Strategy to promote research and innovation in the pharmaceutical sector through interdisciplinary education

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Abstract

Health products and services innovation have a strong economic and social impact, particularly by a BRICS member such as Brazil, considered the 6th largest consumer market for pharmaceutical products. Among the many national strategies to address the vulnerability of the country in this aspect, it is the training of the pharmacist one of the key players in the innovation process. In 2017 Generalist Pharmacy Curriculum Guide was published, which includes innovation, entrepreneurship and interdisciplinarity for the first time as components of the Brazilian pharmacist training. The present study analyzed 3742 disciplines currently offered by 42 universities, taking as a parameter the requirements induced by the new curriculum guideline. The method used was the content analysis, supported by NVivo® software, which generated 113 categories of disciplines, distributed in 8 core areas and 9 areas of knowledge. The result showed there is insufficiency related to health care and health management core areas as well as hours of internship, while there is predominance of health technology (> 75%) with only 2% of innovation besides inexpressive presence of entrepreneurship and interdisciplinarity. The study demonstrates that paradigmatic and substantial changes must be made by Universities in order to comply with the new Curriculum Guide and proposes strategic solutions to promote innovation from an interdisciplinary perspective.

Keywords: innovation, education, interdisciplinary, health, entrepreneurship, pharmacy.

1. Impacts of innovation in the pharmaceutical sector

Health is the third of the seventeen Sustainable Development Goals, established in 2015 (WHO, 2015), and innovation in pharmaceuticals can play an important role in health and well-being maintenance. Philip Abelson, a former editor of Science magazine, acknowledged that pharmaceuticals have accounted for about half of the improvement in health care during this century (ABELSON, 1993). In addition, there is currently a significant paradigm shift in the treatment of diseases and drug options. The genomics, transcriptome, proteomics and bioinformatics have been part of the scientific and business routine for some time, present in the drug development and intended for personalized and preventive treatment (BODROVA, 2012).

Pharmaceutical innovation is a source of intra-industry competitiveness and generates important impacts on the health economy. As BRICS's member, Brazil is the 6th largest pharmaceutical market in the world,

but still shows a clear distance from the world technological frontier (LUPIN LIMITED, 2017; CASSIOLATO, 2015). Even with the unique Brazilian biodiversity, its pharmaceutical market is still characterized by the importation of technologies and copies of medicines, which is insufficient as a development strategy and counterproductive from the point of view of strengthening national innovation systems (GADELHA et al., 2013; SCARAMUZZO; NIERO, 2013).

From any point of view, the university generates knowledge, especially when it is aligned with social needs (CHUNLIN LI, 2016). The university-industry interaction allows the exchange of experiences and knowledge, which almost always results in the development of new products or services, or in the solution of technical problems (LEE, 2000; SANTORO, 2000). This idea, however, is not peaceful, since there are authors who believe that this type of interaction corrupts the university, which must have isonomy, independence and autonomy for its research (ELMUTI, 2005; BERCOVITZ; FELDMAN, 2008).

Rocha (2012) highlights to the excessively academic character of the Brazilian universities, which hesitates to patent its research results, still operating much more in the 'publish or perish' than in the 'apply or perish' logic. In the context of the pharmaceutical industry, however, the patent plays a key role in the research process. The emergence of the concept of open innovation, brought by Chesbrough (2006), could even be a mitigator of such a cultural conflict, if it would not be needed the existence of a mature local innovation system, which is not the Brazilian case, particularly among pharmaceutical sector. The academic myth that patent deprives society of drug access is not true since patent support the advance of the state of the art. In the pharmaceutical industry, 90% of innovations, on average, are only marketed with patent protection (ALBUQUERQUE, 1998; DEMAIN, 2001; JANNUZZI, 2008).

This conservative and linear view, still prevalent in Brazil, has been questioned by nonlinear models of innovation, such as Triple Helix of Leydesdorff (2000), Etzkowitz (2008) and others, which gives the university a prominent role in the economics of trade, until the national innovation systems of Nelson (1993) and Dosi (1999), which consider all the institutionality involved in the process, beyond the mere market, reaching the mesoeconomics sphere.

Despite this, the impact on the economy has motivated the Brazilian government to depend less on drugs of external origin. An important initiative in this sense was the publication of Law no. 10.973/2004 (BRAZIL, 2004), known as the "Law of Innovation", updated by Law 13.243/2016 (BRAZIL, 2016), which became known as the "Legal Framework for Science, Technology and Innovation", both responsible for the creation of mechanisms for greater university-industry interaction. These initiatives come to the need of pharmaceutical innovation system that is still immature, disjointed and needs stimulation to the practice of innovation through the interaction between the industry sector, universities and research centers (MCTI, 2016; CRUZ, 2011; SCHWAB; SALA-I-MARTIN, 2010; VIEIRA; OHAYON, 2008).

Another important initiative of the Brazilian government was the creation of Productive Development Partnerships (PDPs). Regulated by Ordinance 837 of 2012 (BRASIL, 2012), the PDPs seek to reduce dependence on the country by enabling public laboratories to produce strategic medicines through the technology transfer from partnerships with private labs with expired patent. However, some partners have faced problems during their driving and even succumbed to various problems, including the need for more skilled workforce. This is the challenge that the present article will address by bringing together elements coming from the interdisciplinary education (SUNDFELD; DE SOUZA, 2014; REZENDE, 2013).

1.1. Challenges of pharmaceutical innovation and the interdisciplinary teaching

As drug's professionals, pharmacists are co-responsible for the population health and well-being and thus are a kind of "social entrepreneurs." In this sense, it is necessary to nurture the entrepreneurial spirit and innovative skills in undergraduate pharmacy students to promote future health care (BRAZEAU, 2013; COPE, 2005; STINCHCOMB, 2010; GENERAL, 2011).

Innovation is a specific consequence of entrepreneurship (DRUCKER, 1998; SCHUMPETER, 1954) and, although millenary and important, does not receive enough attention from academia. There are no single disciplines to gain a comprehensive view of the role played by innovation in social and economic aspects, what makes indispensable an interdisciplinary perspective (FAGERBERG, 2003).

Since the 1970s, Jantsch (1970) has said the university would have to adopt interdisciplinary approaches. Interdisciplinarity does not mean denying the discipline or specificities of each profession, but rather respecting the cognitive territory of each field, distinguishing points that unite them and points that differentiate them (GRAY, 2005; SAUPE; BUDÓ, 2006). The purpose is for a broader, non-fragmented knowledge, opened to dialogue and the interaction of disciplines and not a knowledge beyond multidisciplinarity, which operates only by juxtaposition and accumulation of knowledge (GARCIA et al., 2007; GATTÁS; FUREGATO, 2006). The interdisciplinary requirement induces the specialties to transcend their own areas, becoming aware of its limits and accepting contributions from other disciplines. This is the way of the university of the 21st century (BILILIGN, 2015).

The perception of this need was recognized by the recently Generalist Pharmacy Curriculum Guide, published through Resolution 6/2017, which establishes new curriculum guidelines for pharmacy courses in Brazil which will have two years to be in compliance with. For the first time, since the previous curriculum guide of 2002, undergraduate pharmacy program should consider interdisciplinarity, entrepreneurship and innovation in the formation of the Brazilian pharmacist (ANDERSON, 2002; BRAZIL, 2017).

Following a global trend of curriculum revision, in which developed countries aims to prepare pharmacy students for future innovations in personalized medicines, information systems and team patient care, and which developing countries seek the practice of pharmacy focused on patient and public health to achieve

universal access to essential medicines, universities in various countries have been reviewing their curriculums. Examples are universities from the United States, Europe, the Philippines, China and Australia (ANDERSON, 2002; ANTIGUA et al., 2015; ASSESORIA, 2017; CUNHA et al., 2016; FIP, 2013; ZM et al., 2014; WIEDENMAYER 2006).

The reality and possible strategies for the various countries, however, are quite different. According to Rampelotto (2016), the use of biodiversity, biomedicines, biotechnology and even pharmacogenetics is already considered a real opportunity for Brazil and emerges as a new paradigm for sustainable health development in the long term. Health education in Brazil is marked by the fragmentation of knowledge, hospital / biologicist vision and use of traditional teaching models, which prioritize a superspecialization and sophistication of the procedures (GONZALEZ; ALMEIDA, 2010; HADDAD, 2008). Therefore, the Brazilian pharmacy curriculum will suffer changes that can led the country to find their own trajectory to prepare interdisciplinary pharmacists for a new era of partnerships, research and development of new drugs and therapies that benefit the patient.

In this context, and considering the Brazilian government's objectives of stimulating health innovation and reducing external dependence, this study intends to analyze the current undergraduate pharmacy program in face of the political, economic and academic challenges that are posed, by the following objectives:

- Identify gaps of current pharmacy curriculum compared to the new Generalist Pharmacy Curriculum Guide (Resolution 6/2017) which is composed of 3 core areas distributed in: 50% of health care, 40% of health technology and innovation and 10 % of health management, excluding internship and additional activities, which must correspond to a minimum of 20% and a maximum of 3%, respectively, of the total course workload of at least 4000 hours. In addition, the course should consist of at least 50% of pharmaceutical sciences as area of knowledge;

- Mapping the current presence of disciplines related to the innovation of pharmaceutical products and services, from an interdisciplinary and entrepreneurial perspective.

Considering the precarious literature related to the subject, this study would provide reflection opportunities to the universities and to the Brazilian government regarding adjustments in the preparation of an interdisciplinary and entrepreneur pharmacist capable to promote products and services innovation, according to the demand expressed by the UN Sustainable Development Goals.

2. Methodology

The research had an exploratory character, involving the qualitative analysis of the disciplines present in pharmacy curriculum programs. The study universe was the list of pharmacy universities present on the Brazilian Federal Pharmacy Council website (CFF, 2017). The study took place through the following steps:

1- **Mapping**: the curriculum of each university was consulted in their respective websites to map all disciplines offered by the pharmacy courses;
2- **Coding**: the disciplines were analyzed through the content analysis procedure (BARDIN, 2009) for correct coding in "macro-disciplines". The nVivo® software was used to analyze the titles of the disciplines and, when they were not sufficiently clear, the syllabuses were consulted and fully analyzed for correct codification.
3- **Classification**: after codification, the disciplines were meticulously categorized into 2 (two) classifications (I and II), based on the definitions presented in Resolution 6/2017 and the objectives of the present study, as demonstrated by Table 1 below:

Table 1. Classification according to core areas and areas of knowledge

Classification I: Time distribution between the main priorities (health care, health technology and innovation, health management), internships and additional activities	
Health Care	Resolution 6/2017 describes as: "health care is understood as the set of actions and services offered to the individual, the family and the community, which considers the autonomy of the human being, its singularity and the real context in which lives, and is carried out through activities to promote, protect and recover health, in addition to preventing diseases, and enabling people to live better. "
Health Technology	Resolution 6/2017 describes as: "health technology is understood as the organized set of all scientific, empirical or intuitive knowledge, used in research, development, production, quality and provision of goods and services."
Health Innovation	Resolution 6/2017 describes as: "health innovation refers to the solution of technological problems, including the introduction or improvement of processes, products, strategies or services, having positive repercussions on individual and collective health ". This definition is also aligned to the Oslo Manual (OECD, 2005), definition. Expressed together with Health Technology by RE 6/2017, this area will be evaluated independently in this study, to meet the proposed objectives.
Health management	Resolution 6/2017 describes as: "health management is understood as the technical, political and social process capable of integrating resources and actions to produce results".
Internship	"Supervised school education act, developed in the work environment, aimed at preparing for productive work" (BRASIL, 2008).
Additional activities	Additional activities have the purpose of enriching the teaching-learning process which can be the participation in educational events such as: academic weeks, congresses, seminars, lectures, conferences, cultural activities; completion of extension courses and / or academic and professional updating; scientific initiation activities, as well as monitoring (BRASIL, 2003).
Undefined Content	These are the disciplines: - Electives (those of free choice of the student to compose his / her curriculum to attend a more personalized training of the future professional) (FRAUCHES, 2012). - Disciplines where the title was not clear (eg, "Special topics") and which the syllabuses described as "varied content".
Multidisciplinary	Disciplines of other courses not related to any of the priorities of the pharmacy course.

Classification II: Distribution by areas of knowledge (including pharmaceutical sciences, interdisciplinary disciplines, entrepreneurship and research and development for product processes and services innovation).	
Social and Human Science	Resolution 6/2017 describes as disciplines of: "ethics and bioethics, integrating the understanding of social determinants of health, which consider social, economic, political, cultural, gender and sexual, ethnic-racial, psychological and behavioral factors, environmental, health-disease process of the individual and the population ".
Exact Sciences	Resolution 6/2017 describes as disciplines that: "cover the fields of chemical, physical, mathematical, statistical and information technology sciences, which comprise their theoretical and practical domains, applied to the pharmaceutical sciences"
Biologic Sciences	Resolution 6/2017 describes as disciplines that: "cover molecular and cellular bases, the structural organization of protists, fungi and plants of pharmaceutical interest, the physiological, pathological and pathophysiological processes of the structure and function of tissues, organs, systems and of the devices, and the study of infectious and parasitic agents, risk factors and protection for the development of diseases, applied to practice, within the life cycles. "
Health Sciences	Resolution 6/2017 describes as disciplines that: "cover the field of collective health, organization and management of people, services and health system, programs and indicators of quality and safety of services, health policies, health legislation, as well as epidemiology, communication, health education, integrative and complementary practices that consider the social determination of the health-disease process "
Pharmaceutical Sciences	Resolution 6/2017 describes as disciplines of: a) pharmaceutical assistance, pharmaceutical services, pharmacoepidemiology, pharmacoeconomics, pharmacovigilance, haemovigilance and technovigilance, at all levels of health care; b) pharmacology, clinical pharmacology, pharmaceutical semiology, pharmacological and non-pharmacological therapies, clinical pharmacy, toxicology, clinical-pharmaceutical services and procedures aimed at the patient, family and community, pharmaceutical care and patient safety; c) pharmaceutical and medicinal chemistry, pharmacognosy, chemistry of natural products, phytotherapy and homeopathy; d) pharmacotechnical, pharmaceutical technology and processes and pharmaceutical, master and industrial operations, applied to allopathic, homeopathic, phytotherapeutic drugs, cosmetics, radiopharmaceuticals, food and other health products, planning and development of inputs, drugs and medicines and cosmetics; e) control and quality assurance of pharmaceutical products, processes and services; (f) deontology, health and professional legislation; g) Clinical analysis, covering the domain of processes and techniques of areas such as clinical microbiology, applied botany, clinical immunology, clinical biochemistry, clinical hematology, clinical parasitology and clinical cytopathology; h) genetics and molecular biology; i) toxicological analyzes, including the control of the processes and techniques of the different areas of toxicology; j) management of pharmaceutical services; k) hospital pharmacy, pharmacy in oncology and nutritional therapy; l) analyzes of water, food, medicines, cosmetics, sanitizing and household cleaning products.
Research and development for product innovation	Resolution 6/2017 describes as disciplines of: "research and development for innovation, production, evaluation, control and quality assurance of inputs, pharmaceuticals, medicines, cosmetics, sanitizers, household cleaning products, products and inputs biotechnologicals, biopharmaceuticals, biochemicals, immunobiologicals, blood components, blood products, and other biotechnological and biological products, in addition to those obtained

	by pharmacogenetics and pharmacogenomics, inputs and equipment for clinical-laboratory, genetic and toxicological diagnosis, food, chemical and biochemical reagents, diagnostic products in vitro and other health-related aspects, as well as its regulatory aspects".
Research and development for process and service innovation	Resolution 6/2017 describes as disciplines of: "research and development for innovation, production, evaluation, quality control and assurance and regulatory aspects in processes and services of pharmaceutical care and health care.
Management and entrepreneurship	Resolution 6/2017 describes as disciplines that includes: "a) projects and processes; b) pharmaceutical business; c) pharmaceutical assistance and health facilities; (d) pharmaceutical services ".
Interdisciplinary	Activities / disciplines not framed in any of the areas of knowledge above and that meet the simpler definition of Berger (1972): "interdisciplinarity is an interaction between two or more disciplines".

Source: Prepared by the Authors

4- **Quantification**: the disciplines were counted per the number of semesters in which they appeared in the curricular program of the courses. This quantification was intended to evaluate the percentage participation of this discipline in relation to the core areas and areas of knowledge required by the new Generalist Pharmacy Curriculum Guide.

3. Results and Discussion

It was analyzed the disciplines of curricular program of 42 universities listed on the Brazilian Federal Pharmacy Council website, as follows:

Table 2. Universities analyzed

	Universities	Website
1	UFG - Universidade Federal de Goiás	http://www.farmacia.ufg.br
2	CESUPA - Centro de Ensino Superior do Pará	http://www.cesupa.br/Graduacao/Biologicas/farm.asp
3	UNIARARAS - Faculdade de Ciênicas e Biologia de Araras	http://vestibular.uniararas.br/cursos/?tag=farmacia
4	PUCRS - Pontifícia Universidade Católica do R.G. do Sul	http://www.pucrs.br/saude/curso/farmacia/
5	PUCPR - Pontifícia Universidade Católica do Paraná	https://www.pucpr.br/escola-de-ciencias-da-vida/graduacao/farmacia/
6	Faculdades Oswaldo Cruz	http://www2.oswaldocruz.br
7	PUCCAMP - Pontifícia Universidade Católica de Campinas	https://www.puc-campinas.edu.br/graduacao/farmacia/
8	UFRGS - Universidade Federal do Rio Grande do Sul	http://www.ufrgs.br/ufrgs/inicial
9	UFSC - Universidade Federal de Santa Catarina	http://ufsc.br
10	UFMS - Universidade Federal do Mato Grosso do Sul	https://www.ufms.br
11	UFMT - Universidade Federal do Mato Grosso	http://www.ufmt.br/ufmt/site/
12	UNIMEP - Universidade Metodista de Piracicaba	http://unimep.edu.br
13	UFMG - Universidade Federal de Minas Gerais	https://ufmg.br
14	UFOP - Universidade Federal de Ouro Preto	http://www.ufop.br
15	UFPE - Universidade Federal de Pernambuco	https://www.ufpe.br
16	UFRJ - Universidade Federal do Rio de Janeiro	https://ufrj.br

17	UCPEL - Universidade Católica de Pelotas	http://www.ucpel.edu.br/portal/
18	UNISANTOS - Universidade Católica de Santos	http://www.unisantos.br
19	UNIFENAS - Universidade de Alfenas	http://www.unifenas.br/index.asp
20	UnB - Universidade de Brasília	http://www.unb.br
21	UNICRUZ - Universidade de Cruz Alta	https://home.unicruz.edu.br
22	UNIC - UNIVERSIDADE DE CUIABÁ	http://www.unic.br/Paginas/Home.aspx
23	UNIMAR - Universidade de Marília	http://www.unimar.br/cursos/graduacao/farmacia/
24	UNAERP - Universidade de Ribeirão Preto	http://www.unaerp.br
25	USF - Universidade São Fransico	http://www.usf.edu.br
26	FCFRP - Faculdade de Ciências Farmacêuticas de Ribeirão Preto	http://fcfrp.usp.br
27	USP - Universidade de São Paulo	http://www5.usp.br
28	UNISUL - Universidade do Sul de Santa Catarina	http://www.unisul.br/wps/portal/home/
29	UNIVALE - Universidade Vale do Rio Doce	https://www.univale.br/PosEaD/
30	UEPB - Universidade Estadual da Paraíba	http://www.uepb.edu.br
31	UEM - Universidade Estadual de Maringa	http://www.uem.br
32	UEL - Universidade Estadual de Londrina	http://www.uel.br/ccs/farmacia/
33	UEPG - Universidade Estadual de Ponta Grossa	http://portal.uepg.br
34	UFBA - Universidade Federal da Bahia	http://www.ims.ufba.br
35	UFP - Universidade Federal do Pará	https://portal.ufpa.br
36	UFPR - Universidade Federal do Paraná	http://www.ufpr.br/portalufpr/
37	UFPI - Universidade Federal do Piauí	http://www.ufpi.br
38	UFF - Universidade Federal Fluminense	http://www.uff.br
39	UNIP - Universidade Paulista	https://www.unip.br/portal.aspx
40	Unifal - Universidade Federal de Alfenas	http://www.unifal-mg.edu.br/portal/
41	UFES - Universidade Federal do Espírito Santo	http://www.ufes.br
42	Centro Universitário Newton Paiva	https://www.newtonpaiva.br

Source: Brazilian Federal Pharmacy Council website (CFF, 2017)

Although there are more than 400 pharmacy courses in Brazil and the present study has considered only the universities listed on the website of the Brazilian Federal Pharmacy Council (CFF, 2017), the majority part of the analyzed universities were well evaluated by the Brazilian government (BRASIL, 2011). Furthermore, as the subject of the study deals with adjustments in the training of the interdisciplinary pharmaceutical professional, entrepreneur and promoter of innovation in products and services, therefore with a strong connection with the regulatory question, it was understood that the sample of the courses explicitly connected with the Federal Council is sufficient for the exploratory study.

The curriculum program of the 42 courses provided 3742 disciplines in total. The analysis of titles and syllabuses of these disciplines, including their use in nVivo® software, led to the coding of 113 "macro-disciplines", which were quantified by the number of semesters that appeared in each course in total. The

content analysis of the macro-disciplines also allowed its categorization in relation to the core areas of Resolution 6/2017 (Classification I) and areas of knowledge (Classification II) of all the sample content, as follows:

Table 3. Disciplines and its classifications (I and II)

	Macro-disciplines (total of 42 universities)	Amount	Classification I: Core Areas Resolution 6/2017	Classification II: Areas of Knowledge
1	celular and molecular biology	114	Pharmaceutical Technology	Biologic sciences
2	microbiology	87		
3	parasitology	80		
4	immunology	79		
5	physiology	61		
6	anatomy	45		
7	histology	32		
8	mycology	20		
9	virology	14		
10	bacteriology	11		
11	embryology	10		
12	chemistry	451	Pharmaceutical Technology	Exact Sciences
13	physical	42		
14	statistics/biostatistics	41		
15	calculus / mathematics	36		
16	publichealth	53	Health Care	Health Sciences
17	epidemiology	51		
18	comunication	9		
19	medicine administration	3		
20	Neglected deseases	2		
21	hospital pharmacy	36	Health Management	Health Sciences
22	health policies	12		
23	Health legislation	7		
24	ethic	29	Health Care	Human and Social Sciences
25	firstaid	12	Health Care	Interdisciplinary
26	Psychology & pharmacy	9		
27	nutrigenomics	2		
28	Environment and sustainability	17	Health Management	Interdisciplinary
29	Economy & pharmacy	9		
30	marketing &health	7		
31	bioinformatics	6	Pharmaceutical Innovation	Interdisciplinary
32	Clinical trials	5		
33	nanotechnology	4		
34	biosafety	21	Pharmaceutical Technology	Interdisciplinary
35	Laboratory animals	2		
36	internship	260	Internship	Internship

37	Graduation work	114		
38	Teaching preparation	15		
39	Pharmaceutical assistance	45	Health Care	Management & Entrepreneurship
40	management	56	Health Management	Management & Entrepreneurship
41	entrepreneurship	8		
42	languages	28	Not Related to Pharmacy	Multidisciplinary
43	History and philosophy	20		
44	Brazilian sign language	19		
45	social sciences	16		
46	economy	7		
47	anthropology	6		
48	forensicscience	4		
49	Study of contemporary man	4		
50	Basic computing	2		
51	cinema	2		
52	cultural activities	2		
53	Occupational safety & health	2		
54	sport	2		
55	acupuncture	1		
56	biogeography	1		
57	bodymaintenance	1		
58	demography	1		
59	education of ethnic-racial relations	1		
60	employability	1		
61	epistemology	1		
62	evolution	1		
63	groupdinamic	1		
64	justice	1		
65	logistic	1		
66	music	1		
67	oenology	1		
68	spirituality	1		
69	Theory of knowledge	1		
70	Diagnosis and clinical analysis	44	Health Care	Pharmaceutical Sciences
71	Clinical pharmacy	26		
72	nutrition	15		
73	semiology	5		
74	pharmacovigilance	3		

75	deontology	36	Health Management	Pharmaceutical Sciences
76	biochemistry	129	Pharmaceutical Technology	Pharmaceutical Sciences
77	food	112		
78	pharmacology	105		
79	pharmacotechnical	101		
80	toxicology	97		
81	Pharmaceutical technology	90		
82	qualitycontrol	81		
83	hematology / hemotherapy	64		
84	pharmacognosy	56		
85	cosmetics	51		
86	pathology	51		
87	homeopathy	41		
88	botany	35		
89	genetics	34		
90	bromatology	32		
91	controle de qualidade	32		
92	Introduction to pharmacy	29		
93	herbal medicine / natural products	28		
94	enzymology	15		
95	pharmacodynamics	13		
96	pharmacoeconomics	8		
97	pharmacokinetics	8		
98	radiopharmacy	7		
99	Fermentation technology	6		
100	oncology	6		
101	Domesanitary products	1		
102	nutraceutical	1		
103	Quality assurance	11	Health Management	Process R&D
104	drug/product development	27	Pharmaceutical Innovation	Product R&D
105	biopharmacy	10		
106	Pharmaceutical production	35	Pharmaceutical Technology	Product R&D
107	biotechnology	19		
108	pharmacogenomics	4		
109	Pharmaceutical care	47	Health Care	Service R&D
110	optional disciplines	30	Undefined Content	Undefined Content
111	Interdisciplinar pharmacy	4		
112	Varied content	140	Additional activities	Additional activities

113	Student exchange	7		
	Total	**3742**		

Source: Prepared by the Authors

3.1 Classification I: core areas of Resolution 6/2017

From Table 3, internship and additional activities represent 10% and 4%, respectively, of the total course time (against the 20% and 3% desired by the new curricular guide) as graphically represented below:

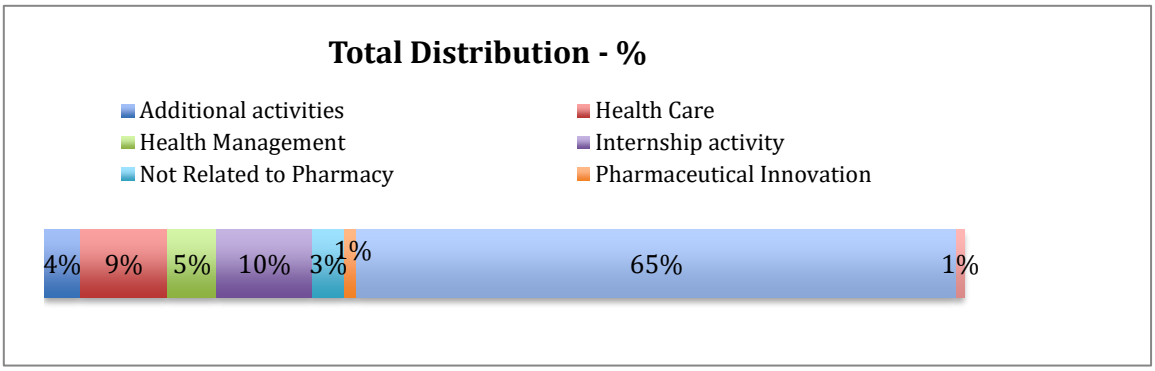

Figure 1: Total core areas (Classification I)

Source: Prepared by the Authors

According to the new curriculum guide, the core areas of undergraduate pharmacy courses should be distributed in 50% health care, 40% health technology and innovation and 10% health management, excluding time for internship and additional activities. Analyzing the 42 universities together, 76% of the course is dedicated to health technology and only 2% to innovation, totaling 78% which is 38 points fold above the 40% expected by the new guide:

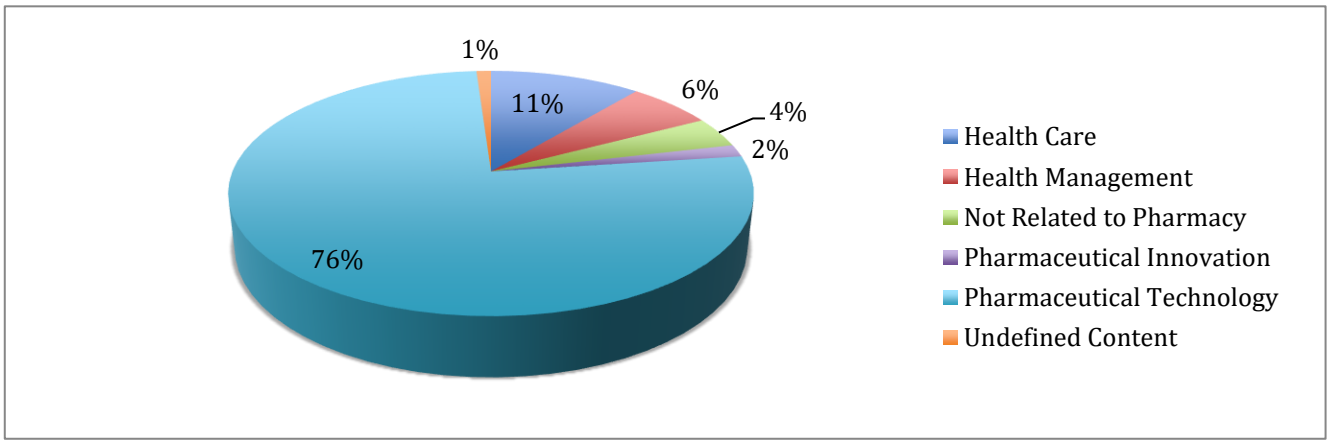

Figure 2: Total core areas, excluding internship and additional activities (Classification I)

Source: Prepared by the Authors

Health care represents 11% and health management 6%, while the new Guide expects 50% and 10%, respectively. Multidisciplinary disciplines from other courses than Pharmacy as well as "undefined content" disciplines represent 5%.

Analyzing each university individually, it is evident the high heterogeneity among universities as demonstrated below:

Table 3. Universities core areas (Classification I)

Universities (*)	Additional activities (%)	Health Care (%)	Health Manag. (%)	Internship activity (%)	Not Related to Pharm. (%)	Pharm. Innovation (%)	Pharm. Technol. (%)	Undefined Content (%)	Grand Total (%)
A	0,0	1,5	4,5	13,6	0,0	0,0	80,3	0,0	100,0
AA	4,3	20,0	5,2	7,8	1,7	1,7	58,3	0,9	100,0
B	14,3	21,4	7,1	14,3	1,8	0,0	41,1	0,0	100,0
BB	5,0	12,1	9,3	5,7	1,4	2,1	64,3	0,0	100,0
C	1,5	9,1	4,5	18,2	1,5	0,0	65,2	0,0	100,0
CC	2,8	11,3	5,6	11,3	1,4	0,0	66,2	1,4	100,0
D	4,2	16,9	9,9	18,3	1,4	5,6	43,7	0,0	100,0
DD	7,5	13,4	3,0	16,4	7,5	0,0	49,3	3,0	100,0
E	0,0	10,7	8,9	10,7	0,0	0,0	69,6	0,0	100,0
EE	3,4	9,2	5,7	10,3	4,6	0,0	62,1	4,6	100,0
F	0,0	8,0	6,0	2,0	2,0	4,0	78,0	0,0	100,0
FF	1,3	9,1	3,9	14,3	5,2	0,0	66,2	0,0	100,0
G	5,6	8,5	2,8	15,5	7,0	0,0	60,6	0,0	100,0
GG	11,1	4,2	8,3	11,1	2,8	0,0	61,1	1,4	100,0
H	13,3	5,3	6,7	16,0	4,0	0,0	52,0	2,7	100,0
HH	4,5	6,1	4,5	15,2	3,0	0,0	66,7	0,0	100,0
I	3,1	7,7	4,6	6,2	1,5	3,1	72,3	1,5	100,0
J	11,2	3,0	4,5	11,2	18,7	1,5	47,8	2,2	100,0
JJ	0,0	11,8	2,9	20,6	2,9	0,0	61,8	0,0	100,0
K	0,0	8,5	4,3	14,9	0,0	1,1	70,2	1,1	100,0
L	1,3	9,0	3,8	11,5	2,6	1,3	65,4	5,1	100,0
LL	4,0	9,3	4,0	13,3	2,7	1,3	60,0	5,3	100,0
M	6,3	4,2	4,2	14,6	2,1	0,0	68,8	0,0	100,0
MM	10,0	6,3	5,0	7,5	3,8	2,5	65,0	0,0	100,0
N	0,0	3,9	9,1	10,4	0,0	0,0	71,4	5,2	100,0
NN	8,5	20,3	6,8	15,3	6,8	0,0	42,4	0,0	100,0
O	1,7	8,6	8,6	7,8	6,0	1,7	65,5	0,0	100,0

P	10,0	7,1	5,3	8,8	2,9	1,2	64,7	0,0	100,0
PP	6,1	10,6	4,5	13,6	1,5	0,0	62,1	1,5	100,0
Q	6,6	14,4	3,0	12,0	9,0	0,6	54,5	0,0	100,0
QQ	5,6	8,3	9,7	8,3	0,0	0,0	66,7	1,4	100,0
R	1,0	7,0	4,0	9,0	3,0	2,0	74,0	0,0	100,0
RR	0,0	7,7	7,7	10,6	1,0	1,9	71,2	0,0	100,0
S	0,0	5,0	5,0	11,7	0,0	0,0	78,3	0,0	100,0
SS	0,9	13,8	4,3	1,7	0,9	6,9	71,6	0,0	100,0
T	1,9	6,7	4,8	10,5	4,8	1,0	70,5	0,0	100,0
U	0,0	9,6	5,5	13,7	5,5	0,0	64,4	1,4	100,0
V	0,0	9,1	2,7	8,2	3,6	2,7	73,6	0,0	100,0
W	2,2	8,0	4,3	8,7	1,4	2,2	73,2	0,0	100,0
X	0,0	5,7	5,7	11,5	4,6	1,1	71,3	0,0	100,0
Y	0,0	7,1	7,1	10,7	0,0	0,0	71,4	3,6	100,0
Z	2,2	12,5	2,7	2,2	1,8	3,1	75,4	0,0	100,0
Grand Total	**3,9**	**9,5**	**5,3**	**10,4**	**3,4**	**1,4**	**65,1**	**0,9**	**100,0**

(*) Use of codes for ethic reasons

Source: Prepared by the Authors

Regarding internships, only the **JJ** University would meet the 20% new criterion. All other universities analyzed would have to increase the time of curricular internship. On the other hand, 19 of the 42 universities must reduce the time of "additional activities" to reach 3%.

For disciplines classified as "health care", where the new Guide expects 50%, the value has a minimum of 1.8% for university **A** and a maximum of 30% for university **B**. For the disciplines classified as "health management", which is expected to be 10%, there is a minimum value of 2.8% for university **Z** and a maximum of 12.7% for university **D**. For disciplines classified as "health innovation", there is a minimum value of 0% for 21 of the 42 universities analyzed and a maximum of 7.3% for university **D**.

In relation to the disciplines classified as "health technology", where the new Guide expects 40%, a minimum value of 55.6% is found for **NN** university and a maximum of 93.0% for university **A**.

The results demonstrated graphically below confirm that the analyzed universities are quite different from each other in relation to the "health care" and "health management" core areas (which should be more expressive to reach 50% and 10% of the curriculum Guide, respectively), while there is inexpressiveness in innovation, which is considered together with health technology by the new Guide:

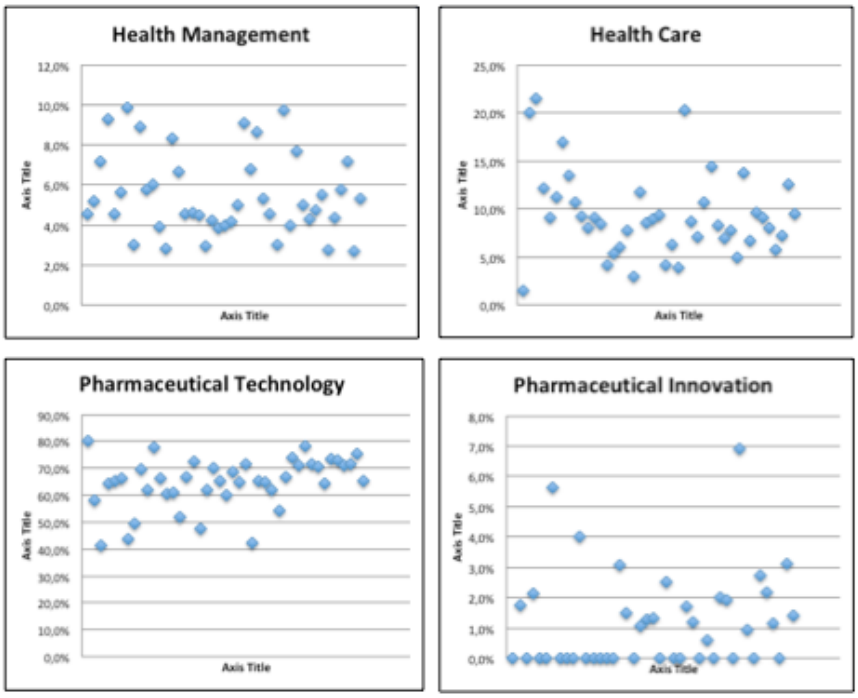

Figure 3: Universities and core areas

It is verified, therefore, that significant adjustments must be made by the Brazilian universities to reach the proportionality required by the new curriculum Guide. As innovation is being considered together with "health technology", there is great risk the decreasing of this core area to 40% can stifle even more the prevalence or even the creation of new disciplines that support innovative process, products and/or services by future pharmacists.

It must be considered whether the offer of "multidisciplinary" / non-pharmacy related disciplines (such as music, demography, history, cinema, etc.) as well as those of "undefined content" should be offered to pharmacy students, even though they occupy only 5% of the total course time.

Universities must rethink their curriculum qualitatively and not only quantitatively when planning the new programs. Otherwise, the proportionality of 50/40/10 required by the new curricular Guide within just 2 years can lead to a simply re-allocation of disciplines, keeping the history of a immature, disjointed curriculum that does not stimulate innovation and does not correlate contents (SOUSA, BASTOS, 2016).

This correlationship can be evidenced by interdisciplinary practices, whose analysis is presented below.

3.2 Classification II: Areas of knowledge

Analysis related to innovation, entrepreneurship and interdisciplinarity.

As shown in Table 1 of the Methodology section, the areas of knowledge of the universe sampled were mapped, giving the following results:

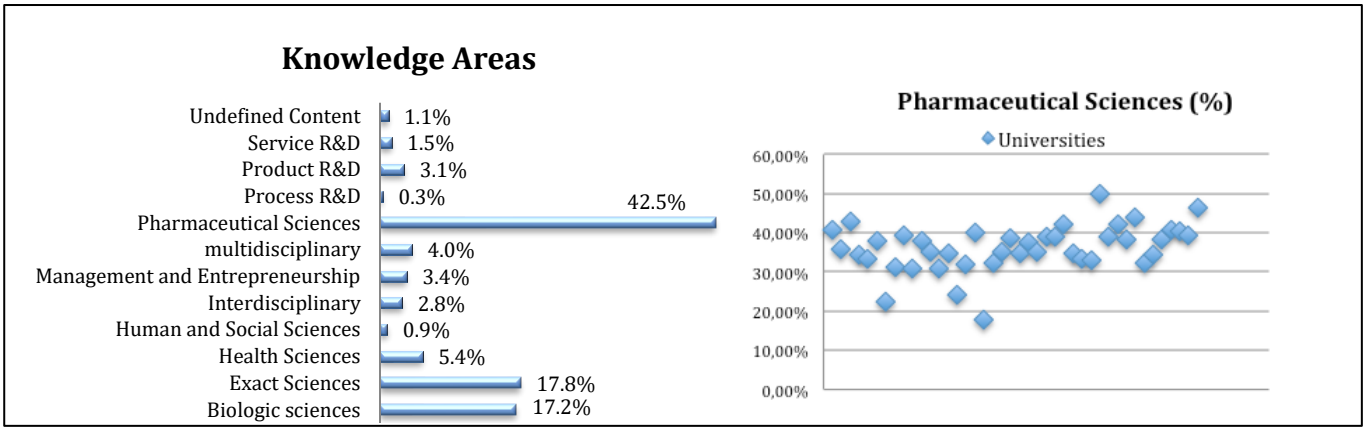

Figure 4: Areas of knowledge with emphasis on Pharmaceutical Sciences

According to a new curriculum Guide, contents in pharmaceutical sciences, except for the internship, must correspond to at least 50% of the course hours. The overall result of all universities together amounts 42.5%, where only 1 university would attend to the new Guide. Increasing biomedical disciplines to meet the new Guide, without considering disciplines or even disciplinary interactions through interdisciplinary practices, can only reinforce the existing problematic. According to Jungnickel (2009), the curriculums usually masses with biomedical disciplines as a way to add more content, while the curriculum of the future should promote the development of transversal competences through interdisciplinary practices: professionalism, self-directed learning, leadership and advocacy, interprofessional collaboration, cultural competence, innovation and entrepreneurship (MEIJERMAN, 2013).

Evaluating the interdisciplinarity and entrepreneurship, there is little expression in the total sample of 3742 disciplines, as shown below:

Table 4: Core areas x areas of knowledge (Classification II)

HEALTH CARE	HEALTH MANAGEMENT	PHARMACEUTICAL INNOVATION	PHARMACEUTICAL TECHNOLOGY
Management and Entrepreneurship	**Management and Entrepreneurship**	**Product R&D**	**Product R&D**
Pharmaceutical assistance (45)	Entrepreneurship (8) Management (56)	Biopharmacy (10) Drug/product development (27) Pharmacogenomics (4)	Biotechnology (19) Pharmaceutical production (35) Pharmacogenomics (4)
Interdisciplinary	**Interdisciplinary**	**Interdisciplinary**	**Interdisciplinary**
First aid (12) Nutrigenomics (2) Psychology & pharmacy (9)	Economy & Pharmacy (9) Environment and sustainability (17) Marketing & Health (7)	Bioinformatics(6) Clinicaltrials (5) Nanotechnology (4)	Biosafety (21) Laboratoryanimals (2)
Service R&D	**Process R&D**		
Pharmaceutical care (47)	Quality assurance (11)		

Source: Prepared by the Authors

In many countries, it is common for pharmacy courses do not offer, for example, disciplines related to drug discovery, drug development, regulation and registration, which knowledge is so important to the pharmacist (MEIJERMAN, 2013; SMITH, 2002). The present data show that, in addition to these disciplines sparkly offered, it was not possible to identify any other discipline or practice that evidences connection or interaction of contents to stimulate the innovation of pharmaceutical products, practices or services in Brazilian universities. Innovation emerges from practices that stimulate creative thinking to visualize better ways to achieve goals and walks along with the entrepreneurial spirit that, in its intended connotations to the pharmaceutical professional, includes such elements as uniqueness, adaptability, potential development, and the creation of new opportunities (LAVERTY, 2015, TURNER, 2018).

This challenge has already been experienced by universities in developed countries such as Netherlands and United States, which have included new educational methods in their curriculum through active learning composed of project-based and problems disciplines. Students were encouraged by a multidisciplinary team of teachers to generate products (reports, protocols, posters, presentations, planning, etc.) related to each stage of drug development from drug discovery, patents, preclinical trials, until led the product to the market. Thanks to combining disciplines from several areas of knowledge of the course, students were encouraged to develop other behavior skills by interaction with industry, practice of scientific research and communication, exercise of leadership, management, self-development and entrepreneurial spirit (MEIJERMAN, 2013, POLOYAC, 2017).

From a first quantitative perspective and in order to comply with the new curriculum Guide (Resolution 6/2017), Brazilian universities will need to increase their hours of pharmaceutical sciences, internship, and disciplines related to core areas of health care, management, innovation and entrepreneurship while, at the same time, they should reduce the disciplines related to health technology. This challenge can be overcome by interdisciplinary strategy as an effective qualitative solution to promote product or service innovation in upcoming pharmaceutical new programs, instead of adding isolated disciplines.

4. Conclusion

Innovation through pharmaceutical products and services is as important for the health of the population as it is for a country's economy, especially Brazil, considered the 6th largest market for pharmaceutical products in the world. Among many national strategies to address the vulnerability of the country to imported technologies, it is the training of the pharmacist one of the key players in the innovation process. In 2017 Generalist Pharmacy Curriculum Guide (Resolution 6/2017) was published, which includes innovation, entrepreneurship and interdisciplinarity for the first time as components of the Brazilian undergraduate pharmacist training.

This innovative study has achieved the proposed objectives by analysis of how current curriculum programs face these political, economic and academic challenges. Results of 42 Brazilian undergraduate pharmacist courses showed very heterogeneous curriculums but convergent patterns regarding the need to make

significant adjustments to comply with Resolution 6/2017. The 3742 disciplines evaluated by content analysis procedure, supported by NVivo® software, have generated 113 categories of disciplines, distributed in 8 core areas and 9 areas of knowledge. The result showed there is insufficiency related to health care and health management core areas as well as hours of internship, while there is predominance of health technology (>75%) with only 2% of innovation besides inexpressive presence of entrepreneurship and interdisciplinarity in the curriculums.

Considering the deadline for such substantial adjustments is only 2 years, Brazilian universities should rethink their teaching model in order to accomodate the Resolution 6/2017 requirements without overload the already extensive courses. Otherwise, disconnection and isolation of disciplines can remains. Therefore, the interdisciplinarity, so necessary for innovation, must be evidenced through disciplines and / or activities that generate a connection of knowledge and that stimulate the entrepreneurial and leadership behaviors for the new pharmacist. Cooperation-based teaching models / partnerships with other sectors, as well as projects and problem solving, should be effective strategies to be considered by universities to meet these current challenges.

Suggestion of future studies include the specific mapping of disciplines that would meet the society needs and Product Development Partnerships promoted by the Brazilian government.

In summary, this is an opportunity for Brazil to build a new trajectory in the training of the pharmacist in order to meet the economic and social needs of the country, which should not be just a consumer market, but also a sustainable knowledge promoter.

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