Innovation Management in University Research Groups

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Abstract
Research groups are the units for generating scientific knowledge in Higher Education Institutions (HEIs). They are a key element for strengthening the Regional Innovation Systems (SRI). The department of Cauca (Colombia) has a significant number of this type of organization, with a long history and experience. However, there are gaps in the articulation between researchers and innovation processes. A qualitative phenomenological research was carried out to analyze the innovation management processes in these groups.

Keywords: Innovation; Research group; Science and society; Regional Innovation systems.

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Introduction

The triple helix model is an innovation model used to foster regional economic growth and promote entrepreneurship, from the understanding of the dynamics of interactions between three institutional dimensions of the university, industry and government (Cai & Etzkowitz, 2020). In this sense, for example Third Mission of universities, which considers the transfer of knowledge, according to the literature, in the generation of university spin-offs for the commercialization of knowledge and technologies, University - Industry relationships are relevant (Martínez et al., 2023).

So, it is important to deepen the understanding of knowledge and innovation management processes from Latin American universities. Because this allows progress in the social and economic impact of the research carried out in universities. So, this study seeks to contribute to the analysis of innovation management dynamics in research groups in a region of a Latin American country such as Colombia.

In Colombia there were 6,160 research groups recognized according to the measurement in 2021. Their scientific production in technological development and innovation only reaches 5 % of the total products (Ministry of Science, Technology and Innovation, 2024). According to the National Science, Technology and Innovation Policy 2022-2031 of Colombia (National Planning Department, 2022), in the country there are barriers to the flow of knowledge with a low dynamic of cooperation to innovate between universities and companies.

In the department of Cauca (Colombia), there is a base of research groups with an important track record and recognized relational capital. But weaknesses related to the low articulation of supply and demand in science, technology and innovation (ST&I) have been identified (Government of Cauca, 2013). According to the Departmental Innovation Index - 2020, there are some aspects to improve in the department of Cauca. These relate to knowledge workers and knowledge absorption. Knowledge-intensive employment has low participation in the productive area of the department and there is a low articulation of companies in the innovation processes of the department (National Planning Department, 2021).

Thus, efforts are needed to promote the articulation and strengthening of capacities for innovation in organizations linked to the innovation system. Research groups represent the basic units of university innovation systems. The incorporation of elements linked with innovation management within their research work can mean greater interactions with the industry and the social sector. In addition, this can help to improve transfer of knowledge and technology and in the strengthening of internal capacities of the universities. It is necessary to promote efforts to generate conditions for innovation, understood as the art of transforming knowledge into wealth (Government of Cauca, 2013).

This article seeks to contribute to the understanding of innovation management processes within research groups in the department of Cauca. For this, the research question is: How is innovation managed in research groups in the department of Cauca? A qualitative methodology was used, to analyze the state of innovation management in the research groups. This to generate solutions relevant to the territory from the use of scientific knowledge generated in the groups.

Literature review

University's Third-Mission. Higher education institutions (HEIs), in addition to their traditional teaching and research missions, also make efforts to develop the third university mission, seeking to generate impact from their research (León et al., 2024). These

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organizations can interact with the context and collaborate with the productive sector. They represent a source of generation of new scientific ideas, training processes for undergraduate and postgraduate students, real experimentation at the frontier of knowledge (Rücker et al., 2021).

In recent years, it seeks to increase the so-called "contribution to society" of universities, identified as the Third-Mission (TM). There is a growing demand for transparency, efficiency and accountability in the face of the socioeconomic impact of university activities. There are also demands for the legitimacy of the actors that surround the university, including industry and society in general; which represents a complex phenomenon (Compagnucci and Spigarelli, 2020).

Another perspective of this approach includes the response required from the university in the face of today's social challenges. The debate has increased regarding the incorporation of social innovation studies in the university teaching process. The university can contribute to the integration of communities and individuals in the knowledge society to solve social problems, such as inequality, sustainability and the democratization of knowledge (Bayuo et al., 2020).

A strong social commitment from universities can contribute to the enrichment of research and its legitimacy. Social innovation can serve to close the gaps between popular collective actors and advanced knowledge, for the promotion of sustainability and equality (Arocena and Sutz, 2021).

Likewise, the university's link to social innovation may result in increased use of a community engagement toolkit. This may include community-based research (CBR); science shops; deliberative science; bottom-up approaches to citizen participation in science; participatory technology assessment and citizen science (Bellandi et al., 2021).

Padilla et al (2023) conducted a review of open innovation in higher education institutions. They identified 36 factors that significantly impact the performance of the technology transfer (TT) process. These factors were organized into four categories: 1) knowledge management and innovation, 2) resources and capabilities, 3) innovation management and collaboration with universities, and 4) university-industry relationship. The first includes factors such as organizational culture, innovation culture, organizational strategy and generation and commercialization of knowledge. Regarding resources, financial assets, human resources and organizational capabilities are included. In the factors of the university-industry relationship, there are external actors and leadership. Related to R&D management within universities include, for example, capabilities and strategies.

University research groups. The term "research group" is regularly associated with formal or informal collaboration between several researchers, including students, to develop joint projects related to a particular research problem (Vabø et al. 2016).

Páez and others analyzed knowledge and innovation management models in engineering research groups in the Colombian Caribbean region. They recognized that this type of models presented an orientation, mainly towards the industry sector. Its application to research groups still represented an effort in early stages. In the sample of groups analyzed, they found an absence of procedures regarding communications, protocols, developed projects. This had resulted in a low production of knowledge, added to a heterogeneous understanding of knowledge management and a lack of strategies for the innovation processes of the groups (Páez et al., 2016).

Also, a study presented results of case studies of a biotechnology research group from a Colombian university. The aim was to promote the creation of green chemical companies as a result of applied research in biotechnology. They explained the need for the contribution of the curriculum in the process of innovation and integration with research groups. It complemented with Project Based Learning methodologies. Incorporating a business view of your research is also necessary. For this, it is necessary to understand the needs of the industry or the community and have continuous interaction to reduce barriers to the transfer of knowledge and technology in the future (Ocampo et al, 2019).

León et al (2024) analyzed the experience of the University of Cauca in terms of valorization of research results for the transfer of knowledge and technology to the business sector and public organizations from research groups.

Likewise, Da Cunha and Ferraz (2017) presented a complete view regarding University-Industry relations. They analyzed the consolidation of these interactions from four universities in Santa Catarina, Brazil. The identified benefits for the companies were access to public resources through the participation of policies for the promotion of innovation and the possibility of improving their processes or products. For the research groups, it represented the opportunity to access public resources, have feedback for teaching and research, provide continuity to the work teams and strengthen their scientific infrastructure.

Method

We developed a qualitative research. Whose approach is based on the understanding of the phenomena, based on the perspective of the participants in a natural environment and in connection with their surroundings (Hernández et al., 2014). In this sense, qualitative approaches offer the possibility of understanding social reality, based on feelings, thoughts and stories of social actors that are reflected from their testimonies (Ugalde & Balbastre, 2013). So, an emphasis about how the phenomenon is experienced by the research participants, from a focus on their subjective experience and interpretation of the world (Trochim & Donnelly, 2007).

Participants. First, a database was created with all the department's research groups, considering the categorization made by Administrative Department of Science, Technology and Innovation (Colciencias), now the Ministry of Science, Technology and Innovation (Minciencias). For this, the Scienti platform was used.

Then the results of calls for innovation projects where the research groups participated were reviewed. These included the InnovaAccion Cauca project (IAC), where groups from all over the department of Cauca participated and the call for processes to transfer research results from the Universidad del Cauca (RRT), where participated groups from the public university that concentrated the largest number of groups in the region. Groups with participation in innovation projects and/or transfer of research results in the department of Cauca were identified.

Afterwards, an intentional sampling of the groups was carried out. The characteristics of the participants are presented in Table 1. This selection shows a concentration of technical sciences, since among the selection criteria for groups that participated in the calls for innovation processes, these were the type of groups that had the greatest participation.

Table 1. Characterization of the sample of interviewed research group leaders.

	Knowledge area	Education level	University type	RRT	IAC
A	Natural Sciences – Computer and Information Sciences	PhD	Public		X
B	Agricultural Sciences --Agriculture, Forestry and Fisheries	PhD	Public	X	
C	Natural Sciences -- Biological Sciences	PhD	Public	X	
D	Social Sciences -- Other Social Sciences	PhD	Public	X	
E	Natural Sciences -- Chemical Sciences	PhD	Public	X	
F	Engineering and Technology – Environmental Engineering	PhD	Private		X
G	Engineering and Technology – Other Engineering and Technologies	MSc	Private		X
H	Engineering and Technology – Other Engineering and Technologies	PhD	Private		X

RRT: Research Results Transfer Call – Universidad del Cauca

IAC: University Industry State Society Call –InnovaAccion Cauca

Data collection. A semi-structured interview was designed to inquire about key aspects for innovation management in research groups. Here, 22 questions were raised on topics such as: Perception of innovation, Leadership, Strategy, Organization, Human resources, Knowledge management, Relationship with the context and the Research process. Semi-structured interviews "are based on a guide of issues or questions and the interviewer is free to introduce additional questions to specify concepts or obtain more information" (Hernández et al., 2014, p. 403).

Semi-structured interviews were carried out with each of the leaders of the research groups in person. The recommendations made by Hernández et al., (2014) regarding the planning, beginning, execution, end and phase after the interview, were followed. We obtained the approval of the interviewees for the audio recording of the interviews and the respective informed consents.

Data analysis. The recorded interviews were transcribed to text to facilitate analysis. Here, texts of the complete interviews were obtained, where all the answers provided by the interviewees are reflected. The Maxqda version 21 software was used to carry out the information categorization process according to what was proposed by Hernández et al., (2014). The analysis of secondary information sources such as articles was also used, which were reviewed. With information from secondary sources and from the characterization carried out with the research groups, the key factors for the construction of an approach for the management of innovation of the groups in the department were identified.

For this, a data triangulation process was carried out. It is understood as a mixture in a single study of different data sources, such as observation, interviews, and written documents (Quecedo and Castaño, 2002). It is a widely used methodology in social research, due to its advantages from the point of view of the contribution of validity and reliability to the process, results and conclusions.

In this step, we contrasted the information for the analysis of innovation management in research groups and in other areas carried out by other researchers. It was complemented with results in the research groups of the department. This was also based on the process of categorizing the information in each of the key factors analyzed. Thus, different perspectives were identified regarding each factor.

The results included a thematic grouping around key aspects for innovation management such as: Strategy, Leadership, Organizational dynamics, Relationship with the context, Human resource, Knowledge management, Resources, Context analysis and Research, development and innovation process.

Results

Strategy. The research groups are recognized as generators of knowledge and support for the training of their researchers. The engagement with innovation processes is not clear. This is possibly due to the little reflection that has been made around this topic within the groups. However, from the interviewed leaders there is a favorable predisposition for the beginning of these processes.

All the groups that do research, do innovation, but they do not make it visible in that way or do not know what they are innovating [...] I think that the groups have the skills but have not identified it (Woman, PhD, public U, social Sciences).

As research groups we should tend to provide the basis for innovation [...] more than facilitators, being support (Male, PhD(c), private U, engineering and technology).

When being consulted in relation to the strategic plan that they have developed as a research group, a variety of cases were found around this. For example, a strategic orientation directed from several elements such as: the institutional articulation with the research groups, the approach to common problems according to their field of work, providing support to postgraduate programs and the common goal that the groups pursue based on in the promotion of category in the classification of Colciencias (Today Minciencias).

However, cases were also found where the need for more work from its strategic work as a research group and a recognition of this lack was manifested. The information regarding the strategic plan of the research groups is presented below.

Table 2. Strategic plans of the research groups

Group	Workplan	Objectives	Challenges
A	Training, strengthening lines of research, infrastructure improvement, national and international positioning, project development	Application of technologies to the development of Colombian society. Formation of human capital. Contribution to industrial development	Support for master's and doctoral programs. international financing
B	Oriented to research lines	To be a benchmark in the generation and transfer of knowledge and technology. Promotion of human resources training. Facilitate establishment of mypimes. Positively impact society	Generation of knowledge and economic benefit through research. Technology transfer. Escalation of processes at the level
C	Training, publications, transformation in a development center, application for intellectual property rights	Oriented to research lines	Product and process innovation
D	ND	Development of research with social commitment. Contribution to the development of the region.	ND
E	Oriented to research lines	Training. Postgraduate study support. Contribution to regional development	Strengthen research lines. Improvement of technological infrastructure. High level publications
F	Project formulation, internationalization, networking, resource management, scientific production	Diagnosis of different types of needs to provide solutions. Contribution to multidisciplinary engineering work	Contribute to solutions in its research line. Impact on group classification. Postgraduate support. Social transfer of knowledge
G	Development of projects, postgraduate training, generation of publications, social appropriation of knowledge	Provide solutions to industrial problems of the department	National and international recognition
H	Training, project management, academic, institutional and business relations	Oriented to research lines. Support for the development of training programs	Generate regional impact. Conduct high-level research. Generate international relations

Source: Consultation service for research groups on the Scienti platform (10/12/2018)

There is heterogeneity in the understanding of the concept of innovation. Under this perspective, it is difficult to project development towards the promotion of innovation, if it is not clear what it represents and how the organization can benefit. This vision must be led from an institutional commitment, beyond teaching and university social extension.

Innovation is a revolutionary and transforming aspect that solves people's lives (Woman, PhD, public U, social sciences).

Leadership. The interviewed researchers show a clear intention to advance in the development of their groups. They are concerned about consolidating their processes and seeking financing to continue growing as a group. However, unlike other types of organizations, in research groups, the leaders also carry out teaching, university administration, and even social projection activities.

> I have several functions depending on the project, a principal investigator seeks that all the objectives are met, management compliance in administrative matters and financial management, technical development [...] (Woman, PhD, public U, social sciences).

The leaders of the research groups play a fundamental role in their development and transformation. They will be the first person who will be influenced by the decisions made based on innovation. These leaders, being also teachers, become the closest figure between the dynamics of the groups and the institutional directives.

A favorable element is the existence of a positive perception regarding the participation of innovation processes. However, tensions and uncertainties were also raised from the lack of knowledge about the role that groups can play in the framework of regional innovation systems.

> There is always a fear when you contact a businessman or an association, what will the interaction be like? What does the businessman expect or what does the community expect of us? And what do we expect from them? [...] (Man, PhD, public U, natural sciences).

Organizational dynamics. The structures of the groups are close to a concept of decentralization against decision-making. Its operation revolves around the lines of research, with autonomy in directing the leaders of each line. Generally, the maintenance of cohesion is the responsibility of a teacher from the institution, which also carries out administrative, extension, and research activities. In addition, research groups are close to adhocratic organizations in several respects. Its concentration occurs around specific projects, small groups of specialized people associated with the lines of research are created within, and they work in contexts of great flexibility and selective decentralization. However, once the projects are finished, there may be problems in the continuity of the group.

> When we had a large project, there were managers for each area. But as a group, as a leader I make some decisions, we have a horizontal organization, but in the end I feel with the same level of listening and learning. (Male, PhD, public U, engineering and technology).

Faced with the organizational structure of research groups, a centralized orientation based on new products or services is suggested. Added to a decentralized position from the processes where the ideas generated in each line of research are leveraged.

> The research group is a knowledge company, that's how I see it, [...] surely this type of models that are structured for our group, which is not easy, are new innovation processes, also, migrate to the laboratory, migrate to the technology-based company, possibly migrate to spin off (Male, PhD, public U, agricultural sciences).

This is important for the internal structure of a research group, which can enable this type of decision-making that favors innovation.

> It depends on the decision, but it is not authoritative, in general it is by consensus [...] I try to direct them to avoid differences between researchers (Male, PhD, public U, engineering and technology).

Regarding culture, it is a component that requires a greater depth of study and inquiry with the other members of the groups. From the testimonies obtained, it was identified that these groups indeed have extensive experience and dynamism in research, specialized in the areas corresponding to their lines of action.

However, the groups are immersed in bureaucratic and rigid structures such as the administrative structures of the universities. This generates tensions, derived from the contradiction between the forms of internal work in relation to the structural dynamics of HEIs. Although within the groups, the researchers maintain their own rules, their functioning and operation is subject to the policies of the institution. These policies directly influence aspects such as its technological capacity, its relational capital and even its sustainability.

Relationship with the context. The research groups have significant relational capital in university or academic matters, with national and international institutions. However, in front of departmental or governmental institutions, there is a distance. Likewise, although some approaches have been established with the business and community sector, there is not a broad dynamic of joint work, knowledge and participatory work. However, an intention to increase rapprochement with the business sector is recognized. Researchers find in this type of relationship an opportunity to become stronger as an organization.

> [...] It is a university policy that we have to work like this and according to the Colciencias guidelines that require work with research groups So we said there are three research groups here, why are we going to go there? (Male, PhD, private U, engineering and technology).

The interviewees referenced their link with the social sector. Some on their own initiative, and others were guided by institutional guidelines. However, efforts are still required to consistently involve civil society, for the development of collaborative processes around ST&I. With the public sector, this is perhaps the sector with the weakest relationship. A strong dynamic of collaboration is not identified. Mainly the public sector, it is understood as the entity that finances projects, but it is not considered as a strategic ally in the development of its activities as a group. Based on this, research groups as active agents of the Regional Innovation System (RIS), need to promote and strengthen their relational capital within the region, with the groups and institutions of the same.

> We have very few relations with the public sector, mayoralties or governorships (Man, PhD, public U, natural sciences).

Likewise, the dependencies in charge of the articulation with the environment of the HEIs must take a leading role in the permanent dialogue with possible allies, to generate a solid bridge that enhances these interactions.

In any relationship that you want to build, the fundamental thing is trust, and knowing the interested parties and then being aware that not everything is done for free, there has to be a counterpart, compensation in some way" (Male, PhD, U public, natural sciences).

Human resource. The human resource is transcendental; the researchers make possible the research groups, their lines and projects. So, there are machinery, laboratories, software; if scientific personnel are not available, the ST&I activity will not be possible. In this sense, the human resource of the groups is perhaps the greatest added value they have. The groups are made up of a critical mass of professionals with a high level of training (Master's, doctorate and post-doctorate) trained in high-quality national and international universities. They have extensive experience in their lines of research and in their area of knowledge. But no cases were found with strength in education and/or training in issues associated with innovation processes and their management.

The research groups are generally nourished by the undergraduate students who enter their research seedbeds, where they develop their initial research. Some continue their training processes up to postgraduate levels. The groups are influenced by the capacities, both for research and innovation that students may have from their training stage. In this sense, it is convenient that the institutions analyze the extent to which their students are receiving training that enhances knowledge and skills for both research and innovation.

So, the high level of training and experience of the members of the groups is a favorable point. But it is pertinent to consolidate training processes oriented towards the study, understanding and analysis of innovation processes. It can be done at the postgraduate level, with training plans to understand the innovation processes. It should be oriented towards research and innovation as complementary tasks.

Knowledge management. Knowledge management in university research groups represents the ability to generate new knowledge, disseminate it within it and incorporate it into all the research processes developed (Cabeza et al., 2019). Faced with knowledge management as a concept, some interviewees linked it with the generation of knowledge companies. From another perspective, this management was associated with different learning and teaching spaces. Among the practices mentioned, the joint work with the communities to listen to them and establish their needs was highlighted. But it was also recognized that it had been a spontaneous process derived from the experience that the teachers had had when touring the region.

Knowledge management is that organizations can maintain what they learn regardless of the people, mechanisms or activities that help them maintain, it may be that in their daily activities when people rotate they continue to advance and it is not necessary to start from scratch, when they rotate (Male, PhD, private U, engineering and technology).

However, according to results, it is possible that these knowledge management processes were taking place within the groups, but not consciously.

This has really been generated spontaneously from professors who have had experience […] (Female, PhD, private U, engineering and technology)

Resources. One of the main concerns of the groups revolved around the constant search for funding for their research. Some had made more progress than others in this regard, but their sources had concentrated on public funding. This each time seemed to be reduced more or increased the high competition to access it. They understood that it was pertinent to diversify the groups' sources of financing, such as in the private sector.

Despite the fact that sometimes other things arrive, such as consulting, we are still not self-sustaining and we depend on projects (Man, PhD, public U, engineering and technology).

Given this scenario, their survival is based on the resources they can manage from their participation in internal calls from the institutions, whose amounts are smaller, added to the access to resources from the recently created Ministry of Science, Technology and Innovation, and in recent years, the General Royalties System (SGR, in spanish). However, it is difficult to speak of homogeneous financing, since only a few groups have been more dynamic and have benefited from their proposals. It could not be affirmed that in all the groups there is access to resources such as those of the SGR, which at the time represented the largest amounts. Likewise, the country still maintains a low investment in these types of items, which are concentrated in regions such as Bogotá DC, Antioquia, and Valle del Cauca.

Research groups do not have their own financial management unit that allows them to manage resources. These processes are immersed in the university structures that manage the other procedures of the institutions. The dynamics of the groups can be diverse. Some depend exclusively on the existence of projects. Others are maintained from undergraduate and/or postgraduate students, and others only have teachers linked to the university institution.

Context analysis. The analysis processes of the nearby technological environment are weak. With some cases, an extended collaboration link is not generally presented to identify real needs of the environment. Spaces for interaction and exchange of knowledge between groups, industry and society are limited. No clear practices are identified regarding market studies or carrying out concept tests.

Extended practices in terms of technological or prospective surveillance exercises are not recognized. Regarding the performance of technological surveillance or prospective exercises, the general trend is to associate technological surveillance with the survey of states of the art. One of the leader's comments that although they do not do it, they do work hand in hand with another group with experience in this type of tool. Regarding the prospective studies, only two of the investigated groups stated that they had carried out this type of research.

Research, development and innovation process. Regarding the generation of ideas, the processes are varied. Some start from the initial identification of problems with work communities. They are also based on bibliographic searches and states of the art, with a chain view, where the suitability or not of the same is analyzed based on the possibilities of future projection. For the selection of ideas, prioritization is used, although they are also subject to the terms of reference of the calls for funding resources. In general, it seeks to articulate the demands of the financing sources.

There is a clear intention to try to identify those problems that can be solved from the lines of research handled by the groups. This dynamic is presented from several strategies such as: the collective construction of problem trees with the communities, the interaction with an interface agent that serves as information supply and identification of requirements. One of the leaders explains the experience of their technological developments that began to be designed from the laboratory, but were adjusted based on tests in real conditions, which they had not considered at the time.

The research groups have maintained an important dynamic regarding their research processes, motivated by various aspects: experience, training, and the need to manage resources for their survival. The groups are shown as a great cluster of developers of ideas, although in various ways, these research groups have been able to consolidate various projects within the framework of their lines of research.

Discussion

About strategy, different strategic scenarios are considered; establishing objectives for the generation of ideas accompanied by resources and monitoring of a work plan (Cooper, 2019). Organizations require relevant means of planning and management. They need to consider innovation more rigorously, as well as understand its strategic nature and develop the capacity to manage it (Tavares & Velez, 2023). For example, in a study carried out on the implementation of sustainability strategies in state universities in Italy, it was found that the main challenges for sustainable innovation are internal, mainly associated with organizational aspects, but with less effect in those universities whose mission already incorporates sustainability (Rotondo et al., 2023).

In this sense, the research groups presented weaknesses in the face of strategic planning oriented towards innovation. Although there was a predisposition and positive assessment of the process, they still did not have a clear strategy for taking advantage of their research results. In addition, there were no guidelines from the universities to improve this.

HEIs can support their interested research groups to develop strategies for the transfer of their research results. The creation or strengthening of areas for technology transfer or linkage with the environment within HEIs can contribute to this.

Likewise, in research groups, the role of leaders is decisive for strengthening their management and promoting their survival (Durand, 2017). Sensible leadership seeks communion between the members of the group, to promote growth, joint learning and a shared vision (Salvador et al., 2018).

In innovation teams, it can be difficult for a single leader or member to master all the required knowledge. Studies have found that shared leadership enables the adoption of a decentered approach to innovation. Here knowledge is shared and disseminated among team members, leveraging individual knowledge at the team level, improving its innovative performance (Tang et al., 2024). In a study of teams participating in innovation and creativity competitions, he sought to explore the effects of team diversity, emergent leadership, and shared leadership on team performance. Here it was found, for example, that team diversity and shared leadership are important factors that affect team performance (Tseng et al., 2024). Similarly, in the analysis of organizations in the fields of information technology (IT), software and mechanical engineering linked to the development and improvement of new technologies, products and services, it was found, for example, that shared leadership had a positive effect on team member exchange, resilience team and team innovation (Tang et al., 2024).

New group leaders face several challenges, related to an expansion of responsibilities and expectations, added to other responsibilities such as teaching or public outreach and others (Monaghan et al., 2023). A similar situation was raised by the leaders interviewed. Their role goes beyond the role of researchers and can reduce time and resources to focus on innovation processes in their groups.

In short, there are several factors in favor of advancing toward innovation dynamics. However, it will be essential that the leaders of the groups are sensitized beyond their role as teachers and researchers and can count on management tools. It will be key for the leaders to direct a clear commitment toward innovation processes, because if they do not have it, it will be very difficult for the other members of the groups to take part in this type of commitment.

On other hand, through the case analysis carried out by Gao et al (2021), the formation of an appropriate cooperation structure and an innovation network for their research teams is found. Where the formation of the open, complex and dynamic ecosystem of the group was formed from the exchange and cooperation of young scientists, with other researchers and postgraduates, becoming a larger cooperative network, forming an open, complex and dynamic ecosystem. Similarly, an adhocratic culture based on flexibility and change is required; where organizations perform in dynamic contexts and their values coincide with creativity, entrepreneurship and risk taking (Naranjo et al., 2016). On the other hand, compared to decision-making based on the level of trust, it requires high integration by the participants and a high transfer of authority to lower levels of the organization to strengthen the orientation on innovations (Sperber, 2017).

However, promoting a culture of innovation within them is a challenge that requires greater efforts. A structural definition that encourages innovation is linked to the possibility of generating interaction with cooperative environments. In this sense, the consolidation of an innovative culture requires the solidification of values, habits and knowledge, such as trust and empathy (Jo and Park, 2018). Likewise, the organizational climate and culture are the fundamental basis for innovative organizations from the promotion of the generation of new ideas (Cooper, 2019; Sperber, 2017).

In this sense, the research groups have flexible structures and their project work are characteristics close to those of innovative organizations. But the administrative work from the universities remains rigid and slow, which makes it very difficult to consolidate processes such as the University-Industry articulation. Given this, it is valuable for university directors to question the fluidity of their administrative, planning, and strategic processes. Also understand how these can be facilitators or barriers to university innovation, technology transfer, technology licensing and University-Industry-State-Society links.

So, the institutional support of HEIs is relevant to facilitate collaborative work with external organizations, because the interaction of researchers with external actors contributes to the strengthening of R&D processes (León et al., 2024). An innovative research group presents basic characteristics of an innovation ecosystem, related to an innovative cooperation network. These groups also require the formation of networks and a cooperation ecosystem, articulated with larger scientific and technological organizations and industry innovation ecosystems (Gao et al., 2021).

For example, Cobo (2024), who analyzed four studies linked to the relationship between academia and community, highlights the role of universities as key agents of positive transformation, and their relationship with communities as a fundamental axis for the articulation of academic research and community knowledge. Therefore, the importance of consolidating collaborations of educational institutions with communities, government agencies and other relevant stakeholders is highlighted.

Also, for example the results of a study carried out with data from 108 selected universities suggest that University-Industry collaborations are relevant in the creation of new technology-based companies in universities. In addition to higher interaction between university and different companies, the probability of creating this type of company increases (Martínez et al., 2023).

However, in this relationship, the value of trust plays a transcendental role, since it enables the exchange of knowledge and the articulation of joint work around complex tasks (Pino et al., 2018). To sum up, the different processes of linking with the environment of the research groups, needs deep reflections regarding the construction of trust. If perspectives of mistrust remain on the part of the academic communities towards the environment and vice versa, it will be a barrier to an effective relationship.

Also, human capital, which includes skills, information, capabilities and personal attributes, is key in the acquisition, organization of knowledge and promotion of innovation in a country. For example, when analyzing data from 39 Asian countries between 2000 and 2021, it was found that institutional quality and human capital are the main drivers of innovation (Danta & Narayan, 2024).

In this sense, incentives are also part of this management, where they can range from monetary rewards to individual recognition (Sperber, 2017). In this regard, Ocampo et al (2019) mention that a first step towards a greater generation of companies has to do with a reorientation of the curricula of science and engineering faculties, with an emphasis on project-based learning with the potential to become alternatives for the market.

In the case of the research groups analyzed, human talent represents one of their most valuable assets. As explained, there are highly trained personnel in specialized areas. However, it is pertinent to analyze how human capital is valued in terms of scientific personnel available to groups and institutions. That is, how research seedbeds, young researchers, professional researchers, and postgraduate students are valued and strengthened. A motivated and valued scientific staff will be key for both institutions and research groups.

In relation to knowledge management in research groups, Páez et al., (2016) identified that these processes are still weak and their effect is little on innovation in research groups. Similarly, in an analysis about research groups, that had the practices of using e-mail, telephone conversations, and research meetings are the most frequent means; added to the presentation of results through publications in journals and attendance at events (González et al 2015). However, in university environments, the barriers to this process are based on the "multidisciplinarity of professions, the high resistance to change, the organizational structure and the lack of incentives for researchers" (González et al 2015, p. 234). In this sense, for this knowledge to circulate within the organization, it is pertinent to have communication channels appropriate to the process and the objectives. So that innovation can be positively influenced from informal communication, such as verbal agreements, conversations or short meetings (Sperber, 2017).

First, there was no clear understanding of this type of process and second, they handled informal strategies for this management. Similar results were found by García & Gómez (2015) in their analysis of knowledge management practices in research groups. They describe that these practices are not planned, but developed informally.

From the understanding of knowledge management, some positions were close to what was proposed in theory. Possibly the groups developed knowledge management processes, but they did not have a high appropriation of these practices. Significant support is required for knowledge management, as a key component both for innovation processes and for research and development.

About resources for innovation, the link with the context, the formation of alliances, the orientation to participatory research and the consolidation of research processes oriented, for example, towards innovation or technology transfer, can provide the possibility of access to new financing opportunities. Funding entities increasingly promote this type of collaboration, as presented in the characteristics of some of the calls made by Minciencias in recent years. In these calls, the formation of alliances with the private, social and public sector is promoted and encouraged, for the consolidation of research commitments. Pre- and commercial validation exercises for prototypes of technology-based companies are also promoted and the possibility is opened for the generation of proposals based on the use of knowledge and its application in products, goods and services.

According to the latest calls for resources from the General System of Royalties, research commitments framed in the solution of the needs of the context are promoted with greater intensity. Given this scenario, it is worth asking, if a research group that prefers to continue with "walls inwards" dynamics, will it have the possibility of accessing this type of resources?

However, the concern of research groups about financing can be related to Colombia's lag in investment for R&D compared to other countries in the region (National Planning Department, 2022).

Moreover, for technology transfer processes, it is convenient to maintain a commercial perspective of developments (Ocampo et al., 2019). Data related to the market (size, growth, and competitive situation) are necessary for the selection of projects (Cooper, 2019). For example, technological surveillance is an important tool for both business and research, where information is sought, managed and used for decision making (Rojas, 2023).

Although progress has been made in understanding the needs of the context, it is pertinent that this dynamic be consolidated in bets aimed at solving real problems. Research groups need to make a pertinent interpretation of the needs of society.

Focus and efforts are needed to collect and systematize information from the department of Cauca, related to the state of local technology, needs, and possibilities. It is pertinent to identify technology gaps, to propose solutions adjusted to local requirements. A focus on local use should not limit your expansion into global markets. It is necessary to establish information systems regarding departmental scientific advances represented in degree works, research articles, books, research projects, and technological development products, among others. The recognition of technological demands and offers represent a key input for the analysis of the environment for research groups.

Conclusions

The study of innovation management requires a deeper analysis from logics other than business contexts. It is pertinent to review its application to the university context, where the growing demands regarding its relevance and socioeconomic and environmental impact are increasing.

In the department of Cauca, Colombia there is an important base of research groups in different areas of knowledge and with different levels of development. But orientation of research group has focused mainly on the generation of new knowledge and the training of human talent. The products of technological development and innovation still do not have a leading role in the results of these organizations. This is not exclusive to Cauca, in Colombia low levels of development and transfer of knowledge and technology to the productive sector prevail (National Planning Department, 2022).

There is interest in promoting practices in search of the generation of innovation from research groups. But limitations, fears, and tensions that have prevented the development of this type of process are recognized. For example, the University - Industry relationship is complex and presents barriers, such as the bureaucracy involved in this relationship, which also makes technology transfer difficult. There is also little knowledge of the benefits of collaborating with external actors. Which is aggravated when there are differences in expectations between potential allies (Bürger & Fiates, 2024).

From results, favorable traits towards innovation management were identified in regional research groups related to strong leadership, high motivation towards their work as researchers, consensual decision-making, functioning around lines of development, high training of human resources linked to an accumulated experience in their areas of knowledge and a positive perception towards innovation. But, weaknesses were identified in the process, mainly related to the distant strategic vision of the scope of results in terms of innovation, the low recognition of knowledge management, the weak relations with the industry and public sector, tensions with the administrative entities of HEIs and differences with the ST&I evaluation models in the country.

The innovation management of the groups in the department of Cauca cannot be understood from an isolated perspective, since it must coincide with the institutional guidelines that influence and determine the development of the groups. Therefore, the consolidation of innovation targets of the research groups requires a strategic, continuous and efficient accompaniment from the different university structures.

The creation of relationships of trust with the communities offers research groups the alternative of carrying out their work based on real parameters and conditions, consolidating new start-ups and fostering social commitment. In addition, the development of technologies without participatory processes, from the communities or from the company, can generate barriers in the transfer of results (Ocampo et al., 2019).

There are factors that even transcend the university context. These have to do with the existence of innovation context, where, for example, a predominantly industrial economy contributes to better results in innovation (Passos et al., 2022). This in a context like Cauca is quite different, because although research groups develop technology, there is still no significant industrial dynamism in the region, in addition to being a context of low technological intensity.

Limitations

Given the limitations and future research, the type of qualitative methodology in a specific geographic region makes it difficult for the results to be generalized to other regions directly. So complementing it with a quantitative approach can be valuable. Likewise, this study based the collection of information with the leaders of the research groups, so the results are based on their responses. This study carried out a general analysis of different factors associated with innovation management, so no depth is generated in specific factors, reducing the specialization of the results.

The available evidence related to innovation management systems and their results is still scarce, with limitations for its generalization and even contradictory. Innovation management still represents a new and expanding process that requires further empirical scientific research (Tavares & Velez, 2023). For that, another important research opportunity is empirical studies on the dynamics of research groups highlighted by their links with the industry, their advances in technological development or their important experience in knowledge and technology transfer processes. Also, it would be necessary to continue analyzing innovation dynamics in research groups at universities and other HEIs in other regions, both nationally and internationally. It is pertinent to continue with research into innovation processes in contexts of low technological intensity.

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