Turning the Innovative Behavior in a University Lab into University-Industry Partnership

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One of the most relevant role of the university in society development is to prepare professionals and to bring new knowledge and technologies to the world. The Laboratory of Bioengineering (Labbio) of UFMG, Brazil, have been experiencing the development of innovative society-driven products and projects. As a research laboratory the main focus is to conduct research and not necessarily generate and transfer technology of market interest. However, an important characteristic of this lab is the guideline to bring to society the health technologies developed, while maintaining an entrepreneurial mindset in its team, mainly formed by graduate and undergraduate students. The aim of this paper is to analyse the current Labbio partnerships with industry and the innovative behavior help from the researchers that can support and contribute to their increase. The results show that the existence of the technology transfer office in the university is one of the means of market interface, but the success of the relationships between the university laboratory and companies is also attained due to the established trust and the possibility of continued research. This experience may be an inspiration to other university labs to analyze their human potential to transform their research results into products and to better communicate with the industry.

Keywords: Innovation, Innovative Work Behavior, University-Industry Partnership.

1. Scenario of a university research laboratory in Brazil

The main goal of research laboratories in universities is usually to develop research, whether basic or applied, that enables the development of science. It is considered that within a research laboratory, besides teachers, students, researchers, equipment and supplies, there is the generation of new knowledge. This article seeks to analyze characteristics of the behavior of innovative researchers in laboratories and the results of industry-university partnerships. This research was carried out in a university research laboratory located in the state of Minas Gerais, Brazil, at the Federal University of Minas Gerais, UFMG.

Brazil's socio-economic context makes it rank 79th out of 188 countries in the United Nations for Development Program's Human Development Index (HDI) list (UNDP, 2016). The HDI is an index measured annually by the UN and uses indicators of income, health and education. The world ranking of human development in the countries presents the index of each nation, which varies from 0 to 1 - the closer to one, the more developed is the country. Brazil recorded HDI of 0.754 in 2015. In that year, in South America, countries such as Argentina, Chile, Uruguai and Venezuela had

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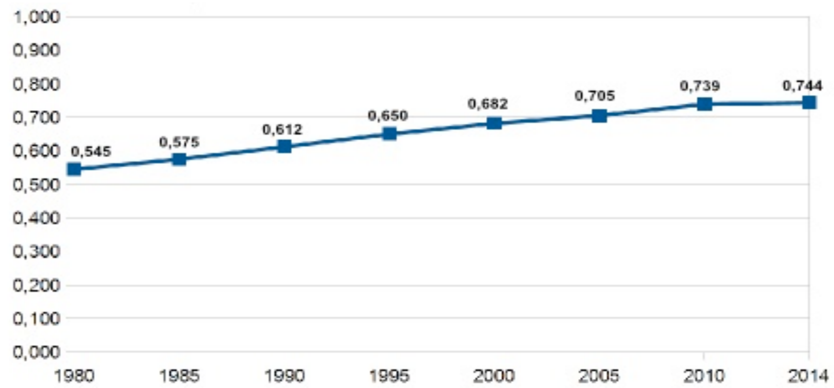
better human development indexes, whereas in the BRICS group, Brazil stood behind Russia and ahead of India, China and South Africa.



Graph 1 - Brazilian HDI Evolution (1980 - 2014) (UNDP, 2016)

The Gross Domestic Product (GDP) is the sum of all the goods and services produced in the country and serves to measure the evolution of the economy. Brazil's GDP grew by 1.0% in 2017, the first high after two consecutive years of decline. The data were released by the Brazilian Institute of Geography and Statistics, IBGE. In current values, GDP in 2017 was R$ 6.6 trillion. The result shows that the Brazilian economy began to recover in 2017, but still does not restore the losses of economic activity in the crisis. In 2016 and 2015, GDP declined 3.5% over the previous year, in the country's largest recession in recent history. The increase in GDP was mainly due to the performance of agriculture. In Industry, the highlight were the Extractive Industries (4.3%), and the decrease in the Construction sector (-5.0%).The main negative results were financial activities, insurance and related services (-1.3%), information and communication (-1.1%) and Administration, defense, health and public education and social security (-0.6%). (IBGE, 2017). The expectation for the GDP growth fell from an optimistic 3% in early 2018 to 1,5% as of August, 2018 (BRAZIL,2018).

Brazil is one of the countries that spends the least on elementary and high school students, but spending on university students is similar to that of European countries, according to the Organization for Economic Co-operation and Development (OECD). Brazil spends US$ 3,800 (R$ 11,700) annually per student in the first cycle of elementary school (up to 5th grade), according to the document. In the final years of elementary school (4 years) and high school (3 years) the situation is no different. Brazil spends annually the same sum of US $ 3.8 thousand per student on these cycles. As for university student spendings, the amount goes to almost US $ 11.7 thousand (R$ 36,000), more than triple the expenses in primary and secondary education (G1, 2018).

Data from the Ministry of Education show the history of federal government transfers to each of the country's 63 federal universities in the last decade, and indicate that 90% of them had a real loss in the budget in the past five years; national budget shrank 28%. Institutions also felt a drop in investment, which hindered the continuation of reforms and works, the opening of new courses, including the stoppage of the purchase of equipment for laboratories and classrooms (G1, 2018).

Federal universities' professor salaries are compulsory expenditure, but not student aid, including scholarship grants for master's degrees and doctorates. Lack of funding paralyzes major research from federal universities. CAPES, which is one of the federal government agencies that supports research granting scholarships, says the cuts planned in the 2019 budget will have serious impacts on its graduate programs. Among the consequences cited in a CAPES High Council document is the interruption of the payment of all masters, doctoral and postdoctoral fellows and other programs, which will impact more than 440,000 students, researchers and professors that would stop receiving financial aid (MEC, 2018).

In this scenario, the Brazilian public universities that have stood out for the quality of their research in laboratories use creativity and move in the direction of seeking partnerships to foster continuity of work and contribution to innovation, whether through the networking relationship of leading researchers in research labs or through partnerships with industries that believe in the potential of university research. The University has the role of forming citizens prepared to meet the specific needs of people's quality of life. In addition to the labor training role, the university has been increasingly prominent in the generation of technology and innovations.

Placed in the southeast of Brazil, the most industrialized region of the country, UFMG, a free-of-charge public educational institution. It was founded in September 7th 1927 with the name of University of Minas Gerais (UMG). Nearly one hundred years later the institution is the national leader when it comes to education, university extension, culture, scientific research and patent generation in several fields of knowledge (UFMG, 2018).

UFMG has a network of 600 laboratories, 755 research groups and 2,500 researchers. Until 2015 UFMG was the largest patent depositner at the National Institute of Industrial Property (INPI) with 738 national patents, 296 international patent deposits, and 78 licensing contracts (technology transfer for the productive sector) (UFMG, 2015). According to the National Institute of Industrial Property (INPI), UFMG currently has 924 registered patents (INPI, 2018). According to the UFMG innovation indicator patents, it is verified that the faculty of researchers has generated new ideas with transfer potential for the industry, however, only having the patent does not mean that there is the relationship between industry for innovation. It is also observed that the number of technological transfers (78) is a low number compared to the total potential (924), it represents around 8% (INPI, 2018).

Thus, the aim of this paper is to investigate whether the innovative behaviors in Labbio (UFMG) impacts on the increase of industry-university partnerships. Our research hypothesis is that innovative behaviors at work influence and support the development and continuity of partnerships between university and industry.

2. Theoretical Framework

2.1 Bioengineering Laboratory

The Laboratory of Bioengineering of UFMG - Labbio, was inaugurated in 1999 and is described as a university research laboratory in the fields of Biomechanics, Photobiomodulation, Assistive Technology, Cardiovascular Biomechanics, Biomimetics, 3D Printing, Photodynamic Therapy and Medical Devices. The research is conducted by a multidisciplinary team from the health sciences (medicine, physiotherapy, pharmacy, dentistry, and physical education) and engineering fields: mechanical, electrical, chemical, and mechatronics (UFMG, 2018). For it integrates multidisciplinarity it is able to focus on the development of devices which solve problems and contribute to human health. Labbio has so far formed 10 postdoctors, 30 doctors and more than 50 masters. Many undergraduates made the first contact with scientific activity through Labbio. Currently, Labbio has 3 postdoctoral students, 8 PhD candidates, 5 master's students and 16 undergraduates. Since its foundation, labbio has produced more than 100 scientific papers and 50 patent applications. The main research areas are cardiovascular engineering, biomaterials, methods of laser therapy and cryotherapy, rehabilitation engineering, methods of diagnosis and therapy in dentistry, neurovision, safety engineering, plastic surgery, cardiac surgery, laser in dentistry, and sports biomechanics (LABBIO, 2018).

Across Brazil, other bioengineering laboratories specialize, in general, in similar areas. The laboratory from the Federal University of Rio de Janeiro (UFRJ) works on the study and optimization of the properties of polymeric biomaterials that can be used in contact with living tissues in order to restore or replace damaged tissues (UFRJ, 2018). The Institute of Aeronautical Technology (ITA), located in the state of Sao Paulo, created a bioengineering nucleus in August 2009, and has ever since developed solutions for the health sector, identified by the partners of the local hospital and university area (ITA, 2018). Lastly, at the Federal University of Santa Catarina (UFSC), the bioengineering develops instrumentation (hardware and software) for the recording and analysis of behavioral and physiological data in the laboratory. These instruments are intended to support research lines in Neuroscience with methods that include observation of the effects of drugs or neural manipulations on both behavior and concomitant physiological signs (UFSC, 2018).

2.2 University - Industry Partnership

The university has traditionally been seen as a structure supporting innovation by providing trained people, research results and knowledge to the industry (Etzkowitz, 2003). What is peripheral and what is central to innovation has been transformed in recent years, since knowledge-producing institutions have developed the organizational capacity not only to recombine old ideas and to synthesize and conceive new ones but also to translate them into use (Etzkowitz, 2003). The traditional triple helix of innovation (university-industry-government) is born with the emergence of an entrepreneurial academic spirit that combines an interest in fundamental discovery and application, and that instead of being subordinated to an industry or a government, the university emerges as an important actor and an equal partner in this "triple helix" of university-industry-government relations (Etzkowitz, 2003).

University and industry collaboration is a critical component to the efficiency of the national innovation system, with diverse benefits ranging from collaboration to R & D agenda and stimulating private investment and exploitation of synergies. The existence of several types of relationship between universities and industries is due to the objectives, scope of work and institutional arrangements (Guimon, 2013).

Open innovation rightly proposes working with intelligent people inside and outside the organization so that external and internal feedback is a source of improvement and sees external intellectual protection as a source of change for improvement (Chesbrough, 2006). In this way, the university, as an organization that has to generate open innovation, must pay attention to the external sources of different areas of knowledge that can add by their intelligence and know-how for the improvement. The next generation of discovery will push the institutions to change the traditional paradigm of researching and go ahead the changes and create scenarios for the future, as Chesbrough (2006) called "the new role of research": to go beyond knowledge generation to connection. In this sense the cooperation for conducting research between technology centers or university laboratories and industry it is recommended that the research be guided by the technology development demands from the industry.

The university is the generative principle of knowledge-based societies just as government and industry were the primary institutions in industrial society (Etzkowitz, 2008). In this way, intellectual property issues and strategies have been a source of confusion at virtually all universities and research labs in developing new technology ventures and industry collaborations (HO *et.al.*, 2010). In most cases, the valuation of patents by the university differs from patents`s valuation by the industry. The intellectual property is not the only source of competitive advantage in starting a new venture, and in some cases, expertise or "know-how" may be a more appropriate source of advantage. One of the most valuable aspect of University-Industry collaborations is the access to the university researchers to experts and thought leaders in relevant industries, to exchange.

According to Chesbrough (2017) traditionally research in intellectual property has been driven by the quest to understand the scope of substantive intellectual property law, so the audience for mainstream legal research on IP is usually other legal scholars, assuming the role of intellectual property as an enabling mechanism for innovation, as a means to promote the open exchange of innovation inputs. However the evolution of intellectual property management practices considers that IP can inhibit open innovation and effectiveness (Chesbrough & Vanhaverbeke & West, 2017). If we consider the university IP protection as a result of any technological development partnership with industry, it is omitted any role for managers of industrial firms in this process. The neglect of any role of management in overseeing the innovation process is a glaring deficiency that deserves to be redressed, so there are many possible paths for IP creation, such as trade secret, copyright, patent, trademark, design right, publish, neglect, rely on lead time (Chesbrough & Vanhaverbeke & West, 2017).

The historical roots of the pattern of interaction between universities and companies in Brazil present the localized existence of "points of interaction" between the scientific and technological dimensions and one of the important causes of the weakness in these interactions in Brazil is the articulation between the late character of creation of the research institutions and universities in the country and the late character of the Brazilian industrialization (Suzigan & Albuquerque, 2007). According to Nussenzveig (2004), the university has two main functions, to generate well-qualified professionals, to form people, and to generate knowledge through research, being that in Brazil public universities are the best in Brazil and are essentially the only ones that produce knowledge. The Nuclei of Technological Innovation, NITs, are considered a bridge between university and market for the transfer of technology to the companies. In Brazil, protection of technology began to be valued only in the 1990s for support to identify the paths and procedures between the research laboratory and the market (Pinto, 2010).

The technological transfer of universities in Brazil to industry involves several channels, and patents are used as a main technology protection mechanism when it involves products, equipment, prototypes or materials, however, new processes or techniques tend to involve industrial secrecy, or other mechanisms since different types of technology require different transfer channels (Povoa & Rapini, 2010). Brazilian universities present a set of products and respective areas of knowledge with greater interaction with companies and government, but the "interaction pattern" identified is quite limited and still insufficient to impose a dynamic of economic growth based on the strengthening of the country's innovative capacity (Suzigan & Albuquerque, 2007). In general, in all products in which Brazil presents comparative advantages in the international scenario, it is possible to identify a long historical process of learning and accumulation of scientific knowledge and technological competence, involving important articulations between productive effort, government and educational institutions and search (Suzigan & Albuquerque, 2007).

In analyzing the Brazilian industrial environment, heterogeneity in the vast territorial extension contributes to the National Innovation System finding irregularities of functions or adaptation of university functions due to the need of the industrial sector (Rapini *et al.,* 2009). According to a survey conducted to evaluate the interaction between companies and universities in the state of Minas Gerais, the role of universities was identified as besides being a traditional source of information and reliable update or repository of specialized labor for training and replacement or complementation of the area of Research and Development of companies (Rapini *et al*., 2009).

The partnership between university research laboratories and industry permeates a relationship beyond intellectual protection and generation of new products, but consists of reconciling the interests of society with the development of applied research relevant to social change.

2.3 Innovative Behavior in the University Research Labs

The concept of innovative behavior at work comprises three forms of behavior: idea generation, ideas promotion and ideas implementation (Janssen, 2000; West, 2002; Woods *et al.,* 2017). The theme of "innovative behavior" is often associated with the performance of people who work with the generation of innovation, described in the literature as practices, habits, routines that facilitate creativity and the generation of ideas, and the consolidation or implementation of innovation. According to Bandura (1977), persistence in activities that are subjectively threatening, but in fact relatively safe, produces, through domain experiences, greater improvement of self-efficacy and corresponding reductions in defensive behavior. In this way, investigating the existence and persistence of innovative behaviors becomes relevant to the research and development of innovation. Researchers around the world develop this theme, correlated to the many factors that impact on the innovation process precisely because the main actor in the innovation process is the people. According to Knippenber (2017), there are key constructs for working with innovation mainly in regard to creativity and teamwork. Innovation is typically understood as the introduction and intentional application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, group, organization, or the society in general (West & Farr, 1990).

The main stages of an innovation process involve: the search for innovation opportunities, selection, implementation and value capture (Tidd & Bessant, 2015). In this way, investigating in each one of the stages which are the drivers can contribute to the identification of innovative behaviors and standards. According to Janssen (2000), surveys conducted since 1994 present scales for assessing innovative behaviors at work and generally refer to the stages of innovation: idea generation, sharing or dissemination of the idea and implementation of the idea.

When considering that the motives that individuals to certain behaviors may be the most diverse, the option of several researchers is to identify the existence of behaviors defined as innovators (Janssen, 2000; Janssen & Vliert & West, 2004; De Jong & Den Hartog, 2010; Woods *et.al*., 2017) and work on obtaining them after measurement. The Janssen metric scale assesses innovative behavior at work by self-assessment or evaluation of others as leaders (De Jong & Den Hartog, 2010). Janssen

(2000) formulated specific questions to measure innovative behaviors in the generation phase of the idea, the innovative behaviors expected in the dissemination phase of the idea and the behaviors expected in the implementation phase of the idea, with a strong statistical correlation between the constructs. Here are the detailed questions of Janssen's (2000) scale of innovative behavior.

According to Collins (2017), one of the functions of the university is knowledge production and development of strategies for global problems solutions, so the university has great potential but can also be subject to criticism of higher expectations. The university research labs emerged and were formed out of the character of institutions and scholars who have a long research agenda history with a specific development focus. It is important to address the function and purpose of the research labs and the behaviors that are expected to be inside of this cultural environment to develop innovation (Collins, 2017).

The innovative work behaviors at University Research Lab is guide by motivation of discovery new technologies or products and knowledge, and represents the way of work in a daily routine of the researchers to get in contact with the new possibilities of technological uses.

3. Methodology

The methodology used in this study was Case Study (Yin, 2005) to analyse the current Labbio - UFMG partnerships with industry and the innovative behaviors from the researchers. According to Creswell (2010), the use of quantitative and qualitative data helps to expand the understanding and convergence or confirm results from different data sources. Field research was conducted in the Bioengineering Lab at the Federal University of Minas Gerais, Brazil. This research has an explanatory character of a quantitative and qualitative nature, with the use of mixed methods procedures: a survey and semi-structured interviews with different stakeholders inside Labbio. The data collection was performed in two concomitant stages. For the quantitative analysis, it was performed through the online application of closed questionnaires (survey) to the respondents. Closed questions are very common because they give greater uniformity of responses and are more easily processed. Mailing the online link of the questionnaires made the respondents more practical and comfortable, and facilitated data analysis. The questionnaire was constructed based on the 9 questions scale of the Innovative Work Behavior (Janssen, 2000) and the 8 questions of the University-Industry partnership typology (Guimon, 2013). The questionnaire closed questions followed the categories indicated by the literature, that is, the Innovative Behavior construct, which comes from the combination of three groups of questions, from the categories: generation of ideas, dissemination of ideas, and implementation of ideas (Janssen, 2000). The questions of the questionnaire regarding industry university interaction follow the three guideline relationship: high relationship, medium relationship and low relationship (Guimon, 2013). The scale of responses of the questionnaire used was the linkert of 5 points, where the minimum value is 1 and the maximum possible value is 5. The sample for the survey consisted of 33 researchers, which represents 66% of the whole Labbio team (50). To carry out the second stage, during the same period in which the online questionnaires were being filled, five interviews were conducted face-to-face at the interviewees' workplace at Labbio.

4. Data analysis and Results

The results present the self evaluation of the innovative behaviors from the Labbio's researchers and the current Labbio partnerships with industry. Qualitative variables were described by means of absolute and relative frequencies, while quantitative questions were described by mean, median and standard deviation.

4.1 Quantitative results

The quantitative analyzes of the results of the questionnaire were performed by statistical software SPSS 19.0, which will present the result of the correlation analysis between the variables surveyed, whose data collection involves the application of a questionnaire.

4.1.1. Measuring the Innovative Behaviors and the University-Industry Partnership

Descriptive Statistics

	Mean	Std. Deviation	N
IdeaGeneration	3,4040	,54491	33
IdeaDissemination	3,2626	,68088	33
IdeaImplementation	3,0606	,80990	33
InnovativeBehavior	3,2424	,59216	33

Table 1 - Descriptive analysis of the construct Innovative Behavior in which it is observed that the highest mean in the Idea generation behavior.

Descriptive Statistics

	Mean	Std. Deviation	N
HighUI	3,2323	,87196	33
MediumUI	2,5000	,94373	33
LowUI	3,5152	,92830	33
University Industry Partnership	3,1515	,93110	33

Table 2 - Descriptive analysis of the construct University Industry Partnership in which it is observed that the highest mean in the type Low UI for the technology transfer.

Correlations

		IdeaGeneration	IdeaDissemination	IdeaImplementation	InnovativeBehavior
IdeaGeneration	Pearson Correlation	1	,594**	,588**	,802**
	Sig. (2-tailed)		,000	,000	,000
	N	33	33	33	33
IdeaDissemination	Pearson Correlation	,594**	1	,707**	,888**
	Sig. (2-tailed)	,000		,000	,000
	N	33	33	33	33
IdeaImplementation	Pearson Correlation	,588**	,707**	1	,907**
	Sig. (2-tailed)	,000	,000		,000
	N	33	33	33	33
InnovativeBehavior	Pearson Correlation	,802**	,888**	,907**	1
	Sig. (2-tailed)	,000	,000	,000	
	N	33	33	33	33

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 - Correlation between the phases of the innovation and the construct Innovative Behavior

The research results showed a significant correlation between the questionnaire questions on each type of innovative behavior and the final construct Innovative Behavior. That is, the questionnaire was validated for this sample and showed that it measured what is available to measure (Table 3). Also, the results showed a significant correlation between the questions on each type of University Industry relationship and the final construct University-Industry partnership. So, the questionnaire was validated for this sample and showed that it measured what is available to measure (Table 4)

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Correlations

		HighUI	MediumUI	LowUI	UIPartnership
HighUI	Pearson	1	,633**	,332	,744**
	Sig. (2-tailed)		,000	,059	,000
	N	33	33	33	33
MediumUI	Pearson	,633**	1	,577**	,862**
	Sig. (2-tailed)	,000		,000	,000
	N	33	33	33	33
LowUI	Pearson	,332	,577**	1	,720**
	Sig. (2-tailed)	,059	,000		,000
	N	33	33	33	33
University Industry Partnership	Pearson	,744**	,862**	,720**	1
	Sig. (2-tailed)	,000	,000	,000	
	N	33	33	33	33

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4 - Correlation of the types of UI relationship and the construct University Industry Partnership

Correlations

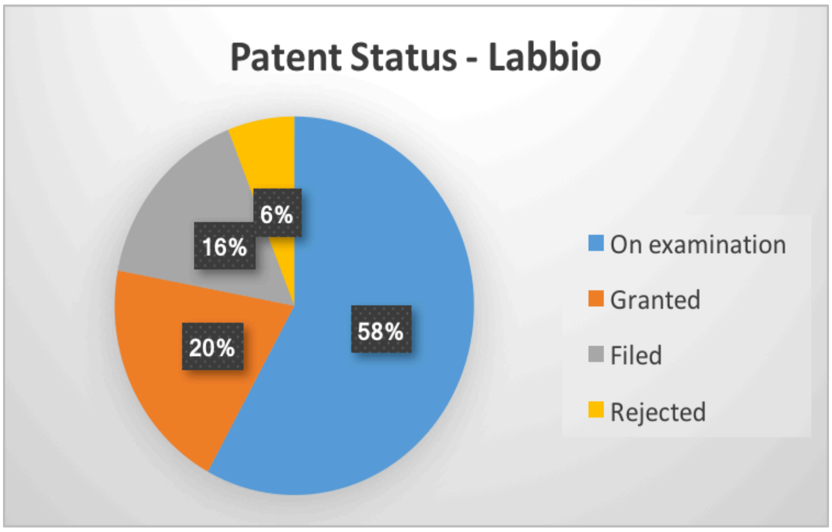
		Innovative Behavior	UI Partnership
InnovativeBehavior	Pearson	1	,023
	Sig. (2-tailed)		,901
	N	33	33
University Industry Partnership	Pearson	,023	1
	Sig. (2-tailed)	,901	
	N	33	33

Table 5 presents that there is no significant correlation between the Innovative behavior and the University Industry Partnership

The results of the survey show that in the Labbio researchers' perceptions about the interaction with industry for partnership present a low interaction. The data showed that is only significant and visible for most of the reseachers the technology transfer relationship between the university and industry. However during the interviews the participants explained the existente of other kind of relationship with industry such as developing products in projects without intellecyual properties relations. In addition the survey results showed (table 5) that there is no significantly correlation between the innovative behaviors and the University Industry partnership. However, the questionnaire questions related the innovative behaviors to the phases of the innovation process, so there is still a possibility of further investigation to describe the innovative behaviors to better measure and understand them to work towards improving U-I partnerships.

The qualitative results will be show that there are other interesting relationship pointed by the interviews with the researchers present a promising relationship between the behaviors cited as innovators and the approach to the industry for partnerships.

4.1.2. Measuring the IP Generation and the University-Industry Partnership for technological transference



Graph 2 presents the 50 patent's status of the Labbio (1997 - 2016)

The process of obtaining patents in Brazil is slow and bureaucratic and it takes an average of 10 years to be granted a patent concession, while in the United States the average time is 3 years. According to a study coordinated by Junior & Moreira (2017) the INPI has witnessed a chronic delay in the processing of patent applications. Patenting time in Brazil jumped four years in a decade, reaching 10.8 years in 2013. The backlog reduces the effectiveness of the system patents by provoking an environment of legal uncertainty, distorting the primary purpose of the patent system, namely the promotion of development of the country.

	Patent Description	Patente Number	Date	Patent status
1	Model of device for measuring weight and loading of vehicles and equipment from pressure or deflection variation in pneumatic systems	MU 7702418-4	26.11.1997	Granted
2	Capacitive discharge valve for sanitary vessels	PI 9902118-8	10.05.1999	Granted
3	Device capacitive discharge valve for sanitary vessels	C1 9902118-8	19.04.2000	Granted
4	Tubular system for the conduct of separation and irrigation cycles of dental radical channels	PI 0205783-2	29.10.2002	Granted
5	Tissues texture pattern set to assist the guidance of special need carriers	MU 8303691-1 PI 0302767-8	12.05.2003	Granted
6	Optical equipment for bio-stimulation of orofacial	MU 8301504-3	15.05.2003	Granted
7	Public telephone with height adjustment	MU 8301505-1	27.05.2003	Granted
8	Optical device for biomodulation of epithelial, bone and muscular	MU 8303493-5	23.06.2003	Granted
9	Triple structure for wheelchair	MU 8401192-0	11.05.2004	Granted
10	Bracing tissue functional control for hand-made by electrical"	PI 0504704-8	21.09.2005	Granted

Chart 1 presents a descriptive analysis of the Granted Patents from Labbio to Industry (1997 - 2016)

The chart 1 presents the 10 Labbio granted patents, and demonstrate how long it takes the bureaucratic process to get one patent granted and so guarantee the University Intellectual Property.

Date	Technology Transfer	Industry name	Patent number	Patent status
26/11/1997	Yes	SEMEMTE -SOCIEDADE EMPRESARIAL DE EMPREENDIMENTOS TECNOLÓGICOS LTDA - ME	MU 7702418-4	Granted
27/12/2002	Yes	APTIVA LUX	MU 8203339-0	Filed
21/09/2005	Yes	BIOTRON EQUIPAMENTOS MÉDICOS LTDA	PI 0504704-8	Granted
09/07/2007	Yes	BIOS SERVIÇOS E COMÉRCIO LTDA.	PI 0705152-2	Filed
15/01/2008	Yes	CROMIC INDÚSTRIA E COMÉRCIO DE CALÇADOS LTDA	PI 0800552-4	On examination
15/10/2010	Yes	BIOTRON EQUIPAMENTOS MÉDICOS LTDA	PI 1004140-0	On examination

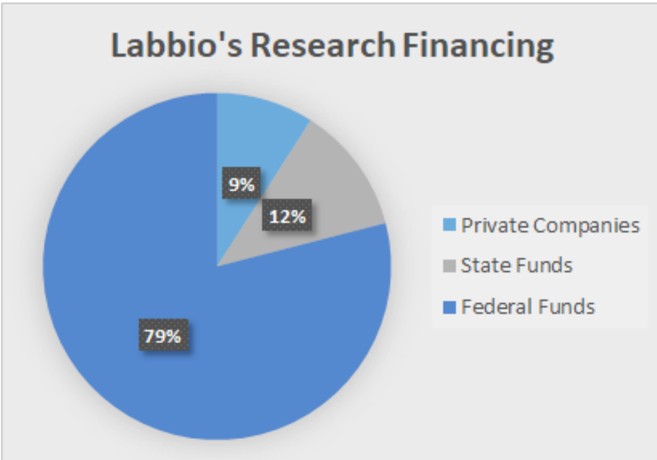
Chart 2 - Descriptive analysis of the technology transfer from Labbio to Industry (1997 - 2016)

In view of the results presented in Chart 2, it can be observed that 6 patents have been transferred by Labbio. This represents 12% of the new technologies developed. It demonstrates that there is a great opportunity to work with researchers and to understand possible markets for the technology they are producing.

4.1.3 Labbio Financial Analysis: incomes and expenses

Labbio seeks financial aid by means of inscriptions in public edicts. The edicts may be from federal agencies such as Ministry of Science Technology and Development, CNPQ, CAPES, FINEP, Ministry of Education or state bodies such as FAPEMIG. In the last 10 years, since 2007, funds raised by Labbio in 21 research projects amount to a total of R$ 5,517,657.25, with funding from Capes, CNPq, Finep, MEC and FAPEMIG. It should be noted that the state budget of FAPEMIG was R$ 657,594.82 in this period. These projects focused on assistive technology, cardiovascular, photosensitizer dyes, neuroscience, biomimetics and events and meetings to discuss innovation. Despite Labbio's industry university partnerships, only R$500.000,00 of the total amount of the Laboratory's funding comes from private investment from government investment.

The laboratory's expenses range from the purchase of inputs and machinery to the payment of researchers with scholarships from government development agencies.



Graph 3 - Distribution of the total amount from (2007-2019). Total amount is R$ 5,517,657.25
Source: Labbio Management, 2018

Scholarship Modality	Quantity	Government Agency	Indivual Scholarship value (R$)	Indivual Scholarship value ($)	Monthly Scholarship (R$)	Monthly Scholarship ($)	Expense Forecast by training period (R$)
Doctorate degree	5	CNPQ/	R$ 2.200,00	$ 611,11	R$ 11.000,00	$ 3.055,56	R$ 118.800,00
Master degree	6	CAPES/	R$ 1.500,00	$ 416,67	R$ 9.000,00	$ 2.500,00	R$ 45.000,00
Undergraduate - CI	4	FAPEMIG	R$ 400,00	$ 111,11	R$ 1.600,00	$ 444,44	R$ 24.000,00
Total	**15**		R$ 4.100,00	$ 1.138,89	R$ 21.600,00	$ 6.000,00	**R$ 187.800,00**

Table 6 - Total expenses with Researcher's Scholarship Labbio (2017)

Analyzing Labbio's financial data, there is evidence that the value received by research incentive funds for the payment of master's and doctoral scholarships represent a significant amount, but presents a financial lag that leads researchers to frequently seek a second source of income, and that can impact the pace of the research progress. In Brazil it is common practice for master's and PhD students to teach undergraduate or graduate courses in private universities to complement the source of income due to a legal opening for the researcher's education.

4.2 Qualitative results

The results of the five interviews conducted with researchers enable the understanding and description of behaviors considered innovative and relevant to promote innovation in the laboratory. They will be presented in the form of excerpts from the interview reports and the descriptive of three cases of partnership with industry. Through the interviews it was possible to describe some partnerships with industry built over the years and the description of the relationship process. Some sections of the five interviews will be presented, for which, in order to facilitate the understanding, three categories were defined according to the methodology content analysis of the answers (Bardin, 1977): (a) Difficulties in the university industry relationship; (b) characteristics of innovative behavior; (c) training and development of researchers.

a) Category: Difficulties in the University- Industry Relationship

"Lack of financial resources. Difficulty in managing the investments of development agencies has many limitations and rendering of accounts. Researcher's time is different from company time. The pace of the university and the pace of knowledge are necessary for the progress but it has a lot of impact. What is positive is when the researcher conquers what he proposes" (Interviewee 1).

"We have a few examples such as Project Orthesis (private partnership with Biotron), Projects of Lapan - Lab. Research applied to neuroscience (Intercession between the Labbio and Hospital of Eyes), but the main bottleneck is the lack of financial resources" (Interviewee 2).

“We have examples such as the partnership with Hospital da Baleia, partnership with the Physiotherapy Clinic of UFMG and PUC Minas, Hospital of Eyes of Belo Horizonte in the area of neurovision" (Interviewee 3).

"The lack of financial resources often leads researchers to develop research in collaboration with companies and industries. Some research projects for theses and dissertations of postgraduate students lead to contact with industry." (Interviewee 4) "For the development of new technologies, you need to know what the market is interested in and seek the fastest route. In Brazil, everything is very bureaucratic, so you have to act fast so you do not lose your timing. In the case of the transfer of technology to Cromic, Professor Pinotti saw a more tactile conversation with the industry, and then to license." (Interviewee 5).

b) Category: Characteristics of innovative behavior

Respondents reported that in addition to technical skills and competencies, the laboratory researchers present innovative behaviors such as interpersonal relationships to work in teams and cooperate in a multidisciplinary environment.

	Innovative Behaviors
Interviewee 1	Dialogue; Cooperation; Teamwork; Interest
Interviewee 2	Curiosity; Teamwork
Interviewee 3	Creativity; Leadership; Technical knowledge of Computer program, modeling, dyes and chemical agents
Interviewee 4	Work with multidisciplinarity
Interviewee 5	Test; Persistence
n= 5	

Chart 3 - Description of the Innovative behavior at Labbio in the perceptions of the interviews.

c) Category: training and development of researchers

	How the team is formed and developed at Labbio
Interviewee 1	Students of scientific initiation (graduation) are all welcome. Masters / PhD students / researchers are selected in selective processes of the UFMG Graduate Programs, Mechanical Engineering or other schools or other programs with co-orientation request of Labbio professors.
Interviewee 2	Technical trainings such as the 3DS printer are offered by the equipment supplier. But there is a formal organization of doctoral students support masters, masters support undergraduates and also in different hierarchies.
Interviewee 3	Everyone develops together. Natural process. Slowly each one is training himself and the others as well. Research coordinators hold meetings with specific members.
Interviewee 4	The team works to develop a technology with two leaders: A (Doctorate - Occupational Therapist) and B (Master - Mechanical Engineer). They define the activities, they divide the team. Professors only guide.
Interviewee 5	Leadership by qualification - Eg: C is graduated in microbiology / D has experience in fundraising and ideas for design and product.
n= 5	

Chart 4 - The characteristics of the team formation and team building at the Labbio.

It is observed that all interviewees present in some of the categories points of convergence and points of divergence; it can be attributed to the diversity of formations and performance of each one in this multidisciplinary team, besides different hierarchical positions.

Next, some results of the laboratory partnership with industry are demonstrated in this article specifically involving neurosurgery, orthopedics and photodynamic therapy. The following research projects will be described: (a) Good Start Project; (b) Cromic Project; (c) Spin Off Aptiva Lux.

a) Good Start Project Case

The project is carried out in partnership with UFMG, *Hospital de Olhos Minas Gerais* (Hospital of Eyes) and the City Halls of Ibirité and Nova Lima, both municipalities in the state of Minas Gerais.

The idea started from Dr. Ricardo Guimarães, the owner of the *Hospital de Olhos Minas Gerais* (Hospital of Eyes). He wanted initially to identify children in the public schools with Irlen's syndrome (a type of dyslexia related to vision) but then the opinions of teachers helped shape the project, which turned out to be more focused on promoting health within the school environment, not only being restricted to vision but to health as a whole. The project includes workshops at weekends to involve the parents, in activities such as plays and cooking classes. With an education focused on health prevention, children create healthy habits that are harder to change in adults, and can protect their parents' health at home, not just the other way around. The project has a prototype developed in Labbio that integrates 5 solutions previously available in the market to carry out various examinations and measurements, such as weight, height, pressure measurements, among others. A software takes the child's data and generates a history of the child to which the parents have access. It also serves to determine if the child needs further treatment of their vision.

The results of this project show some benefits for the university lab, such as the opportunity to test in large scale the technologies and products developed in the lab. Also, open access to the market needs. Another benefit for the university is to receive financial support for research and help improve health in society. In this sense, there are some specific benefits for the company partner: being in contact with the new technologies that have been developed by the university research labs; getting access to qualified human resources to exchange knowledge, ideas and opinions.

b) Cromic Shoes Project Case

Cromic is a sneakers company based in Contagem-MG, and around 2010 was having difficulties with their products owing to strong competition. The shape of the sole of their sneakers enabled little impact absorption and needed a new design. Cromic CEO approached the Federal University of Minas Gerais (UFMG) after contacting the Federation of Industries for the state of Minas Gerais (FIEMG). On this occasion, he met Prof. Marcos Pinotti, from the Mechanical Engineering Department. Pinotti proposed him a partnership to develop the technology so that it could be licensed to Cromic after it had been granted intellectual property rights. The design of the new sole used biomimetics concepts and enabled better impact absorption at a lower cost of production.

Like in case a, the Cromic project was a good opportunity for the laboratory to get financial support as well as to test in large scale the products developed in the lab. Also, it allowed contact with market needs and to increase the laboratory incomes through royalties or consultancy fees. For the industry partner the benefits consisted mainly in the creation of a competitive product; being in contact with the new technologies that were being developed in the lab, and the opportunity to exchange ideas, knowledge and technological points of view. Not only that, it was more economical to develop new technology and share risks.

c) Case Aptiva Lux Project

APTIVALUX was founded in 2004 as a spin off of the Bioengineering Laboratory of the Federal University of Minas Gerais. The company is formed by four dental surgeons (Masters in Laser Dentistry by IPEN/FO-USP and PhD in Bioengineering by UFMG), a veterinary doctor (master in surgery by UFMG) and a Mechanical Engineer (Master and PhD in Mechanical Engineering by UNICAMP).

Aptivalux was created to meet a national demand for new products in the area of photobiomodulation, photodynamic therapy (PDT), dental bleaching, mucositis, periodontics and light activated disinfection (LAD) of bacteria or fungi. For this, the company has invested in research and development of new dyes in photodynamic therapy. In 2008, Aptivalux, in partnership with Hypofarma Laboratory, launched in the Brazilian market the *Chimiolux*, the first Brazilian product for LAD registered with ANVISA (Brazilian authority) with application in periodontics, endodontics and implantdontics. In 2013, Aptivalux licensed the *Chimiolux* brand with DMC Equipamentos to manufacture and distribute the product in a new packaging and new commercial proposal, since Hypofarma had no interest in renewing its licensing agreement with Aptivalux.

In this case some of the benefits for the university lab included the opportunity to create a company, develop in large scale technological products, generate incomes for the researchers inventors. Also, allowed learning on how to become an entrepreneur and be in contact with the market needs for the specific technology, apart from increasing the laboratory incomes by royalties payments or product selling. As for the partner company, benefits include establishing a long-term relationship with the research from the lab, exchanging knowledge with new researchers over the years to keep constantly updated. I was also an economical option to develop new technology and to share risks.

The cases presented showed the description and also the benefits of the relationship between the university research lab and the companies or industries based on partnership with and without involving intellectual property.

University-Industry Relationship Benefits	
Benefits for the university's research Lab	**Benefits for the industry/company partner**
To test in large scale the technologies and products developed in the Lab. be incontact with the market needs. Receive financial support for research. Help the society to increase the health.	Be in contact with the new technologies that had been developing by the university research labs. Exchange Knowledge and viewpoint. Increase their social marketing mídia and help to develop the society. Get access to qualified human resources.
To get financial support for new technology development. Capacity to test in large scale the products developed in the Lab. Be in contact with the market needs. Increase the laboratory incomes by royalties receiving or consultant hours.	Be in contact with the new technologies that has been developing by the university research labs. Exchange ideas, knowledge and, technological viewpoint. More economy to develop new technology. Sharing risks.
To create a company (spin-off / startup). Develop in large scale technological products. To generate incomes for the researchers Lab inventors. Learning how to become an entrepreneur. Be incontact with the market needs for the specific technology. Increase the university's laboratory incomes by royalties receiving or products sell.	Long-term relationship with the research from the lab. Exchange Knowledge and viewpoint with the new researchers over the years to keep constantly update. Economic option to develop new technology. Sharing risks.

Chart 5 - The benefits of the University-Industry partnership.

As the information presented above summarized in a frame the benefits of the University-Industry partnership for both sides. It is based on the perception of the interviews, but is also confirming the literature review presented in this paper.

5. Conclusions

The aim of this paper was to analyse the innovative behaviors from the researchers at Labbio UFMG, and the possible impact on the current University-industry partnerships. The methodology was a case study with qualitative and quantitative analysis. The data were collected from different sources, as, interviews, institutional reports, and institutional websites information. The results of the interviews show some of the innovative behaviors that are fundamental and important for working at the Labbio. However, the survey reached with 33 lab workers did not show any significant correlation between innovative behaviors and university-industry partnership. This data showed that is only significant and visible for most of the reseachers the technology transfer relationship between the university and industry. Although, during the interviews the participants explained the existente of other types of relationship between the lab and the industry such as developing products in projects without intellectual property transference relationship. To point that, the questionnaire questions related to the innovative behaviors express the phases of the innovation process, so there is still a possibility of further investigation to describe the individual innovative behaviors to better measure and understand them to work towards improving University-Industry partnerships.

This study also analysed the 3 case studies in which Labbio had partnerships with industry and companies. They showed that the benefits can motivate the innovative behaviors. However, the results show that the existence of the technology transfer office in the university is one way to reach market interface, but it is not efficient enough once they have a reduced staff and also they have to deal with the bureaucracy of UFMG and INPI, which leads to an average of 10 years for an IP concession. On the other hand, the results showed that Labbio has been creating different strategies to deal with the partnerships trying to include the technology transfer office to work in all the negotiations that involves any type of funding. As the university research lab has to deal with a lack of public investments and the excessive control of their research expenses by the governmental agencies, the successful partnerships between the university laboratory and companies were also attained due to the established trust between the researcher leader and the sponsors based on the possibility of continued research.Furthermore, the innovative work behaviors described by the researchers showed the importance of evaluating their individual innovation behaviors and capabilities based on their specific needs, according to the cultural and institutional environment.

The results of the data analysis demonstrated that Labbio's current innovation strategy focuses mainly on intellectual protection, but the researchers understand the social nature of the laboratory which allows a variety of research to be driven by the demands of philanthropic institutions such as hospitals, public schools and others.

The results indicated that the management of the human capital and the resources can be one way to increase university-industry partnerships. There is a need to take better advantage of the market opportunities that the technologies developed in the laboratory present, either by strengthening the skills and behaviors of the researchers or by forming a solid partnership network.

This experience might be an inspiration to other university labs to analyze their human potential to transform their research results into products and to better communicate with the industry. There is a considerable opportunity to understanding deeply the innovative work behaviors in the university labs and correlating with the experimentation results that can improve the industrial sector activity. However, the need to develop workplace observation and evaluation tools focused on the needs of each laboratory and each local culture.

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