

Original article

Management of the scientific reserve at the Center for Industrial Biotechnology. Training of the scientific leader



Gestión de la reserva científica en el Centro de Biotecnología Industrial. Formación del líder científico

Gestão da reserva científica no Centro de Biotecnologia Industrial. Formação do líder científico

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ABSTRACT

In recent years, a trend of diminishing human potential dedicated to scientific activity has been observed in research centers, science, technology and innovation institutions and universities. This situation shows the need for a management strategy that ensures the continuity and sustainability of scientific research and technological development demanded by the country. The objective is to the socialization of experience accumulated in the management of the scientific reserve at the Industrial Biotechnology Center, with the purpose of promoting the renewal of human potential linked to scientific activity and contributing to the training of scientific leaders. The methods used are of an

empirical and theoretical nature, inherent in scientific research, allowing an open analysis of the management process. This process is structured in well-defined stages, beginning with the recruitment of talents and culminating in the training of scientific leaders. The results show that the students who participated in the Biotechnology student scientific group will subsequently be inserted in research activities, highlighting their professional and academic development. In addition, we have identified scientific leaders who stand out for their scientific production, reconnaissance and contribution to the advancement of knowledge. The management strategy of the scientific reserve of the Industrial Biotechnology Center has contributed to the sustainability of its scientific potential and to the formation of leaders recognized for their non-collective performance, in the academic community and in the national and international scientific fields.

Keywords: biotechnology; students; scientific leader; project; scientific reserve.

RESUMEN

En los últimos años se ha observado una tendencia a la disminución del potencial humano dedicado a la actividad científica en centros de investigación, entidades de ciencia, tecnología e innovación y universidades. Esta situación hace necesaria la implementación de una estrategia de gestión que garantice la continuidad y sostenibilidad de la actividad científica y el desarrollo tecnológico que requiere el país. El objetivo estuvo dirigido a socializar la experiencia acumulada en la gestión de la reserva científica en el Centro de Biotecnología Industrial, con el propósito de favorecer la renovación del potencial humano vinculado a la actividad científica y contribuir a la formación de líderes en este ámbito. Los métodos utilizados fueron tanto empíricos como teóricos, propios de la investigación científica, lo que permitió un análisis integral del proceso de gestión. Dicha gestión se estructura en varias etapas claramente definidas, que inician con la captación de talento y culminan con la formación de líderes científicos. Los resultados evidencian que los estudiantes que han formado parte del grupo científico estudiantil en Biotecnología han logrado incorporarse posteriormente a la actividad investigativa, destacándose en su desarrollo profesional y académico. Asimismo, se identifican líderes científicos que sobresalen por su producción científica, reconocimiento y contribución al avance del conocimiento. La estrategia de gestión de la reserva científica del Centro de Biotecnología Industrial ha favorecido la sostenibilidad de su potencial científico y ha contribuido a la formación de líderes que se distinguen por su desempeño dentro del colectivo, en el ámbito científico, tanto nacional como internacional.

Palabras clave: biotecnología; estudiantes; líder científico; proyecto; reserva científica.

RESUMO

Nos últimos anos, tem-se observado uma tendência de diminuição do potencial humano dedicado à atividade científica em centros de pesquisa, instituições de ciência, tecnologia e inovação e universidades. Essa situação evidencia a necessidade de uma estratégia de gestão que assegure a continuidade e a sustentabilidade das pesquisas científicas e do desenvolvimento tecnológico demandado pelo país. O objetivo esteve voltado à socialização da experiência acumulada na gestão da reserva científica no Centro de Biotecnologia Industrial, com o propósito de favorecer a renovação do potencial humano vinculado à atividade científica e contribuir para a formação de líderes científicos. Os métodos utilizados foram de natureza empírica e teórica, próprios da pesquisa científica, permitindo uma análise abrangente do processo de gestão. Esse processo está estruturado em etapas bem definidas, iniciando-se com a captação de talentos e culminando na formação de líderes científicos. Os resultados evidenciam que os estudantes que participaram do grupo científico estudantil de Biotecnologia conseguiram se inserir posteriormente na atividade de pesquisa, destacando-se em seu desenvolvimento profissional e acadêmico. Além disso, foram identificados líderes científicos que se sobressaem por sua produção científica, reconhecimento e contribuição ao avanço do conhecimento. A estratégia de gestão da reserva científica do Centro de Biotecnologia Industrial tem contribuído para a sustentabilidade do seu potencial científico e para a formação de líderes reconhecidos por seu desempenho no coletivo, na comunidade acadêmica e nos âmbitos científico nacional e internacional.

Palavras-chave: biotecnologia; estudantes; líder científico; projeto; reserva científica.

INTRODUCTION

The mandate given to science as a fundamental pillar for the development and socioeconomic transformation of the Cuban social project is a unique feature of the Revolution. On January 15, 1960, Fidel Castro declared that Cuba's future had to be one of "men and women of science," and three decades later, he stated that "independence depends on development, technology, and science." National sovereignty and science, technology, and innovation (STI) are interconnected

processes. The country's major scientific milestones over the last 35 years are sufficient to demonstrate the enduring relevance of these ideas.

The preeminence of education and scientific research as instruments for improving the quality of life of the population led to the beginning of an accelerated process of growth and progression of human potential. The Literacy Campaign became the first action. Subsequently, the University Reform of 1962 gave way to a process of transformation aimed at achieving the link between university and society and the implementation of a scientific teaching system geared towards the comprehensive training of professionals and the population in general (Laurencio Leyva & García Hernández, 2018).

Accepting the social responsibility of science implies growth in human potential and infrastructure. Nurturing talent in new generations and training highly competent young researchers are a current necessity and priority for the country's development, given that Cuba's sovereign integration into the global economy can only be achieved through science, technology, and innovation (Torres *et al.*, 2023). Defining human potential, science, technology, and innovation as a strategic axis confirms that the determining variable in science, technology, and innovation (STI) is human potential.

Over the past ten years, the human potential involved in scientific activity at research centers, science, technology, and innovation (STI) entities, and universities has shown a declining trend. The most frequent causes are: a decrease in the number of scientifically categorized personnel, insufficient replacement of leaders and specialists, a growing exodus of qualified young talent, insufficient attention to scientific categorization in universities (Zamora Rodríguez, 2022), and a slowdown in scientific and postgraduate training (Torres Valdespino *et al.*, 2023), often resulting from a lack of awareness or inadequate implementation of the third component of the continuing education model.

Science, technology, and innovation (STI) entities have as their core activities scientific research, innovation, scientific and technological services, and specialized production with added value. They are classified as research centers when their fundamental mission is scientific research and innovation. STI entities can incorporate university graduates for their training as researchers using the Scientific Reserve (CR) category. Therefore, they must have a strategy that ensures the CR necessary for the sustainability of research and innovation (Rodríguez and Núñez, 2021).

University graduates constitute the social group that possesses significant human capital because their academic and educational trajectory is the longest and most heavily invested. The Science and

Technology Reserve (STR) is the human potential that allows for the natural replacement of personnel directly linked to the country's scientific, technological, economic, and social development (Roque *et al.*, 2015). It is built upon the identification, selection, and preparation of a pool of daytime university students with potential for performance in STI (Science, Technology, and Innovation) activities. These students can be recruited directly by the STI entity or assigned to it during the job placement process. In either case, the STI entity guides their training and comprehensive development.

The Center for Industrial Biotechnology (CEBI), awarded the Carlos J. Finlay Order (2022), is transitioning from a research center to a science, technology, and innovation (STI) entity due to its upward scientific development. Since its creation in 1992, it has prioritized investment in its human potential as a key strategy for scientific recognition, visibility, and growth, ensuring that its personnel are equipped with the skills and competencies necessary for teaching and research leadership. To ensure sustainability, renew scientific potential, and fulfill its mission, a strategy for managing the STI entity's scientific pool has been established, which also contributes to the training of its scientific leaders. The objective of this work is to present over 20 years of experience in managing CEBI's scientific pool to support the replacement of human potential linked to STI and the training of scientific leaders within the STI entity. The impact of scientific leadership on science indicators and the role of the student scientific group (GCE) are also discussed.

MATERIALS AND METHODS

Empirical and theoretical methods were employed to gain a comprehensive understanding of the scientific reserve management process. The empirical methods included systematic observation and semi-structured group interviews, conducted with 15 members of the Scientific Reserve (SR), 10 researchers, and 6 science leaders from CEBI. These techniques facilitated the collection of direct information on experiences, perceptions, and dynamics related to the training, development, and performance of scientific potential within the institution. The group interviews were designed to be flexible, allowing for in-depth exploration of aspects such as motivation, guidance received, opportunities for involvement in projects, and the main limitations encountered in the transition to research. Observation, in turn, helped identify behaviors, levels of participation, interaction among stakeholders, and organizational practices in the spaces where the scientific reserve operates.

Regarding theoretical methods, the historical-logical, analytical-synthetic, and inductive-deductive approaches were employed. The historical-logical method allowed for the examination of the

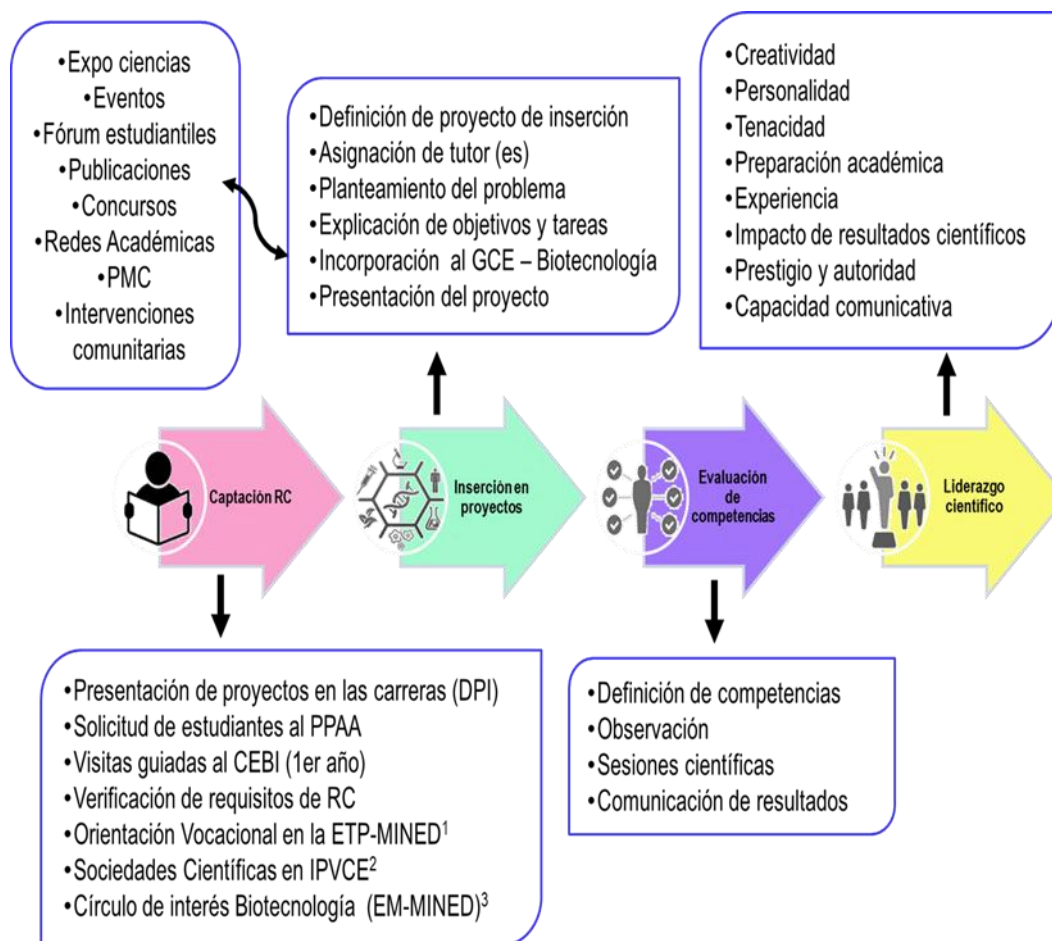
evolution of work with the scientific reserve and its correspondence with institutional transformations and national policies in science, technology, and innovation. The analytical-synthetic study enabled the processing and integration of information from diverse sources, while the inductive-deductive method facilitated the development of inferences and generalizations from the data obtained.

Document review was an essential component of the study. Regulatory documents related to working with the scientific reserve, the operation of science, technology, and innovation (STI) entities, and the CEBI strategic project's progress report for the period 2014-2024 were analyzed. In addition, self-evaluation reports and opinions issued by the National Accreditation Board (JAN) in the external evaluation processes of the Master's and Doctoral programs in Biotechnology were reviewed.

In addition, the CEBI self-assessment forms submitted to the Ministry of Higher Education (MES) and the Ministry of Science, Technology and Environment (CITMA) were considered, allowing for a comparison of institutional information with the requirements of the governing bodies. The analysis was enriched by the perspectives of directors from the University of Oriente (UO), specialists from the CITMA territorial delegation in Santiago de Cuba, and heads of science, technology, and innovation (STI) programs in which CEBI participates with its experts. These contributions helped to contextualize the results and validate the interpretations made. The reviewed documents belong to the archives of the Directorate of Organization, Planning, Evaluation, and Quality of the University of Oriente (DOPEC-UO) and the CEBI General Directorate, ensuring access to official, up-to-date, and relevant information for the research.

RESULTS

The mission and vision of CEBI specifies: ... "the training of specialized human resources" ... as an essential condition of quality to contribute to the development of the UO with relevance and impact; promoting technical and inclusive preparation for all workers, with emphasis on young people as a seedbed and source of the entity's scientific leaders, as shown in figure 1.

**Figure 1.** Management model of the CEBI scientific reserve

Legend: DPI, Main Integrative Discipline; ETP, Technical-Professional Education; IPVCE, Pre-University Vocational Institute of Exact Sciences; EM, Secondary Education; GCE, Student Scientific Group

General characterization of each stage of management of the Scientific Reserve (SR)

Scientific Reserve acquisition stage

Universities play a crucial role in providing and training human potential in science. Therefore, the process of recruiting students for the research pool is carried out directly by the leading scientists at CEBI, in coordination with the senior lecturer for each academic year. Selected students must meet the requirements established in CITMA Resolution R-4/2019. The CEBI research pool primarily includes second- and third-year students from the natural and exact sciences (Chemistry, Biology,

and Pharmacy) and technical fields (Chemical and Industrial Engineering), as these are the most aligned with the center's mission. To a lesser extent, students from the social sciences and humanities (Economics and Sociology) are also selected.

During the recruitment process for the Research Center (RC), students drawn to research and who envision a professional career in a scientific institution are brought together. Since the number of students to be selected is not fixed, all students who wish to join the Center are accepted. Priority is given to prospective graduates with top honors and candidates for the Scientific Merit Award (PMC). However, if a student does not meet the academic index requirement, their case is evaluated individually, and other aspects such as interest and dedication are considered. Vocational guidance in Technical and Vocational Education (TVE) facilitates the integration of technical personnel who work directly in the laboratories to carry out research projects and maintain the scientific hierarchy.

The Biotechnology interest group (Figure 2a) fosters motivation for the basic sciences that are strongly linked to Biotechnology as a scientific discipline (Chemistry, Biology, Microbiology). Currently, efforts are underway to incorporate mathematicians, cyberneticists, and computer scientists into the scientific pool. All recruited students join the Biotechnology Student Scientific Group (Figure 2b).

In the 2024-2025 academic year, CEBI, under the framework agreement between the Center for Molecular Immunology (CIM) of the BioCubaFarma business group and the University of Oriente, experimented with a different approach to recruiting researchers. The CIM's demand for research projects enabled the participation of second- and third-year students from the Chemistry, Biology, and Chemical Engineering programs in a training modality. This training provided them with intellectual preparation in cell culture techniques, cancer immunology, and immunochemistry. The evaluation of this training corresponded to the grade in the main integrative discipline (DPI) course for the academic year in which each student was enrolled. This entirely novel experience was designed as a research process; that is, teaching research skills through the transmission of theoretical and practical knowledge, based on the principle that "by researching, one learns to research," through discovery, reproduction, and repetition.



Figure 2. Images of scientific activities: (a) Biotechnology Interest Circle, (b) Biotechnology Student Scientific Group

Upon completion of the training, the students highlighted the following positive aspects: shared knowledge, responsibility, dedication, and integration into a nationally and internationally recognized research center. 83% of the students (5) found the knowledge gained through research, particularly within a project that provided remuneration, to be valuable. Another positive aspect was the integration of work and study. The length of stay at the CIM was the only negative factor, cited by 100% of the students.

The experience gained from this scientific talent recruitment training program allowed four students (66%) to remain in the experiment and for other disciplines to be included in the next phase. The

reason for leaving the experiment, as determined in the group interview, is related to visualizing oneself as a professional in a research center.

Integration phase in CEBI research projects

The possibility of solving problems through a research project with an interdisciplinary approach facilitates research training, since assimilating and enriching scientific knowledge with increasing levels of depth allows preparing the future scientist to achieve objectives of greater scope and the fulfillment of more transcendental tasks (González *et al.*, 2022)

This second stage is a learning phase, where the student is assigned a problem by their tutor, who is also responsible for the outcome. The problem is an objective, or part of one, of an ongoing project. The students selected are assigned to the various research projects being developed at CEBI. Student placement in projects takes into account their motivation for the topic, the need for specialists in their field of study, and their level of rapport with the tutor. The project ensures that the student can develop their research until graduation and, whenever possible, pursue postgraduate studies leading to a scientific degree.

Stage of evaluation of research skills

This stage becomes more evident after the young person joins the STI entity as a worker in the Trainee/RC qualification; however, some competencies may be apparent from the previous stage. Young people who arrive at CEBI from other institutions, without prior affiliation with the STI entity, also participate at this stage (Figure 1).

Competence is the satisfactory behavior that arises from a specific task. Therefore, the researcher must possess sufficient knowledge to solve problems effectively and with various solutions. It develops within a specific situation or context; thus, the biotechnologist must be able to construct, deconstruct, and reconstruct learning methods and knowledge itself in a creative and positive manner, think of effective counter-projects, and demonstrate proficiency in communicating and implementing them.

The processing of documentary information revealed that 68 students have participated in the GCE Biotechnology program as part of the scientific reserve; of these, four were international students and 13 came from Technical and Vocational Education (TVE). 31% (21 students) of the reserve joined

CEBI as researchers upon completing their undergraduate studies. 81% achieved a doctoral degree, and 52% of those with doctorates currently remain at the STI institution.

The data also showed that 45.4% of students who completed the multi-award-winning GCE Biotechnology program graduated with a Gold Diploma and received Scientific Merit Awards (PMC) for their achievements. 21% of students are recognized as authors of national ACC awards, along with their advisors, and 25% received some type of award at university or national student forums. Notably, 60% of the ETP students who completed their internships at CEBI joined the STI entity after graduation and are currently advancing their careers.

The leading scientists interviewed agreed that the scientific training within the Biotechnology GCE helped them grow and develop as researchers. They unanimously concurred that the GCE is a research incubator where students learn, interpret, and modify their social and cultural environment as they develop as researchers through the production of scientific knowledge. There is a consensus that further work is needed on the social appropriation of this knowledge; therefore, the work with interest groups, science fairs, and community outreach programs is constantly being refined to make them more socially participatory. The ultimate goal is to train well-rounded researchers: scientists, revolutionaries, and cultured individuals capable of meeting the demands of an increasingly discerning society on the path to prosperous and sustainable development.

The review and processing of the data obtained from the interviews with leaders and RCs identified the research competencies most evident in CEBI (Figure 3). Working in teams, presenting and publishing results, and establishing, selecting, and developing techniques and procedures were the most highly valued competencies.

Stage of scientific leadership

A scientific leader is a researcher with innate and acquired personal qualities (Figure 1) to motivate, unite, and guide other researchers in pursuing socially relevant projects with innovative contributions. Academic and research training, a broad cultural background, and the effective management of research projects, as well as the achievement of relevant scientific results in their field of knowledge, are acquired qualities of scientific leadership. Researchers who met five or more indicators were identified (Figure 1). Six scientific leaders from the natural sciences were identified (two with degrees in Biochemistry and four with degrees in Chemistry).

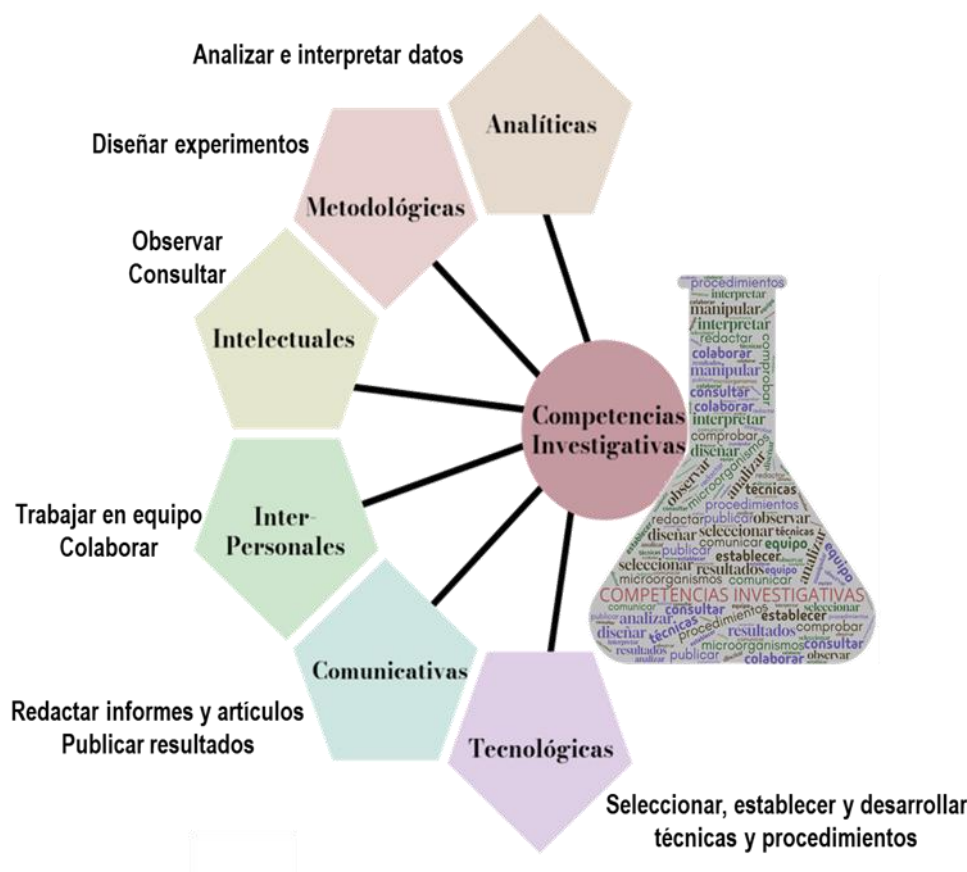


Figure 3. Research skills demonstrated by researchers at the CTI CEBI entity

A review of the curriculum vitae in the self-evaluation file of the Biotechnology PhD program, along with academic networks, corroborated the visibility of publications, citations, and recognition for scientific activity. Group interviews were conducted with the leaders, supplemented by some individual written responses. This procedure allowed for an assessment of their self-recognition of scientific leadership. The results are as follows:

General information

- Graduates with Gold Degree (3)
- Scientific degree of Doctor in a specific area of knowledge: Biological Sciences (3), Chemical Sciences (2), Technical Sciences (1)
- Teaching categorization: Full Professors (6)
- Scientific category: Senior Researcher (2), Assistant Researcher (1)

From the group interview

- They are recognized for the impact of their scientific results
- They lead research projects and are experts in science, technology and innovation (STI) programs due to their results and specialization.
- Management charts as a result of their leadership (5)
- They come from the RC (3)
- Student leaders (3)
- They recognize themselves as scientific leaders and consciously embrace it.
- Successful and recognized performance as teachers
- Communicative competence with influence on students
- Effective link between scientific activity and teaching
- They are distinguished by the introduction of scientific results into teaching content (3)
- Professional motivation towards research
- Tenacity to simultaneously manage administrative direction with scientific direction (6)
- Recognition of scientific leadership among them (6)

The instrument itself revealed that at least one scientific leader identified another within the STI entity, and at least one was recognized by another, demonstrating consolidated scientific leadership at CEBI. This recognition of leadership led to the inclusion of two researchers whose authority and prestige within the group were acknowledged by 50% of those interviewed, despite not meeting the established number of indicators.

The leaders acknowledged that the main challenge is ensuring that the knowledge generated during project development is disseminated simply and directly to society, the primary beneficiary of scientific results. They agreed that there is no single model or specific leader because each one has their own unique style and approach.

Through interviews and internet searches (Google Scholar, Research Gate, LinkedIn) of scientometric indicators: scientific publications, citations, H-index, national awards from the Cuban Academy of Sciences (ACC), and recognitions for scientific activity and participation in events, the numerical data in table 1 were recorded. The identity of the leaders was protected using a code of numbers and letters.

Table 1. Impact indicators of CEBI scientific leaders

Leader	Publications	Citations (H-index)	ACC Awards	Awards
AI *	255	286/-	4 (co-author)	>100
II-B	165	2006/24	6 (2 co-authors)	>100
III-C	75	2756/16	2	>60
IV-D	75	1256/17	1	>40
V -E	57	427/12	-	>20
VI-F	49	462/11	-	>20
VII-G	39	179/6	2 (1 co-author)	>50
VIII-H	35	288/8	2 (co-author)	>30

* Does not have a profile on academic networks

The presence of the indicators is evident in most of the leaders, with emphasis on publications, citations and recognitions in four of them, which confirms their outstanding performance as researchers.

DISCUSSION

The management of the scientific reserve at the Center for Industrial Biotechnology (CEBI) is systematically linked to the development of human potential, integrating both the scientific and technical reserves into a coherent institutional strategy. This integration is key, since the technical reserve, once incorporated, is strengthened through the same training mechanisms that support the scientific reserve, thus guaranteeing functional and academic continuity within the institution. In this sense, the management of the scientific reserve is not an isolated process, but rather part of the overall human resource development strategy of science, technology, and innovation (STI) entities (Abalos Rodríguez *et al.*, 2024).

The model implemented at CEBI is structured in clearly defined stages, ranging from early student recruitment to the consolidation of scientific leaders. This progressive approach fosters a process of scientific socialization in which students gradually integrate into real-world research dynamics. The conception of the process as a "beginner-to-beginner" system allows each member to assume specific

roles according to their level of development, which aligns with contemporary approaches to research training based on active and contextualized participation (Humanez Martínez, 2023; Brew, 2010).

Young researchers who make up the scientific reserve are an essential component for the sustainability of research projects. Their training depends largely on the existence of a solid pool of talent that guarantees the generational renewal of scientific knowledge. This succession process not only ensures the continuity of research lines but also fosters their evolution through the incorporation of new perspectives and approaches. In this context, CEBI's strategy has proven effective in sustaining the institution's scientific potential by training leaders who achieve recognition both nationally and internationally.

Scientific leadership, as evidenced in this study, does not emerge spontaneously nor is it limited to formal appointments, but rather it is the result of an intentional process of identification, training, and competency development. Early identification of potential leaders and their systematic support are key elements in this process (Piñón González, 2020; Pareja *et al.*, 2022). The CEBI scientific leaders who participated in the research, with more than two decades of experience, demonstrate the effectiveness of this model, having previously worked in the scientific reserve, which reinforces the validity of the internal training approach.

The evaluation of research skills acquired by young people during their time in the student research group (SRG) allows for defining their position within science, technology, and innovation (STI) entities. This evaluation process combines observation of performance by mentors and research leaders with an assessment of their participation in scientific sessions, ensuring a comprehensive evaluation of their abilities. In this regard, postgraduate training plays a fundamental role, providing theoretical and methodological tools that enhance scientific development.

In particular, the master's and doctoral programs in Biotechnology coordinated by CEBI contribute significantly to the development of advanced research skills. The master's program fosters specialization, critical thinking, and integration into professional networks (Beltrán Delgado *et al.*, 2023), while the doctoral program promotes scientific autonomy, leadership, the ability to solve complex problems, and strategic vision. These results are consistent with international studies that highlight the role of postgraduate studies in training researchers capable of leading innovation processes (Lee *et al.*, 2020).

Scientific leadership is based on a set of indicators that include personality, prestige, authority, and communication skills (Torres *et al.*, 2013). These elements, considered invariant, are complemented by the development of research competencies, which form the basis for generating new knowledge. In the field of biotechnology, these competencies encompass intellectual, methodological, analytical, communicative, technological, and interpersonal dimensions (Larpin *et al.*, 2023; Navas, 2025), highlighting the need for comprehensive training.

Project-based learning, implemented at the GCE, is positioned as an effective pedagogical strategy for developing these competencies. This approach allows students to learn by doing, integrating knowledge into real-world contexts and actively contributing to the solution of scientific problems (Humanez Martínez, 2023). It also fosters the production and dissemination of knowledge, as well as participation in scientific events, publications, and spaces for academic recognition.

The research training approach based on the active participation of students in real-world research contexts aligns with proposals that highlight the need to transform traditional academic practices toward more integrative models. In this sense, participation in research communities fosters not only the acquisition of knowledge but also the development of a scientific identity, a key element in the training of researchers.

Contemporary doctoral training is conceived as a process that transcends the acquisition of specialized knowledge, incorporating the development of transferable skills, leadership, and innovation capacity. This approach is consistent with the results observed at CEBI, where postgraduate programs contribute significantly to preparing researchers capable of addressing complex scientific challenges and leading processes of change.

The development of human capital in the scientific field is a strategic process that requires collaboration among academic institutions, research centers, and productive sectors. In this sense, CEBI's experience aligns with contemporary approaches that highlight the importance of inter-institutional collaboration for solving complex scientific problems and developing advanced professional competencies. González *et al.* (2022) emphasize that developing human capital through real-world industry problems fosters the integration of theory and practice, an aspect reflected in the dynamics of the student research group. Similarly, the development of research competencies, understood as a contextualized and progressive process, strengthens students' ability to face real

scientific challenges, as Navas (2025) argues, emphasizing the need for training situated within the specific conditions of higher education.

Furthermore, the consolidation of scientific leadership at CEBI is based on intentional training and mentoring processes, in accordance with transformational leadership approaches in the university setting. Pareja *et al.* (2022) emphasize that effective leadership in higher education institutions is built upon the interaction between the development of personal competencies, academic influence, and the ability to guide collective research processes. This approach is complemented by the articulation of the science, technology, and innovation system as a driver of economic and social development, as noted by Rodríguez and Núñez (2021), which reinforces the relevance of institutional strategies such as CEBI's. Likewise, experiences such as the redesign of training programs for scientific reserves demonstrate the need for flexible and systematic structures to guarantee the sustainability of scientific potential (Roque *et al.*, 2015).

The multidisciplinary nature of biotechnology fosters the development of diverse skills and facilitates the achievement of indicators for scientific activity and postgraduate training. In this regard, CEBI's experience confirms that strategic management of the scientific pool, linked to coherent training and evaluation processes, is an effective way to guarantee the sustainability of scientific potential and the development of leaders in the fields of science, technology, and innovation.

The management of the scientific reserve at CEBI is a strategic and comprehensive process that links the development of human potential with the needs of institutional scientific sustainability. Its structured, phased approach, from recruitment to leadership training, has proven effective in ensuring the continuity and development of research activity.

Implementing a model based on the early integration of students into research projects, project-based learning, and systematic mentoring by tutors and scientific leaders fosters the progressive development of research skills. This process is strengthened by postgraduate training, which consolidates advanced skills and promotes autonomy and scientific leadership.

Consequently, CEBI's strategy not only ensures the generational renewal of knowledge but also contributes to the development of scientific leaders recognized at various levels. This model serves as a valuable reference for other institutions seeking to strengthen their scientific potential and guarantee the sustainability of their research and innovation processes.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.



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