TECHNOLOGY DEGREE COURSES IN BRAZIL: RESEARCH AND INNOVATION[1]

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Abstract

Focusing on the formation and conception of research and innovation, this article is an excerpt from the study *Technology degree courses in Brazil: translation of public higher education policies in official documents and professional profiles*. The objective is to assess the extent to which the text of public policies aimed at higher education is reflected in the curricular guidelines, in the *National Catalog of Technology Degree Courses* and in the professional profiles of this type of higher education in the country.

Keywords: Technology Degree Courses. Research. Innovation.

1. Introduction

The Technology Degree Courses (CSTs) appear in the history of the industrialization process in Brazil with the nomenclature of undergraduate short courses in the mid-1960s, with Federal Law no. 5.540/68 – also known as University Reform of 1968 (JUCÁ; OLIVEIRA; SOUZA, 2010). Concomitantly, a series of political decisions arising from the modernization required by this economic and political context is now being implemented through laws, decrees, and ordinances.

In the National Education Guidelines and Framework Law of 1961 (BRASIL, 1961), there were already indications of courses differentiated from traditional ones, with their own curricula, called short courses. However, it was only in 1968 that, according to Brandão (2006), together with the University Reform, these differentiated courses from the traditional ones started to gain space.

Despite the apparent innovation, Jucá, Oliveira and Souza (2010) warn of the prejudice created in relation to associate

degrees, which made them no longer valued, as they mistakenly are not considered as progression in studies. Even more, it persists the false conception that technical training does not have the objective of providing good education to people, but only to meet the needs of the market at a certain moment in history.

It is difficult to undo a preconception about some idea, but what is perceived in current policies in relation to technologists is not a matter of prejudice, but an intentional policy, ratified by some educational institutions, which believe that courses should be offered only to serve the market, without worrying about stimulating critical thinking.

In view of this context, the delimitation of the theme of this article reflects the excerpt of the research by Stryhalski (2016) *Technology degree courses in Brazil: translation of public policies for higher education in official documents and professional profiles*. The focus will be on the relationship between the courses offered, the expectations regarding a higher education course and the conception of research and innovation within these training programs.

This is a documentary research of a qualitative nature. Fore data treatment, it uses the content analysis by Bardin (1977). Twenty-six CSTs from all regions of the country and documents that guide their offer are under this analysis. The data dialogues with several authors, such as Demo (2011) and Pacheco (2011), as well as with the *General National Curriculum Guidelines for Technological Vocational Education* (2002); the *National Catalog of Technology Degree Courses* (CNST); the current National Education Guidelines and Framework Law – Law no. 9,394/96; and other official documents.

Therefore, this article aims to assess the extent to which the text of public policies aimed at higher education translates into the curricular guidelines and professional profiles of Technology degree courses in Brazil.

2. Research and innovation concept

Before addressing how research and innovation are present in the discourse of documents and professional profiles, it is important to be clear about what is meant by research and innovation, often these terms are used superficially, without being careful with their essence.

2.1 Research method

Severino (1994) explains that the articulation of the teaching, research and extension tripod is based on the needs of the audiences involved in the practice of research: teachers and students need it for effective teaching and meaningful learning, respectively. The community, on the other hand, expects to use the products of this knowledge, while the university needs research to mediate education.

The concept of research is very widespread, but often in the wrong way. Lüdke and André (1986) comment that, when in schools teachers ask their students to research

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a certain theme, what they end up doing is a consultation, often a copy of the theme requested by the teacher, calling it as research. In addition, this research can be summarized by clipping articles.

There is a certain lack of understanding about the search for sources in the library, the bibliographic survey, and the research. Often, what happens in school boards is only the bibliographic survey for mapping sources, but the practice of research itself only begins from the limited number of people who come to receive the scholarships for scientific initiation.

In this sense, this article uses the research concept in line with Lüdke and André (1986, p. 2) thinking:

> In order to carry out a research, it is necessary to promote a confrontation between data, evidence, information collected on a given subject, and the theoretical knowledge accumulated about it. In general, this is done by studying a problem, which at the same time arouses the researcher's interest and limits his research activity to a certain amount of knowledge, which he undertakes to build at that moment.

Richardson (1999) approaches that the research can have the following objectives: to solve specific problems (usually, of practical order), to generate theories (relative to questions that are not yet clear or are difficult to find) or to evaluate theories already known. More than identifying the type of relationship that exists, the research aims to determine the existence of a relationship so that the process of testing and formulating theories is often confused:

> When clearly formulated theories are repeatedly tested and confirmed and consistent empirical information is available, a new stage can be started in the formulation of theories: the search for mathematical constants in the formulas that make up the theories (RICHARDSON, 1999, p . 17).

For Lüdke and André (1986), the popularization of the word "research" from schooling to higher education compromises its true meaning and even its quality, which notably only reaches a higher level in graduate school, especially in the *stricto sensu*.

2.2 Innovation concept

Often presented as a result of research, innovation has a very broad concept, which permeates several sectors, but mainly, the business, which bets on technological innovation to stand out in the market. "Technological innovation has been increasingly invoked as a strategy to redeem companies, regions, and nations from their chronic economic woes and to promote development" (PLONSKI, 2005, p. 25). In this line of thought, innovation keeps the company competitive.

According to Fuck and Vilha (2012), the term innovation came up with the economist Joseph Schumpeter (1883-1950), who associated it with the idea of producing other items or the same, although in a different way, a concept that has been improving

over time. Fuck and Vilha (2012) also emphasize that the conceptual care about innovation still is often lost in a world in which the processes of change are so present that evokes it to the center of analysis in the most diverse types and means.

But after all, what is innovation indeed?

For the present research, however, the concept in vogue is in line with the Technological Innovation Law (Law No. 10.973/2004), whereby innovation is the "introduction of novelty or improvement in the productive or social environment that results in new products, processes or services" (BRASIL, 2004). Freeman (1982 *apud* PLONSKI, 2005), one of the most renowned scholars in innovation highlights: "[...] Innovation is the process of turning opportunities into new ideas and putting them into practice for extensive use" (FREEMAN, 1982, *apud* PLONSKI, 2005, p. 27).

But after all, what is innovation indeed? It is not enough to create something that is not relevant to society. Take, for example, the development of the microwave oven. In 1939, Albert Wallace Hull developed magnetron[2], which generates microwaves for radars. Ten years later, Percy Spencer happened to notice that this magnetron melted the chocolate in his pocket. Thus, he realized that it could be used for heating food. In 1960, according to Nunes (2008), the manufacture of microwave ovens for domestic use started and, in 1975, these ovens exceeded expectations due to their practicality and low cost, being sold in a large scale. According to the definition of Brazilian Law 10.973/2004, it can be considered an innovation because it resulted in the introduction of novelty in the social environment through a new product.

It is worth mentioning that, due to the economic bias, there is a classification of the types of innovation that companies can use. According to Fuck and Vilha (2012, p. 7), it is possible to elaborate on the following table:

Table 1 - Classification of innovation

Marketing	It involves the implementation of a new marketing method, with significant changes in appearance and product.
Organizational	Linked to new methods of disposition and management of the company's business practices, in the organization of its workplace or in its relations with external actors.
Technological	Introduction of technologically new products, services or production processes to improve existing ones.

Source: Own depiction.

Plonski (2005) adds by saying technological innovations in products and processes are not mutually exclusive, unlike, they combine, for example the sale of DVDs (product innovation) over the internet (process innovation).

In Brazil, the legislation establishes the incentive for innovation and scientific and technological research in the productive environment, also aiming at industrial development, defining that innovation is the "introduction of novelty or improvement in the productive or social environment that results in new products, processes or services" (BRASIL, 2004). It should be noted that the Technological Innovation Law mentions support for research, teaching, and extension projects of a scientific and technological nature as fundamental, especially in Scientific, Technological and Innovation Institutions (ICTs).

> Art. 3rd The Union, the States, the Federal District, the Municipalities and the respective development agencies may encourage and support the formation of strategic alliances and the development of cooperation projects involving national companies, ICT and private non-profit organizations aimed at research and development activities, intended at generating innovative products and processes.
>
> Single paragraph. The support provided for in this article may include international technological research networks and projects, as well as technological entrepreneurship actions and the creation of innovation environments, including incubators and technology parks (BRASIL, 2004)

However, is Brazil prepared in terms of professionals able to develop research that meets the demand for innovation? Do graduates leave universities ready to develop researches? With enough knowledge to produce innovation for the country, as suggested by the mentioned law in chapter 1 Art. 1?. "This Law establishes measures to encourage innovation and scientific and technological research in the productive environment, with a view to training and achieving technological autonomy and industrial development in the country" (BRASIL, 2004) In this sense, Fuck and Vilha (2012, p. 3) complement:

> The Technological Innovation Law (no. 10,973/2004), the main legal reference on the subject, was enacted in 2005, the result of a discussion that had been maturing since the 1990s. One of the objectives of the Law is to favor greater articulation between the University, the Research Institute, and private companies about scientific and technological research. In other words, to expand the dialogue between the academic and business worlds, a particularly important aspect for companies looking for new opportunities and new markets.

It should be noted that universities have a crucial role in innovative technological development, which occurs through research, but as a warning by Fava-De-Moraes (2000, p. 9):

> The participation of business financing in university research must, however, be very cautious so that 'secrecy and privatization (capitalization) of knowledge' does not occur, which would be a total disaster for academic values.

In line with Fava-De-Moraes' (2000) thoughts, universities and researchers must not be strongly influenced by the productive sector, to the point of not disclosing research and innovations due to sponsorship. The author gives the example that occurred in 1996:

> [...] When a pharmaceutical company banned the publication of research accepted by a reputable scientific journal since it showed that much cheaper drugs from competing companies proved to be efficient therapeutic substitutes, a fact that would compromise the market for its drug by US$ 600 million yearly (FAVA-DE-MORAES, 2000, p. 9).

It is necessary to take due care that universities and researches are not exclusively at the service of sponsors

In other words, it is necessary to take due care that universities and researches are not exclusively at the service of sponsors, since these delays and impairs development, whether in health or in the technological issue itself. Even so, the author warns that: "[...] the basic research carried out 'spontaneously' by the University is still proven to be a greater source of applicable results than the research called 'commissioned' by the company" (FAVA-DE-MORAES, 2000, p. 9). Certainly, the industrial sector sees technological research as a very promising future for innovation.

3. What do the documents and professional profiles say about research and innovation?

Although the opinion of the National Education Council (CNE) 29/2002 states that the Technology Degree Courses have different characteristics according to their completion profile, all are considered, by law, as higher education degrees and must be structured in the light of the National Curriculum Guidelines, approved by the CNE and approved by the Ministry of Education (MEC), "[...] no exception is made" (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 5). According to the Opinion, these courses graduate for a specific professional area, to resolve operational situations within the company. However, when analyzing the document, there is a certain contradiction. In another moment, the text is as follows: "The MEC's proposal presents the technology degree courses as 'one of the main responses of the educational sector to the needs and demands of Brazilian society" (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 2). Also, it complements:

> the expansion of Brazilian participation in the world market, as well as the increase in the domestic market, will depend fundamentally on our technological training, that is, on perceiving, understanding, creating, adapting, organizing and producing inputs, products, and services (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 2).

Create, adapt, organize; produce inputs, products, and services; or innovate, all of this requires investment in research. Demo (2011, p. 10) contributes by saying that "[...] research seeks knowledge to be able to act based on knowing how to

think, education seeks critical awareness [...], research becomes important in any undergraduate course for being that base of thinking".

However, in addition to investment in research, according to the LDB (BRASIL,1996), it seeks to "stimulate cultural creation and the development of the scientific spirit and reflective thinking". The way the course curriculum is organized contributes to having a professional who, besides meeting the specific needs of the market, also has a more in-depth knowledge of the course menu.

The objectives of the 26 courses selected for this research present the concept of research and innovation in a superficial way and many do not even mention it. The curricular organization of CSTs is in modules, which makes the sequence harder to have a good research project, which will be in fact the study of a problem. There seems to be a certain lack of identity in technology degree courses. The Curricular Guidelines, at certain times, advocate training more focused on the labor market, such as:

> Technologist training is obviously denser in technology. It does not mean that you should not have scientific knowledge. Its focus should be on technology, directly linked to the production and management of goods and services. The graduation of the Bachelor, in turn, is more focused on science, although without excluding technology. It is, in fact, a matter of density and focus on the organization of the curriculum (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 29).

At other times, the emphasis on scientific training that meets research and innovation, as in the following passage:

> Industrial technologies, although successful, are mostly imported. This is perhaps the reason for the current crisis in our industry and its need to acquire international competitiveness. For that, possibly we are not lacking in engineers, competent scientists, and skilled workers. What is evidently lacking in our industry and our research laboratories are technologists (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 30).

When admitting that there is a lack of technologists in the research laboratories, which indicates a failure in the curricular organization of the courses and a lack of knowledge of what the legislation foresees for a higher-level course, the assumption is the failure in the elaboration of the courses and the lack of connection between what the official documents say about research and innovation and what is being put into practice in offering courses. The objectives of the courses, profile of the graduate and CNST provide for the densest training in technology, however, immediate, which lasts a short time to dedicate more time to the labor market processes.

It seems that in the preparation of the CNST, the higher education policies, LDB, and curricular guidelines have not been taken into account. What is found in the catalogs and consequently in the objectives of the courses and professional profiles are more focused on the industrialization processes.

The LDB postulates for higher education courses that research must be in line with the scientific principle, based on the frontier of knowledge. In Article 43:

> encourage research and scientific investigation work, aiming at the development of science and technology and the creation and diffusion of culture, and, thus, develop the understanding of people and the environment in which they live (BRASIL, 1996).

The research is foreseen in the official documents and should be present in all undergraduate courses

In the words of Lüdke and André (1986): "the role of the researcher is precise to serve as an intelligent and active vehicle between this knowledge accumulated in the area and the new evidence that will be established from the research". This way, what is perceived a priori in the professional profiles and objectives of the courses is that the professional will not have contact with the frontier of knowledge, with research and consequently innovation, but should be able to develop certain situations and contingencies that may occur during his daily routines.

The impression is that research is very distant not only from technological courses but also from other higher education courses. It seems that research is only the duty of the stricto sensu graduate program, and Demo makes very specific observations in this regard: "Research needs to be internalized as an everyday attitude, not just as a special activity, of special people, for special moments and salaries" (DEMO , 2011, p.12). And yet: "[...] it is necessary to overcome the unilateral vision of considering as research only its sophisticated stages, represented by the solemn products of a master or doctor". (DEMO, 2011, p. 12). The research is foreseen in the official documents and should be present in all undergraduate courses, not only in technological courses.

A weakness that seems to exist in technological courses is that there was a large number of offerings, both in public and private institutions and only afterward were defined the National Curricular Guidelines for vocational education at a technological level. As the Guidelines itself points out: "It is like fulfilling the task of 'fill the tank of the plane during the flight'" (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 3). In other words, first, there was the offer and then the thought about the organization and structure.

Even with the elaboration of the Guidelines somewhat late, the national catalog was elaborated in 2010. In its presentation, the publication explains that it was inspired by the Guidelines and in line with the dynamics of the productive sector, also taking into account "the requirements of nowadays society" (BRASIL, 2010). However, there is more explicit evidence about the market than to the Guidelines themselves – which predicted the role of the technologist in the application of technology applied in research (CONSELHO NACIONAL DE EDUCAÇÃO, 2002).

The CNST does not seem to bring research and innovation as relevant. Despite being from 2010, the impression is that that vision of the 1960s remains when the first short courses were enacted. The scientific preparation (research) was in

charge of the engineers, and the short-term course, to the technologists, who would graduate in three years and would only take care of the industrial processes, that is, the processes' operationalization.

To paraphrase Brandão (2006), the technologist can operate, but not to produce new technologies. This argument by Brandão brings the following reflection: how will a professional know how to operate the technologies, if he does not have an in-depth theoretical knowledge? How to innovate?

The Catalog, in its presentation, proposes that its preparation be guided by the Guidelines, and aims to guide the courses' offers:

> The catalog organizes and guides the offer of technology degree courses, inspired by the National Curricular Guidelines for Vocational Education at the Technological Level and in line with the dynamics of the productive sector and the requirements of today's society. Thus configured in the perspective of training professionals able to develop, fully and innovatively, activities in a given technological axis and with the capacity to use, develop or adapt technologies with a critical understanding of the resulting implications and their relations with the productive process, the human being, the environment and society (BRASIL, 2010, p. 9).

In the description of the Catalog that guides and organizes each course, there seems to be only a description of competencies:

> Vocational Education is no longer conceived as a simple instrument of assistance policy or linear adjustment to market demands. It is now conceived as an important strategy for citizens to have effective access to society's scientific and technological achievements, which both modify their lives and work environments (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 352).

The scientific preparation of students for future social and wide-ranging interventions and innovations within their field of action needs further study. In this sense, Pacheco (2011, p. 16) addresses the issue of globalization interfering in educational systems:

> By valuing education and training as referents of change, globalization reinforces the foundations of human capital theory, which emphasizes the vision of education as a process of social formation, oriented towards competitive markets, claiming that educational organizations must respond to immediate challenges.

In Pacheco's words, everything indicates that education is becoming a business. For this reason, it is being insufficient in research, innovation and scientific preparation, especially in higher education. However, in this research, it is also verified that, in the specific case of CSTs, which have a reduced workload concerning other higher education courses, this aspect is even more compromised in relation to research and innovation, a presumption present in the higher education legislation. In this context, the 2009 World Conference on Higher Education pronounces as follows:

> Higher education institutions, through their main functions (research, teaching, and community services) established in the context of institutional autonomy and academic freedom, must increase the interdisciplinary focus and promote critical thinking and active citizenship (CONFERÊNCIA MUNDIAL SOBRE ENSINO SUPERIOR 2009, p. 2).

Given the current context, critical thinking and active citizenship seem to open space with more emphasis on the process and the operation of specific posts on the production line. In this sense, when thinking about reform, what you find are technical measures "[...] whose ideas are centered on technical opinions from working groups, politically oriented and controlled, without the real sense of school change" (PACHECO, 2011, p. 16). This is what has been called the "commodification of knowledge".

In this line, it can be said that the CNST brings strong evidence of "commodification", including the profile of graduates and course objectives. The verbs used to describe its objectives, such as implementing, executing, controlling, bring the feeling of adequacy to the market exclusively, with no apparent concern with reflective and critical thinking. Regarding this issue, Opinion 29/2002 addresses that:

> The modern organization of the productive sector is demanding from the worker skills that guarantee greater mobility within a professional area, not being restricted to training specifically linked to a job (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 18).

The opinion also highlights that professional education has a strategic conception of citizens' access to scientific and technological achievements, by which it is necessary to overcome the traditional approach, which was directed to the mere execution of tasks in a given job.

The CNST only proposes the execution of a set of tasks, disregarding, apparently, the concern with research and, consequently, with innovation. In this sense, Pacheco (2011) warns that as a standardization mechanism: "[...] globalization weaves strong bonds both between knowledge and economics, as between education and training [...] (PACHECO, 2011, p.16). To paraphrase the words of Pacheco (2011), these strong ties are associated with the idea that if the workforce is of quality, well trained by educational systems, there is an economic benefit associated with this performance.

Within this context of the search for good economic performance and qualified labor, what seems to be falling into oblivion is what Demo (2011, p.1) calls attention to, the research question. This author explains that the research goes through a reconstructive questioning, which "encompasses theory and practice, formal and political quality, innovation, and ethics" (DEMO, 2011, p. 1). Moreover, he adds: "From innovation, it is about critical and creative knowledge (DEMO, 2011, p. 1).

Although the CSTs have different characteristics, as the guidelines themselves address, it is necessary to overcome the view that technological training falls short of what has been designed for bachelor's degrees with other characteristics.

In other words, it is relevant to think about technological courses that meet the dissemination of scientific and technological research, which advance research, innovation, and creativity, as defined by the LDB and the 2009 World Conference on Higher Education.

Using and applying new technologies requires an in-depth theoretical basis, which is accomplished through research

Accordingly, Opinion 29/2002 addresses that technological courses aim to "[...] develop professional skills that allow both the correct use and application of technology and the development of new applications or adaptations in new professional situations [...] (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 23). Given this statement, using and applying new technologies requires an in-depth theoretical basis, which is accomplished through research. "Research always includes the emancipatory perception of the subject who seeks to make and make himself an opportunity, as it begins and reconstitutes itself through the systematic questioning of reality" (DEMO, 2011, p. 9). The author also adds that when you have a critical and creative subject you can find in knowledge the most powerful weapon to innovate.

In this sense, it is observed that although the training of the technologist is denser in the technological area, it does not mean that he does not need to have deep scientific knowledge. Regarding the professional profile of technologists, Opinion 29/2002 addresses:

> The professional profile demanded and duly identified constitutes the main subject of the pedagogical project of a course, indispensable for the characterization of the itinerary of professionalization, qualification, initial or intermediate qualifications of the curriculum and the duration and workload necessary for its formation (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 30).

Because of this, there is a lack of connection between the documents that organize these courses. In the relevance for critical, reflective thinking and advancement in research and development, which is so emphasized in the LDB and the 2009 World Conference on Higher Education, little is seen concerning these issues in the Catalog.

Demo (2011, p. 17) warns of the fact that the educational process is based on formal and political quality, which combines means and ends through competence, citizenship, and competitiveness. Given Demo's arguments (2011), one can also refer to what Pacheco refers to in terms of the curriculum (2011, p. 25): "Globalization reinforces the centrality of the curriculum as a vehicle of knowledge, which is now valued as a resource economic". The curricula are hardly aligned with research and innovation, so it can be seen both in the CNST and in the objectives and profiles of graduates.

Therefore, in the Guidelines, it is seen that cutting-edge technologies are increasingly related to scientific knowledge and "the role of technologist, who is expected to have

an aptitude for the application of technology associated with the ability to contribute to research, if makes it more strategic" (CONSELHO NACIONAL DE EDUCAÇÃO, 2002, p. 30).

4. Final considerations

What is found in the official documents does not translate into the offer, professional profiles, and objectives of higher technology courses in the matter of research and innovation. What is expected from the offer of a technological course is conditions to develop skills and professional awareness, without being completely restricted to skills directly demanded for a specific area of the market. Thus, most technological courses in Brazil are not yet able to meet these purposes.

When higher education is organized into modules, it is more difficult to develop a research project that will aim at higher education. Thus, technological courses do not have the necessary interdisciplinarity. The big issue here is that there was an accelerated growth of CSTs, but without an adequate structure, without ceasing to be an intermediate course, similar to the short courses created in the 1960s. There was an exchange of nomenclature, but along with it, the principles and purposes that a higher education course needs to have were not reviewed.

Thus, the present analysis of the main conceptual milestones that generated advances and setbacks in the development of higher technology courses in Brazil serves for future investigations on the technologist's professional profile and the relationship between the creation of courses and support for research and innovation.

Notes

[1] This research was supported by the Coordination for the Improvement of Higher Education Personnel (Capes).

[2] According to Santos (2011, p. 2) "Magnetron is a valve that generates microwaves, which are electromagnetic waves, with wavelengths from 1mm to 1m. Microwaves are in the electromagnetic spectrum between radio and infrared waves. Corresponds to the frequency of 300 MHz to 300 GHz. "

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