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Artículos científicos

Los recursos económicos para la investigación y su impacto en estudiantes de posgrado

The economic resources for research and its impact on graduate students

Recursos financeiros para pesquisa e seu impacto sobre os alunos de pós-graduação

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Resumen

El objetivo del presente trabajo de investigación fue mostrar datos cuantitativos de los recursos para la investigación y su impacto en los estudiantes de posgrado del Centro de Investigación e Innovación Tecnológica del Instituto Politécnico Nacional. La pregunta que guio el presente estudio fue la siguiente: ¿cuál es la relación que existe entre los recursos para la investigación y su impacto en los estudiantes de posgrado? El diseño de la investigación fue no experimental, y la metodología que se utilizó fue cuantitativa, mientras que el enfoque del estudio fue exploratorio y descriptivo. Como técnica de investigación se utilizó el estudio de caso. Los resultados de la investigación revelaron que el número de proyectos de investigación con financiamiento interno fue disminuyendo de 14 en el año 2015 a 13 en el 2016, y 11 en el año 2017, pero en el año 2018 se incrementó a 16. Se evidenció que el monto de recursos económicos no es directamente proporcional al número de proyectos de investigación, pues si bien en el año 2018 hubo un incremento de cinco trabajos con respecto al año anterior, en esa fecha el monto de los recursos no se elevó sustancialmente. Asimismo, la cantidad de estudiantes participantes en proyectos de investigación fue decreciendo: los datos indicaron que en el 2015 participó 51.6 % de los estudiantes de maestría y doctorado,



48.3 % en 2016, 38.5 % en 2017 y 37.5 % en 2018. Esta tendencia no fue proporcional con el número de proyectos. Los productos de investigación que se encontraron relacionados con los proyectos y con los estudiantes de posgrado fueron las tesis y las publicaciones. Las primeras incidieron abiertamente en los estudiantes, en los profesores investigadores y en el posgrado. Las segundas trascendieron en los estudiantes de doctorado debido a que fue un requisito para graduarse. Se concluye que la realización de proyectos de investigación se relaciona a la cantidad de recursos económicos y es un elemento inherente a la existencia del posgrado. Las tesis y las publicaciones que se derivan de ellos son evidencia tangible de su magnitud, además de favorecer la formación de los estudiantes en la investigación. Estudiar y medir estos elementos permite describir su composición, conocer su interacción y reflexionar sobre sus propósitos intrínsecos para optimizar su entendimiento.

Palabras clave: administración de la ciencia y la investigación, centro de investigación, financiación de la ciencia, gastos de la ciencia, proyecto de investigación.

Abstract

The objective of this research work was to show quantitative data on research resources and their impact on postgraduate students at the Center for Research and Technological Innovation of the National Polytechnic Institute. The question that guided this study was: What is the relationship between research resources and their impact on graduate students? The research design was non-experimental, the methodology used was quantitative, and the study approach was exploratory and descriptive. The case study was used as the research technique. The results of the investigation revealed that the number of internally funded research projects decreased from 14 in 2015 to 13 in 2016 and 11 in 2017, but in 2018 it increased to 16. It was evidenced that the amount of economic resources is not directly proportional to the number of research projects, since in 2018 it increased by five compared to the previous year and the amount of resources did not increase substantially. The number of students participating in research projects was decreasing, the data indicated that 51.6% of the master's and doctoral students participated in 2015, 48.3% in 2016, 38.5% in 2017 and 37.5% in 2018. This trend was not proportional with the number of projects. The research products that were found related to the projects and to graduate students were theses and publications. The first ones had an open impact on students, research professors and postgraduate students. The second ones came out in the doctoral students, because it was a

requirement to graduate. It is concluded that the realization of research projects is related to the amount of economic resources and is an inherent element in the existence of the postgraduate program. The theses and the publications derived from them are tangible evidence of their magnitude, in addition to favoring the training of students in research. Studying and measuring these elements allows describing their composition, knowing their interaction and reflecting on their intrinsic purposes to optimize their understanding.

Keywords: Administration of science and research, research center, financing of science, expenses of science, research project.

Resumo

O objetivo deste trabalho de pesquisa foi apresentar dados quantitativos sobre os recursos para a pesquisa e seu impacto na pós-graduação do Centro de Pesquisa e Inovação Tecnológica do Instituto Politécnico Nacional. A questão que norteou o presente estudo foi a seguinte: qual a relação entre os recursos de pesquisa e seu impacto na pós-graduação? O desenho da pesquisa foi não experimental e a metodologia utilizada foi quantitativa, enquanto o foco do estudo foi exploratório e descritivo. O estudo de caso foi utilizado como técnica de pesquisa. Os resultados da pesquisa revelaram que o número de projetos de pesquisa com financiamento interno diminuiu de 14 em 2015 para 13 em 2016 e 11 em 2017, mas em 2018 aumentou para 16. Foi constatado que O montante de recursos econômicos não é diretamente proporcional ao número de projetos de pesquisa, pois embora em 2018 tenha havido um aumento de cinco empregos em relação ao ano anterior, naquela data o montante de recursos não aumentou substancialmente. Da mesma forma, o número de alunos participantes em projetos de investigação foi decrescente: os dados indicavam que em 2015 participavam 51,6% dos alunos de mestrado e doutoramento, 48,3% em 2016, 38,5% em 2017 e 37,5% em 2018. Esta tendência não era proporcional ao número de projetos. Os produtos de pesquisa encontrados relacionados aos projetos e aos alunos de pós-graduação foram teses e publicações. O primeiro teve uma influência aberta sobre alunos, professores pesquisadores e alunos de pós-graduação. A segunda transcendeu em alunos de doutorado porque era um requisito para a graduação. Conclui-se que a realização de projetos de pesquisa está relacionada ao montante de recursos econômicos e é um elemento inerente à existência do programa de pós-graduação. As teses e as publicações delas derivadas são evidências tangíveis de sua magnitude, além de favorecer a formação de alunos em pesquisa. Estudar e

mensurar esses elementos nos permite descrever sua composição, conhecer sua interação e refletir sobre seus propósitos intrínsecos para otimizar sua compreensão.

Palavras-chave: ciência e administração de pesquisa, centro de pesquisa, financiamento de ciência, gastos em ciência, projeto de pesquisa.

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Introduction

The training of researchers is considered a necessary systematic process that allows to specify processes related to a large amount of content on a specific topic (Fonseca, 2020). Graduate students learn to do science by participating in research groups, either in communities of practice or epistemic, in which they acquire methodological and intellectual competencies (Feldman, Divoll and Rogan-Klyve, 2013), where they can see the social and the importance of their work, a factor known to strengthen academic and professional persistence in the fields of science (Weinberg, Trott and Sample, 2018).

Therefore, student questions play an important role in science learning and inquiry-based approaches. For Herranen and Aksela (2019) “research teaching that is based on students' questions is promising, as long as a holistic vision of research and practice is not lacking” (p. 1). In this way, it is feasible not only to develop connections with scientific identity research, but also to enrich the research with self-concepts of science and technology (Rüschepöhler and Markic, 2019). The thematic axes of the students must respond to the needs of academic fields and to the resolution of practical problems of work environments (Castro and López, 2020), as well as the social context in which they are immersed (Martínez and Márquez, 2015), linking research with projects that achieve a positive impact on the environment (Cantú, Medina and Martínez, 2019).

From these perspectives, the training of researchers in their scientific practice is the result of the knowledge shared by consolidated researchers, on the way to accessing an understanding of the phenomena of nature and society (Fonseca, 2020). In this regard, García, Pérez and Miranda (2018) mention that researchers are motivated to “transfer knowledge and technology by the implementation of scientific knowledge in real situations, by the generation and development of ideas with the potential to become innovations, and by the need to help various sectors of society” (p. 52).

However, it is unrealistic to expect students to achieve full mastery of traditional research experiences in the short term, or to expect them to conduct authentic scientific inquiry themselves, as their experiences must be structured into highly organized research groups with mentors who explicitly teach them how to do science (Feldman et al., 2013). In this context, the teacher's role is affected by how much emphasis is placed on science learning and how much value is placed on students' questions (Herranen and Aksela, 2019). In this way, teachers make changes allowing students to advance and acquire the necessary skills for their training (Peinado, 2020), which at the same time influences the professional development of teachers, their formal education and their participation in research (Griffioen and De Jong, 2015).

However, the way in which research is taught is directly related to each discipline, which is evidenced in the advisory processes that take different forms according to the orientation of the program and its internal guidelines (Castro and López, 2020). In this regard, Ortiz, Topete and Bustos (2018) explain:

Inappropriate practices in research and their training have not yet been avoided, this is attributed to the structural problem of policies, which respond to power interests and the design in the evaluation strategy, inappropriate for the training of researchers in science, which is a wrong direction that detracts from the quality of research and academia, since it generates workload, interests of power groups and inbreeding by monopolizing strategic academic elements such as thesis direction, accepting students without investigative competencies, carrying out processes Simplistic or non-demanding training with flexible juries (p. 17).

Another important aspect is that interdisciplinary research is a popular mode of knowledge production that is intensely promoted in research centers around the world (Woiwode and Froese, 2020), through the construction of networks of organizational participation in processes and practices that They allow the sharing of values such as trust, respect, accepting to disagree, and celebrating diversity (Taysum, 2016). Sometimes, work networks are given out of sympathy or because they already know each other, which generates a better job, done for pleasure and in a natural way, since they identify with each other (Ortiz, Topete & Bustos, 2018). However, the stimuli for multidisciplinary proposals are not attractive enough for researchers, since the number of participants and the resources for each member are less than those that each would obtain separately, a factor that probably

discourages the creation of this type of projects (Fabila, 2014). Even so, it should be noted that interdisciplinarity can respond to socioeconomic and environmental problems (Rosas-Baños, 2019), hence it is the responsibility of public education institutions to promote and encourage it.

Financial resources for research

Expenditure on research and experimental development (GIDE) is a component of national spending on science, technology and innovation, which for 2017 was an estimated 97 166.1 million pesos, a figure that decreased 6.4% compared to 2016. The sector that contributed the most was the public with 62.94% of the total. The GIDE as a percentage of gross domestic product (GDP) is an indicator that provides insight into the efforts made by countries to carry out research and experimental development; In 2017, the relationship of the GIDE with the GDP in Mexico was 0.48% (National Council of Science and Technology [Conacyt], 2017).

Mexico is below the average GIDE / GDP ratio in Latin America with 0.51, although it is above Chile, Uruguay, Colombia and Panama. However, with member countries of the Organization for Economic Cooperation and Development (OECD) the gap is greater when compared to nations such as South Korea (which invests eight times more than Mexico). The leading countries in scientific and technological activities such as Germany, the United States or Japan allocate resources above the OECD average, while Canada, France, Spain and the United Kingdom are below the average (although they also invest three and four times more than Mexico) (Conacyt, 2017).

On the other hand, the United Nations Educational, Scientific and Cultural Organization [UNESCO] (2019) published an analysis of 126 countries where it is indicated that only nine nations have more than five thousand researchers for every million inhabitants. In Mexico, there are only 244 researchers for every million inhabitants, a figure that is obtained from the number of members of the National System of Researchers (SNI), if all areas of knowledge are considered. The figure is very low compared to countries with more than 5,000 researchers per million inhabitants, and it is even lower than most countries that invest the same proportion of their GDP, such as Cyprus, Thailand, Senegal, Macedonia and Qatar, which do more with fewer resources and surpass Mexico in the number of researchers. The country with the highest number of researchers is Norway, with 3,345, followed by

Singapore and Iceland, with 3,058 and 2,825, respectively (Román, June 25, 2019). In addition to the above, in developed countries scientific and technological research is carried out mainly in the field of research and development units of companies, without this preventing their projects from having public financing (Álvarez, Chávez, Montiel, Topete and Maldonado, 2015).

However, in economically disadvantaged countries, research appears to be a particularly neglected practice (Nguyen and Van, 2018). For this reason, Álvarez et al. (2015) indicate;

In the countries of the Latin American region, the participation of public and private educational institutions continues to be necessary, due to the low investment both in the proportion of GDP and in spending per scientist, quasi-public financing, mechanisms for the allocation of unclear and competitive resources (p. 29).

These institutional conceptions are aligned with neoliberal educational policies (Rosas-Baños, 2019). In this context of inequalities, higher education institutions and their research centers must face numerous challenges for the effective management of their resources (Mestry, 2018), since they do not have a sufficient budget for the conditioning of their facilities (Pantoja, 2019), hence the need to contribute more resources to postgraduate programs and research.

In addition to this, work must be done to simplify administrative bureaucracy (Ortiz et al., 2018), since cumbersome procedures wear out researchers and research centers (Peinado, Cerecedo and Jaramillo, 2015). For this reason, it can be said that the perception of research professors regarding institutional financing policies is not positive, hence this is another aspect that should be considered when talking about resources for research.

Furthermore, it should be anticipated that universities today receive fewer resources than in previous times (Warshaw and Upton, 2019). In this sense, Coccia and Rolfo (2013) establish that “organizational weaknesses and economic threats to public research centers are generated by the research policy based on the reduction of budgets and the reduction of research personnel” (p 256). This has a direct impact on the economic resources assigned to the substantive activities of institutions such as the National Polytechnic Institute (IPN), so that the resources for their research centers, indispensable inputs for teaching and research, could be scarcer. (Peinado, Montoy y Torres, 2020).

Due to all of the above, the objective of this research work was to show quantitative data on research resources and their impact on postgraduate students at the Center for Research and Technological Innovation (CIITEC) of the IPN.

The question that guided the present study was the following: what is the relationship between the allocation of resources for research and its impact on graduate students? To answer this question, the number of projects with internal financing per year was investigated, the amounts per project and per year were determined, the percentages of student participation in the projects were established, and their impact was quantified by specifying the products of research that are directly related to graduate students.

Method

The research design was non-experimental. The methodology used was quantitative, through an exploratory and descriptive study. The case study helped to examine and analyze in depth the interaction of the factors that caused changes in the topics evaluated, and as a research technique allowed to investigate all the elements that were important in the history and development of the case from a complex approach. In this way, the study contributed to the knowledge of individuals, factors and organizational phenomena related to the object of study.

At the beginning of the research, data was collected from the IPN research centers to support, guide and dimension the investigation of the relevant topics for the case study, which were addressed due to their intrinsic implications, as well as the factors and elements that constitute it.

In the first stage of the research related to the case study, the sample was selected; For this purpose, those with internal financing corresponding to the years 2015, 2016, 2017 and 2018 were chosen —of the total of internal research projects carried out by CIITEC—, which include individual, multidisciplinary, innovation projects and those of the special consolidation program. and formation of research groups.

In the second stage, secondary data was collected, which had to be investigated and collected for statistical analysis; then it was necessary to categorize them and finally explain them as indicators to support the research question. The information was documented from each of the CIITEC departments that have this data under their protection. The third stage focused on obtaining the primary data, information that was collected exclusively for

examination (the figures were obtained from the directors of each research project). To collect the data, their integration was meticulously examined, emphasizing the type of project and the participating students.

Results

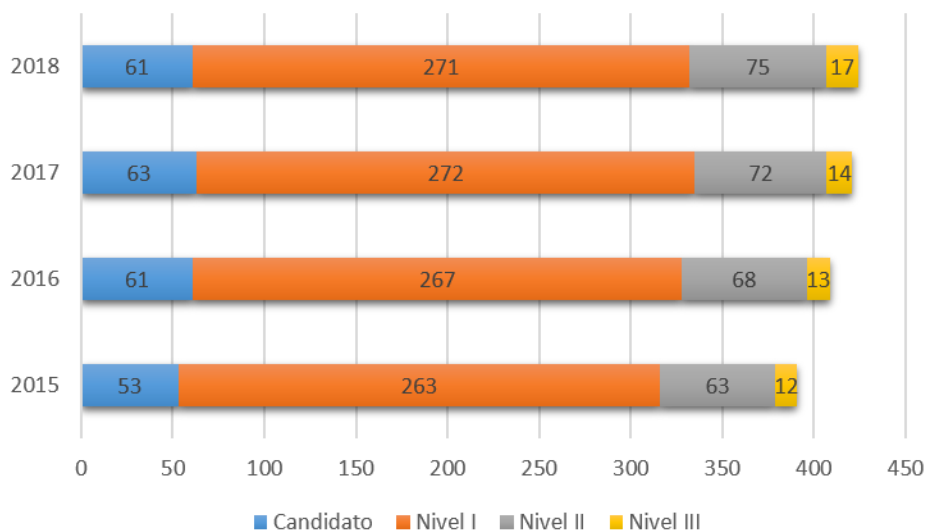
The IPN has 20 scientific and technological research centers. The Organic Regulation of the IPN (2020) specifies the following:

They are academic units that are in charge of carrying out basic, applied research and technological development, directing their results to solving problems in strategic areas of national development, to generate knowledge that contributes to the advancement of science and technology, to the formation of high-level human resources, to improve the quality of life of the population, meet specific needs of the public, social or private sectors and the conservation and sustainable use of the country's natural resources (p. 58).

In these research centers there are 1,113 professors, 466 with a doctorate, 322 with a master's degree, 29 with a specialty, 275 with a bachelor's degree. Of these, 1,027 are hired full time and the rest are distributed in three quarters of the time (eight), part time (12) and by the hour (66) (IPN, 2018).

The number of SNI researchers in research centers has remained constant with a small increase in the last four years (from 391 in 2015 to 409 in 2016, and from 421 in 2017 to 424 in 2018). The quantities by level are presented in Figure 1.

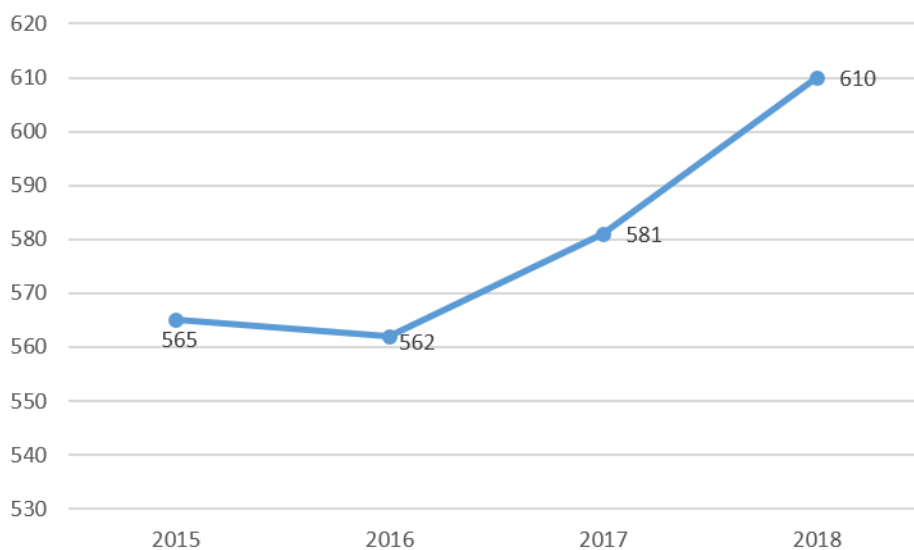
Figura 1. Incremento de investigadores SNI en los centros de investigación del IPN



Fuente: Elaboración propia con información del IPN (2018, p. 55)

From 2015 to 2018, it financed 2,318 research projects with internal funding for research centers (the amounts per year can be seen in Figure 2).

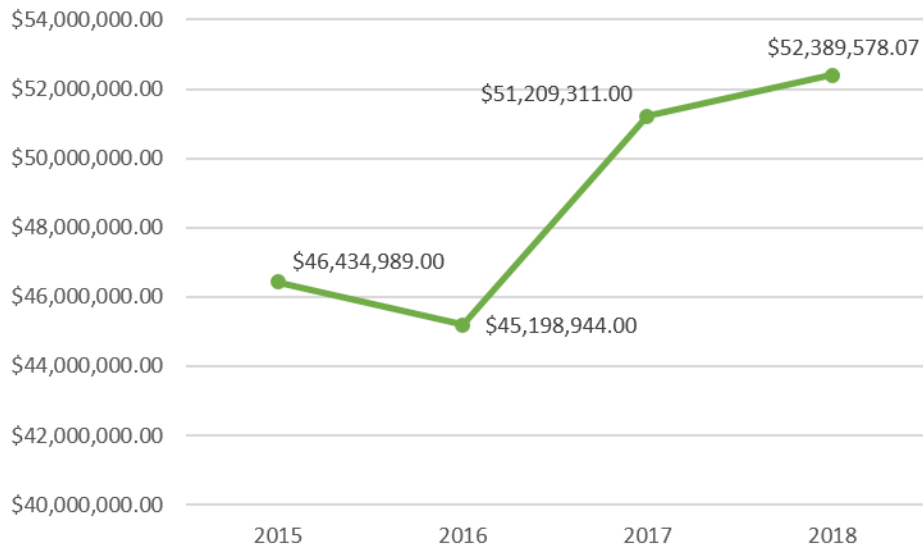
Figura 2. Cantidad de proyectos en centros de investigación del IPN



Fuente: Elaboración propia con información del IPN (2018, p. 53)

The accumulated total economic resources of projects with internal financing for the research centers was 195 232 822.07 million pesos. The amounts for each year can be seen in figure 3.

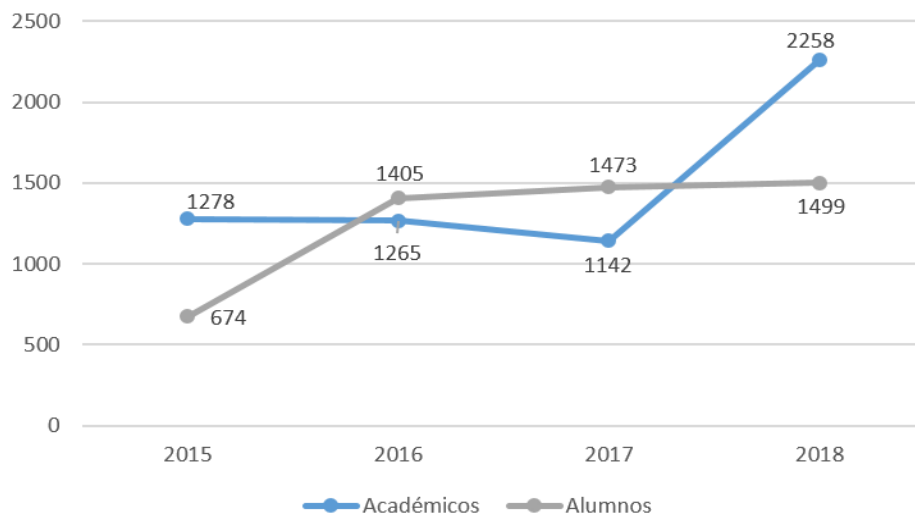
Figura 3. Montos de los proyectos en centros de investigación del IPN



Fuente: Elaboración propia con información del IPN (2018, p. 54)

The general total of academics in these projects was 5943, while the total of students was 5051. In figure 4 you can see the numbers of participants in the last four years.

Figura 4. Participantes en proyectos de centros de investigación del IPN



Fuente: Elaboración propia con información del IPN (2018, p. 54)

Case study of the Center for Research and Technological Innovation

CIITEC was founded with the objective of contributing to the strengthening of the productive and educational sectors through applied research, technological development and technological innovation (Bonilla and Peinado, 2014). Its mission was focused on training human resources with high creative and innovative capacity to integrate into the productive and service sectors, with pertinent postgraduate academic programs, consultancies, technological services and through the creation and execution of related and research projects (Peinado, Cerecedo and Jaramillo, 2016).

CIITEC's master's program in Advanced Technology was created in 2007 with the aim of training high-level academic human resources through research, technological development and innovation. The curricular structure of the master's degree was planned for four semesters, with specialization, complementary, innovation learning units and three research seminars (Bonilla and Peinado, 2014).

Applicants must have an interest in developing research, applying the scientific method that leads to innovation. Therefore, analysis, synthesis and abstract reasoning skills are required to develop experimental activities. They must also master the English language or another foreign language (Peinado y Jaramillo, 2018).

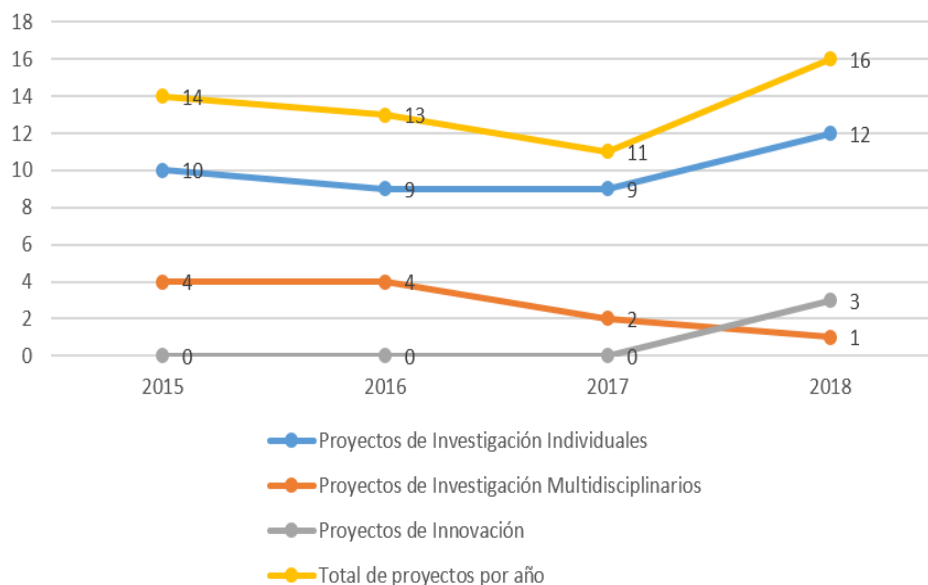
CIITEC's doctoral program in Advanced Technology includes three compulsory departmental seminars; The innovation subject is included only if the student requires it, and the elective subjects are incorporated if the student needs to develop additional strengths to carry out their research (Bonilla and Peinado, 2014). Applicants to enter the doctorate must be interested in developing research that leads to the strengthening of engineering, technology and innovation, taking into account projects related to those developed by the members of the teachers' college. Must be a graduate of a master's degree in technology, engineering or related areas, and have an interest in developing basic and / or applied original research, technological innovation and academic capacity in the area of advanced engineering and technology. Therefore, skills of analysis and synthesis of abstract reasoning are required to develop experimental activities, which have prepared their master's thesis preferably by research or development of prototypes. Must master English or another foreign language (Peinado and Jaramillo, 2018).

The basic academic nucleus of the CIITEC Teachers College is made up of 12 teachers, four women (33.33%) and nine men (66.67%). All have a doctorate, three of them

did it in Mexico and nine abroad (75%) (six in France, one in the United States, one in England and one in Japan). Of them, 11 belong to the SNI, 5 are level two (41.67%) and 6 are level one (50.00%). Eleven are appointed as a collegiate professor and one as a subject. Regarding the expanded academic nucleus, it is made up of seven people: two women (28.57%) and five men (71.42%). Two have a doctor's degree (28.57%) and five have a master's degree in science (71.42%). All are appointed as subject lecturers, none belong to the SNI and all completed their postgraduate studies in Mexico (Peinado, Mayagoitia & Cruz, 2019).

The first step in developing the case study was to determine the number of projects per year at CIITEC. Figure 5 specifies these amounts in the years 2015, 2016, 2017 and 2018. It should be noted that in the individual projects the research projects of the special program for the consolidation and formation of research groups were considered, these are only two in 2018.

Figura 5. Cantidad de proyectos con financiamiento interno por año



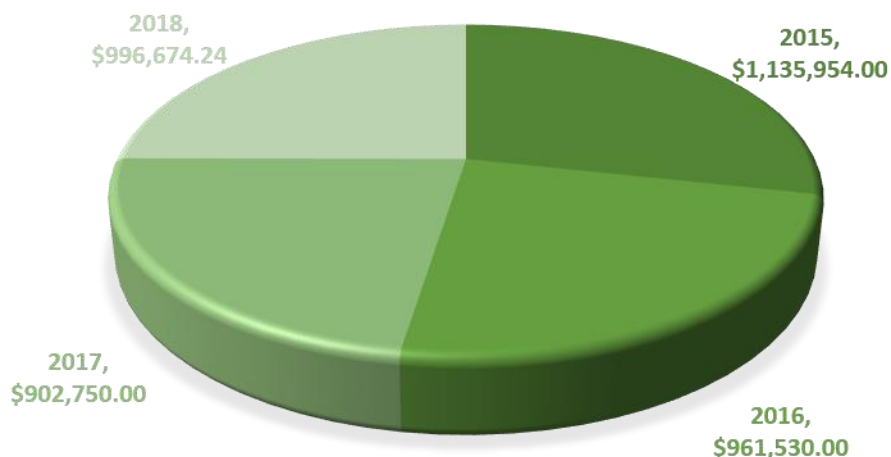
Fuente: Elaboración propia

Some variations were found among the results. Figure 5 shows that the number of research projects with internal funding decreased from 2015 to 2017, but in 2018 it increased. It should be noted that multidisciplinary projects decreased to one in the last year, individual projects increased and innovation projects were ventured.

Another important point to mention is that it was only in 2018 that innovation projects were started. This could be justified because its researchers are mainly SNI, hence their research products are different from those arising from an innovation project. It should be noted that the professors who have so far obtained this type of project at CIITEC are engineers with a master's degree, two women and one man, they have not been appointed by the SNI and they lack additional financial incentives.

The second step was to inquire about the amounts of the projects per year. In figure 6 you can see the total amounts of the projects with internal financing from the years 2015 to 2018. The figure compiles the individual, multidisciplinary and innovation projects.

Figura 6. Montos de proyectos con financiamiento interno de 2015 a 2018



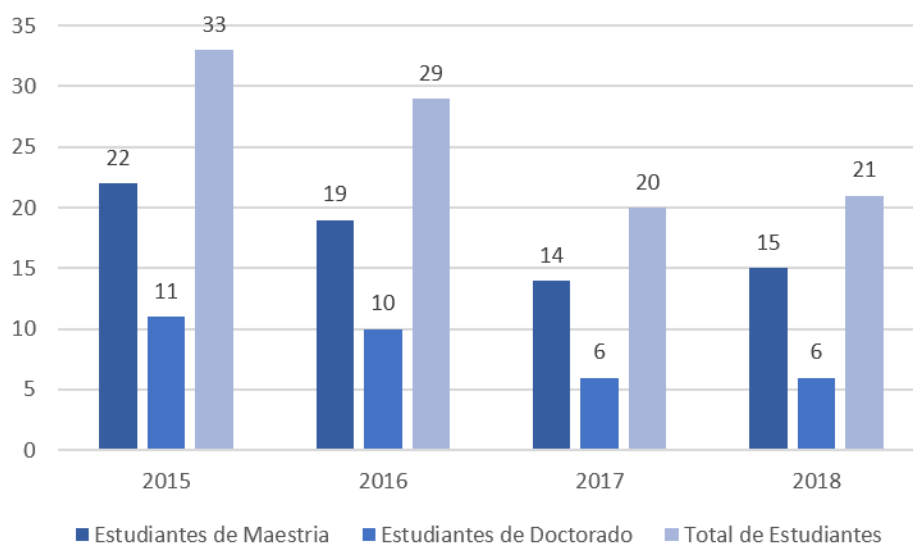
Fuente: Elaboración propia

It was evidenced that the amount of economic resources is not directly proportional to the number of research projects with internal financing per year. The above was observed in figure 5, since the number of projects increased in 2018 by five compared to the previous year; The amount of resources also increased, but not in the same way, since in 2015 the number of projects was lower than in 2018, but the amount of resources assigned was higher.

In the third step, the impact of projects with internal financing on CIITEC graduate students was determined, for which the following procedure was carried out: first, the Department of Human and Financial Resources was asked for the number of projects authorized by the SIP, the amounts of each project, as well as the director of each of the projects from 2015 to 2018. Afterwards, a list of students enrolled in the master's and doctoral

programs was managed in the CIITEC Postgraduate Department, dated admission, graduation and thesis director professor, from 2011 to 2018. Subsequently, the CIITEC professor-researchers were asked how many and which students had participated in their SIP research projects from 2015 to 2018. Then, with the data provided by the professors about the participating students, was verified with the lists of students enrolled in the master's and doctoral programs, which and provided by the CIITEC Graduate Department. The number of projects and the director of each project were verified with the information provided by the Department of Human and Financial Resources, which gave certainty about the research professor and the students who participated in their projects. Figure 7 shows the data found.

Figura 7. Participación de estudiantes en proyectos con financiamiento interno



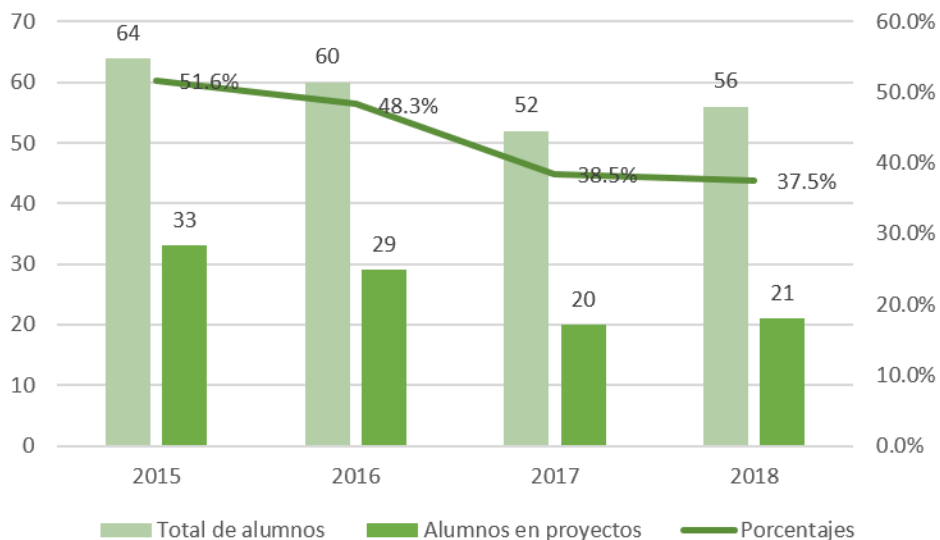
Fuente: Elaboración propia

Figure 7 shows that the number of students participating in research projects has been decreasing, as well as the number of projects from 2015 to 2017. This trend cannot be considered as a factor, as it is not proportional. This is because in 2018 there were five more projects than in the previous year, but the number of students increased by only one. It should be noted that some students participate in one or more projects in the same year; Furthermore, to have a better overview of these statistics, students assigned to other IPN schools were not considered.

To better visualize the participation of the students, with the information provided by the CIITEC Graduate Department, an approximate total of master's and doctoral students per year was established, then it was compared with the number of students participating in the

projects and later added total projects per year. The data present the total number of active master's and doctoral students (approximately half participate in the projects). This information is shown in Figure 8.

Figura 8. Estudiantes y proyectos con financiamiento interno



Fuente: Elaboración propia

The fourth step consisted in establishing what other research products are directly related to both internally funded projects and graduate students; After a careful documentary search, two main elements were found: the students' theses and the publications. The former openly affect students, research professors and graduate students. The second impact on doctoral students because they must publish as a requirement to graduate (IPN, 2017). This would not be possible without the existence of the research projects and the necessary financial resources.

To show the statistics of these research products, the categorization that CIITEC currently has on its innovative line of applied research and technological development was taken as a reference, which is multidisciplinary and was defined as engineering and advanced technology. Its objective is to develop, adapt, innovate and apply knowledge in the field of engineering and technology (Peinado, Mayagoitia and Cruz, 2019). Next, figure 9 is presented, where the publications made in the last three years by research discipline are observed.

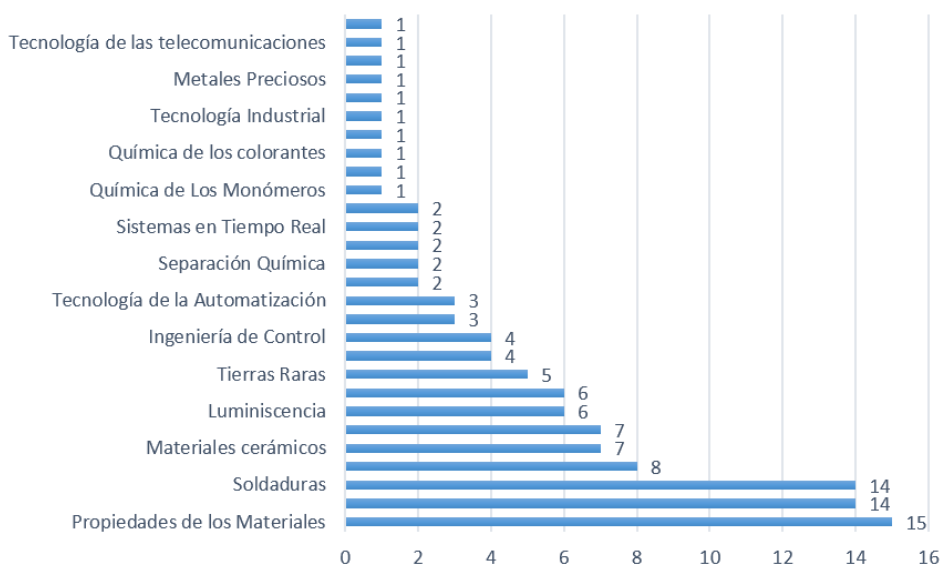
Figura 9. Artículos de investigación por disciplina de investigación



Fuente: Elaboración propia con información del Departamento de Posgrado del CIITEC

The participation of thesis students in research projects contributes in multiple ways, for example, learning, training in the field of research and the contribution they make to teachers in their line of generation and application of knowledge. With respect to the master's theses, figure 10 shows 116 works by research discipline.

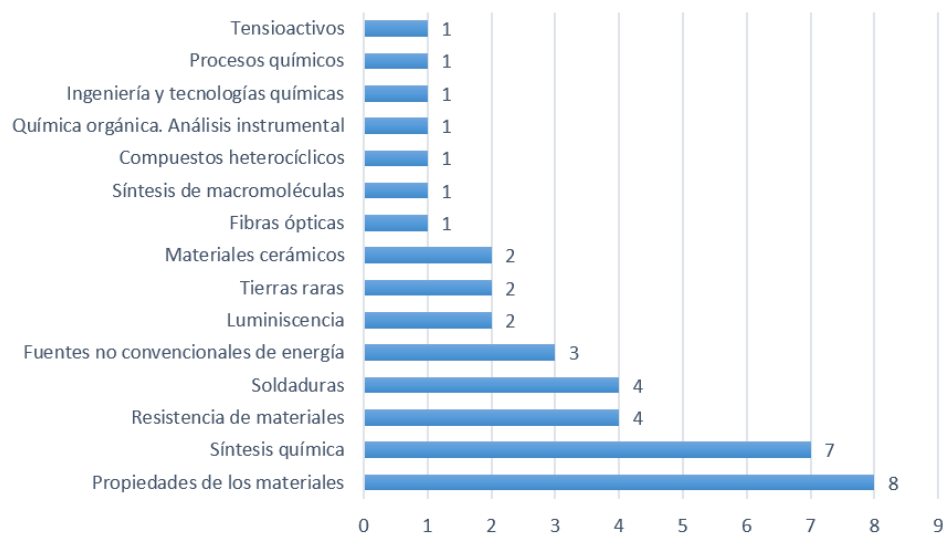
Figura 10. Tesis de maestría por disciplina de investigación



Fuente: Elaboración propia con información del Departamento de Posgrado del CIITEC

Regarding the thesis works of doctoral students, figure 11 shows 39 works also by research discipline.

Figura 11. Tesis de doctorado por disciplina de investigación



Fuente: Elaboración propia con información del Departamento de Posgrado del CIITEC

Discussion of results

Research and teaching are generally consumers of economic resources, hence the HEIs must allocate a large amount of them to perform these two substantive functions. But the resources are not immeasurable, and their dispersion must be adequate to the needs and justified in the feasibility of each investigation. Hence, its measurement is feasible, transcendent and necessary to observe its valuable contribution.

The research orientation focuses on the training of researchers and the generation of knowledge (Castro and López, 2020), so the development of self-management capacities in the research process revolves around the aptitude to investigate, qualities, skills and assigned work (Fonseca, 2020). In this sense, students who face different problems frequently propose proposals to solve them, which shows their level of creativity and responsibility (Peinado, 2020). For this reason, their participation in research projects contributes to the solution of different unknowns from a fresh and innovative approach, and not only with the contribution of technical work.

Considering the training of young people as scientific apprentices is comparable to the transmission of a trade, which requires accompaniment, instruction, and guidance (Fonseca, 2020). For this reason, students who enter a research group leave as novice researchers, competent technicians or producers of knowledge (Feldman *et al.*, 2013).

According to this perception, and based on the results of this research, it is necessary to incorporate more students in the projects, since their participation varies approximately in 50% of the total number of students in master's and doctoral degrees. Greater inclusion would provide more field work and favor closeness with the research professors who guide the work.

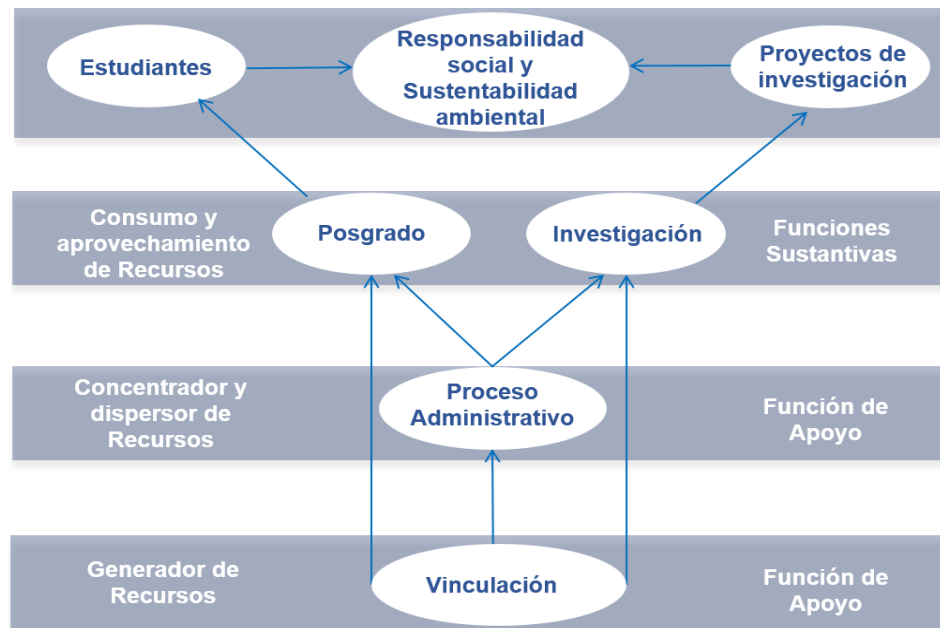
On the other hand, the tendency to conduct interdisciplinary research is influenced by structural factors such as study programs and their academics (Martínez and Márquez, 2015; Woiwode and Froese, 2020). This type of joint work allows access to knowledge of other disciplines and increases organized and binding work (García et al., 2018), which offers better results because a problem is addressed from different approaches (Fabila, 2014).

Now, in the case of CIITEC, it can be said that interdisciplinary work in research projects is an element that is promoted and prevails, which is evidenced in research articles and master's and doctoral theses. Likewise, it is worth noting that although the contribution of more resources for research and postgraduate programs is a primary need (Ortiz et al., 2018), the results of this work show that projects do not always increase with more capital, the which is at the discretion of the authorities that disperse the resources.

Even so, it should be noted that IPN research centers such as CIITEC cannot subsist solely on the federal budget granted or with the resources allocated to projects (Peinado et al., 2020), so other actions must be taken that allow obtaining greater liquidity to carry out research activities (Peinado *et al.*, 2015).

In response to the problem of more economic resources for research —and as a proposal—, outreach represents an important means for obtaining resources as a support function; likewise, the administrative process would also concentrate and distribute them. These efforts would have a positive impact on postgraduate studies from two perspectives: the first in the economic field and the second in postgraduate students, who would approach the industrial or services sector to obtain experience and to apply their knowledge with social responsibility and in favor of the environmental sustainability. To illustrate the previous point, figure 12 presents these functions.

Figura 12. Funciones sustantivas y de apoyo en el CIITEC



Fuente: Elaboración propia

Finally, it can be said that the importance of this research was based on confirming and expanding the knowledge about the topic studied, which justified the critical part of the case. The perspective of uniqueness in the research was manifested as being unrepeatable and characteristic for the subjects that intervene in the context and for the circumstances that make it even more different (Peinado et al., 2020). Additionally, the study allowed to see its revealing character when observing and analyzing the phenomenon, since the concrete situation of the allocation of resources for research and its impact on graduate students was evidenced. Likewise, it allowed to know the detailed and exhaustive description of the real situation that currently prevails, and offered detailed and complete information on the circumstances, phenomena, aspects and elements that comprise it. Therefore, it is positive to highlight that the study found the quantitative evidence investigated. Among the limitations, however, it can be noted that it is not generalizable or conclusive.

Conclusions

Producing science is a sublime task, since it is the basis of the development of a country. Research is an important and fundamental task because, through its development, solutions have been found to improve the quality of life of human beings, although this requires resources. In this sense, the allocation of resources for research is directly related to

graduate studies based on two antecedents. The first refers to the financial resources necessary to carry out the research, through the purchase of various materials and the contracting of different services. The second points to the participation of students in research projects, which contributes to promoting their own learning, as well as the lines of generation and application of knowledge.

Research projects, therefore, are an inherent element of the existence of postgraduate courses at the IPN, especially those found at the PNPC of Conacyt. The by-products derived from them, such as theses and publications, are tangible evidence of their impact, as well as the qualitative factors they provide, such as the participation of IPN students, the training of new researchers, as well as the growth, development and consolidation of those already formed.

Within the substantive activities of a research center such as CIITEC are teaching and research, both related to teachers and students. These four elements must generate a symbiosis that manages the link between these components, which benefit from a reciprocal correlation. Studying and measuring the aforementioned elements allows us to describe their composition, know their interaction and attend to their intrinsic purposes to achieve the ideal conjunction and improve their understanding.

Future Research Lines

It is pertinent to continue researching this topic to reinforce this line of research. For future work, it is recommended to extend the study to other IPN research centers, separately or simultaneously. Similarly, it is suggested to increase the dimension of this topic, including the federal budget, self-generated resources, economic incentives (scholarships) that students and research professors receive. The implication of environmental sustainability and the social impact of research projects and their influence on graduate students should also be considered.

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