Methodology for the construction of research agendas in academic engineering programs

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Abstract A collective project was developed to build research agendas for academic programs; as a prospective strategy to prioritize areas of action, use of resources and institutional capacities in a relationship between the university and the productive sectors of the region, from the development of intervention and study strategies, in 11 training scenarios. A collaborative and interdisciplinary methodology in the analysis of documents related to development, science and technology, allowed identifying common productive sectors of interinstitutional interest for the development of engineering programs of Systems and Industrial Engineering, analyzing their performance, good practices in research, technological surveillance of research centers, prioritize emerging thematic areas, build research intervention strategies and generate project profiles. The strategy gives greater relevance to the training of professionals, establishes a path of knowledge construction in areas of interest; that immersed in the curriculum plan; allow articulating research units in framework projects by research lines. The article presents significant aspects of the methodological route in the construction of these agendas, focused on two academic programs of the faculty of engineering.

1. Introduction
Traditionally, researchers direct thematic of study in their own disciplinary needs, within a wide variety of approaches, topics and theoretical aspects of great richness [1], driven by internal and external factors [2], but with little articulation to needs and problems of the productive sectors, trends in science and technology, the operationalization of state policies and their impact on the professional training of engineers. The responsibility of universities in the training of engineers in the knowledge society requires the consolidation of skills and abilities to comprehensively understand the social, productive and environmental fabric with deep ethical and professional commitment [3], and act with solvency in contexts closely linked to the productive and business sectors with solid sociocultural, analytical and management competences [4], in addition to their specific disciplinary domains. In this sense, his research training must be framed within innovation and creativity to build knowledge at the frontier of knowledge of his engineering field [2].

It can be said that the definition of the Research Agenda is polysemic. They are added to its conformation, application components such as academic research agendas [5]; knowledge agendas [6]; strategic research agenda [7]; research and technological development agenda [8]; prospective research agendas [9], research and innovation agendas [10] among others. There is a common thread in all the meanings that consists in the search for connection between scientific knowledge and society, that is, the necessary interrelation between what is researched and what man requires for his...
daily existence, as a link in the research and society relations and between technology and society, within highly dependent contexts [5,11]. The society is a producer and claimant of knowledge and the research centers are based, in turn, on the offers and demands of these to advance in the construction of new knowledge (theories, methods, technologies) that are again appropriate for society in a hermeneutic circle of investigation-action-transformation [12].

Then, the research agenda is an integrated, dynamic and flexible program of projects and strategies established to make productive use of knowledge within a given sector [13], based on the rescue of social commitment, overcoming isolation, non-repetition of pre-established routines and the formation of close links with institutions [14] and is constituted as a space for dialogue and concertation, interactive and participatory of various social agents [10] in the search to establish synergies and commitments to face problems and challenges in the areas of scientific and social knowledge.

The experience set out as objectives to offer the academic community an updated, contextualized and consensual prospective analysis to direct the research processes in the short and medium term; guide the work of the basic units of research and academic programs of industrial engineering and systems, in the training courses of the research area and of the specific professional component linked to the research lines. Finally, reference points for planning and integration of the teaching, research and extension functions for the coming years were built.

2. Materials and methods

The construction included teachers and coordinators of the EUREKA research groups, of the seedbed of investigation "Visionarios" and Silice "SIO2" of industrial engineering and the research group in software development "GISOFT" and the seedbed of investigation "tendencias al servicio de la sociedad – TISOS" and "lenguajes de programación - SILPRO "of the systems engineering program. in the elaboration of the agendas, interdisciplinary work groups were established by academic program accompanied by the leaders and research coordinators. through a collaborative and participatory methodology, the departmental development plans of the central eastern Colombian region were analyzed; constituted by 4 departments. Institutional, national and international references were studied; through focus groups. Productive sectors of interest for the university were selected using concordance matrices. The performance of the selected productive sectors, the good practices in research and the technological surveillance of research centers in the sectors of interest were analyzed. Priority was given to the thematic areas of research interest by sector - TARI to build intervention strategies - EI. Profiles of research projects, analysis of capacities and technological demands, analysis of organizational and context demands, estimation of financial resources and monitoring and control of the research agenda were elaborated.

3. Results

3.1. Identification of the productive sectors and prioritization of thematic axes by sector

Analysis of the departmental development plans of the eastern central region of Colombia (area of influence of the UDES) was carried out to determine the needs and interest of local governments in devoting resources to the productive and service sectors of their territorial entities. This review allowed the identification of 23 productive sectors and the selection of 8 (agriculture and forestry, logistics and transport, tourism, graphic industry, ICT, environment, leather, footwear and manufacturing and biotechnology) of interest for the engineering programs developed by the university. Likewise, institutional, national and international references were explored with the purpose of establishing correspondences between the thematic axes of the productive sectors of the central east region and the development and research policies.

3.2. Thematic areas of research interest

From the identification of the thematic axes by productive sector and the valuation of the good practices and technological vigilance, the topics of research interest for the professional engineering programs were defined. An example of what is contemplated in some sectors and axes is presented, in Tables 1 and 2, about the themes to the topics of interest in the axis of entrepreneurship in the sector of ICT information and communication technologies; in the axis rural development and productivity in
the agricultural and forestry sector. The two of interest for the engineering programs of systems, and others of the industrial engineering program.

| Sector                     | Thematic Area | Area of Interest (TARI)                                                                 |
|----------------------------|---------------|----------------------------------------------------------------------------------------|
| Agriculture and forestry   | Rural         | Transfer and appropriation of agricultural technologies                                   |
|                            | development   |                                                                                       |
|                            | and productivity |                                                                                       |
| Information and Communication Technologies | Entrepreneurship based on ICTs | Use of ICT in organizations, Bioinformatics, Software Engineering in the company, E-services, Collaboration Engineering, Microenterprise and ICT, Start-ups, Incubators of technology-based companies, Connection & Development - C + D, Customer Relationship Management CRM and data mining in the company |

| Sector                     | Thematic Area | Area of Interest (TARI)                                                                 |
|----------------------------|---------------|----------------------------------------------------------------------------------------|
| Logistics and Transportation | Supply chain management | Optimization of the supply chain                                                        |
|                            | Prospective   | Modeling and simulation of scenarios: Development of software for the modeling and simulation of scenarios that may affect the normal performance of supply chains. |
|                            | and trends in logistics |                                                                                       |

3.3. Prioritization of the thematic areas of research interest (TARI)
The diversity and breadth of TARI, leads to a selection of topics according to the interests, needs and capacities of the Academic Programs and the Basic Research Units; research groups and seedbeds. In reference to prioritization, TARIs were classified into interdisciplinary work groups with the following criteria; giving each one a maximum weight between 0 and 10: Relevance (1.6), Opportunity (1.2), Feasibility (1.6), Impact (1.7), Validity (1.3), Ability to link actors (1.3), Sustainability (1.4) and Technological capacity (1.1). The highest scores obtained indicated the TARI to be selected for the construction of the Research Agenda. Figure 1. presents the results of prioritization for the agricultural and forestry sector, and logistics and transportation in the work table of the industrial engineering program.

3.4. Construction of research intervention strategies (RIS)
The development of this activity took as a reference the strategies elaborated by the working groups in the analysis of the productive sectors of interest for the construction of research agendas and the results obtained in the work tables. In the elaboration of the RIS, it differed in RIS for basic research units and RIS for academic programs, incorporating the training scenarios; spaces for the improvement of skills, profiles, skills and languages through specially planned instructional activities, with content and structures that respond to curricular proposals [15], as well as respective actors to each academic instance. In the RIS, 4 objectives related to the quality criteria of the research culture were considered in a professional training program. These are: Strategic training for the development
of skills for research, Strengthening of ICT’s for research, development of research in the strict sense and social appropriation of knowledge. Table 3. describes the research intervention strategies in optimization supply chain (TARI) of de industrial academic engineer program, so as, Table 4. describes the RIS of groups and seedbeds; basic research units.

Figure 2. Prioritization TARI logistics and transport sector.

### Table 3. Research intervention strategies in optimization of the supply chain, TARI

| Scenarios              | Research Intervention Strategies (RIS) by scenario                                                                 |
|------------------------|-------------------------------------------------------------------------------------------------------------------|
| Working in the Classroom | Strategic Training: Include the subject in the curricular contents of the course.                                  |
|                        | Promote group discussion -Optimization of the supply chain of different production processes.                      |
|                        | Strengthening of ICT’s: Strengthen knowledge about the optimization of the supply chain of different processes in the national and global scope through the use of computer technologies. |
| Training practices     | Strategic Training: Plan field visits and practices that optimize the supply chain of different production processes in the region. |
| Business practices      | Strategic Training: Establish alliances with the productive companies of the region for the realization of professional practices that allow knowing and improving the supply chain. |
| Classroom projects      | Investigate strictly: Conduct research in class about the optimization of the supply chain of different production processes in the region. |
|                        | Strengthening ICT’s: Inquire in social and academic networks content related to the optimization of the supply chain of different productive processes in the region. |
|                        | Strategic training: Carry out group workshops for students, designed to learn about the optimization of the supply chain of different production processes in the region. |
| Workshops               | Investigate strictly: Develop theoretical investigations and / or practices on the optimization of the supply chain of different productive processes in the region. |
| Tutoring of degree works | Social appropriation of knowledge: Promote the participation of students and teachers in academic, business and social events related to the optimization of the supply chain. |

4. Discussion

The research agendas are constituted as strategic tools of collective planning, based on the contextual demands and the institutional offers for the strengthening of the Basic Units of Investigation, of the programs of formation of the engineers, when granting meaning and meaning to "for what "Research and academic relevance to university research [11], through participatory construction with the utmost respect for the diversity of issues, experts [6], needs and potential of contexts, and the use of multidisciplinary methodologies for analysis and systematization of information, in close contact with social actors, and the knowledge dialogue between experiential and academic knowledge to establish
a consensual roadmap [16] and reflect the points of view of interest groups and researchers [7]. Likewise, research agendas are valuable knowledge management tools to better support the processes of teaching, formative research and knowledge transfer [17]; elevate researchers and students in a high level of understanding of the immediate environment and global trends in science and technology to produce sustainable and ethical actions at the frontier of knowledge [2] and; delineates the possibilities of higher education institutions to become world-class universities [18] based on the relevance and impacts of research.

Table 4. Research intervention strategies (RIS) for basic research units.

| Thematic area of research interest (TARI) | Research intervention strategies (RIS) |
|----------------------------------------|---------------------------------------|
| Collaboration engineering              | Strategic training: Train in business development and innovation. |
|                                        | Social appropriation of knowledge: Create educational platforms based on the tics to introduce the engineering of the collaboration in the training of competences of the industrial engineer |
|                                        | Investigate strictly: Strengthen projects for the creation of technology-based companies that impact vulnerable communities. |
|                                        | Create projects for virtual research networks. |

5. Conclusions
The construction of research agendas follows a rigorous process of identification, systematization and analysis of the internal (university-region-country) and external (globalized world) factors that allow identifying the situation and position of research in Colombia with respect to the practices and trends that mark the research processes in the international avant-garde academic centers. The identification of gaps and opportunities, which provide competitive and comparative advantages, constitute first-rate inputs to configure a theoretical and methodological body that directs the research and training of engineers in the short and medium term, in accordance with the national science and technology policies and the UDES.

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