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Artículos científicos

Las redes de investigación en el marco de la revolución industrial 4.0 y la Cuarta Transformación

Research Networks Within the Framework of the Industry 4.0 and the "Fourth Transformation"

Redes de pesquisa no âmbito da Revolução Industrial 4.0 e da Quarta Transformação

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Resumen

Teniendo como telón de fondo tanto la revolución industrial 4.0 como la Cuarta Transformación, el objetivo del presente trabajo fue determinar los retos que enfrentan los coordinadores de redes de investigación en las organizaciones educativas en México. La investigación surgió ante la necesidad de crear nuevas redes de este tipo en el Instituto Politécnico Nacional (IPN). Se analizaron las características relacionadas con la innovación y la generación de nuevo conocimiento de la revolución industrial 4.0 y la Cuarta Transformación, las cuales tienen algunas similitudes aun cuando sus diferencias son más que patentes. En medio de estas dos corrientes, y ante la necesidad resolver problemas de gran envergadura, las redes de investigación son una herramienta imprescindible. El método fue inductivo-deductivo, con un estudio diagnóstico que contó con la aplicación de una guía de entrevista bajo la modalidad de debate. La muestra fue de 16 expertos. La información se manejó mediante el *software* Atlas.ti, con análisis reflexivo y de frecuencias. Entre los retos identificados se encuentran la falta de conocimiento del coordinador cuando se inicia una red sobre la variedad de investigadores y sobre las orientaciones respecto a un mismo tema, así como retos de comunicación y de organización. Como parte de las conclusiones, se aporta nuevo conocimiento teórico y propuestas para establecer políticas de acción para la creación y operación de redes de investigación institucionales; propuestas que pueden ayudar a mejorar la gestión y dinámica de las redes de investigadores formales e informales.

Palabras clave: cooperación en investigación, interdisciplinariedad, redes de investigación.

Abstract

In the context of both the Industry 4.0 and the “Fourth Transformation”, the objective of this work was to determine the challenges faced by the coordinators of research networks in Mexican educational organizations. The research arose out of the need to create new networks of this type at the Instituto Politécnico Nacional (IPN). The characteristics related to innovation and the generation of new knowledge of the Industry 4.0 and the Fourth Transformation were analyzed, which have some similarities even when their differences are more than evident. In the midst of these two currents, and faced with the need to solve large-scale problems, research networks are an essential tool. The method was inductive-deductive, with a diagnostic study that included the application of an interview guide in the form of

debate. The sample was of 16 experts. The information was managed using Atlas.ti software, with reflective and frequency analysis. Among the challenges identified are the lack of knowledge of the coordinator when starting a network on the variety of researchers and on the guidelines on the same topic, as well as communication and organizational challenges. As part of the conclusions, new theoretical knowledge and proposals are provided to establish action policies for the creation and operation of institutional research networks; proposals that can help improve the management and dynamics of networks of formal and informal researchers.

Keywords: cooperation in research, interdisciplinary, research networks.

Resumo

No contexto da Revolução Industrial 4.0 e da Quarta Transformação, o objetivo deste trabalho foi determinar os desafios enfrentados pelos coordenadores de redes de pesquisa em organizações educacionais no México. A pesquisa surgiu da necessidade de criar novas redes desse tipo no Instituto Politécnico Nacional (IPN). Foram analisadas as características relacionadas à inovação e à geração de novos conhecimentos da revolução industrial 4.0 e da Quarta Transformação, que apresentam algumas semelhanças mesmo quando suas diferenças são mais do que evidentes. No meio dessas duas correntes, e diante da necessidade de resolver problemas de larga escala, as redes de pesquisa são uma ferramenta essencial. O método foi indutivo-dedutivo, com um estudo diagnóstico que incluiu a aplicação de um guia de entrevistas na forma de debate. A amostra foi de 16 especialistas. As informações foram gerenciadas no software Atlas.ti, com análise reflexiva e de frequência. Entre os desafios identificados estão o desconhecimento do coordenador ao iniciar uma rede sobre a variedade de pesquisadores e as orientações sobre o mesmo tópico, bem como os desafios de comunicação e organização. Como parte das conclusões, novos conhecimentos e propostas teóricas são fornecidos para estabelecer políticas de ação para a criação e operação de redes institucionais de pesquisa; Propostas que podem ajudar a melhorar a gestão e dinâmica de redes de pesquisadores formais e informais.

Palavras-chave: cooperação em pesquisa, interdisciplinaridade, redes de pesquisa.

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Introduction

The Fourth Transformation

The so-called Fourth Transformation is based on three important armed movements in the history of Mexico: Independence, the Reform and the Revolution (Fuentes, 2018), which, at the time, changed the structure of the Government, as well as the way of doing politics in Mexico, all of them through the war. Some of these changes were short-lived, therefore, they do not correspond to any innovation; Others, however, still persist in 2020, such as the separation of Church and State, and in the case of the Revolution, the promulgation of the Constitution that currently governs Mexico. Indeed, these are repercussions that profoundly transformed the lives of citizens. Currently, profound changes are sought in the country considering two axes: the structural and the political.

The above is related to aspects of innovation. So, before continuing, it is worth defining that term, innovation. Etymologically, the Latin root of this concept, innovavo-are, means "to make new, to renew"; in refers to 'inward', and novus-a-um corresponds to 'new'. That is, in its beginnings, it was associated with doing something new from within (Rivero, Asenjo & Martínez, 2009). In a business context, Schumpeter (cited in Fagerberg, Martin and Andersen, 2013) indicated that innovation consists of making new combinations with existing resources. What is relevant here is that it corresponds to a process of qualitative change in a historical moment.

In the above context, innovation occurs in products, production methods, forms of supply, markets or ways of organizing companies or industries, modifying the organization's relationships within and with its environment.

Therefore, the Fourth Transformation, based on these change processes, perceives the country as a company that seeks to change the relationships between the various actors. However, to carry out an innovation of any kind, planning, organization, control and evaluation are required (processes that have been more than clear up to now), steps that allow achieving the proposed objectives. Furthermore, the changes should be permanent over a relatively long time and have the possibility of evaluating the results of the intended innovation. In an innovation, the transformation is spiral, which means that the existing knowledge can be increased by improving it, without discarding it; This is impossible when it is intended to generate such changes in a linear and top-down manner, as observed in the Fourth Transformation.

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The industrial revolution 4.0

The Industrial Revolution 4.0 is based on technological innovation processes. If we keep in mind the previous conception of innovation, it remains to address that of technology. Pier (1989, cited in Gómez, 2014) mentions that technology is derived from both theory and practice, both points are prerequisites of a technological fact, therefore, technology is a body of knowledge, tools and techniques derived from the science and practical experience that is used in a firm, production or application of products, processes, systems and services.

For his part, Lara (1998) conceives technology as a set of specific knowledge and processes to transform reality and solve a problem. In the case of Gómez (2014), it determines that technology is any object (tools, equipment, furniture or any object that has dimensions, characteristics and the possibility of being measured), a process or procedure that required a set for its design and elaboration of integrated knowledge and, therefore, the possibility of being applied. In a summarized and practical way, technology is understood to be the set of knowledge applied to generate an innovation. In the shelter of the previous concepts of technology, the industrial revolution 4.0 develops

The Industrial Revolution 4.0 is characterized by the fusion between the physical, the digital and the biological: the boundaries between these three fields of knowledge are broken and new connections are established: machines with machines, machines with products and products with people. Therefore, this revolution is identified with robots, the Internet of things, additive manufacturing, big data, big data analysis, cloud computing, simulation of virtual environments, artificial intelligence, cybersecurity and augmented reality, which has implications in the various sectors and social networks (Schwab, 2016, citado en Basco, Beliz, Coatz y Garnero, 2018).

A substantial indicator of social changes, forms of relationship and communication, forms of consumption and even vision of life, derived from the different industrial revolutions, is that these changes were not imposed, they were not planned, they were derived from a naturally by the use of technology and its transformation through the application of greater knowledge, that is, of greater technology in existing technologies, which makes them non-linear transformations, but yes in spirals, which allow permanent improvement, creating new needs, new human relationships, other forms of consumption and communication, without an external guideline that indicates its conclusion in time, as it is determined by the development of technology itself.

Education 4.0 and Industry 4.0 emerge from the Industrial Revolution 4.0. For its development, both education and industry require the integration of work through collaboration networks with other actors in the productive ecosystem, as well as with the Government and consumers through automation, digitization and connectivity. In addition, it must be considered that the management of information and communication technologies (ICT), cloud computing, the Internet of things and big data further reduce coordination costs at a global level. Other aspects that favor competitiveness in the framework of industry 4.0 is the link with infrastructure, logistics and digital connectivity, the energy cost and the talents of the people according to the demands.

> Among the main challenges for emerging countries, the following stand out: reducing the digital divide with respect to developed countries; promote the penetration and adoption of 4.0 technologies in their productive ecosystems; establish new commercial integration strategies in global chains; improve the articulation between the scientific community and the productive sector; strengthen local innovation ecosystems and promote the emergence of new actors and new markets (Basco *et al.*, 2018).

The industrial revolution 4.0, both in industry and in education, originates from research through the work carried out by experts from different areas of knowledge, with collaborative interdisciplinary research work, where the limits of a field of knowledge must blur and even blend to provide more oriented social, economic and political solutions. Thus, collaborative work is imperative and research becomes more important.

According to the previous context, three elements become relevant: empirical knowledge, collaborative exercise and a planned, organized and evaluated work. These elements have been fundamental for the development of technology, but also for social transformation worldwide. Unfortunately, for the Fourth Transformation and Industrial Revolution 4.0 these elements have different purposes. The first seeks structural change, to change the forms of organization that affect management processes; and the industrial revolution 4.0 guides education and research towards the conjunction of the various areas of knowledge with the field of technological development: digital, robots, the Internet of things, additive manufacturing, big data, big data analysis, computing in the cloud, among others, however, the objectives that are sought are in the fluctuation of the conditions that occur in time.

In this way, researchers in networking encounter challenges of context, of public policy in the field of science and technology, which, on occasions, is exceeded by the speed of technological, social and environmental change, in addition to organizational problems in the internal dynamics of networks, all these situations and others, as we said, must be faced jointly by the members of the networks.

Importance and conceptualization of networks

Teamwork and collaboration have become the vehicles for the integration of knowledge, efforts and capacities for research processes. This has required going beyond disciplinary, institutional and geographic limits for the study and solution of these problems by the scientific community (Bermeo, De los Reyes and Bonavia, 2009). Among the properties of networks that have been most analyzed in management studies or that follow the perspective of social capital, are the centrality of the network, its density, its size and the presence of structural holes in them.

Centrality is the property that identifies the nodes with the greatest number of links within a network (Wasserman and Faust, 1994). The most central actors may have an advantageous position over others in that they have more alternatives to satisfy their needs, more possibilities of access to resources and it is considered that they are less dependent (Hanneman and Riddle, 2005). The most central nodes in the structure of a network are also called star nodes, since due to their high degree of relationship they stand out from the others

Luo (2005) relates the centrality of the group's network to leadership aspects, considering that a centralized network can present strong leadership, and that there may be greater control of the group's activities and greater organization, but also a very strong network. Centralized action can limit the freedom of action of group members.

Conception of the term networks

Newman (2000), In his article on the structure of networks, he defines a social network as a collection of people, each of whom is familiar with some subset (understanding subset as the elements that, due to some characteristic or specific knowledge, make up a group that is part of the larger group). However, Newman (2000), when speaking of collaboration networks, points out that her study is located in the field of social networks, and confirms it in the following paragraph:

> Social networks have been the subject of both empirical and theoretical studies in the social sciences for at least 50 years, partly due to the inherent interest in human interaction patterns, also because their structure has important implications for the dissemination of information. and disease. It is clear, for example, that the average variation in the number of individuals involved, also called the average degree of the network, could substantially influence the spread of a rumor, a fad, a joke or this year's party. (pp. 406-407).

Even so, its definition is worth highlighting, since, despite being developed for social networks, it can be considered suitable for any type of network, including networks created for research purposes.

One of the aspects that give importance to research networks is the possibility of co-authored publications, since, as mentioned by Adams (2012), the new regional networks are reinforcing competition and research capacity in emerging economies. One way to face the challenges of educational institutions and research centers is collaboration seen from a broader public perspective. For example, knowledge transfer can occur better by being in collaborative conditions and publications of co-authored articles are cited more frequently.

Co-authorship derived from network research work has increased the number of co-authors in articles. In the 1980s, it was rare to see more than three or four authors. In 2012, articles with more than 3000 authors were presented in the magazine Natura (Adams, 2012).

Networked research can generate a research workforce in various regions in a relevant way for 2020. In Latin America, research is conducted through various networks, made up of Brazil, Mexico, Chile and Argentina.

The benefits of networking include, according to Adams (2012), the following: 1) it provides access to resources, includes funding and facilities for research and generation of new ideas; 2) access to equipment located in large facilities with the possibility of access to high-quality quality data that can promote the rapid dissemination of knowledge; 3) co-authored publications are more frequently cited; 4) research networks are an internationalization tool for diplomacy; 5) Exports of excellent research equipment, as an example, the case of Germany, whose exports were generated from their alliances.

Some authors mention that researching online increases productivity (Lee and Bozeman, 2005); others that senior researchers prefer to work advising doctoral and postdoctoral students (Bozeman and Corley, 2004). These same authors state that “although

such collaboration is likely to improve the productivity of some parties, others may be an obstacle to the productivity of the more experienced researchers, therefore, for the latter, this may represent a voluntary contribution" (pp. 599-616)

Sebastián (2000) considers that cooperation networks are associations of stakeholders whose objective is to achieve jointly agreed results through participation and mutual collaboration. Research networks, also called laboratories without walls, are group associations for the development of research and technological development activities through joint work.

Typology of networks

There are various approaches to classify networks. A summary of these is shown in Table 1.

Tabla 1. Clasificación de las redes

Clasificación	Características
Por su alcance	Institucional, nacional, regional o internacional
Propósito u objetivo	Redes de información y comunicación, redes académicas, redes temáticas, redes de investigación, redes de innovación y redes de servicios tecnológicos
Por la naturaleza de su asociación	Formales e informales

Fuente: Elaboración propia

According to the classification in Table 1, this research corresponds to an institutional one; For its purpose, it is research; by its nature, it is both formal and informal.

In research networks, members collaborate to conduct larger and more complex investigations, which requires interdisciplinary work. Research networks, or also called by some more knowledge networks, consider the participation of both researchers and users of the research. The capacities are complemented and there is an equitable distribution of tasks. Their importance lies in the fact that they have transformed the modes of production of knowledge and the development of technology; by revaluing collaboration, it enables interdisciplinarity. They tackle complex problems and favor the improvement of investigative capacities.

Collaboration-cooperation

In a globalized world, the importance of research to solve common problems in different countries and different communities acquires greater relevance. And when it comes to highly complex problems, collaborative work becomes even more important. According to Schlattmann (2017), there are numerous reasons why collaboration is important in science and it highlights: 1) the most prominent scientists seek to work with the most prominent colleagues in their field; 2) interdisciplinary research approaches determine collaborative processes, through interdisciplinary research centers, institutional networks or centers of excellence, and 3) there is a greater appreciation of interdisciplinary research by funding organizations.

But the theoretical positions and perspectives of what is understood by cooperation and collaboration are found. For example, Schneider (2006, cited in Gómez, 2019) determined a difference between both terms. He defined cooperation as "a process in which everyone works shoulder to shoulder in the same direction and with the same purpose. It is a job in full agreement between the parties, rather than a job in competition "(p. 7). Collaboration is different, it corresponds to "a process in which individuals work together in a complex intersection of common goals, although from competing attitudes and diverse interests" (Schneider, 2006, cited in Gómez, 2019, p. 7). Therefore, while cooperation is a collective work from consensus, collaboration, for Schneider (2006, cited in Gómez, 2019), is a collective work in conflict, where others are trusted the more they seek to achieve the goals. own interests and where the plurality of positions is not reduced.

The term collaboration in the world has been handled interchangeably with other terms such as cooperation and alliances. Collaboration occurs at the level of individuals or institutions. In the case of collaboration between organizations, it includes well-defined reciprocal relationships to achieve common goals, and collaboration between individuals is defined as a process to share the creation of something, where subjects interact to create and share knowledge or for its development . In this sense, collaboration is a process to share knowledge, but also to achieve common goals (Bermeo *et al*., 2009).

Communication

There are aspects that cannot be left aside in a collaborative research work through networks, if it is considered as a social interaction: culture, language and the particular characteristics that are embedded in a scientific research activity, especially when The work is multidisciplinary and in each area of knowledge there is a special technical language to name similar concepts but with different meanings or similar meanings with different terms. Within this framework, researchers prefer to work with those who use the same language, among peers from the same area, or with those who do not speak English, who will be less requested to collaborate.

National Polytechnic Institute and its research networks

The National Polytechnic Institute (IPN) was created in 1936. It is the first institution nationwide in the field of science and technology and the second in terms of enrollment. The number of its programs amounts to 249, which are grouped into three areas: engineering and physical-mathematical sciences with 156 programs, medical-biological sciences with 59 programs and social sciences with 34. The offer includes the educational levels of baccalaureate, bachelor's degree , Masters and doctors degree. In the 2019-2020 period, there were 185,358 students in the school system and 5,895 in the non-school system, in such a way that enrollment amounted to 191,253 students. Its distribution is throughout the Mexican Republic, with a significant concentration in Mexico City (IPN, 2020a). Of the programs offered by the postgraduate level, 105 are in the National Quality Postgraduate Program (PNPC). A high percentage of its graduates are of high level and internationally recognized. Currently, two of the best researchers in the robotics and health areas, along with other researchers in the country, will represent Mexico in the work for the protocols and the vaccine against COVID-19 (IPN, 21 de mayo de 2020).

Research networks at the IPN

The research and postgraduate networks of the IPN were created as of November 30, 2006 as advisory, consultation, support and coordination bodies of this house of studies. Its purpose is to "promote the training of human resources of academic and professional excellence, as well as the generation of cutting-edge scientific knowledge and its transformation into useful applications to society in this matter" (Secretariat for Research and

Postgraduate Studies [SIP] and Coordination of Research and Postgraduate Networks [Coriyp], 2019, para. 4).

The guidelines for the admission of professors to any of the research networks, among other aspects, are: 1) have a full-time, 40-hour professor appointment; 2) in the last three years, having published works related to the specialty of the network to which they are applying; 3) submit their curriculum to the National Council of Science and Technology (Conacyt) —this because it must be part of the National System of Researchers (SNI) - updated with productivity from the last three years; 4) have participated during the last three years in formal research projects on topics of the network to which membership is requested, in the case of networks of experts (in these cases it is not required to be a member of the SNI) they must have evidence of professional work as advisor, consultant or participation in the development of standards in the areas of telecommunications or robotics and mechatronics or having participated in formal research projects with internal or external financing or in related projects or having publications in the last three years in the areas already mentioned; 5) agree to comply with the obligations of the members of the research and postgraduate networks, described in the agreement to create these, and 6) not belong to more than two research networks or IPN experts.

As can be seen, a researcher, prior to entering a research network, must have personal or individual investigations to join the network that interests him / her to investigate. Table 2 shows the number of members, number of publications, multidisciplinary projects in which they participated, number of patents submitted for registration, this in 2016. The number of publications is minimal due to the fact that the results of the research are technological, so this is reflected in the number of patents submitted for registration.

Tabla 2. Características de las redes

Redes	Miembros	Publicaciones	Proyectos multidisciplinarios	Patentes
Biotecnología	139	2	37	28
Medio ambiente	110	3	28	4
Nanociencia y micro nanotecnología	94	9	34	9
Computación	74	0	8	11
Energía	66	1	11	2
Desarrollo económico	72	0	3	0
Telecomunicaciones (expertos)	37	0	4	2
Salud	59	0	7	16
Expertos en robótica y mecatrónica	63	0	3	1
Total	**714**	**15**	**135**	**73**

Fuente: Necoechea (2018)

In the framework of the industrial revolution 4.0, which sets guidelines for technological development, and the political orientation of the Fourth Transformation, whose purpose is to change organizational and political structures, and taking into account the need to work in a network to solve large-scale problems, the research questions guiding this one were as follows:

- What kinds of problems did the research network coordinators face in creating and organizing a network?
- What elements of the Industrial Revolution 4.0 and the Fourth Transformation would favor the creation and organization of research networks?

Method

The inductive-deductive method was used. It included a reflective analysis around the information obtained through a debate called Experiences in the formation, operation and permanence of research networks. In total, 16 people participated in the debate, among whom were both former coordinators and coordinators of the networks. The impact that was had was considerable, since 1,200 people attended as listeners, including managers, researchers and undergraduate, master's and doctoral students.

The topics that guided the debate were: challenges faced for the organization and structuring of the network; problems faced in the operation of the network: administrative,

organization of researchers, resistance, integration of groups; strategies that were implemented to generate cohesion in the network, and influence of technology for the operation of the network.

The information was analyzed through the Atlas.ti software. In addition, use was made of the analysis of frequencies of identified categories, as well as a reflective analysis that allowed to achieve the following objectives: a) to identify the main challenges of operation and integration of a research network and b) to detect the research results in the different networks.

Results

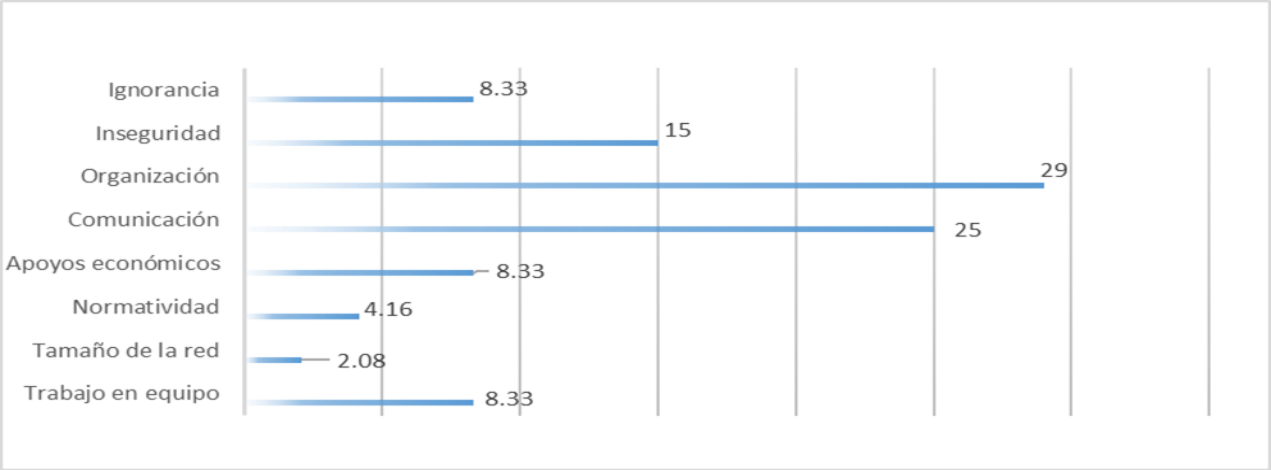
Eight areas presented the greatest difficulty, according to the former coordinators and coordinators of the networks, for the organization and operation of these: 1) Lack of knowledge by the coordinators about who investigates on the subject of the network; 2) Insecurity on the part of the members to maintain their personal productivity in the network; 3) Organization; 4) Communication; 5) Supports; 6) Regulations; 7) Size of the network, and 8) Teamwork. Table 3 and Figure 2 show the most significant results. Figure 1 shows the most frequent challenges.

The problems that coordinators faced in creating and organizing a network

It must be borne in mind that the IPN is an institution at the national level and has campuses throughout the Mexican Republic, so it is difficult to determine where and who works on the lines of the network, and also on how to work in it.

For the work with other networks, the challenge was to find active members of other networks that would be interested in participating in nanotechnology and computing projects, which were already addressing health issues in their work. Some other aspects that he faced was the availability of sufficient time, since researchers generally carry out various activities such as research, academic and personal activities, but, above all, the desire to participate was required.

Figura 1. Problemas identificados



Note: The challenges identified and of which no study related to them was found were: regulations, financial support, insecurity and ignorance; and the most frequent and affecting all networks is communication and organization.

Source: self made

In addition to what has already been mentioned, it must also be taken into account that when networks are started little is known about the expertise of each member. As there are several specialties, the challenge is for the members to join in collaborative work.

Another aspect that was characterized as a challenge was communication through technology. Although this challenge was handled in terms of communication, it is also related to the infrastructure, since without a fast, extensive and efficient computing platform that can contain and process the information that is generated, the job becomes complicated. Table 3 highlights the main challenges faced by research networks.

Tabla 3. Principales retos enfrentados por las redes de investigación

Reto	Características
Desconocimiento	En la red de salud, el reto fue integrar miembros vigentes que les interesara participar en proyectos nanotecnología y computación en las redes.
	Desconocimiento de quiénes y dónde, en el mismo IPN, hacían investigación sobre el tema de biotecnología (hay que considerar que el instituto tiene centros de investigación en todo el país).
	Poco se sabía del *expertise* de cada miembro.
	Cada investigador tiene *expertise* diferente, por lo que el reto es introducirlos al trabajo colaborativo.
Retos de comunicación	Los investigadores cambian frecuentemente los correos electrónicos, lo que genera problemas serios para la comunicación y la socialización de la información.
	Dificultad para poner en contacto a los investigadores de los diferentes centros.
	Comunicación a través de la tecnología. Si no se tiene una plataforma informática rápida, extensa y eficaz que pueda contener información, el trabajo se complica.
	Falta mayor comunicación, debido a que requieren mejores canales de comunicación.
	Conjuntar y considerar que todos somos expertos en el área y que el otro no siempre tiene la razón, aun cuando se trabaje en lo mismo.
	Falta comunicación más efectiva entre los investigadores de los centros o de las instituciones de educación superior con las empresas, ya que los tiempos se manejan de manera diferente. El tiempo de una investigación para un investigador puede durar ocho años; para un empresario debe durar meses y lleva el sello de pesos. En el caso del Gobierno, es necesario que se den cambios y el impacto, en medida de lo posible, debe darse dentro de un periodo gubernamental.
	Falta de comunicación entre miembros.
	La traducción de las diferentes formas de expresión técnica entre los miembros que pertenecen a diferentes áreas del conocimiento, así como a las metodologías que utilizan.
	No se sabe, en muchas ocasiones, en cuántos proyectos de investigación participan para solucionar problemas nacionales, se tiene que hacer una búsqueda exhaustiva.
	La complejidad de los seres humanos puede impedir la comunicación.
Retos de organización	Se muestran en la figura 2.

Fuente: Elaboración propia

Some of the researchers establish research networks with researchers from other institutions; the problem is the difficulty for these researchers to report with whom they do it and if it is at the national or international level. Therefore, it is unknown which researchers and in how many projects participate to solve national problems. This problem extends to the difficulty of obtaining information from Conacyt.

A challenge that seems simple, but that in a network of these characteristics becomes something complex, is the form of technical expression that is generated in the different areas of knowledge. Networking includes interdisciplinarity. This generates limitations and, in the least of cases, restrictions to advance in the work. Another challenge is the methodologies used depending on the area of knowledge.

A threat to linkage is the lack of effective communication between researchers from centers or higher education institutions with companies, mainly due to the fact that the times in both sectors are different. The time of an investigation for an investigator can last eight years; for an entrepreneur it must last for months, due to the stamp of pesos that this entails.

Organization as a challenge in a network

At this point, there are problems that seem personal, but that were integrated into this area since family activities overlap with professionals, especially when a network coordinator is at the same time director of a school or of a research center or section of postgraduate.

As mentioned earlier, unlike a research network, an expert network is more flexible in its requirements. The robotics network was formed as one of experts because each level of expertise in this field is relevant, however, the organizational problem that arises is to bring together their efforts in a few lines of research, since each member has their own line.

This next problem is faced by all institutions, therefore it is considered understandable, since every individual has a personal life that needs to be reconciled with work and research activity, in the case of researchers; Thus, the question they ask themselves is: how does a person organize himself when he works up to 12 hours a day? It is difficult to serve students, direct theses, teach undergraduate and graduate classes, see where research results are published and how and what is written.

Among the workload that each researcher carries out, it is found, together with the work of developing investigations and teaching classes to the groups assigned semester, that of complying with the administrative procedures requested by the IAPA as part of its function.

Researchers are always looking for and delivering documents to request the productivity incentives to which they are entitled, in addition to all the aforementioned activities.

Organizational problems faced by the coordinators also included the following: lack of motivation on the part of the members to work in a network; application of the elements of the organization process, this was reflected in the moment when, at the central level, there were changes of administration in the Coriyp, which affected the organization within the networks, for example, of the 120 members in the power grid, only 20 remained; greater integration is needed, especially in the energy network; the workload of the coordinators of a network must be carried out without support personnel, since, generally, in addition to being network coordinators, they are civil servants or teachers, or they perform all three functions at the same time. No doubt more liaison is required between the node representative and the members of that node.

Figura 2. Retos de organización

Fuente: Elaboración propia

Another problem that coordinators face is the frequency with which support staff rotate. In the networks where it does exist, this staff is important to achieve the objectives, so their permanence as support is necessary.

Discussion

Although both the Industrial Revolution 4.0 and the Fourth Transformation can be located in the field of innovation, however, there are various aspects of the latter that could limit the development of research networks, among which are the lack of strategic planning, monitoring elements, impact evaluation, but above all, the form of collaboration, since the networks work in horizontal collaboration and in the Fourth Transformation decisions are made from the top down.

In the case of the industrial revolution 4.0, whose origin is naturally linked to the development of science and technology, with horizontal collaborative work by expert researchers that facilitated the increase of said knowledge, in a dynamic and spiral way, whose permanence in time corresponds to natural conditions and depends on the speed with which knowledge is transformed, taking into account all this, this scenario, of course, facilitates networking for scientific and technological research directed towards solving problems of large wingspan.

The congruence between one and the other lies in the fact that public policies, depending on how they are determined, but above all on how they are managed, will impact both to a greater or lesser extent, the research work and especially the management of the coordinators of the networks. The greatest impact of the Fourth Transformation will be in the organization and change of structures in institutions and of the industrial revolution 4.0, in economic and infrastructure support for the development of research.

This work provides empirical evidence of the challenges and difficulty faced by network coordinators in knowing the number of researchers who address the same topic, at the national level, and their different edges. Among the studies that have been carried out on networks, collaboration and cooperation are found as central topics, as well as communication barriers between members of the networks.

Conclusions

It is concluded that the challenges faced by the researchers in the process to create and coordinate the research networks in the IPN were: 1) lack of information on the part of the coordinators of the networks about who investigates on the subject that interests them to these in the different IPN campuses; 2) insecurity of researchers to maintain their personal productivity by participating in the network; 3) organizational problems; 4) communication problems; 5) lack of financial support; 6) regulations in construction; 7) size of the network, and 8) teamwork.

The challenges of greatest incidence correspond to the categories of organization in the network and in the forms of communication, this includes instruments, capabilities and network coverage.

The research networks in the IPN are of an institutional nature, and a greater link is required between the Coriyp with the coordinators of each network and with its members, which induces centralization by the authority and flexibility in the operation.

A relevant conclusion was to identify that, for the management of a research network, a coordinator is required who is widely recognized by researchers, since, in a network where all members are national researchers, a dynamic of egos is generated. and, therefore, the difficulty for coordinators is increased when coordinating leaders in their area of knowledge and who are experts in their field.

Regarding the political and structural framework of the Fourth Transformation and the Industrial Revolution 4.0 as development and transformation of technology, it was concluded that both currents have had an impact on the generation of social, economic and political changes.

Proposals

The coordination of networks should have the position of an address within the SIP, since the number of research networks, as well as the networks of experts and the networks that are being created, require attention according to their purposes, structure and dynamics, which would facilitate the creation of a network of networks according to national and institutional needs

Generate physical and human infrastructure in the different venues where the coordinator of each of the networks is located. The functioning of the network in management processes will depend on the collaborative work of teachers and researchers.

The participation of the social sciences in the field of medical and biological sciences and in the field of all engineering networks is necessary. An administrative vision is always necessary, not as technical elements, but as researchers in the field of knowledge of networks.

The work of specific but broad topics that require prompt results; They will have to work in small network groups to achieve functional work.

Some lines of research that emerge from this research are: financing of research networks for their operation and development; evolution of networks; comparison between the informal organization and communication of an institution and the informal communication organization of networks; political grouping within the networks, and leadership in the operation of the networks.

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