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Techno-Science in the Training of Technologists in SENA-Colombia

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Abstract: This is a reflective article on the problem of integration in teaching-learning of scientific-technological knowledge within the training of apprentices at the Technologist level in Colombia, specifically in the National Learning Service (SENA). The text examines the link between contemporary applied research (techno-science that is developed internationally and nationally, within the concept of "industrial, academic and defense complex"), with economic and social development plans, at the levels: international, regional and local. Which derives for the case of Colombia in its National Development Plan in which it contemplates within the educational sector, the training of Technologists in the National System of Tertiary Education (SNET), in particular in the SENA (technical professional training), entity public that is primarily responsible for the design and implementation of technology training programs. Type of education that is alternate to that carried out by universities, but that also conforms, in this type of program, to the accreditation conditions required by the Ministry of National Education (MEN) for all tertiary education institutions. The above, to present the problem of the need for techno-scientific education in the training given at SENA and the use of the methodology of applied research projects, to complement the technical and technological training of the apprentices. Aspects that justify technological research projects from the perspective of Applied Research, Experimental Development, and Innovation, linked to academic training programs. In this context, the project-based learning methodology (training and applied research) is derived for the training of technologist apprentices. Projects in which the logical-epistemological and methodological structure of the basic scientific, technological and technical knowledge used, require an unobjectionable orientation and clarity, to favor their successful execution. For this, the theories and concepts of technoscience are necessary for useful reasons in the training of new workers.

Keywords: Techno-scientific Training, Job Training, Occupational Technologists

1. Introduction

Throughout the 20th century and so far in the 21st, there has been a great growth in scientific and technological production, understood as the set of products generated through activities related to research, technological development and innovation. Tasks carried out by researchers in basic sciences and technologies. Such products are usually: articles, patents, books, book chapters, communications, among others [26].

This growth has been corroborated with the application of mathematical and statistical methods for the study of scientific literature, constituting at the core of a metric technique called bibliometry which, through different indicators, facilitates knowledge about the relevant information of scientific publications, such as It is indicated in the works of Leydesdorff and Milojević [29], López-Piñeiro and Terrada [30], García [24] and Gómez and Rodríguez [25]. This technique is part of a new science called scientometrics which can be defined as the study of the measurement of scientific production and its analysis. Components of such a study include impact measurement, analysis of article reference statistics to establish the impact of journals and research institutes, statistical analysis of scientific citations, mapping of scientific research topics, and generation of indicators for use in policy formulation and knowledge management.

Now, it is necessary to explain how such production is made, what is the organization and the economic, political and social infrastructure on which it rests and is energized.

As the scenario in which scientific and technological knowledge is produced is presented, these concepts will be defined, along with those of techno-science and engineering. Such conceptual clarities will allow to sustain and argue the final purpose of the article.

Between 1900 and 1945 (end of World War II) the development of science and technology was carried out in parallel, with several channels of relationship between the two. The characteristics of this development, according to Ortíz, Uribe and Segovia [39], focused on:

a. The paradigmatic revolution in the physical sciences, mathematics and logic.
b. The appearance of Big Science[1] with the Manhattan project[2].
c. The use of fuels and energy power (gas turbine in locomotives, oil, electricity, atomic power).
d. The development of the industry and Innovation (improvements in iron and steel, construction materials, plastics, synthetic fibers, synthetic rubber).
e. Increase in food production and agriculture.
f. Development of Civil Engineering.
g. Increase in Military Technology.
h. Transportation / Communications Development.
i. Development of pharmaceutical and medical technology. [39].

In the second half of the 20th century, an era of technology developed in favor of the space race, which was under the threat of a nuclear war between the United States and the Soviet Union, countries that were empowered after World War II. "Although the bombs have not been used in a war since that time, the weapons have had a great development. This technology contributed to the polarization of two world powers, which strove to be cautious." [39]. In this period, other alternative fuels emerged: Nuclear Energy from the Fusion of Hydrogen from Water and Solar Energy. In addition, there was the appearance of:

a. Gas turbine (jet planes; ships, railway locomotives and automobiles).
b. Materials (new uses for old materials, plastics, glass fibers, carbon fibers, ceramics resistant to high temperatures).
c. Automation and Computers (control engineering, automation and computing).
d. Food Production (rapid cold drying and irradiation methods to preserve food; farm mechanization; pesticides and herbicides; aquaculture and hydroponics).
e. Civil Engineering (control engineering techniques, earthmoving and excavating machinery, block apartment construction, household equipment).
f. Communications (television, transistor, new printing techniques, new optical devices -zoom lenses-, physical techniques such as lasers).
g. Military Technology (restructuring of strategies for nuclear weapons released by ballistic missiles; helicopter and a wide variety of armed vehicles).
h. Space Exploration (Sputnik, the first artificial satellite put into space by the Soviet Union in 1957, which started the space race, Vostok spacecraft –URSS- with Yuri Gagarin in 1961, Apollo Program –USA- that it put on the moon on 20 July 1969 to Neil Armostrong and Edwin Aldrin; Hubble Space Telescope lens repair).
i. Transportation (powered airplanes). [39].

In explaining the origin and development of science as a large industry, de Solla Price [40] stated that: "In the atomic and space era, science is rapidly becoming far too important to be left to the scientists. Part of the reason for this is that scientists have displayed incredible ingenuity over the ages in furthering their self-interest." [40]. In other words, this means that the economic and political power groups realized that science was rapidly becoming too important and strategic a public matter for the management and conduct of human actions on a large scale. Which could not be left to the scientists. It can be said that part of the reason this happened is that scientists at the time were incredibly naive about the end use of science results, focusing their attention primarily on promoting their own scientific interest., without taking into account the economic, political and military challenges and possibilities of its findings. Today the body of scientists is constituted in an army of researchers with a hierarchical system, which is established by the authorities of the States[3] and disciplinary interest groups, which have corporate ties with the instances of power, through the academic entities of the specialists. In this regard, Bauer says that: "Increasingly the corporate organization of science has led to monopolies of knowledge, which, with the involuntary help of the uncritical mass media, carry out a type of censorship. Since scientific organizations control research funding, by denying funding for unorthodox work, they function as research cartels, monopolies of knowledge. A related aspect of contemporary science is its commercialization" [2].

Münch [31] agrees with Bauer [2] in that in the

1 The science of large infrastructure, scientific and technical conglomerates, called big science in English, is a term used by scientists and philosophers of science, originally proposed by Derek de Solla Price [40], although already it had been proposed in 1961 by Alvin Weinberg when he ran the Oak Ridge Laboratory. Especially used in the subjects of the History of science and technology. With this concept, a series of changes in scientific and technological research that occurred in industrialized countries during and after the Second World War are described and encompassed.

2Manhattan Project was the code name for a techno-scientific project carried out during World War II by the United States with the participation of the United Kingdom and Canada. The ultimate purpose of the project was the development of the first atomic bomb before Nazi Germany manufactured it.

3 In the case of Colombia, a hierarchy of researchers is established at three levels: senior, associate and junior. After these, there is an extended roster of members in research groups that begins with "doctoral student" and ends with "linked member". [12].

environment of the worldwide expansion of New Public Management (NPM), the evident shift of higher education institutions into companies that compete for scientists, students and money for research, it fuels the monopoly consolidation operating device in technoscience. Monopoly that is articulated with the economic power of production and defense systems.

Applied Research, Experimental Development and Innovation [4] in defense systems have been developed by private companies throughout the planet. The expression «technological and industrial base of defense» "has been increasingly used by the North American vision in numerous studies of an economic or strategic nature. In Europe, it was officially used since 2007, basically in two documents: in the one entitled "Strategy for a European Defense Technological and Industrial Base", made by the European Defense Agency (EDA), and in the text "Strategy for a stronger and more competitive European Defense Industry" [1].

It is necessary to bear in mind that the economic growth of Europe and the United States in the second half of the 20th century had a lot to do with the reconstruction of the countries that had received the blows of the Second World War. This situation increased the dynamics of production, generating more income and more workers in the economic system. It is in this way that the systematic use of science and technology within the production process is consolidated. Process in which the spearhead was established by private corporations at the service of defense systems, in the framework of the Cold War, producing what was called *the military industrial complex.*

An example of the above is the publication that is made periodically on defense matters[5], there appear the data of the list of the 100 main contractors in this area. The information comes from the annual data that the companies provide, from the research of specialized analysts and the Defense News staff. Businesses are contacted by this news agency and asked to complete a survey that reports their total annual revenue and revenues derived from defense, intelligence, national security, and other national security contracts.

It is worth saying that according to Echeverría [22] the new forms of production of wealth and knowledge have dramatically transformed power relations and the distribution of wealth in countries, continents and businesses. Military power, to point out a paradigmatic case, requires a high techno-scientific and informational development. Development that requires careful examination, since this not only serves to create, discover, invent and build, but also to annihilate and destroy.

The recomposition of power relations and the distribution of wealth coincides with the fact that, in the mid-1980s, at the initiative of the United States and Great Britain, a process of economic globalization began to be generated, consisting of the growing economic integration and interdependence of national, regional and local economies around the world, through an intensification of commercial exchanges of goods, services, technologies and capital. A matter that made the production process of scientific and technological activities more intricate and complex, generating an inseparable fabric between basic science research, applied research and transdisciplinary research of the *new sciences*[6]. That is why the concept of technoscience arises. "The term "technoscience" was used by Bruno Latour in 1983 just to abbreviate the endless phrase "science and technology". Many other authors have used the same term in an all-encompassing way." [21].

The current *techno-science* system refers, in the vision of Echeverría [21], to a modality of scientific and technological activity that needs to be analyzed. His approach is framed in an evolutionary perspective and lies in the fact of recognizing that there is still science and there is still technology. This in reference to the cultural tradition, in which science and technology, understood as engineering, continue with an independent development in each of the usually known disciplinary areas; However, at the same time, in such a process, a change has taken place, an organic combination of great complexity, structural and productive between science and technology, for its advancement and progress.

In other words, a new evolutionary branch has emerged in the production of knowledge and the generation of possibilities for the transformation of the natural, social and artificial world: *technoscience*. This means that advances in basic research, for example in astronomy, in molecular biology and in the physics of new materials, are achieved thanks to the development of complex electronic, mechatronic, computational, robotic and informational devices. At the same time, the advancement in technologies, for the generation of new devices for operation, observation, measurement, comparison of magnitudes, calculations, transformations, among others, require the latest generation knowledge of basic sciences and other pre-existing technologies. existing. Which makes technoscience a complex for the industrial production of knowledge, for knowledge itself, but also for the economic production of goods and services. It is the "knowledge-based economy", this "is an expression coined to describe the current trend, in developed economies, towards a greater dependence on knowledge, information and high qualifications, and towards a growing need, on the part of the companies and

4 Applied research also consists of original work done to acquire new knowledge; however, it is primarily directed toward a specific practical goal. [36]. Experimental development consists of systematic work that takes advantage of existing knowledge obtained from research and / or practical experience, and is aimed at the production of new materials, products or devices; to the start-up of new processes, systems and services, or to the substantial improvement of existing ones. [36]. Innovation refers, according to Schumpeter, cited by the Oslo Manual [37], to a process of "creative destruction", in which new technologies replace old ones, giving rise to changes, those that can be radical or incremental.

5 https://www.defensenews.com/

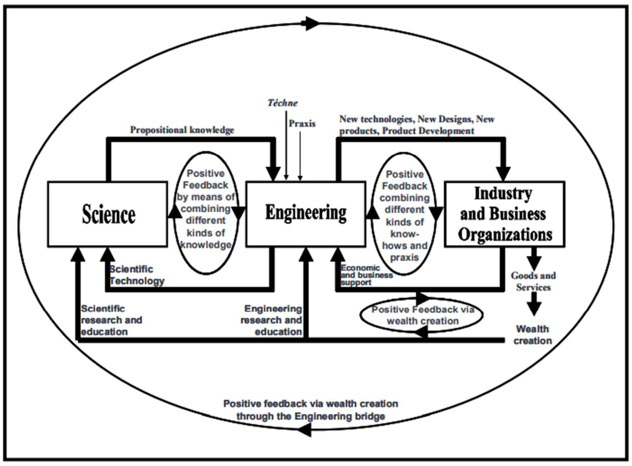
6 The sets of the new sciences are known today as sciences that study problems that bring together several of the old analytical scientific disciplines (physics, chemistry, mathematics, etc.), which appear with names such as: earth sciences, space sciences, life sciences, computer sciences, health sciences, complexity sciences, big data sciences, and cognitive sciences.

the public sector, to access all of this. Knowledge and technology have increased in complexity, increasing in turn the importance of interrelationships between companies and other organizations to acquire specialized knowledge. In parallel with this process, the relevance of innovation in the service sector in developed economies has also increased." [37].

The emergence of *techno-science*, in addition to having changed science and technology, has helped to generate a great economic and social transformation. It is about the consolidation of information and communication sciences and technologies (ICT), which began in the last decades of the 20th century and which, foreseeably, will continue to develop during the 21st century. The link between *techno-science* and the emerging information society together with the *industrial revolution 4.0* is complete. Such a revolution is related to the automation in cybernetic type, in web interconnection, of the industrial production process on a large scale. The term "is widely used in Europe, although it was coined in Germany. It is also common to refer to this concept with terms such as "Smart Factory" or "Industrial Internet". In short, it is about the application to the industry of the "Internet of Things" (IoT) model. All these terms have in common the recognition that manufacturing processes are in a process of digital transformation, an "industrial revolution" produced by the advancement of information technologies and, particularly, information technology and software." [20].

Considering the previous development and admitting the hegemony of the economic system of global capitalism, it is necessary to say that the training of human talent in research, technological development and innovation (R + D + i), demands to occur within the framework of the relationships between science, technology and society. It requires a focus on the training of researchers in basic sciences, specialists in applied research and knowledge managers for the design and development of goods and services. This forces to bring the academy closer to production in the different sectors and subsectors of the economy, national and international business, public planning institutions and other social organizations.

The reason for the previous statement is due to the fact that as Figure 1 shows, the whole of society is a dynamic of complex interconnected systems, in which economic production that involves the industry in the extraction of raw materials, agricultural production and livestock, the processing of materials for all productive needs, the industrial production of goods and the production of services for well-being, is linked to the generation of wealth, through work, using knowledge and techno-scientific devices. This use is carried out through the engineering bridge, whose task is to articulate, through design and innovation, new responses to society's needs and opportunities to improve the quality of life, as well as the development of new businesses to generate work and wealth.



Source: [5].

Figure 1. *Complex system of economy and society.*

But at a broader level of the exposed system, there is also a role for *meta-engineering*, for which, the vision of Enright and others [23] will be used here, in which they refer to a software development framework, called *Rapid Realtime Development Environment*, as the engineering of an engineering process. This is because the engineering processes themselves require their own redesign and development with the support of computer science. Which tends to make the processes and protocols of technoscience, together with economic production, more efficient in the midst of the complexity of relationships that are established between these universes of knowledge and human action. This meta-engineering redesigns the global production processes in which it redefines and plans the use of new technologies for the production of goods and services, through the innovation of financial investment in new markets, in financing state-of-the-art scientific and technological research. Process in which the productive system is articulated with the educational system that is supported by science.

Following the presentation of the system, it is necessary to say that, in the production of goods and services in industry and business organizations, new technologies, new designs, new products and new developments are based on the role of the engineering and meta-engineering. Which leads to the creation of wealth and well-being as already indicated, which in turn supports and finances the action of engineering companies in a feedback cycle.

Now, the dynamics of engineering is closely related to the education of human talent. This establishes a necessary link with the educational system, formal and non-formal. Therefore, the universe of basic research (particular sciences), that of applied research (technologies of all kinds) and that of transdisciplinary research (techno-science), leads to a fundamental approach of the educational system with the sectors of the production. Know-how as a set of technical and administrative knowledge that are essential to carry out a production and commercial process, which are not necessarily protected by a patent; it requires articulating with the results of applied research studies for the improvement and production of new goods or services.

As already said, scientific activity today is connected with technological development (techno-science). For this reason, for the improvement of the productive capacity of the countries and regions, It is required that, in the educational processes of new human talent, an intense training in *technoscience* is carried out.

The productive capacity, understood as the link that exists between what has been produced and the means that have been used to achieve it (labor, materials, energy, etc.), which is usually associated with efficiency and with time: the less time is invested in achieving the desired result, the greater the productive character of the company, region or country; It can be obtained by combining human talent, techno-scientific-based productive infrastructure, and financial capacity.

The above, in the world arena, is orchestrated through international institutions such as the UN[7], the World Bank, the International Monetary Fund, the World Economic Forum and the OECD[8], who synthesize and formulate the directions and trends of the global economy.

The UN in the *Post-2015 Development Agenda* [9] emphasizes the need for economic growth to be articulated with eco-systemic sustainability. It affirms that one of the most important results of the Rio + 20 Conference was the agreement reached by several of the Member States to achieve sustainable development objectives, which would result as a mechanism to focus coherent actions in such development.

This requires a rapprochement between the States (through the governments in office) with civil society (companies, the financial sector, workers, social organizations and other stakeholder groups) in all countries; and with greater emphasis on those that still show a productive deficit, as is the case of Colombia. Hence, the need for educational institutions to be allied with companies (productive sector).

This macro organization of the economy and society is permeated by the interests of financial power groups, which are supported by the political and military power of governments and supranational institutions. These interests are expressed in a specialized way in the genesis of theories and concepts on progress, development, social cohesion, sustainability, competitiveness, etc., which correspond to ways of approaching social, historical and economic reality, in certain ways (derived from techno-science), with the purpose of favoring the prevailing productive system. The foregoing, under the cloak of scientific objectivity and methodological technicality of such theories and concepts.

It is worth saying that the idea of progress appeared in the 18th century within the European Enlightenment, with a deployment in two great moments during the 20th century; first, with the emergence of the development concept itself after World War II and, second, its subsequent replacement by the concept of competitiveness since the early 1980s [18]. The most recognized and completed version of the theory of competitiveness is the one constructed by the World Economic Forum (WEF), which publishes each year a global report on competitiveness, taking nations as the unit of measurement and analysis. [18]. The most notable result is a competitiveness index by country, built with the contributions of renowned contemporary economists such as Michael Porter, Jeffrey Sachs and Xavier Sala-i-Martín. [18].

Due to the reconfiguration of geostrategic relations after the fall of the Soviet Union, together with the liberalization of markets advocating economic and cultural globalization, the countries of Latin America and the Caribbean experienced important changes in their governance and management models. public. In these transformations, it is worth highlighting the reorganization of planning for development. Despite the fact that at the end of the 20th century, sectoral, territorial and urban planning was maintained in many cases, in almost all countries the use of it lost strength, in more comprehensive processes related to the conditions of national development. This new way of understanding and carrying out planning has involved collective learning in order to strengthen and consolidate it as a common practice in different governments.

In this process of consolidation and learning of public management and its institutional framework, different multilateral organizations have joined forces in the expansion of planning methodologies and technicalities for the generation of the imaginary of acceptance and uncritical participation of the hegemonic production model. Among them, the Organization for Economic Cooperation and Development (OECD) and the World Bank appear again, as well as the Inter-American Development Bank (IDB), the Latin American Center for Development Administration (CLAD), the Economic Commission for Latin America and the Caribbean ECLAC, through the Latin American and Caribbean Institute for Economic and Social Planning (ILPES).

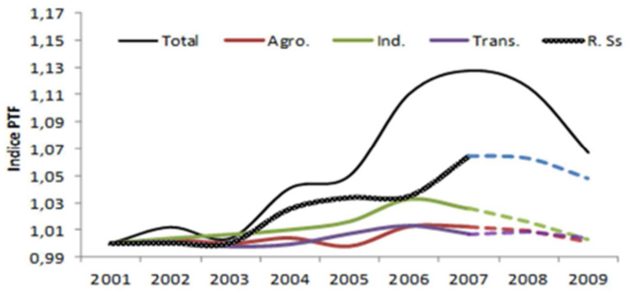
In the particular case of Colombia, within its economic and social planning system, it is customary, as in other countries, to formulate a National Development Plan within each presidential term. The last plan that ended three years ago[10] the need to increase Colombia's productivity in the aforementioned competitiveness framework, becomes a matter of crucial importance, since, according to the defenders of globalization, the country's economy faces a situation of low productivity, in an environment of supposed macroeconomic stability, greater trade openness, a greater flow of foreign investment and a positive perception of the role of the private sector as an agent of productive transformation.

7 The United Nations came into being in 1945, following the devastation of the Second World War, with one central mission: the maintenance of international peace and security.

8 Organization for Economic Co-operation and Development.

9 http://www.un.org/es/development/desa/development-beyond-2015.html

10 Plan Nacional de Desarrollo 2014-2018 “Todos por un nuevo país”.



Source: [13].

Figure 2. *Evolution of the Productivity Index.*

According to Figure 2, low productivity growth can be explained by low levels of production sophistication[11]. A reflection of this is that Colombia is ranked 66 in the Global Competitiveness Index of the World Economic Forum, below Chile, Brazil, Mexico and Peru. [14].

These low production levels are related to six (6) determining aspects of the shortcomings in diversification and sophistication. Among which is "the weakness in the articulation of the National Competitiveness System and the National System of Science, Technology and Innovation that has prevented an adequate articulation of the instruments aimed at increasing the productivity and business efficiency of the country." [14].

It is because of the above that, to obtain growth in productivity, improvements in the innovation capacities and technological absorption of Colombian companies are required. Behind this there are different causes related to weaknesses in the country's science, technology and innovation capacities. The OECD [35] states that Colombia has a total of 81 universities (32 public and 49 private). Three quarters of the student population attends public universities. Only a small part of teachers in tertiary education have a doctorate and elite universities are concentrated. The increase in external funding since the middle of the last decade and the government's new research and innovation impetus appear not only to have driven an increase in the national production of doctorates but also to have encouraged universities to "professionalize" the management of research. with vice-rectors for research. Modern intellectual property (IP) legislation in the spirit of the Bayh-Dole Act in the United States has encouraged the creation of offices of technology transfer (OTT) and other specialized functions, but labor conditions and regulations hinder the creation of spin-offs, which are business initiatives promoted by members of the university community, characterized by basing their activity on the exploitation of new processes, products or services based on the knowledge acquired and the results obtained at the University itself. [35].

This implies a low culture in basic and applied research. Research funding for universities comes from various sources. A small proportion of core funding is now allocated based on the number and quality of scientific output from universities. Project-based income comes from grants administered by Colciencias (Ministerio de Ciencia, Tecnología e Innovación - MINCIENCIAS) and other external contracts. The income from the investigation of industrial contracts is minimal, since the links between them are precarious and inadequate. [35].

Along with the above, the Program for International Student Assessment, PISA, which is a study carried out by the OECD, has become the main global benchmark for evaluating the quality, equity and efficiency of education systems. PISA helps to identify the characteristics of the highest performing education systems, which can allow governments to recognize effective policies that they can adapt to their local contexts with the purpose of increasing the quality of education and enhancing the future productive capacity of their respective nations.

For the 2015 tests, the study focused on science, leaving reading, math, and collaborative problem solving as secondary areas of the assessment. In Colombia, the coordination and application of the PISA test has been in charge of the ICFES since 2006. The application of PISA in 2015 evaluated the educational systems of 72 economies and deepened in science skills. In 2015, Colombia had the highest number of students evaluated compared to the previous applications. About 12,000 15-year-olds took the test in the country. Colombia obtained 416 points in science, 425 in reading and 390 in mathematics. These scores are below the statistical mean of the total population of the 72 countries examined, which is between 493 and 500 points. In the same way, in the consolidated science, reading and mathematics with respect to the proportion of students with an excellent level in at least one subject, only 1.2% of Colombian students obtained that qualification. Along with the above, for the Colombian case, the proportion of students with low performance in the three subjects was 38.2%. [32].

The data presented tend to be congruent with each other, with respect to low productivity growth, low research culture, research income from minimal industrial contracts, precarious and inadequate higher education-industry linkages, and low level of performance in tests on science, math and reading.

Now, from February 2011 to May 2018, in the author's work experience as a methodological advisor for training projects and applied research, at the Design and Metrology Center of the National Learning Service SENA; It has been evidenced through 1652 advisory actions to training projects, in relation to their logical structure (statement of the problem or need to attend, justification of the project, general objective and specific objectives), that there is a deficiency in the reading of instructions for the completion of the project formats, a failure to organize the elements of the aforementioned logical structure into a coherent whole and a very poor writing is very often presented, expressed in a poor organization of the statements of phrases and sentences, as well as a bad spelling, both letters and accents. Issue that

11 Productive sophistication, within the process of the production of goods and services, refers to the inclusion of technological research and development activities, knowledge incorporated in the workers, and the training of human talent in cutting-edge technologies to improve and increase production.

characterizes a precarious use of written language, that is, the texts they write are very rustic, because they lack logical connectors and meaning that give coherence to what is written, with a low degree of correctness, style and understanding. This happens despite having received an instruction and in some cases previous explanatory talks. With the writing they present, they do not demonstrate being able to adequately solve the necessary tasks in academic life and in training in an occupation or profession. An example of what has been said is the abundant documentary evidence compiled in the review of the training project formats. This translates into a growing concern, since the academic tasks in the training of technologists require them to develop activities such as writing research projects, preparing essays, writing technical reports, producing articles of original research, producing book chapters, among other activities. This could be indicative of poor competitive performance, because if student apprentices in general are in this situation, they will be seriously limiting their interaction with information and communication technologies, with industry 4.0 technologies within the production process, with their efficient participation in applied research teams, among other possible areas. Limitations that collectively reproduce the phenomenon of low competitiveness in the country's production.

This information is consistent with what was indicated by Ochoa-Rojas [34] in the presentation of a technical and didactic proposal for SENA apprentices and instructors, in the process of formulating training projects within the process of technological and educational training. technical, in the different programs that the institution imparts in the country's centers. There the deficiency found in reading and writing texts was mentioned in the process of formulating these projects by the apprentices. This deficiency is referred to the weak capacity to understand and interpret the meaning and structure of texts. This competence must be evidenced in the structure and organization of a text (training or applied research project).

The foregoing makes it necessary to characterize the situation of the training of technologists at SENA, with respect to the knowledge of basic sciences and state-of-the-art technologies (techno-science), as well as the competences of the use of language in terms of reading. writing, to generate an institutional design in response to the needs and shortcomings that are detected.

According to the thread of the argument exposed so far, the following question appears:

How to increase training in techno-science and skills in the use of language in the training of technologists in the National Learning Service SENA of Colombia to contribute to the qualification of human talent on the path of improving productivity and competitiveness of the country?

2. Materials and Method

The method used for the preparation of this reflective article was the reading, comparison, interpretation of documents related to the topics of science, technology, research, economic production and education in Spanish and English, review of the instructions on the formulation of training projects given Through a written document, compared with the performance of the student apprentices in the Technologist in Analysis and Development of Information Systems program, at the SENA Design and Metrology Center, in 942 completed forms of resulting training projects, in 1652 actions consultancy, between 2011 and 2018, an exercise carried out by the author in his capacity as methodological advisor for training projects. Along with the above, there is a compilation of the author's experiences as a researcher in education, as a university teacher and as an advisor of degree projects at the Master's level in Education, specifically in the areas of Research Epistemology, Philosophy of Science and Research Methodologies for 18 years.

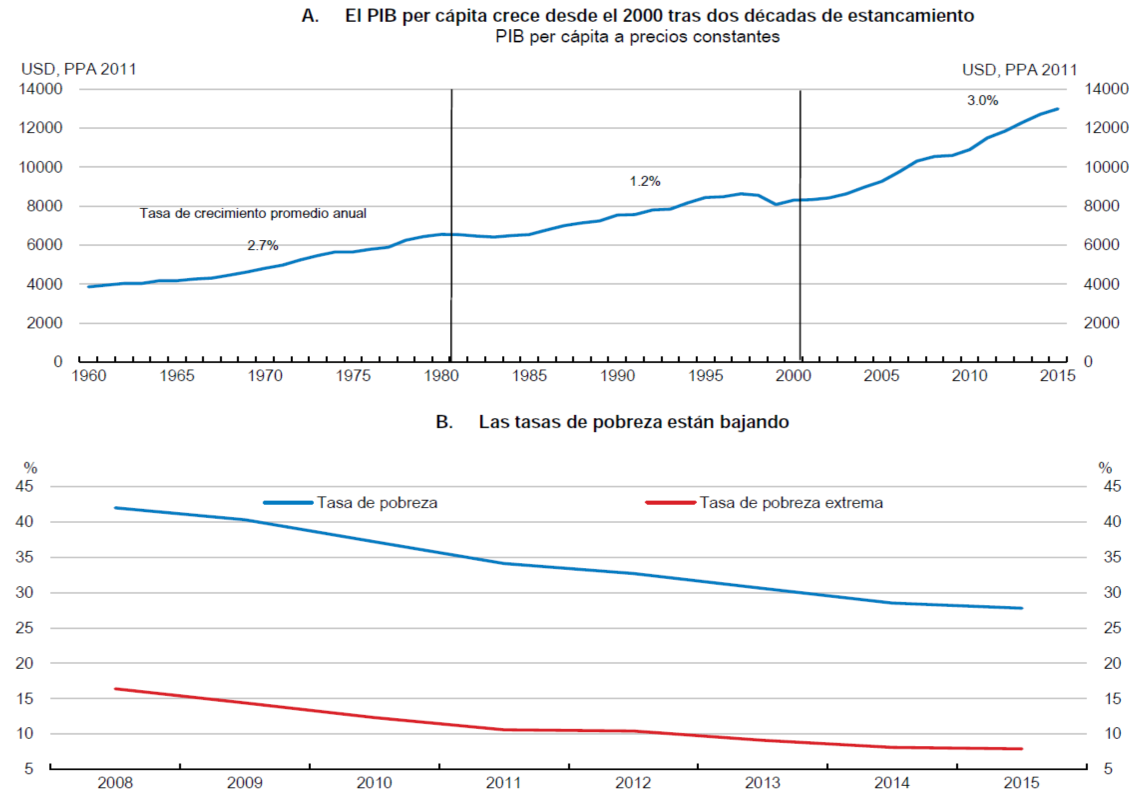
3. Results

Taking into account the nature of the article and what has been developed so far; In order to approximate an answer to the question posed in the Introduction, we proceed to present below, as results, some reflections and propositional arguments, derived from the above, with respect to the economic-productive horizon of the country, based on technological development and innovation, as well as the qualification of the training of human talent in relation to the general policies of Science, Technology and Innovation (STI), aspects that are created enhance the productivity and competitiveness of the country. On a smaller scale, some reflections and proposals are made around the training of apprentices in research hotbeds, in techno-science, through the methodology of training projects and applied research, with respect to knowledge, as advanced as possible, in natural physical sciences, mathematics, logic applied to engineering design and techno-scientific literacy. This, to the extent that progress is made in identifying solvable problems in the productive sector, within the training programs for technologists in the National System of Tertiary Education (SNET) [12], particularly in SENA. The above, through a gradual incorporation process.

According to what has been said, it is necessary to first indicate the economic trends of Colombia in the light of the OECD, which is taken as a basis to be able to derive the final argument that is defended here.

Since the beginning of the 21st century, the quality of life of the Colombian population has improved significantly. This statement could be associated, as a hypothesis, with the macroeconomic and social policies that have been implemented in the different governments, which has been linked to strong GDP growth and poverty reduction (Figure 3).

12 The SNET is understood as an organization of the different levels of post-secondary education, which comprises two routes or two different educational options according to their academic or occupational orientation, ordered according to degrees of complexity and specialization and, with possibilities of transit and recognition between they. The two routes are: i) university education and ii) professional (technical) training in which SENA is included. In: https://www.mineducacion.gov.co/1759/w3-article-355208.html

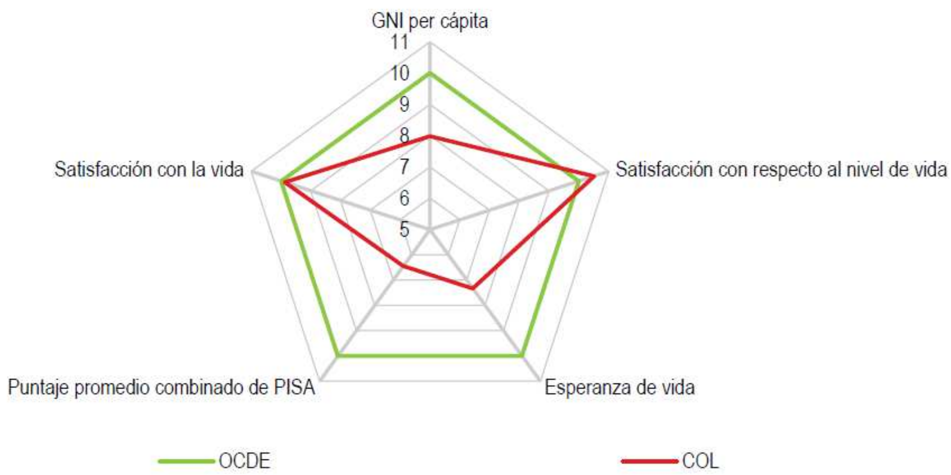


Fuente: Banco Mundial, base de datos World Development Indicators, base de datos International Comparison Program, DANE, Gran Encuesta Integrada de Hogares, base de datos de Gallup, OCDE PISA 2006 y 2012, y base de datos de la OIT.

Source: [33]

Figure 3. *Gross Domestic and Poverty Rates.*

In the period between 2002 and 2015, the poverty rate fell from 50% to 28% and extreme poverty from 18% to 8%. Well-being and satisfaction with life, in the Colombian imagination, is above the OECD average, although income, education and life expectancy are still insufficient (Figure 4). Economic and social reforms have reduced informality and improved the business environment. In the same way, it is believed that the peace agreement that has been signed will further boost economic growth and well-being over time. [33].



Source: [33]

Figure 4. *Well-being and life satisfaction indices.*

These trends could be prolonged and intensified on the basis of another hypothesis, consisting in that the sophistication of the productive infrastructure and productivity, as mentioned above, take effect, qualifying the processes and results of the techno-scientific training of human talent. in tertiary education. The foregoing, without the detriment of the qualitative improvement of basic and secondary education, since education and the development of knowledge and skills play a key role towards more inclusive growth and increased productivity [33]. These measures must be carried out in conjunction with other participation policies, economic and social.

In this framework, Colombia needs to reconfigure the General Royalties System (SGR), to establish a special regime for public, open and competitive calls, through which investment programs and projects are financed with resources from the Science, Technology and Technology Fund. innovation (FCTeI), establishing at the same time, the regulations for the turn and order of the expenditure of said resources, in accordance with the provisions of paragraph 5 of article 361 of the Political Constitution. This political and legal measure contributes to expanding the capacity to execute Science, Technology and Innovation projects, as part of the attention to the recommendations of the OECD.

At the same time, it is required that investment programs or projects that can be financed with resources from the FCTeI of the SGR, must be defined by a decision-making body of Science, Technology and Innovation, through public, open and competitive calls; in which the conditions that the public and private applicants of the National System of Science, Technology and Innovation (SNCTI)[13] must meet, for the presentation of research proposals to be financed.

The conditions of the calls should be structured based on general lines of techno-scientific research contemplated in the emphasis on economic-productive development foreseen in the National Development Plan, the Colciencias (MINCIENCIAS) Strategic Plan and in the recommendations of the OECD. The foregoing, for the contribution to regional development and the country's goals in science, technology and innovation.

On the other hand, together with what has already been said, it is necessary to promote the development of alliances between industries and companies with the institutions of the National System of Tertiary Education (SNET). System, which as said at the beginning of this document, is an organization of the different levels of post-secondary education in the country, which has two different educational routes according to their academic or occupational orientation, which are organized in levels of complexity and specialization, with traffic and interactive recognition between them. The routes are: on the one hand, university education and, on the other, vocational (technical) training. SENA is part of the latter. It is very important to explain that the purpose of said system is to provide a better response to the requirements of equity and competitiveness of the country through education. This can be encouraged through various tax and financing mechanisms for R + D + i projects, as well as through the generation of new businesses.

These alliances, in conjunction with the policies for economic development and competitiveness, science, technology and innovation established in the National Development Plan, should lead to the lines of research formulated by Colciencias (MINCIENCIAS) within the SNCTI. In which its conception needs to be inter[14], trans[15] or multidisciplinary[16], aiming at the characterization of the needs, obstacles, difficulties, risks, opportunities for innovation, adaptation or technology transfer that occur in industries or groups of companies, institutions, sectors or subsectors of production, whether at the national or regional level; and that need to be solved or proposed to satisfy established direct clients and / or future clients. Areas in which the contribution of the productive sector (industries and companies) and the SNET institutions is needed. The above, emphasizing applied research for productive purposes, which can be worked through technological entities of professional training and universities. The above, without prejudice to basic research in the pure sciences.

For the specific case of SENA, taking into account what has already been said, it is necessary to review in the cases that are pertinent, that in the curricular structure of each technologist training program, within the respective training project, a strengthening in Basic and advanced knowledge (theoretical and practical) of the sciences and technologies associated with the performances described in the competencies and in the learning outcomes of the same, using the methodologies of applied research projects. Reformulate the curricular structure of training courses based on skills in applied research that is in force in 2018, to adapt it to the systemic and multidisciplinary approach of

13 The Entities of the Science, Technology and Innovation System are those entities that are constituted in the national territory, that develop Science, Technology and Innovation activities; and that they have the suitability and techno-scientific trajectory. All of the above, in accordance with the provisions of the Administrative Department of Science, Technology and Innovation (Colciencias), in accordance with the regulations issued by the national government for this purpose.

14 The classic interdisciplinarity brings together disciplinary experts, each of whom carries out the study of their plot and presents a report according to its enclosure. Here there is no dialogue between the disciplines, nor between the subjects, there is no lingua franca, nor a new knowledge, each specialty does its own thing, without worrying about what the others do and think, and even more, without wondering how it does. what it does. [42].

15 Trans-disciplinarity refers to a knowledge and principles that are beyond any single discipline and therefore, that which crosses them all, therefore goes beyond the disciplinary, is a disciplinary goal. [42].

16 In some investigations or activities, it is necessary to have experts from different subjects who form a working group. These teams are called multidisciplinary. The main characteristic of all of them is the following: combining different knowledge and methods to approach an issue that requires different perspectives. In this way, multidisciplinarity is the coordinated interaction of different areas of knowledge. (Definition ABC. In: https://www.definicionabc.com/ciencia/multidisciplinariedad.php).

the combined technologies that participate in the different production processes. In the same way, carry out practices with training in methodologies, techniques and instruments for collecting and processing data in applied research, which are related to the core technologies of each program, with the research seedbeds. This through virtual courses on the application of methodological tools in research: Scientific publications and SCIENTI platform of Colciencias (MINCIENCIAS) and application of methodological tools in research: Science, technology and innovation processes.

In particular, intensify through workshops, the writing of academic texts (essays, technical reports, techno-scientific articles, book chapters), taking into account aspects related to the organization of texts, in their general structure, construction of sentences (sentences), construction of paragraphs with sequences of sentences, construction of the text according to the general structure and sequence of paragraphs, revision of the sequence of paragraphs to the text as a whole (coherence and cohesion). The latter, if one takes into account that numerous studies have raised how in the different disciplines particular ways of writing are promoted that, in short, are linked to specific ways of thinking about the phenomena under study, to the interest groups to which they belongs who already writes the way in which knowledge and practices are promoted in the different academic communities [3, 4, 6-10, 27, 28, 41, 43]; among others.

For example, Carlino [11] points out that Latin American experiences and publications on the teaching and practice of reading and writing in higher education have configured a field of research, action and thought in the last fifteen years. He considers the need to deal with reading and writing in higher studies. Now, he wonders by whom, how, where, when and why to do it. It is clear that in the case of SENA, two levels must be considered. One referred to the basic competences of communication (adequate use of oral and written language in the productive environment). The other referred to the knowledge and performance related to the exercise of writing techno-scientific texts.

The special programs on techno-scientific writing mentioned above could be systematized by cycles of workshops with a gradual increase in complexity, starting with the bases of the elements of the use of language (style) in the construction of a text, such as: construction of a paragraph, orthographic uses (writing of words and punctuation marks), use of logical connectors and connectors (semantic, metatextual and discursive operation) between sentences and between paragraphs, use of simple, short and concise expressions, use of Impersonal narration (in the third person), use of different types of sentences (declarative, interrogative, doubtful, exhortative and wishful). To then move on to the structure of scientific articles, citation, types of citation and reference according to standards. And end with disclosure formats in publications, publication process and choice of publication medium.

The above, with the support of SENNOVA, which is the Research, Technological Development and Innovation system of this institution. System created through agreement 00016 of 2012, which is responsible for strengthening the quality and relevance conditions of Comprehensive Professional Training.

The conceptual training and the technical-methodological training, which are articulated in the development of the training project of each program and the applied research projects associated with it, will contribute to improving the performance capacity of the graduates in the productive environment. Qualified performance, which seen on a larger scale, becomes the improvement of the productive and therefore competitive capacity of the industries, companies or businesses where graduates fall.

The strengthening of performances related to the knowledge and practices of techno-science and techno-scientific writing implies an implicit development of the logical and methodological capacities of scientific and technological reasoning and argumentation in apprentices and later graduates. Acquisitions that favor the formulation, execution and evaluation of training, applied research and *spin-off projects*.[17]

The applied research project methodology workshops within the training process require being guided by an engineering, managerial and pragmatic perspective. Since the emphasis of these projects must tend to generate concrete, effective, efficient and efficient solutions to real or simulated problems derived from the production process. The engineering perspective is due to the fact that it is imperative to design with meticulousness and relevance the processes of investigation of the problem area, the formulation of response and its execution with previously defined performance standards. The managerial vision is linked to the fact that in the workshops the participants learn, assume and practice the management of knowledge, activities, materials, resources and results, in times and operating environments, depending on the goals of success. The pragmatic perspective is related to the previous ones, its profile is to obtain the expected results, in the different orders (knowledge, well-being, profitability, user satisfaction), effectively, effectively and efficiently.

Applied research projects need to be aligned with the technological lines that cross the core competencies of the training program, since that knowledge and technological performance is what is put to use within the production process. These knowledge and practices with expertise are what, together with the project's products (reports, articles, devices, devices, functional models, prototypes, industrial property records, patents, among others) show the results of this type of research. It is here where the use of the knowledge of natural, physical, social, logical,

17 Spin-offs are business initiatives promoted by members of an academic community, originally university students, but also apply to SENA, characterized by basing their activity on the exploitation of new processes, products or services based on the knowledge acquired and the results. of learning obtained in the training institution itself.

methodologies and techno-scientific writing will be reflected.

The basic logic of applied research projects must be derived from the training projects of each training program. Logic that in general points to the articulation and systematic relationship between the following components:

I. Identification of the problem,
II. Project justification,
III. General objective of the project,
IV. Specific objectives,
V. Analysis or diagnosis phase for a state of the art,
VI. Design or planning phase of a solution to the problem area,
VII. Development or execution phase of the solution and,
VIII. Evaluation phase of the solution and the satisfaction of the interested parties.

In the execution of the training of technologists, using the methodologies of applied research projects, according to each type of need or problem to be dealt with within each training program, the most advanced knowledge available in science and technology will be used. of the pertinent technologies, associated with the core competencies of the respective program. It is impossible in a space like this to be able to name such scientific and technological knowledge in particular, since it goes beyond its limits. What can be pointed out is that such knowledge will be used on the basis of fundamental knowledge in natural, physical and social sciences, mathematics, project logic and literacy skills of student learners, as already indicated.

With regard to the latter, it is recommended, if current law allows it, that for calls for student apprentices to study technologist-level training programs, in addition to the established requirements, the results of the SABER 11 Tests are required, In accordance with Decree 869 of March 10, 2010, setting a minimum score to be accepted in a certain program, taking into account the global scores and by specific area, associated with the knowledge of the competencies of the program to which it is aspired. The above, without prejudice to the reception, less rigorous, of applicants to other types of training for work offered by the institution through the different Centers responsible for Vocational Training.

Along with what is proposed, it is necessary to raise the techno-scientific quality of the instructors. This implies that the SENA administration needs to generate teaching-research contracting modalities, in which the development of research projects in the core technological areas of each training program is agreed, starting with diagnoses, whether already carried out or to be done in the respective productive sector, articulated with the information from the science and technology observatory, labor market observatory and labor observatory for education, the research system (SENNOVA) and with the conditions for Qualified Registration and High Quality Accreditation[18]. This must be done with new personnel to be hired, with a Master's degree onwards and proven research experience, through publications in indexed journals, in areas related to the training program where you intend to work. In the same way, aspiring instructors must have taken virtual courses on the application of methodological tools in research: Scientific publications and SCIENTI platform of Colciencias (MINCIENCIAS) and application of methodological tools in research.

4. Conclusion

Usually within SENA, work is done on the fulfillment of goals adjusted to public policy guidelines. Such work is often done mechanically to meet the administrative demands for centralized reporting, without a proper understanding of the context in which the goals are embedded. This is linked to the transitory nature of the entity's managerial staff and to the lurching that has occurred on various occasions by the public policies of different governments.

Therefore, it is necessary to explain the network of relationships that constitutes the complex system of the productive process and social development of the country, in which it is stated that productivity and competitiveness are linked to the sophistication of the productive infrastructure and qualification technoscientific of human talent; that for the latter it is necessary to improve the level of training given in tertiary education (scientific and technological); that SENA and other technologist training entities need to work on this improvement, based on the results of the *Pisa* and *Saber 11* tests, in what corresponds to the knowledge of basic physical-natural and mathematical sciences, as well as in literacy skills. writing in the new generations that are inserted in the economic system. With this, it contributes to enhancing the country's productive and competitive capacity in the world's goods and services markets, as recommended by the OECD.

In this line of argument is that several general proposals of State policy and some particular ones of academic, administrative and techno-scientific action within SENA have been raised here to the question initially raised.

Colombia is faced with the challenge of improving its productive capacity and its ability to generate the greatest satisfaction of international consumers through prices and product quality that equal or exceed other supplying producing countries. This is achieved on two fronts: development of sophisticated productive infrastructure and training of human talent with the ability to competently operate that sophisticated productive infrastructure. SENA has a responsibility there in training world-class technologists.

18 The Qualified Registry is located within the framework of basic regulation by the Colombian State to ensure that training programs provide their services only if they meet quality conditions and other requirements. The High Quality Accreditation, within the National Accreditation System, aims to guarantee society that the institutions that are part of it meet the highest quality requirements, as well as that they carry out their purposes and objectives in their work.

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