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Management model for applied research and technological innovation as a strategy for productivity and impact on the productive sector. Case: Technological University of Tula - Tepeji

Modelo de Gestión para la Investigación aplicada e innovación tecnológica, como estrategia para la productividad e impacto en el sector productivo. Caso: Universidad Tecnológica de Tula – Tepeji

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Abstract

Currently, in the face of a competitive economy, it is important that companies innovate. Innovation has become the engine that drives the transformation and growth of companies and is essential to improve living standards. There is a close relationship between innovation, research and University: research produces knowledge and innovation, and universities are the main place to conduct research, because they concentrate infrastructure and qualified personnel. Through teaching, advice and participation in projects, the researchers transmit knowledge about innovation and projects, methodologies and strategies; which contributes to the mission of the Universities to train professionals to solve current and future challenges. This article is generated from a documentary research on management models, with the aim of serving as a reference to propose a documentary model of research management, which is feasible to apply in a Public Higher Education Institution, the contribution of which will be a mechanisms that allow the teacher to carry out research and technological services to impact the productivity indicators of the productive sector.

Management Model, Applied Research, Innovation

Resumen

Actualmente, ante una economía tan competida, es importante que las empresas innoven. La innovación se ha convertido en el motor que impulsa la transformación y el crecimiento de las compañías y es fundamental para mejorar los estándares de vida. Hay una estrecha relación entre innovación, investigación y Universidad: la investigación produce conocimiento e innovación, y son las Universidades el principal sitio para realizar investigación, porque concentran infraestructura y personal calificado. A través de la Docencia, la Asesoría y la participación en proyectos, los Investigadores transmiten a los estudiantes conocimientos de innovaciones y proyectos, metodologías y estrategias; lo que contribuye con la misión de las Universidades de formar profesionistas para resolver retos actuales y futuros. El presente artículo se genera a partir de una investigación documental sobre modelos de gestión de investigación, con el objetivo de servir como referencia para proponer un modelo documental de gestión para la investigación, que sea factible de aplicar en una Institución de Educación Superior Pública, cuya aportación será el que se generen los mecanismos que permitan al docente realizar investigación y servicios tecnológicos para impactar los indicadores de productividad del sector productivo.

Modelo de Gestión, Investigación aplicada, Innovación

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Introduction

Research is an activity that can give rise to the creation of new products and to the innovation of processes that man uses in all areas, thus modifying his way of life and, at the same time, leading to the economic development of countries. According to Diego Bernal (2018), innovation is an engine of growth for companies.

Universities are environments for experimentation and research, and they have specialized personnel, which makes them a suitable place to carry out research and technological development.

This project will serve as the basis for generating a research model which will allow a Public University of Mexico, specifically the Technological University of Tula-Tepeji (UTTT), to carry out research and technological development processes that will contribute to improve the productivity of the industrial and service sectors, due to the fact that, presently, the institution does not have guidelines, procedures or sufficient and adequate resources to carry out research.

The current research models of traditional universities have different characteristics that do not fit the model of a Technological University. Hence, a model is required that takes into account the characteristics of a Technological University, which were created in 1991 in Mexico to prepare Higher University Technicians who would work at operational levels; however, the needs of the region and the demand of young graduates, the society in general and the business sector grew, so in 2009 the teaching of Engineering majors (Bachelor's level) started and in the current year, 2019, the first Master's degree will be introduced. Its full-time professors, in addition to teaching, develop research and technological services, which require a context with processes that regulate and allow the proper development of the research function.

This project arises from an investigation on the role of innovation in the development of countries, assessing the benefits and the needs identified by international organizations such as UNESCO, and analyzing the current needs in both first world countries and developing countries to propose a Management Model for Research.

The first section mentions the origins of innovation, its concept and importance; it also discusses the relationship between research-innovation-university and addresses the importance of innovation and research in Higher Education.

The second section deals with the problem about research worldwide and in Mexico, and specifically mentions the model of Technological Universities, also, the aspects required to carry out the function of Research in the UTT are mentioned. The statement of the project is included.

The third section presents the justification of the project, which addresses the issue of investment by developed countries in research, as opposed to that by developing countries. The benefits of research and the current situation of the UTT are discussed. The objectives of the project are included.

The fourth section discusses the methodology, the application of a survey and the processing and analysis of the information.

The fifth section mentions the results available and those that are expected by the end of the project.

The sixth section mentions the conclusions on the research, the advantages and recommendations.

The last part includes the references consulted.

Background

Importance of innovation.

Innovation has become the engine that drives the transformation and growth of companies (Bernal, 2018), which require to be close to the customer and know their needs and trends.

Innovation is fundamental to improving living standards and has far-reaching effects, influencing people and the economic sector in different ways, as mentioned by the OECD (OECD/EUROSTAT, 2018).

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Usually, innovation is not generated after analysis, it does not occur spontaneously, it happens after observing variables, testing and researching. The research process commonly takes place within universities, because they have places (laboratories) with equipment and people (research teachers) who have experienced, worked and dedicated time to study different methods, new forms. (Canós L., 2015).

History and concept of innovation

Throughout history, man has been creating multiple objects that helped him perform all kinds of work, so today man uses tools, products and new ways of doing things, all created at some point in history by someone. Man's intelligence has made him an inventor, but mainly it has allowed him to discover the properties of nature, according to Patricio Barros (2012) "...the history of inventions is the history of man's life and how it has been related to nature...”

The World Intellectual Property Organization (WIPO) states that an invention is a new product or process that solves a technical problem, while in Mexico, the Mexican Institute of Industrial Property (IMPI) (2017) defines an invention as any human creation that allows the transformation of matter or energy that exists in nature, for its use by man and to satisfy specific needs.

The research-innovation-university relationship.

The research process commonly takes place within universities, because they have places (laboratories) with equipment and people (research teachers) who have experienced, worked and dedicated time to study different methods, new forms. (Canós L., 2015).

Importance of innovation-research in Higher Education.

The United Nations Educational, Scientific and Cultural Organization (UNESCO), with its programs, contributes to the achievement of the sustainable development goals defined in the 2030 Agenda, adopted by the General Assembly of the United Nations in 2015.

Among other things, UNESCO (UNESCO, 2019):

- Seeks to establish peace through international cooperation in education, science and culture.
- Supports science programmes and policies that function as platforms for development and cooperation.
- As a laboratory of ideas, it helps countries to adopt international standards and manages programmes that promote the free flow of ideas and the exchange of knowledge.

At the end of the 1990s, UNESCO took on a renewed leadership role in the international context and emphasized other subjects in which knowledge is key to economic development (Rovelli, 2018).

UNESCO, within the "World Declaration on Higher Education for the Twenty-first Century: Vision and Action" (UNESCO, 1998) states that knowledge and new technologies should be shared and cooperated in order to reduce inequalities. Likewise, it points out that Higher Education and Research are a fundamental part of sustainable cultural, socio-economic and ecological development of individuals and nations, and within the Missions and Functions of Higher Education, in Article 1: The mission to educate, train and carry out research, it mentions that the promotion, generation and dissemination of research knowledge contributes to the cultural, social and economic development of societies.

Within the section II of Priority Actions at the level of the systems and institutions (UNESCO, 1998), it indicates that University Teachers should carry out functions of teaching, investigation, support to the students and direction of institutional aspects. These tasks mentioned by UNESCO are perfectly in line with the general requirements of the Programme for the Professional Development of Teachers (PRODEP) of the Ministry of Public Education in Mexico, so that teachers may obtain recognition for the Desirable Profile (Ministry of Public Education, 2017), an aspect that will be addressed more openly in the development of the present project.

Universities are the main place to generate scientific production, because the required infrastructure and competent personnel are concentrated in them, as mentioned by Jaim Royero (2017) in his article "Management of University Research Systems".

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UNESCO recognizes that because of their contribution to development in Higher Education it is necessary to carry out and promote research in all disciplines (including social sciences).

Problem

Research in the world

The model that our universities follow belongs to the 19th century, the universities of the Middle Ages were essentially teaching universities. Research universities emerged at the beginning of the 20th century in the United States and Europe (Vargas, 2017).

Today, there are differences in the vision and role of higher education institutions in North America, which have a solid economic development; contrasting with those in South America, which are developing. (Dorin M. & Machuca de Pina, 2017). Work in the 21st century needs to be directed toward skills relevant to today's innovation.

In developed countries, such as the United States and Canada, the needs are covered and resources are allocated for research; however, in Mexico, these opportunities of financial, material, methodological and training resources, among others, are not available.

For the United States, technological development is the main pillar of its competitiveness, which is why it is a priority to have resources for research in its educational institutions. Its technological development is linked to the Government -private initiative- Universities and Research Centers. In many cases, the resources come from the same corporations that obtain profits from the implemented knowledge coming from the financed researches; however, most of them come from federal and state organizations. In contrast, in Latin American countries, Higher Education is commonly financed by a public budget and resources from government entities, and therefore becomes insufficient and does not guarantee quality. (Dorin, 2017).

In Latin America, the research budget depends on the resources of universities. Research has been neglected in the last years of the 20th century (UNESCO, 1998).

Latin American government entities must visualize that their economic development will not be achieved only by opening new major or increasing specialization, but they must also invest heavily in research and adequate management systems. Research leads to new technologies that can improve the use of natural resources and the jobs that these resources generate.

Research in Mexico.

Funding for public higher education in Mexico has been insufficient to meet international requirements. (Zepeda, 2016). In Mexico, as is well known, research is carried out in the main universities; however, there is a scarcity of resources for this function. The low investment in S&T (Science and Technology) by the government and the private sector, since 2003, is the result of a series of laws and government programs that allocate 1% of the GDP.

The Ibero-American Network of Science and Technology Indicators (RICYT) reports that in 2015, Mexico invested 0.39% in R&D (Research and Development), against 1.27% in Brazil, which is the regional leader in investment and scientific production (RICYT, 2017). According to the period from 2008 to 2017, the highest level was registered in 2010, with 0.49% and from that year onwards it shows a downward trend until reaching 0.33% in 2017.

Due to the lack of procedures, the low amount of resources, the low number of researchers, and the low number of innovation projects, the results are reflected in the indicators of Mexico.

At the Technological University of Tula-Tepeji (UTTT), research is carried out by Full Time Professors (FTP) integrated in Academic Bodies and some individually. We conducted an analysis to know the characteristics and current situation of applied research and development of technological innovation, and we detected the lack of some elements that can support the work of research and help carry out the processes in a more efficient way and, at the same time, regulate the development of research projects; among the aspects that stand out are the following:

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– Area or Office dedicated to knowledge transfer
– Resources for research projects
– Job descriptions
– Procedures for initiating, managing and supporting research projects and activities
– Project and research training
– Creation and signing of agreements, Binding
– Registrations and patents (Patent Center)
– Labor aspects
– Lack of resources
– Recognition for achievements
– Dissemination of activities, results and achievements of research projects
– Life Plan of the Academic Bodies
– Information and process control

Problem Statement

There is no management model for applied research and technological innovation, as a strategy for productivity in the industrial and service sector, at the Tula-Tepeji Technological University, during the period 2019.

Justification

UNESCO, in the World Declaration on Higher Education for the Twenty-first Century: Vision and Action (UNESCO, 1998) states that without adequate higher education and research institutions with a pool of qualified and trained people, no country will be able to ensure genuine endogenous and sustainable development; in particular, developing and poor countries will not be able to catch up with the developed industrialized countries.

According to the World Bank, all countries allocate resources for research and technological development, in this list the United States ranks 10th, while Mexico ranks 68th with only 0.49% in 2016.

By examining the data reported by UNESCO on research and development in Mexico, it is possible to identify at least three more aspects that require urgent attention. The first corresponds to the number of researchers working in national territory; the second, to their gender distribution; and the third, to the participation of different social actors in providing resources for research and development.

In Mexico, there is great inequality in the levels of development among HEI (Higher Education Institutions), and therefore it is not adequate for the scientific, economic and social development of the country. (Arechavala, 2017)

According to Dr. Alfredo Sandoval Villalbazo, Coordinator of the Physics Department Service Program of the Physics and Mathematics Department of the Universidad Iberoamericana Mexico City, National Researcher Level II (SNI), mentions that according to statistics published by the United Nations Educational, Scientific and Cultural Organization (UNESCO), Mexico devotes only 0.5% of its Gross Domestic Product (GDP) to the areas of research and development. Not giving science the place it deserves in society translates into technological dependence, low wages and high levels of poverty.

In a research-innovation process the benefits are difficult to measure, because they affect positively from the individual entities until they reach the macro level; at the micro level the benefits are direct on the Teachers who carry out the research, the students who interact with the Professor, the University whose teachers improve by participating with the researcher increasing their performance indicators, as well as the State that gathers the achievements of its public HEIs and equally increases its indicators; which is shown in Figure 1.

The Universidad Tecnológica de Tula-Tepeji (UTTT), a pioneer institution in the model of Technological Universities, located in the State of Hidalgo, began operations in 1991, offering studies at the Higher Technical University level. Over the years, this institution has distinguished itself for its quality service. Dedicated to the integral formation of its students, it applies diverse strategies such as: a close link with the business sector, training of its teachers, the application of best practices, the integration of diverse services and support for teaching; it works with an Annual Operational Program (AOP) which is closely monitored for the fulfillment of short-term goals, and an Institutional Development Plan (IDP) in which long-term goals are planned, which are derived from the State and National Development Plans.

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Derived from the needs of customer demand and the industrial and commercial growth of the environment, the UTT has developed by expanding the services and modalities offered, currently provides multiple engineering programs, some in the mixed modality (virtual and classroom) and begins in 2019 with the delivery of the first Master's program. The growth of the institution requires current procedures, guidelines and methodologies that support the new needs, being one case, the research activities carried out by Full Time Professors of the institution.

The UTTT shows the importance of research in its Institutional Mission, which states: "The UTTT is a higher education institution that promotes research, technological development and entrepreneurship to boost knowledge-based economy, forming comprehensive, relevant and universal values to competent professionals committed to sustainability" (UTTT, 2019).

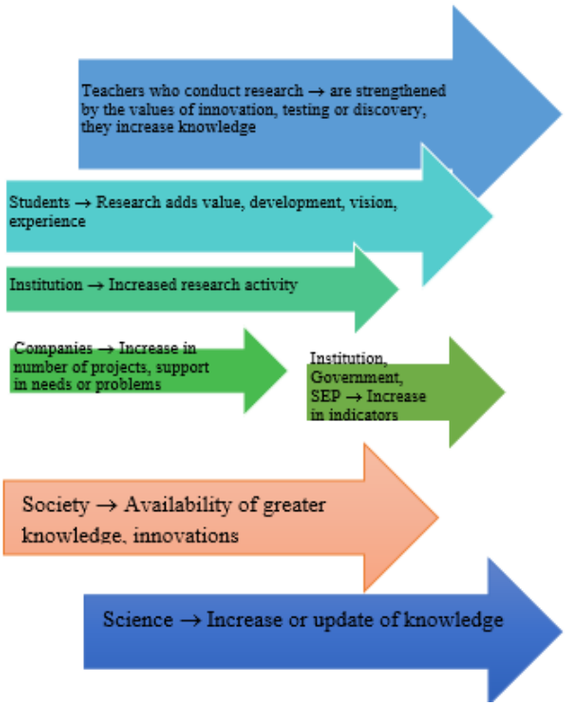

Figure 1 Benefits of doing research in a government HEI
Source: Prepared by the authors

Overall objective

To develop a conceptual model for the management of applied research and technological innovation in a Technological University, using the best practices from the models analyzed and characteristics of the UTT.

Specific Objectives

– To carry out a documentary research and study of the Art on Management Models for Research and Technological Innovation
– To carry out a study of the industrial sector of services to know its expectations on applied research and technological innovation
– To propose a documentary management model for research that can be applied in a public higher education institution, the contribution of which will be to generate the mechanisms that allow research and technological services
– To design an object-oriented information system for recording and managing information on researchers, academic bodies, production, projects, and obtention of indicators
– To evaluate the impact of the model using specialized software.

Research questions

What characteristics should the management model for applied research and technological innovation have in order to support the productivity of the industrial sector?

What procedures, activities, guidelines and formats are required to carry out the function of applied research and technological innovation?

Methodology to be developed

A survey will be designed and applied, which will be counted and analyzed to find out the main research needs in the organizations; with the application of the survey and also by the type of analysis with the values of the variables, we defined to use a quantitative approach and deductive method.

Because this research is conducted under a quantitative approach, the logic or reasoning of the deductive method is used (Sampieri, 2014), in which the research problem was posed and both the objective and the research question (what is to be developed and whether it is a productivity strategy) were defined.

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The quantitative process is sequential and probative, each stage follows another, and no steps can be omitted, although stages can be redefined. The quantitative research will be as objective as possible, avoiding the trends of the researcher. Quantitative studies will follow a structured process and order, and the intention is to generalize the results found in a sample in relation to the population.

Mixed approach: quantitative and qualitative processes will be used.

Method: Investigation-action (with collaboration of participants)
Logic or reasoning of the deductive method (Sampieri, 2014)

The variables identified are:

Independent variable: The Research and Technological Development Management Model

Dependent variables, which depend on the independent variable:

– The processes around the implemented research
– The policies established for Teachers-Researchers
– Recognition of researchers
– Remuneration for research
– The training received by the teacher
– The procedures to be followed
– Management support and follow-up
– The resources available

Once the proposed model has been developed, a simulation exercise will be implemented using the ProModel software to check its veracity, and verify the results, given the variables that influence the model.

Techniques for obtaining information.

In order to develop the State of the Art and the Theoretical Framework, we are researching with Internet repositories and obtaining information from project publications, books, theses, and registered pages. Likewise, physical books were consulted.

A survey will be designed to find out the characteristics and needs of the productive sector of goods and services in the area, in terms of research and technological innovation. This information will be used to define the characteristics required to design the model of applied research and technological innovation management.

The survey has a simple and executive design (10 questions), so that the management of the Company will answer it without requiring too much time. The application mode is through digital media using SurveyMonkey, thus taking advantage of using digital media.

Information processing and analysis

This study is cross-sectional in nature, because cross-sectional research designs collect data at a given time, from a single moment, in a single time. Its objective is to describe variables and analyze their incidence and interrelationship at a given moment, as if a photograph were taken at a specific time. (Sampieri, 2014).

Transectional-descriptive design aims to find out the impact of the modalities or levels of the variables in a population. The procedure consists of classifying a group of people, living beings, objects, situations, contexts, phenomena, communities, etc., into variables and generating their description. They are completely descriptive studies.

The procedures and guidelines of the different models currently under investigation have a process approach, where there are input elements, which come as an output from another process.

The results of the survey that will be applied to the Productive Sector of goods and services in the area of influence will be analyzed in an agile way and in real time. The SurveyMonkey tool has among its characteristics the ability to observe the trends of the results, which allows to see the progress in the application of the instrument. In the same way, the tool offers comparison with the global average, which helps to obtain the results automatically and facilitates their analysis to obtain the interpretation of the results.

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Results

On the Research Management Models consulted at the time, it is observed that the main procedures coincide; however, there are processes and characteristics not compatible with the model of Technological Universities, because the procedures of each institution are different given the age of the institutions and the subsystem (autonomous institution, Technological Institute, Polytechnic) and the period of work semester vs. bimonthly, access to resources, type of recruitment, employment guidelines, benefits, among others.

The creation of an Office dedicated to knowledge transfer is proposed, which could be in the Sub-directorate of Academic Liaison or Technological Services. The creation of this office seeks to centralize and speed up the support procedures for Researchers and Academic Bodies, an area in charge of programming the colloquium for the demonstration of the projects developed and the coordination of the annual Work Plans for Academic Bodies. Another of its functions would be to manage greater resources for research work, equipment and participation in resource program windows such as CONACYT (National Council of Science and Technology), to guide the Researcher and facilitate management and increase the amounts directed to research and projects.

Dissemination of activities and results. The same knowledge transfer Office will carry out activities to publicize the achievements in research and technological services, coordinating with the areas of press, dissemination, media, as well as conducting an event to recognize the work done and achievements:

– Recognition event
– Sample event of achievements and projects

An important activity will be to visualize the Life Plan of the Academic Bodies and Colleges, to program the time they will be in each Level before PRODEP, and to orient the activities towards the achievement of the next level or to remain in consolidation.

The Institution already has the registration of a Patent Center of the IMPI, the main functions of which will be the registration of patents; among its functions will be:

– Guidance and advice for patenting and registering intellectual property (protecting)
– Patent preparation
– Participation in the properties (teachers, UTTT, company, students)
– Facilitate and carry out the procedures of processing and monitoring, filling out forms, payments.

The following are included in the processes developed for the Research and Technological Service:

– Work methodology
– Guidelines for training
– Guidelines for the operation
– Guidelines and process for research
– Guidelines and process for mobility
– Networking Guidelines

In the aspect of Training, work will be done on the formation of training courses that affect the attitude, aptitudes and training as a Research Teacher for the best performance of their functions:

– Awareness and attitude
– Institutional development programme for the preparation and training of researchers
– Research Training
– Training for the promotion of Collegiate and Academic Bodies

The model developed proposes the creation of two different positions for full-time professors, with different distribution of hours in the activities. In this way, they will be able to direct their efforts towards their strengths and training and education will be more appropriate to their main functions. Their activities are proposed as follows:

– Full-time Professor (FTP): with greater work load in Teaching, group tutor, Thesis direction, activities to support the Educational Program, can be a member of the Collegiate or Academic Body.

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– Research Professor (RP), will have more time to devote to research projects and technological services, registered academic production, publications in formal media, prototypes and patents, presentation of papers in Congress, will seek to have a level before the SNI (National System of Researchers), provide training to teachers. Less dedication to teaching and less administrative support.

A JTP Job Description Manual of the Knowledge Transfer Office Manager will be developed.

Liaison procedures will be established:

– Collaborative work with other research bodies
– Networking
– Methodology and procedure for the signing of framework and specific agreements

The proposal that is being developed addresses the needs detected in the work of current researchers in the administrative and labor aspects:

– Timetable and activities of the Teacher-Researcher
– Benefit or Stimulus Program for the Teacher-Researcher
– Recognition for individual and team achievements
– Researcher appointment
– Appointment as Leader, Member or Collaborator of Academic Body

Information and control. To design an object-oriented diagram showing the information needed for the development of an information system with which to control the information of:

– FTP
– Academic Bodies
– Projects Monitoring, evaluation and control of the activities of the Researcher and Academic Bodies
– Determination and generation of indicators, statistics, lists, comparative graphics, historical

Conclusions

Research leads to innovation in products, processes and methodologies, which are necessary to raise living standard and generate development in countries. There are several organizations and authors who recognize the importance of conducting research to generate innovation, such as Diego Bernal (2018) who mentions that innovation is an engine of growth for companies.

Universities are a favorable place to conduct research because they concentrate both laboratories and equipment, as well as prepared labor; hence the importance of generating the environment, with the appropriate elements and conditions, to promote and control research efforts.

After 28 years of the creation of the UTT, it is necessary to have processes and guidelines that promote and regulate activities according to current requirements. The Management Model for Research that will be generated with this work will have special characteristics, designed to work according to the system of Technological Universities.

This project considers the generation of a whole model to manage research, integrated by procedures, guidelines, and, among other things, it is necessary to create a Technology Transfer Office, which controls and supports the development of projects of Academic Bodies and Colleges, which manages a greater amount of resources for projects, publications, academic production, equipment, mobility, exchange, participation in networks, etc.; so it is also required the advice on the processes of prototypes, registration and patents.

It is required to give recognition to people for their achievements in research through events and distinctions, as well as to carry out the diffusion of the advances and achievements.

It is expected that at the end of the Management Model, a simulation will be performed to test the impact it has on the productivity of the business sector; likewise, it is recommended that a second project be carried out for the elaboration and implementation of the computer system for the control of the information generated and the obtention of reports, statistics, and indicators.

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