish to integrate and publish them as executable constructs and services. The above requires:

• New profiles of users, services, processes, etc.
• DT development tools
• Interaction with different users and suppliers

Understand PSED objectives and define successful environments

Give importance to problems to be solved then think of technology Requirements analysis

Define domain in which circumscribe the problem Scope of application of DT in the organization

Attack small parts of the problem (subsystems)

Understand all application semantics that exist in the domain

Understand the nature of information that will be exchanged

Identify possible cases

Avoid contradictions

Understand all services available in the domain: How many, where are they? Goals? Objectives? Relationships?

Security problems - Access

Define new processes and the limits of information for those processes

Automate interaction between services

Integrate services and information flows

Select technology

Deploy that technology

Test, verify, validate, legitimate and evaluate

B. DT METHODOLOGY

The methodology refers to a systematic process of reasoning, thinking in order to express and represent a problem and obtain an appropriate solution. It also refers to the way of planning and determining problems: it is the art of problematization. It is also the way to build a solution and at the same time verify that the solution is correct.

Our methodology covers the use of multiple paradigms ranging from information engineering, modern software engineering, data, information and software architectures, knowledge engineering with artificial and computational intelligence (ACI), and evidently WEB engineering.

Planning, includes the determination of the solution system prior to fine-tuning the objectives to be developed, the detailed quantification of physical, human and technological resources, and the definition of security aspects over the Internet.

The study of the system for the diagnosis of the DT, includes the requirements engineering and processes. The design involves the proven specifications of the system through evolutionary prototypes. The construction of the system is supported by tools for development of software of 4th and 5th Generation, such as tools like Qlick.

KE is used to represent educational/administrative knowledge and reasoning systems, organize the knowledge bases, their distribution and their communication, widening the bandwidth through hypermedia for fluid communication inside and outside the organization. The Functionalities are described in Table 3

VI. FINAL CONSIDERATIONS

A. Remarks

1. DT started several years ago and is consolidating.
2. At FESSANJOSE we have been working on academic digitalization for several years, supporting these implementations with numerous publications.
3. Many evidences show that 30% of investment returns is feasible.
4. The digital challenge is the new business culture based on digital skills.
5. Current millennial users deserve special attention: It is necessary to listen to them, who will see everything and educate with mobile phones. The social and economic are being redefined, in which the daily life will change, including promoting changes in the world order, economically and socially.
6. DT Focuses on business; prescriptive analytics; agile and modern infrastructure; staging capacity; improve the use with dynamic IOT platforms; cloud-native apps.
7. Using the Modern Analytics: How to generate greater value through the data, wherever possible? ¿At any opportunity? It includes: data integration; unified data-types; and involve different sources.
8. DT develops a readable hyper-plan (layout) of the Architecture. Develops it in house internally or by outsourcing contract.
9. It makes intense use of management and performance metrics and indicators; e.g., applies ROI (Returns on Investment), conversion rates, qualified talent, condition of marginality, organic rate of repurchase (without investment in marketing), SLA (level of service). Permanently evaluates the virtualized experience of the user.
10. DT is not reengineering neither retro engineering: it is digital mapping, extended horizontally and vertically.

B. Conclusions

The DT of our society changes the way we live, work, learn, communicate and collaborate. This disruptive change interacts with all the processes and systems that are important enablers of activities for the DT for years.

We contribute to the literature by presenting this new perspective for adaptable digital educational architectures for the university with our **Dual DT Model: curricular digitization and institutional digitization, i.e. knowledge and data**.

C. FUTURE WORK

We are publishing a book: ARTIFICIAL INTELLIGENCE ENGINEERING FOR POSTSECONDARY EDUCATION DIGITAL TRANSFORMATION, with NOVA Sc, which collects our experiential learning in DT for PSEd; with PT, T and P levels. They include several methodological innovations in DT and several views of our proposed and implemented DT model.

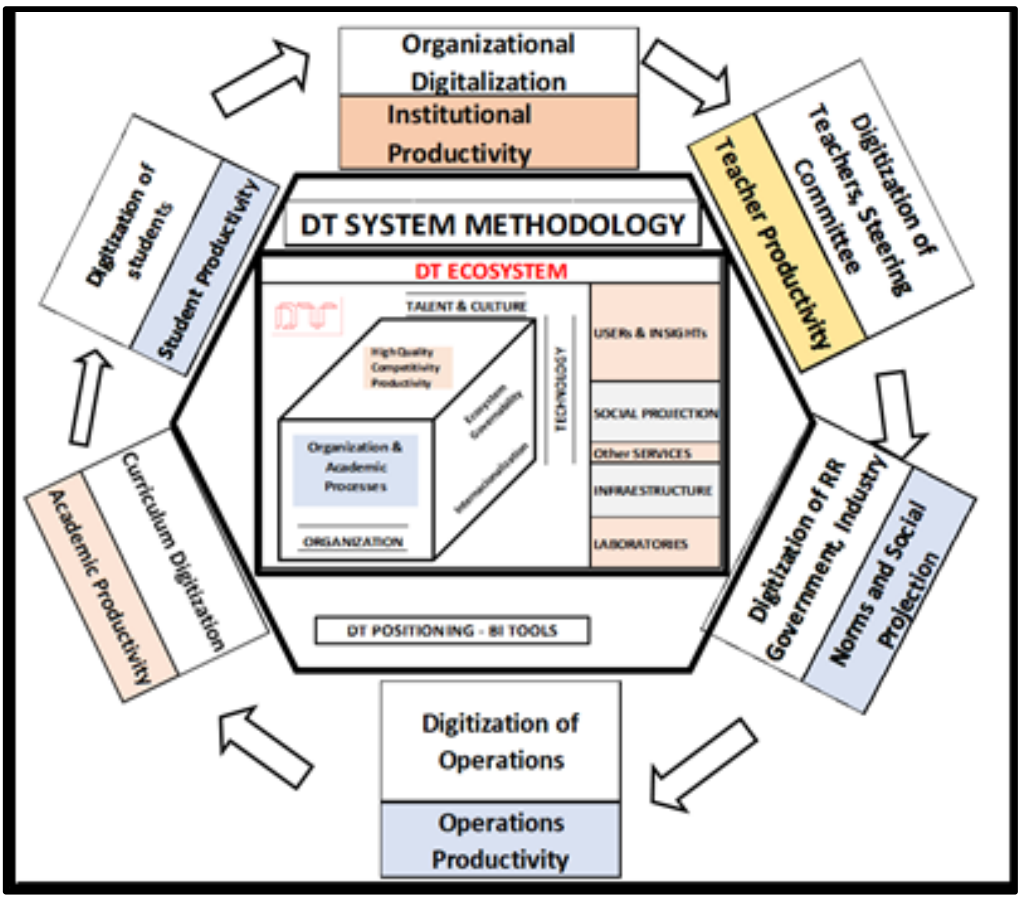

Figure 5. DT Methodology

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