

Design of an Architectural Traceability as an Observatory for Decision Making in Undergraduate Curriculums

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Curriculums play an important role in academic production, in managing investigative dynamics between various departments and in creating synergy within different areas of study. They are also an important factor in asserting competence and enforcing challenges that derive in both national and international standards, which in turn guarantee high standards in the classroom. In this context, being able to trace curriculums becomes fundamental in identifying information in aspects such as: content tracking, written academic production, syllabus evaluations, managing networks of knowledge, and tracing the future impacts that predominant content will have on a national level as a result of the student body and their prospective. Through this investigation we will present the construction of a model that tracks curriculums through technological systems, taking into account process variables like resources, materials and both cultural and social influences in order to facilitate the study program's visualization, tracing and control mechanism. The investigation looks to construct traceability indicators that are easy to use in order to observe and monitor the content's impact; as well as decision making regarding technological surveillance, the creation of future outlines and lateral ways of thinking. All of this based on a specific case of study.

Key Words

(01) Architecture, (02) Traceability, (03) Quality (04) Curriculums, (05) Decision making.

Introduction

The creation of a system of traceability as a necessity curriculums allows for the existence of quality control and the identification of critical factors. It also permits as the development of knowledge and the creation of better practices for technology and innovation, starting with the breaking of barriers that cause regional universities to lag in front of the demand since they aren't able to demonstrate the quality of their products versus international rankings. When developing innovation it is paramount to have a holistic view by means of various disciplines which will help us to observe an issue from different perspectives,

which in turn allows us to determine how they are interacting with each process in the cycle of life of management when referring to the actors that are involved in the traceability process (Becerra & Cervini, 2005). The tendencies can be established through the set of problems, contexts and indicators by using three axes: socio cultural tendencies, technological tendencies and environmental tendencies. This can be achieved through the construction of vigilance technologies. This investigative project is structured under four phases, as an undergrad thesis that has been developed alongside the students that participate in the case study. At the moment the project is assigned to the investigative group of the University of Cundinamarca (GIPA) and is actively working on its first stage. In the following chapters you can find a collection of background information, the framework for traceability architectures on the quality of curricular meshes for decision making processes; as well as references to the implementation of the construction of future scenarios based on the socio-physics study carried out by the technology operating the platform of traceability.

The Necessity of Traceability for Decision Making in Curriculums Generalities of Traceability

The objective of traceability is to compile all of the information that a system can procure, whether it is a tangible or intangible product (Dabbene & Gay, 2011). However it has been demonstrated that both a common and a solid theoretical framework, that shows the implementation of traceability systems and how they impact the decision making process, has not been created. These processes have a tendency to be unique in their creation and their materialization depends on the interpretation and manipulation given to each process. This is what causes the construction of a traceability architecture to be established by the flow of information from only one system (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). According to Opara there are six aspects in which traceability can be made and they are: (01) Traceability for the product, which determines where the product is physically found; (02) Traceability of the process, which provides the type and sequence that influence the product. (03) Genetic Traceability, which is in charge of the constitution of what is tracked; (04) Traceability of supplies or the origin of the properties that make up the final product. (05) Traceability of diseases and plagues, which determine biological dangers associated to the product and finally (06) the measurement of the traceability which relates the results of these measurements with the established protocols (Opara, 2003).

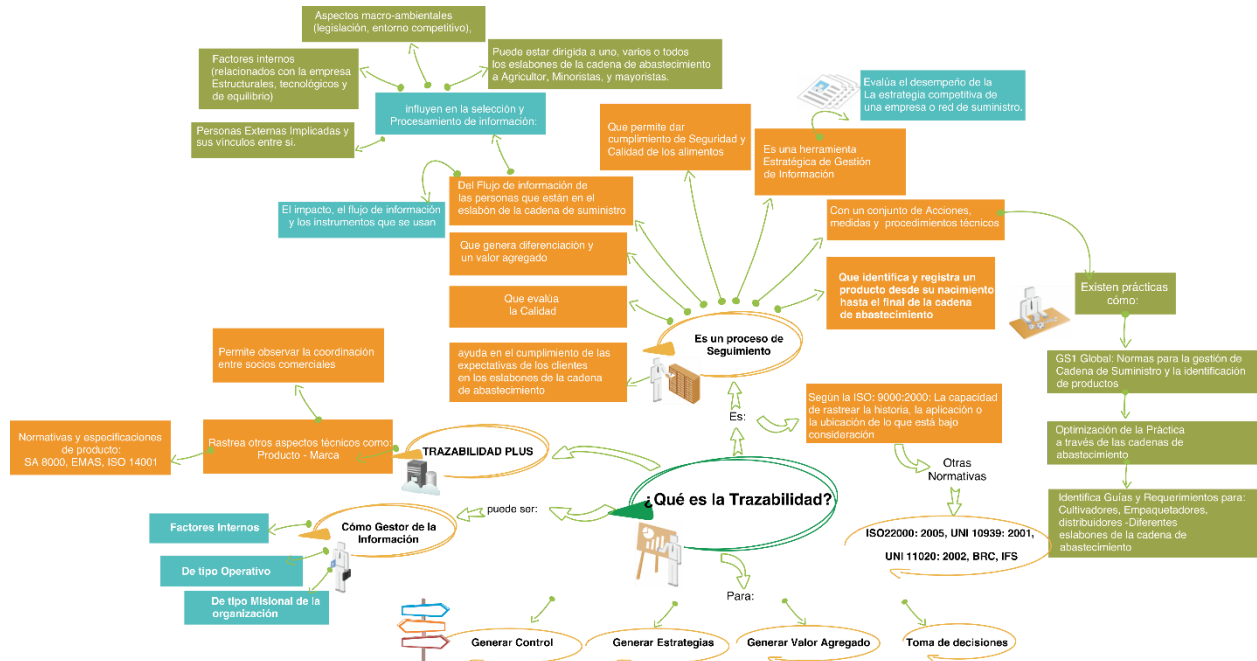


Figure 1. What is traceability?

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Duply was the first to inquire on the evaluation and optimization of the systems of traceability and various authors later began to apply his methods. Others like Tamayo used algorithms to optimize processes, in 2010 Wang proposed a combined optimization between manufacturing by lot and the dispersion of lots, introducing risk functions for tangible products (Dabbene & Gay, 2011). Within the construction of information for the evaluation architectures there are three dimensions of investigation that contain elements of information (they are the ones that can identify and perceive their own message): independent network (which have the capacity to configure themselves) and smart applications; which have intelligent control and the capacity to treat the information (Badia-Melis, Mishra, & Ruiz-García). In 2011 Dabbene and Gay stated that the following considerations existed to observe the performance of traceability systems and they go as follows. (01) Evaluation of the performance of a specific system of traceability; (02) the design of the flow of information, that allows the determination of priorities between the different aspects to be analyzed at an early stage and is in itself the point with the most influence within the quality of the system. In the architecture certain aspects of quality are present like security, manipulation and the ability to be flexible; as well as the current and future cost of the effort that is put into the development. Illustration 1 shows that it is a small structured model that is intellectually comprehensible with all of its systems working together (Dávila, Germán, Crutas, & García, 2015).

The Proposal for a Traceability Architecture built for Universities.

For the construction of the architecture of traceability the flow of information must be taken into account, as it has been described in illustration 2. The flow of information between its actors must first be evaluated in the whole system, followed by creation of requirements based on the methods of extraction of this information which are then also evaluated. This second test could be determined according to the needs of each individual case.

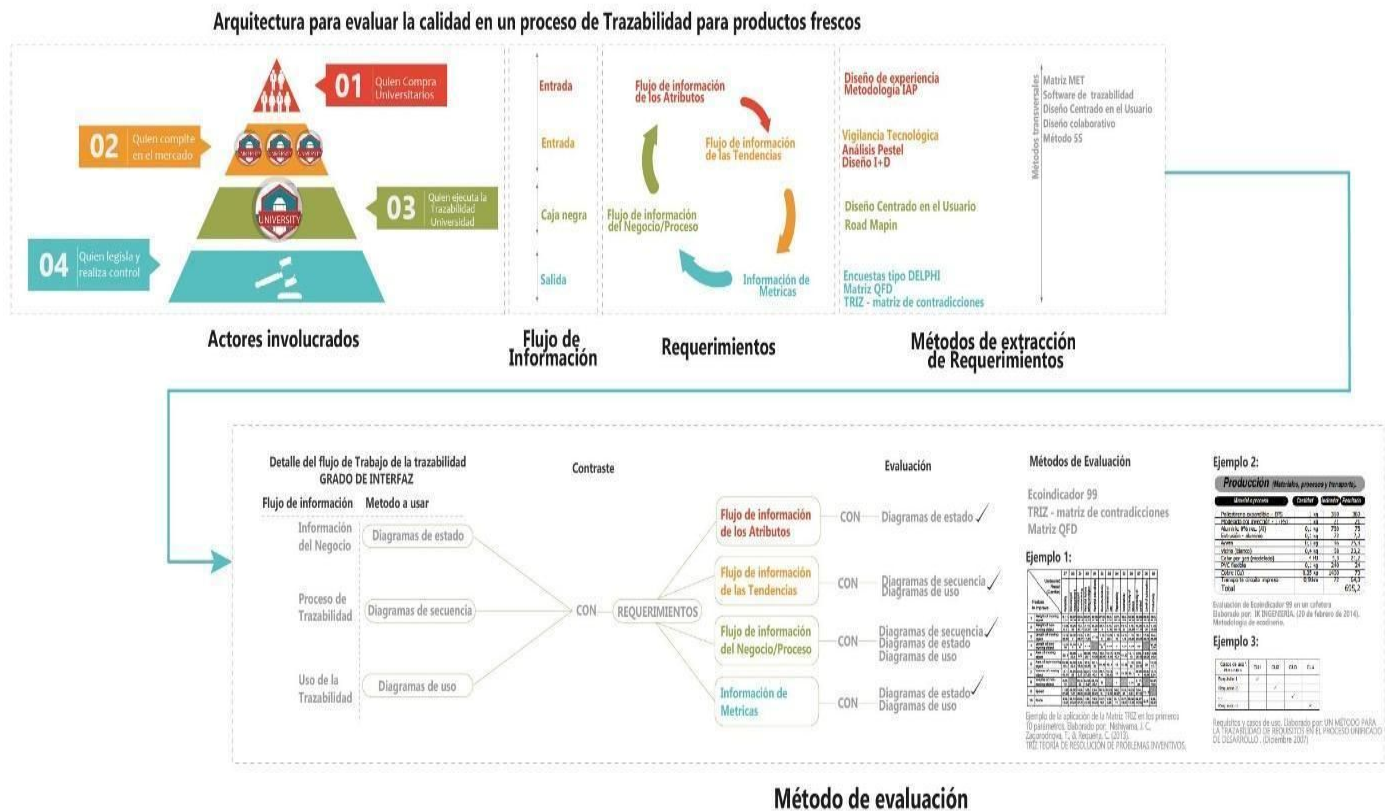


Figure 2. Methods of the Architecture of Traceability

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For the analysis of this information we keep in mind factors that are akin to the tendencies that are associated to the four levels of actors involved, like the construction of technology for vigilance. This allows for the creation of various requirements, as well as project indicators.

Architectures of Traceability within curriculums

When we speak about the creation of a methodology for the construction and implementation of a curriculum for undergraduate programs it is necessary that we have previously defined the profile of that graduates, as well as the abilities and skills that they will acquire as their studies progress. Sutcliffe (2005) shows how a study plan based on skills is structured based on the content of the thematic foundation that enhances the abilities of the student and future graduate and differentiates them in their professional lives. Tobón (2004) manifests that a skills based curriculum permits the generation of evidence and control through the quality of the academic process. When the abilities the graduate should achieve along any course of studies are defined properly the it becomes imperative to create indicators that allow the measurement of the level of advancement of each skill (Braislovsky, 2001). There are also other models that can be associated the design of these study plans, for example the one proposed by Crawley (2007). This model is based on the results of learning and the depth of understanding and dominium that the

students demonstrate about the technical foundations of the career, which in turn allows them to be innovative in the creation of new products and/or systems framed within the strategic value of their jobs. Another model is that of Thomas Markham (2011) which is based on knowledge acquired by projects. In this case the pedagogy is centered around the student and his or her formation process. It is seen in the knowledge they collect by solving everyday problems. Yet another is based on the relation between learning and providing services Jacoby (1996), where the fundamental aspect sits on the construction of projects with high social impact that provide support to the local community.

Taking M Muñoz and C Martínez's work (2016) as a reference, where curricular activities are traced at a micro level and the engineering graduates profile is traced on a macro level, it is possible to determine that there periodic evaluations for each level that structure themselves through models like the one that can be observed in illustration 3.



Figure 3. Traceability of the achievements of the graduates profile.

Created by: M Muñoz, C Martínez , 2016

There are several traceability models in existence for graduate profiles and various curriculums that adjust the the assertive philosophy of the institution. In the previous paragraph we showed the trace of a graduate profile for a CDIO methodology and how it is structured to evaluate periodic results in learning. Currently there aren't any standard models or traceability architectures in existence that are able to evaluate the curricular system and that is where we find the importance of creation this model which will allow for three things: the evaluation of quality within the curricular mesh, the perspective and construction of future scenarios and the decision making process. For the construction of this architecture we propose to create it based on the model exhibited in illustration 2, following the steps declared in the implementation chapter.

Investigation Methodology

In order for the development of the traceability architecture to permit the evaluation of the curricular mesh based on a digital platform, the possibility to carry out investigations under creative methodologies is evaluated. In this way we can conclude the following: First phase; the search for factors that have influence over the investigative problem. Second phase: perspective; the description of activities and guidelines for the traceability architecture. Third phase: the cognitive perspective; the constitution of requirements and indicators and finally the fourth phase: the computational stage, which is divided into the analysis and synthesis that provide the results of the arrangement of recommendations of use and continuity within the proposal. This investigation is tied to the development of the phases previously mentions and are carried out by the team of the University of Cundinamarca, and is linked to the undergraduate thesis work of students of industrial engineering since they are the first actors involved that allow for the architecture to be created, based on their experience and formation.

Currently the investigation process is in stage one, where we are initiating the development of the flow of information of the different actors involved. This is described in illustration 4.

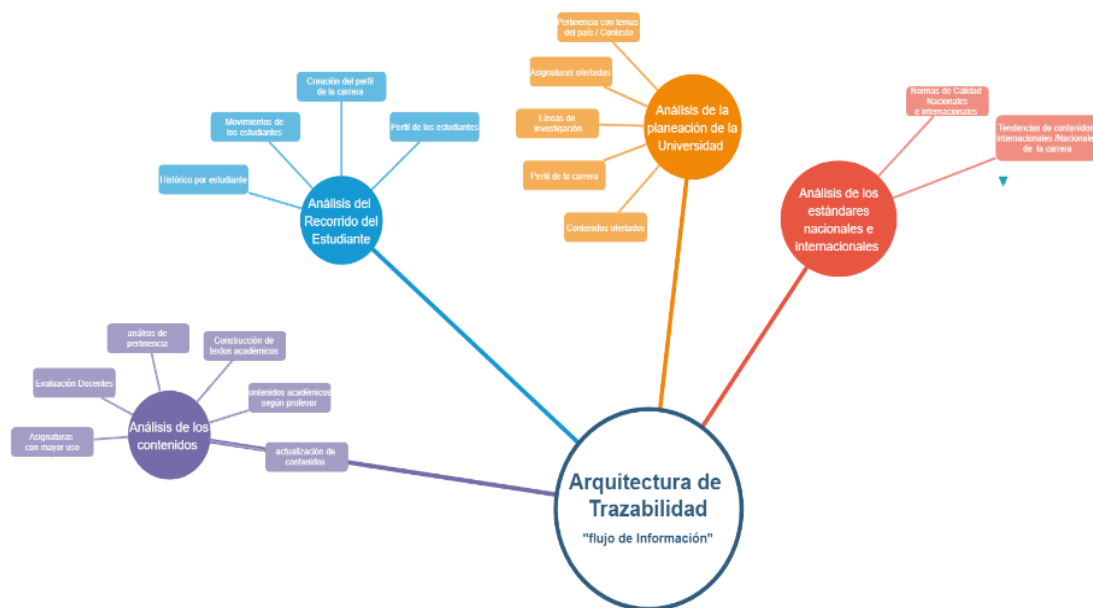


Figure 4: Flow of information with the architectural evaluation

Created by: The authors

With this process we can be sure to obtain a flow of information that allows for the following phases to be carried out, while we observe the internal and external factors of the system. Such as the variables of resources, and the processes and influences that are associated to the context.

Case of Study

The University of Cundinamarca is a public institution that is managed on a state and national level. It was founded in 1969 and has the following faculties: Faculty of Administrative, Economic and Accounting Sciences which accounts for majors in business administration, public accounting and technology for tourism management. The faculty of Physical Education and Sports Sciences, which has the following careers: BA in Physical Education and Physical Education with an emphasis on elementary schools and Recreational and Sports Science. They also have the Faculty of Agricultural Sciences with the following careers: Agronomic Engineering, Technologies for Cartography, Zootechnical Studies, Environmental Engineering and Agricultural Administration. As well as the Faculty for Health Sciences, the Faculty for Social Sciences and Humanities, the Political Science Faculty and the faculties for Music and Psychology; the faculties for Licenced Mathematics, and Early Childhood Development with emphasis in humanities and english and spanish language. As well as the Faculty for Basic Education with emphasis in Social Studies and finally the Engineering faculty which careers in Technology and Software Development, Industrial Engineering, and electronic engineering.

This case study works with the industrial engineering program which is attached to the the faculty of engineering. The program has 824 students and 24 professors. The second group is divided into six professors that teach by chair hour, nine professors with four month contracts, twice a year and the rest under contract during ten and a half months of the year. The course of studies began in the year 2008 in the town of Soacha that is located within the state of Cundinamarca. It also counts with an investigative group in environmental and industrial processes (also known as GIPIA). It is important to mention that the town of Soacha has a total of 1,250,000 inhabitants and an approximate population density of 6,830 inhabitants per square kilometer, where major social and economic issues can be put into evidence like the lack of functional educational, health and transportation services; amongst others.

The engineering faculty and the industrial engineering program coordination are advancing efforts for curricular reform aimed at the CDIO methodology and the service-learning methodology. For this reason, it becomes of great importance that they define a model that allows them the trace the contents in their curricular mesh in relation to the academic production and this this in turn permits the evaluation and systematic monitoring for the course of studies that the program is contemplation, while always keeping the graduate's profile in mind.

The intention is to carry out a different curricular proposal than the one that is currently instated, where traceability is possible and where the current mesh can be compared. Keeping in mind that the investigation proposal should be accomplished in two phases, the following times of execution, actors and people in charge have been selected for each stage:

PHASE	TIME (months)	ACTORS	PEOPLE IN CHARGE
1. Descriptive	3	General community	Main investigators.
2. Perspective	4	Professors and Students	Professors and main investigators
3. Cognitive	4	General community	Professors, students and main investigators

4. Computational	4	Professors and students	Professors, students and main investigators
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Table 1: Description of the actors involved in the case study

Discussion

Based on the bibliographic references we consulted the following could be determined:

1. In the construction of a traceability architecture there currently doesn't exist an established standardized model and for this reason it is necessary to create a model for the decision making process in curriculums.
2. The traceability architecture proposed should permit the development of future scenarios based on the analysis of information procured from the technological platform by means of the flow of information provided by the actors involved; for example "the beneficiaries", in this case the students and the route they take across the various subjects and a mesh of subject. This is done with the goal that the University can redesign and/or update the curricular mesh according the pertinence of the student's needs.
3. The traceability architecture is specific to the project's formulation, generation response to the dynamics of the context in which it is applied. In this way, the proposal of the investigative project also promotes the analysis of the context and its interpretation through the methodology used as an innovative approach. To be exact we intend to establish the analysis by means of a kinetic model of exchange of opinions where the interactions between the students (on a micro level) can generate structural properties in the graduate's profile (on a macro level). In this way we will accomplish the development of future scenarios.
4. We will validate the construction of the traceability architecture as a source of control of quality for the curricular meshes, while we observe the behaviour, influence and impact that it has.

Acknowledgments

- We thank the investigative group of social, economic and productivity studies of the National University of Colombia (SERPO).

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Biographies

Lina Nataly Alvarado is an industrial designer with a Masters degree in industrial engineering from the National University of Colombia. She works within this university as well as in the Global Campaign, 100 million for a 100 million, led by the Foundation for a Better world. Her investigative projects can be classified in three lines of study within innovation: competence strategies, as she won the award for the undergraduate thesis for her development of new products and processes in small businesses; communication strategies for her work obtaining the Guinness World Record with the creation of a mobilization strategy that enforced public policy within the country and finally social innovation with the creation of an investigative group on this topic for her alma mater. She was an Incae Business School scholar and a trustee in the Social Entrepreneurial Summit hosted by the international non profit VIVA for her work in socially innovative projects.

Jefferson Aldamer is an industrial engineer from the Military University of the New Granada and a physicist from the National University of Colombia; he is currently a candidate to a masters degree in physics from this same university. He is also the coordinator for the industrial engineering program in the University of Cundinamarca and is a member of both the Investigative group of Industrial and Environmental Processes and the Econophysics and Sociophysics investigative group in the institutions previously mentioned. He has experience in the design and implementation of betterment strategies, and tracking evaluation processes, as well as creating management reports, designing and analyzing management indicators, handling statistic and mathematical programs for organizational management,

training focal population, guiding academic processes and generating and implementing strategies for significant learning based on evidence and support of communicative processes in an academic community by using information technologies.