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Review article

Postgraduate approach to strengthening innovation capabilities: Master's in Biotechnology

Aproximación desde el posgrado al fortalecimiento de las capacidades de innovación: maestría en Biotecnología

Abordagem de pós-graduação para fortalecer as capacidades de inovação: Mestrado em Biotecnologia

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ABSTRACT
In Cuba, the Ministry of Higher Education prioritizes the management of knowledge and innovation for sustainable social economic development, however there are still deficiencies to reach appropriate levels of interconnection between the management of research and innovation and its impact on the territory and /or locality. In this sense, the academic programs of the universities are called to generate abilities and skills in the graduates that allow them to implement innovative strategies to solve the problems of the environment. In the present work, the projection of the Master's Program in Biotechnology is addressed in terms of strengthening innovation capacities in professionals, taking advantage of the potential offered by its curricular design, as part of its continuous improvement and in order to obtain more professionals, competent, trained and innovative. A bibliographic review was carried out in several databases, related to the development of innovation capacities from the postgraduate level, supported by scientific articles from the period between 2017 to 2022 and the characteristics of the curricular design of the Master's program were taken into account, the types of courses and their contents, in addition to the innovative contribution of each one of them to the academic training of the master students. The articulation of teaching methods, the carrying out of investigative activities, with innovative outputs, the methodological work, and the application of instruments for evaluating the innovation capacities of graduates and employers, will contribute to the continuous improvement of the program, to respond to the socioeconomic demands of the territory and the country.

Keywords: innovation; biotechnology; postgraduate; master's degree.

RESUMEN
En Cuba, el Ministerio de Educación Superior prioriza la gestión del conocimiento y la innovación para el desarrollo económico social sostenible; sin embargo, aún existen deficiencias para alcanzar niveles de interconexión apropiados entre la gestión de la investigación e innovación y su impacto en el territorio y/o localidad. En este sentido, los programas académicos de las universidades están llamados a generar habilidades y destrezas en los egresados, que les permitan implementar estrategias innovadoras para resolver las problemáticas del entorno. En el presente trabajo, se aborda la proyección del Programa de Maestría en Biotecnología en cuanto al fortalecimiento de las capacidades de innovación en los profesionales, aprovechando las potencialidades que brinda su diseño curricular, como parte de su perfeccionamiento continuo y en aras de obtener profesionales más competentes, capacitados e innovadores. Se realizó una revisión bibliográfica en varias bases de datos, relacionada con el desarrollo de capacidades de innovación desde el posgrado, apoyados en artículos científicos del período comprendido entre 2017 a 2022 y se tuvieron en cuenta las características del diseño curricular del programa de maestría, los tipos de cursos y sus contenidos, además del aporte del carácter innovador de cada uno de ellos a la formación académica de los maestrandos. La articulación de métodos de enseñanza, la realización de actividades investigativas con salidas innovadoras, el trabajo metodológico y la aplicación de instrumentos de evaluación de las capacidades de innovación en egresados y empleadores contribuirán al perfeccionamiento continuo del programa, para dar respuestas a las demandas socioeconómicas del territorio y el país.

Palabras clave: innovación; biotecnología; posgrado; maestría.

RESUMO
Em Cuba, o Ministério da Educação Superior prioriza a gestão do conhecimento e a inovação para o desenvolvimento socioeconômico sustentável; no entanto, ainda existem deficiências para atingir níveis adequados de interligação entre a gestão da investigação e inovação e o seu impacto no território e/ou localidade. Nesse sentido, os programas acadêmicos das universidades são chamados a gerar habilidades e habilidades nos graduados, que lhes permitam implementar estratégias inovadoras para resolver os problemas do meio ambiente. No presente trabalho, a projeção do Mestrado em Biotecnologia é abordada no sentido do reforço das capacidades de inovação dos profissionais, aproveitando as potencialidades oferecidas pelo seu desenho curricular, no âmbito da sua melhoria contínua e com vista à obtenção de mais profissionais competentes. , treinados e inovadores. Foi realizada uma revisão bibliográfica em várias bases de dados, relacionada com o desenvolvimento de capacidades de inovação a partir do nível de pós-graduação, suportada por artigos científicos do período entre 2017 a 2022 e foram tidas em conta as características do desenho curricular do programa de mestrado, o tipos de cursos e seus conteúdos, além da contribuição do caráter inovador de cada um deles para a formação acadêmica dos mestrandos. A articulação de métodos de ensino, a realização de atividades investigativas com saídas inovadoras, o trabalho metodológico e a aplicação de instrumentos de avaliação das capacidades de inovação em graduados e empregadores contribuirão para a melhoria contínua do programa, para responder às demandas socioeconômicas de o território e o país.

Palavras-chave: inovação; biotecnologia; pós-graduação; Mestrado.

INTRODUCTION

The university-business link is currently an effective tool, aimed at strengthening the innovation capacity of the productive sector, which has a direct impact on society.

In this sense, it is necessary to train trained, competent and creative professionals who can respond to the demands of their economic and social environment. In this way, in said training must be implicit, not only the acquisition of new knowledge, but also the incorporation of the subject of innovation.

Hence, universities have an important mission in the inclusion of innovation in their management models, to transform their substantive processes, which will contribute to their impacts being visualized at the level of localities, society and the Environment (Díaz -Canel *et al*, 2020).

This element is important, since it is in universities and research institutions where human capital can be trained, knowledge generated and technology transferred, in order to achieve a greater link with production entities and services.

In Cuba, for example, the Ministry of Higher Education (MES) has always contemplated, within its strategic planning, knowledge management and innovation for sustainable social economic development (Díaz-Canel et al., 2020).

In recent years, this has come to be harmoniously synchronized with the country's development plan and the strategic objectives until 2030, in all its axes and strategic sectors (Díaz-Canel & García, 2020). For this reason, an entire work system has been implemented from the government itself, capable of harmonizing science and innovation based on macro-programs, programs and projects, with the support of various institutions that have a direct impact on society (Alpízar & Velázquez, 2021).

In particular, the postgraduate course, as an important scenario within Higher Education, is a strategic path for the preparation of human and scientific capital, which also incorporates the management of new knowledge, innovation and the development of human capacities. as sources of sustainable economic growth and confronting the dissimilar problems of society (Bernaza *et al.*, 2020).

In addition, in the postgraduate it is taken into account that all its training and development processes are articulated with educational proposals referred to this level, which are linked to the work activity.

In this scenario, the biotechnology sector constitutes a fundamental pillar to fulfill such purposes, due to its close links with various sectors, from the medical-pharmaceutical to the energy sector.

In this sense, the vertiginous development of biotechnology in our country has allowed the obtaining of new products that constitute the second line of export of material goods and an important area for the reduction of imports.

In this regard, at the Universidad de Oriente, a Master's Program in Biotechnology has been developed since 1996, belonging to the Center for Industrial Biotechnology Studies (CEBI), with more than 130 graduates and whose purposes are aimed at raising the scientific level of students. professionals linked to the Productive Scientific Pole, not only from the province of Santiago de Cuba, but from the entire eastern region. All this through a correct application of biotechnological techniques and procedures to industry, agriculture and the Environment (Universidad de Oriente, 2019).

As part of the Program Evaluation and Accreditation System, the program has held the category of Certified since 2005 and Excellent in 2010 and 2018, respectively. In addition, he received the Postgraduate Excellence Award from the Ibero-American Postgraduate University Association, 2014.

The central axis of the program, in its new refinement, establishes an integration between the investigative activity, with the multidisciplinary approach that is required and the theoretical-methodological training, together with the collective work in scientific groups, which are supported for their work in research projects.

In general, the program is conceived as a training process for the master's degree in Biotechnology, whose center is scientific research, oriented towards the creation of new knowledge or the development of innovative technical solutions, which is complemented by academic, methodological training, communicative and educational. The research specified in the thesis constitutes the unifying element and is integrated into the research subsystem through a project and a line of research of the program (Master's Program in Biotechnology, 2019).

However, due to several factors, the levels of interconnection between academic training and its impact on the economic-social environment, with innovative approaches, are still insufficient. In fact, there have been several models and approaches used to increase the links between the scientific and productive sectors. That is why, on the subject of innovation, certain capacities are required to achieve results that have a more efficient impact on the different sectors of the country's economic and social life.

Hence, universities with their postgraduate and research activities can generate changes in the training, learning and innovation models of all the human capital that is required for the social, productive and economic transformations that society demands (Moré, 2019).

Taking these aspects into consideration, the problem of this work is the need to socialize how the innovation capacities of professionals who enter the Master's Program in Biotechnology are strengthened, based on the curricular design itself.

The objective is aimed at socializing how the strengthening of innovation capacities is worked and projected in the professionals of the Master's Program in Biotechnology, through the curriculum itself, taking advantage of the potential of the territory.

MATERIALS AND METHODS

For the analysis of the present investigation, a bibliographic review related to the development of innovation capacities from the postgraduate level was carried out. For this, the academic Google and other databases such as Redalyc, Latindex, Scielo, among others, were used.

In the search for the articles, the following keywords were used: capacity for innovation; postgraduate; innovation; biotechnology sector; Science, Technology and Innovation; postgraduate in Cuba. The selection of the articles was made through indexed journals, in the period of 2017-2022.

The characteristics of the curricular design of the master's program, the types of courses and their contents, in addition to the innovative contribution of each of them to the academic training of the master students, were taken into account.

Taking into consideration the experience of the faculty and the methodological work carried out, some actions were proposed that contribute directly to the strengthening of innovation capacities in the students of the master's degree in Biotechnology.

RESULTS

From the bibliographical review carried out in the present investigation, related to the development of innovation capacities from the postgraduate level, several elements were obtained:

- The first of them was aimed at deepening the concept of innovation and innovation capacities, given the importance that these have, as the central axis of the work.

- The second, was aimed at deepening how the issue of training innovation capabilities behaves within academic training in our country, specifically in the figure of the master's degree.

- The third of them was the analysis of the subject and future projections within the Master's Program in Biotechnology, taking advantage of the benefits offered by its curricular design.

In this regard, the results showed that the concept of innovation could imply various interpretations, which is why it is considered a broad concept, in which several authors have made contributions, such as:

- New or improved products, processes, new organizational forms, the assimilation and implementation of new technologies and much more (Díaz-Canel, 2021).

- Original, radical creation, which starts from previous knowledge and is distinguished from previous practices, resulting in a new product or process, which should not necessarily be used or applied for any useful purpose (Gómez, 2018).

- Practical or useful purpose that it reports to obtain or develop processes or products other than those established or used at present (Suárez, 2018).

- It is the introduction of a new, or significantly improved product (good or service), a process, a marketing method or a new organizational method, in the internal practices of the company, the organization of the place or external relations. (Oslo Manual, Organization for Economic Cooperation and Development [OECD], 2006).

Regarding the term innovation capacity, some authors have referred to several elements. Such is the case of Robledo (2017), who states that "innovation capabilities correspond to a particular set of organizational capabilities that contribute to the achievement of the organization's innovation objectives."

On the other hand, Morales & Díaz (2019) refer that innovation capabilities are a set of skills necessary to develop new technologies and execute them in practice. Within these capacities are the capacities of invention, innovation and improvement of existing technology.

In this sense, taking the postgraduate degree as a fundamental axis, and within this the master's programs, Cardoso & Cerecedo (2019) mention that an educational program is of quality as long as the training processes generate useful capacities, abilities and skills that allow them to graduates to design and implement innovative strategies to solve the problems of the labor sector.

In our work, the Master's Program in Biotechnology of the Universidad de Oriente

is analyzed, which has been training specialized professionals in the biotechnology sector for 26 years, especially in the eastern region.

The curricular model of said program, divided into two mentions: Industrial and Environmental, for a total of 60 credits, includes investigative training, with compulsory content courses that contribute a total of 33 credits (55%); the remaining 45% (27 credits) corresponds to the theoretical-methodological training part, with general compulsory, specific compulsory and optional contents (figure 1).

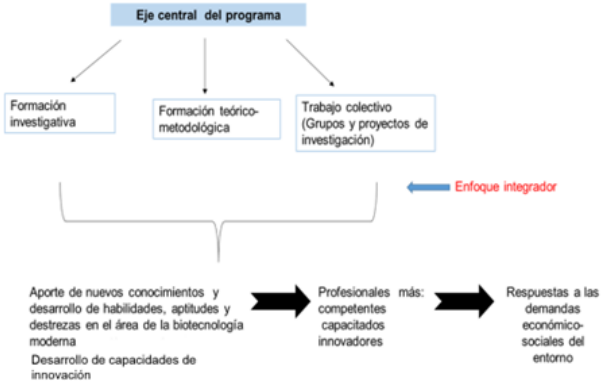

Fig. 1- Central axis of the Master's Program in Biotechnology

The theme of innovation is present in the courses; however, the formation of innovation capacities in students could still be further strengthened. In this regard, Table 1 shows several examples of the program courses in which this purpose could be achieved: Introduction to Biotechnology, Selection of Technologies, Enzyme Biotechnology, Food Biotechnology, among others.

Table 1- Some examples of the methodological treatment of the course contents of the Biotechnology Program

courses	General objectives	Contents/ treatment*
General compulsory		
Introduction to Biotechnology	Interpret the general conception of Biotechnology as a science, its development, fields of application and importance for its application in socioeconomic development.	• Different biotechnologies (Industrial. Agricultural, Environmental). Application examples and products obtained from biotechnologies. • Industrial and Intellectual Property. *Students carry out an analysis of different publications, to classify the type of biotechnology, type of processes, and others. *They also develop a seminar-workshop where the "Future and perspectives of biotechnologies" are addressed.
Research Methodology - Scientification	Know and deepen the theoretical-methodological tools necessary for the investigation and elaboration of scientific	• Stages of scientific research. • Methodology and Methods of Scientific Research. *Students must present,

	problems, which derive in an investigation. Master the theoretical foundations and carry out activities related to: bibliographic review and analysis, reports of research results achieved through reports and/or scientific articles.	in a seminar-workshop, the thesis draft.
Selection of Technologies	Contribute to the development of the ability to acquire knowledge and its domain, with a high degree of generalization, through the approach of tasks of a multidisciplinary nature and the search for information and the synthesis required for its use with professional rigor. Carry out, at a productive level, the design of industrial plants, based on an	• The projects and their solution strategy. *An analysis is carried out by the students for the valuation of an investment project in different sectors to which biotechnology is taxed.

	investment project that is required to be carried out and knowledge of a biotechnological process, using economic indicators for this and, in turn, based on the information collected in catalogues, books, magazines and the internet.	
Specific Required		
Fermentation biotechnology	Update and deepen the basic concepts and principles that govern fermentative processes and their link with industrial efficiency indicators, equipment, operations and scaling of this type of process, as a basis for the graduate to be able to develop research, design and select operating conditions and control in obtaining products of	• Fermentative process: integral elements and stages. • Microbial growth kinetics. *A workshop on Solid State Fermentation is held. Your applications. *The visit to a fermentation industry is also taken into account. *Students prepare and defend a project based on a "case study", related to obtaining a fermentation product.

	microbial origin.	
electives		
food biotechnology	Complement and deepen the different biotechnological processes of food for human and animal use.	• Food obtained from microorganisms. • Production of food and beverages by fermentation. *Students do an independent activity: Making my fermented food! *In addition, in a seminar-workshop, they analyze the production of food through biotechnology. *They also visit industries where food is obtained through biotechnology. *They must submit a project, where they propose the use of agro-industrial residuals derived from companies or institutions in the territory for the biotechnological preparation of food for human or animal consumption.
enzyme biotechnology	Update the student about the physicochemical and biochemical fundamentals that determine the particularities of enzymes as catalysts and that serve as the basis for their applications in industry, analysis and therapy, in the context of a comprehensive view of enzymes as product and starting point of biotechnological processes.	• Fields of application of enzymes. • Recent advances in enzyme technology. Future perspectives. New approaches to the discovery of new enzymes. New applications to old enzymes. *The master students carry out a development project for a product or process that involves the use of enzymatic technology.

On the other hand, the lines of research of the Master's Program also contribute directly to the strengthening of innovation capacities in students. Some of them are listed below:

1. Biological treatment of residuals

- Study of the anaerobic fermentation of waste (solid and liquid).

2. Biotechnology of higher fungi

- Culture of basidiomycetes (edible fungi), by solid fermentation from organic waste.
- Obtaining high added value products.
- Obtaining animal feed.
- Obtaining immunomodulators.

3. Obtaining biomass for animal feed, using unconventional culture media

4. Enzymatic and microbial technology

- Obtaining industrial enzymes by solid and submerged fermentation.

5. Bioleaching of minerals

6. Production of immunodiagnostics for environmental control

7. Agrobioproducts

8. Biofuels

***In vitro* culture of plants of economic interest**

These lines and research topics are reflected in the thesis topics. This paper refers to some examples of theses defended within the program in recent years:

- Evaluation of improvements in the formulation of the anti D hemiclassifier, from the concentrations of the active pharmaceutical ingredient.2021.
- Effect of three lignocellulosic agroindustrial substrates on the production of *Pleurotus ostreatus* and *Lentinula edodes* .2021.
- Biostimulant effects of *Brevibacillus* sp. B65 on the cultivation of *Vigna unguiculata* subsp. sesquipedalis. 2020.
- *Pleurotus sp* mushrooms in the cultivation of papaya and banana. 2020.
- Production of a bacterin to stimulate the immune system of shrimp postlarvae.2018.
- Feeding rabbits with diets that include the remaining substrate from the production of *Pleurotus sp.2018 mushrooms.*
- Proposal for a production process to obtain an anti-B.2017 blood classifying reagent.

DISCUSSION

In the concept of innovation, all the definitions agree that it is the creation of a new product or process, which is why it has an original character; however, in some cases, certain authors state that it should not be applied to have a useful purpose; others, for their part, do establish the need for its application and usefulness.

In our work, we believe that innovation must be a process or product that is created with applicability and utility.

Hence, public institutions and the state play an important role in creating a legislative framework and the necessary conditions for innovation to be possible. In addition, it is necessary to strengthen collaborative relationships between the business and scientific sectors for these purposes.

In our country, particularly, since the triumph of the Revolution, the government has always considered science as an essential element for the entire economic and social development of the country. In fact, starting in 2011, with the VI Congress of the Communist Party of Cuba (PCC), the process of updating its economic, political and social model began, defining a series of guidelines, including to innovation. On the other hand, since 1996 the Science, Technology and Innovation System (SCIT) was implemented and in recent times there is a whole Government Work System oriented towards Science and Innovation, which has increased the visibility of other fields sciences such as agricultural sciences,

engineering and technology, social and humanistic sciences, and natural and exact sciences.

Consequently, there have been several regulations that from the legal point of view support this entire government strategy; Such is the case of Decree-Law 7/2020 of the Science, Technology and Innovation System, with its corresponding regulation contained in Decree 40/2021. In article 2, subparagraph a, it is defined that the SCIT is aimed at "increasing the contribution of science, technology and innovation, to economic, social and environmental development, through the integration between its components and the requirements of society ".

There are other regulations to highlight are Agreement 156/2021, in which the creation of the National Innovation Council was approved, published in the official gazette.

In Cuba, Higher Education has qualified human potential and knowledge institutions that make notable contributions in education, training and in the generation, dissemination and use of knowledge; in addition to having an important weight in innovation (León *et al.*, 2021).

However, it is still recommended to strengthen this innovation not only on scientific bases, but also in master's degrees, doctorates, publications and awards from the Cuban Academy of Sciences (Díaz Canel & García, 2020). In addition, the registration of patents and scientific publications can be incorporated in books or indexed journals.

One of the most important processes within Higher Education is academic training, which includes the postgraduate specialty, the master's degree and the doctorate, whose fundamental objective is aimed at postgraduate education with high professional competence and advanced capacities for the specialized professional performance, research, development, innovation and artistic creation, which is recognized with an academic title or a scientific degree (Ministry of Higher Education, 2019).

Particularly, within Higher Education, the postgraduate course should not be seen only as a training process itself, but as implicit in other important elements such as research, innovation, artistic creation, among others (Bernaza et al*.,* 2020).

The master's degree, in this sense, provides university graduates with a broad and advanced scientific culture in a certain area of knowledge, as well as greater capacity and development for teaching, administrative, research, development and innovation, artistic creation or other activities related to professional performance, in correspondence with the needs of production and services, and the economic, social, scientific, technological and cultural development of the country (Postgraduate Regulation 140/19, article 41).

Some researchers such as Moré (2019), in the Cuban context, have generated models for the management of innovation capacities from postgraduate training. Said model, applied in the Human Capital Training and Development Management specialty, was based on the project approach, which was supported by various methods and integrated various processes, resulting in the design and execution of projects by students, in their entities of origin, with satisfactory results.

In the case of the Master's Program in Biotechnology, its curricular design offers potential to socialize how to strengthen innovation capacities in master students.

In general, the program is centered on scientific research, supported by projects

and research lines that contribute to the sectors and strategic axes of the country; Therefore, the thesis, as a form of culmination, constitutes an important unifying element for the training process of the graduate.

How, then, are innovative capacities promoted from the curriculum in the students of the Master's Program in Biotechnology?

For several years, and particularly more recently, the increase in inter and multidisciplinary relationships between the contents of the different courses has been intentionally promoted.

For this, the different types of classes, the research and teaching experience of the faculty, as well as the collaborative relationships with the different institutions and companies of the territory are used.

In the development of innovative capacities, it is taken into account, especially the needs demanded by the institutions, companies and organizations from which the students come.

In this sense, an insufficient degree of interconnection between academia and Science, Technology and Innovation entities with the productive, goods and services sectors of the different territories is still observed in our country (Díaz-Canel, 2021). What it is about then is precisely to promote innovation capacities from the academic training itself.

In particular, the master's program has an impact above all in the eastern territory, where there are various institutions and companies that pay taxes to the biotechnology sector, so an academic training, impregnated with the development of innovative capacity in professionals belonging to this sector, will have an impact directly in the local development of the territories where these entities are located.

In addition to the courses that are part of the program's curricular design, the use of Information Technology and Communications (ICT) is promoted for the search and processing of scientific-technical information, as well as the communication itself between teachers, tutors and students. On the other hand, as part of the continuous improvement of said program, the design of some of the courses in the distance modality has been included, an issue that is of interest, since progress is made within the concept of Education 4.0.

From the industrial point of view, biotechnology has applications in important areas such as health, agriculture, environmental care, among others. The biotechnology industry, due to its characteristics, implies strong research, which generates inventions that are brought to the market.

In Cuba, the biotechnology industry is represented by several entities, with significant results. This is supported by the presence of a highly qualified staff, and a portfolio of high quality and effective products, which are exported worldwide.

Within the theme of biotechnology there are important issues to take into account, which do not escape the intentions of training or preparation that the master's program offers to all professionals interested in this field. For example, one of these aspects is related to the issue of intellectual property, patent applications and the protection of innovations.

On the other hand, the insertion of the processes and technologies generated from biotechnology into the digital transformation, visualized in what is known as Industry 4.0, should not be lost sight of.

It is necessary to highlight that, in addition to all the work that is carried out from the teaching-learning process itself by the faculty, the possibility of increasing activities that promote innovative thinking in students is not ruled out, such is the case of carrying out of visits and practical activities in industries or production centers of the territory, the delivery in seminars-workshops with such purposes, use of ICT in certain biotechnological processes that require it.

It is also proposed to design evaluation instruments that allow measuring the development of innovation capacities in graduates of the program and their employers. This element can be incorporated into the impacts generated by the program, which is why adequate indicators are required for its implementation.

In addition, methodological activities could be carried out such as: seminars, methodological classes, in which the contributions of each course to these topics and the teaching methods through which they work are specified, always favoring interdisciplinary integration.

It can be concluded that the curricular design of the Master's in Biotechnology provides an adequate scenario for strengthening innovation capacities in students who enter its program. The articulation of teaching methods, the carrying out of investigative activities, with innovative outlets, the methodological work, as well as the proposal of evaluation instruments of the innovation capacities in graduates and employers, will contribute to the continuous improvement of the teaching of Biotechnology in postgraduate, to give a much more effective response to the economic and social demand of the territory and the country.

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