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*Scientific articles*

## **Reconfiguración de la Internacionalización en Programas de Posgrado de la Universidad de Sonora (2018-2022)**

***Reconfiguration of internationalization of graduate programs at the University of Sonora (2018-2022)***

***Reconfiguração da Internacionalização nos Programas de Pós-Graduação da Universidade de Sonora (2018-2022)***

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### **Resumen**

Este estudio analiza los desafíos que enfrentan los programas de posgrado en la Universidad de Sonora (Unison), en Ciencias Físicas y Ciencias de Materiales, debido a transiciones políticas, económicas y a la pandemia del COVID-19. La investigación buscó responder: ¿Cómo han enfrentado los programas de posgrado en la Unison los retos de la internacionalización impuestos por las transiciones políticas, económicas y la pandemia? Al entender la internacionalización como un proceso de integración de una dimensión internacional e intercultural en la enseñanza y la investigación, se utilizó una metodología cualitativa que se basó en entrevistas en profundidad con coordinadores e integrantes de los posgrados, un análisis documental, así como una revisión de literatura para evaluar el estado de la internacionalización en estos programas. La información recopilada fue transcrita y codificada para su revisión y los resultados mostraron una disminución significativa en la

movilidad estudiantil y la participación en eventos internacionales, afectadas por la crisis sanitaria y la reducción del financiamiento. La dependencia de fondos públicos limitó la capacidad de adaptación de los programas, lo que afectó negativamente en su productividad e innovación. Aunque se han implementado estrategias de adaptación, como el establecimiento y fortalecimiento de colaboraciones internacionales y seminarios virtuales, estas estrategias han sido respuestas reactivas a las condiciones externas, más que a iniciativas planificadas con anticipación. Para mejorar la resiliencia y competitividad de estos programas, es fundamental un enfoque integral que priorice la diversificación del financiamiento, la renovación de la planta docente y el fortalecimiento de redes de colaboración internacional.

**Palabras clave:** ciencia y tecnología, estrategias, flexibilidad, internacionalización y posgrado.

### **Abstract**

This study analyzes the challenges faced by graduate programs at the University of Sonora (Unison) in the fields of Physical Sciences and Materials Sciences, due to political and economic transitions as well as the COVID-19 pandemic. The research aimed to answer the following question: How have the graduate programs at Unison addressed the challenges of internationalization imposed by political, economic transitions, and the pandemic? Understanding internationalization as a process of integrating an international and intercultural dimension into teaching and research, a qualitative methodology was employed, based on in-depth interviews with program coordinators and participants, document analysis, and a literature review to assess the state of internationalization in these programs. The collected data was transcribed and coded for analysis, and the results revealed a significant decline in student mobility and participation in international events, affected by the health crisis and reduced funding. The dependence on public funds limited the programs' ability to adapt, negatively impacting their productivity and innovation. Although adaptation strategies have been implemented, such as the establishment and strengthening of international collaborations and virtual seminars, these strategies have been reactive responses to external conditions rather than planned initiatives. To enhance the resilience and competitiveness of these programs, an integrated approach is essential, prioritizing funding diversification, faculty renewal, and the strengthening of international collaboration networks.

**Keywords:** science and technology, strategies, flexibility, internationalization and graduate programs.

## Resumo

Este estudo analisa os desafios enfrentados pelos programas de pós-graduação da Universidade de Sonora (Unison), em Ciências Físicas e Ciências dos Materiais, devido às transições políticas e econômicas e à pandemia de COVID-19. A pesquisa procurou responder: Como os programas de pós-graduação da Unison têm enfrentado os desafios da internacionalização impostos pelas transições políticas e econômicas e pela pandemia? Ao compreender a internacionalização como um processo de integração de uma dimensão internacional e intercultural no ensino e na investigação, utilizou-se uma metodologia qualitativa que se baseou em entrevistas em profundidade com coordenadores e membros dos cursos de pós-graduação, numa análise documental, bem como numa revisão de literatura para avaliar o estado da internacionalização nesses programas. As informações coletadas foram transcritas e codificadas para revisão e os resultados mostraram uma diminuição significativa na mobilidade estudantil e na participação em eventos internacionais, afetados pela crise sanitária e redução de financiamento. A dependência de fundos públicos limitou a capacidade de adaptação dos programas, o que afetou negativamente a sua produtividade e inovação. Embora tenham sido implementadas estratégias de adaptação, tais como o estabelecimento e o reforço de colaborações internacionais e seminários virtuais, estas estratégias têm sido respostas reativas às condições externas, em vez de iniciativas pré-planeadas. Para melhorar a resiliência e a competitividade destes programas, é essencial uma abordagem abrangente que priorize a diversificação do financiamento, a renovação do corpo docente e o fortalecimento das redes de colaboração internacionais.

**Palavras-chave:** ciência e tecnologia, estratégias, flexibilidade, internacionalização e pós-graduação.

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## Introduction

The internationalization of higher education, understood as the integration of an international dimension into the substantive functions of universities (teaching, research, and social engagement), has been consolidated as a fundamental strategic dimension in the academic sector. It is also recognized as a complex process of adaptation to global transformations, political shifts, and structural inequalities. This evolving process requires not only institutional adjustments but also the development of long-term sustainable strategies that enable higher education institutions (HEIs) to remain competitive in an increasingly uncertain and volatile environment. The global COVID-19 pandemic exposed the vulnerabilities within educational systems and accelerated the urgency to reassess and redefine international policies and practices. In addition, ongoing political, economic, and social changes have introduced a new level of complexity, requiring a constant adaptation of academic strategies to address these challenges.

The international dimension of higher education goes beyond academic mobility. According to Knight (2021), the internationalization strategy encompasses a range of policies and activities designed to facilitate this integration. These include student and academic staff mobility, international research collaboration, the development of joint programs, and the internationalization of the curriculum, all of which are implemented in both face-to-face and virtual modalities. From this perspective, the international dimension is viewed as a transformative mechanism that aims not only to enhance educational quality, through the formation of human capital with global competencies, essential for institutional advancement and effective participation in the knowledge economy (Gacel Ávila, 2017; Knight, 2020; Marinoni, 2019).

According to de Wit (2019), the internationalization strategy must be dynamic and responsive to global changes, such as economic and health crises, as well as political transitions that shape educational priorities. Thus, international adaptation is not an end, but a means to enhance the relevance of higher education and contribute significantly to social and economic development. In this context, internationalization serves as a transformative mechanism, preparing students and academics for an increasingly interconnected global environment. This process is grounded in the development of human capital with global competencies, which are essential for institutional advancement and effective participation in the global knowledge economy (Gacel Ávila, 2017; Marinoni, 2019). Conversely, Berry and Taylor (2014) argue that each HEI adapts international strategies according to its own

priorities, approaches, and perceptions. Given its dynamic nature, the process of internationalization adjusts to the specific contexts in which it is implemented, continuously reconfiguring itself to address the unique needs of each environment.

However, external factors exert significant pressure on universities, complicating their ability to adapt and leading to adverse effects that must be critically considered. The commercialization of higher education, the intensification of inter-institutional competition, and the growing selectivity of institutions reflect the market-driven logic that has increasingly infiltrated HEIs. This shift prioritizes economic gains over equity and universal access (Teferra, 2020; Wysocka et al., 2022). Such a mercantilist approach often leads to a segmentation of access to international opportunities, privileging academic elites and undermining the principles of inclusion and social justice that should guide educational policies (de Wit & Altbach, 2021). Consequently, this critical perspective is essential for understanding the limitations of international education as a tool for promoting equity.

A recent example of these adjustments and disparities can be seen in Latin America and the Caribbean, a macro-region where UNESCO-IESALC estimates that 83% of tertiary education institutions have incorporated internationalization into their Institutional Development Plans (Gacel-Ávila & Rodríguez-Rodríguez, 2018). However, in the aftermath of the COVID-19 pandemic, these institutions have been compelled to restructure their strategies, prioritizing virtual exchanges and online collaboration. This virtualization of the international dimension has exacerbated existing inequalities, as not all institutions possess the necessary technological infrastructure to participate equitably in such exchanges (Gacel-Ávila, 2022; Abdrasheva et al., 2022).

In Mexico, the internationalization of HEIs has been largely the result of a reactive adaptation to government policies stemming from the negotiations of the North American Free Trade Agreement (NAFTA) in the 1990s. This agreement established policies to promote and fund academic cooperation and mobility programs. Postgraduate communities were among the first to benefit, largely due to the support of the National Council of Humanities, Science and Technology<sup>1</sup>(Conahcyt) (Didou, 2020), a pioneering institution that has promoted international activities at this level since 1970 by providing credits and

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<sup>1</sup>The transition from Conacyt to Conahcyt was [officially formalized](#) on May 18, 2023, as part of a broader reform of scientific legislation in Mexico. This change, approved by the Senate and the Chamber of Deputies in April and signed into law by former President López Obrador, explicitly [incorporated](#) the humanities in the council's [mandate](#), [restructured](#) its organizational [framework](#), and revised research and funding priorities. This transformation was [framed](#) as a strategy to democratize access to knowledge and [align](#) research [with](#) social needs.

scholarships for postgraduate studies. As a result, scientific postgraduate education in Mexico has been marked by a strong international dimension, reflecting its high sensitivity to global trends.

During the 2010s, the international dimension of higher education in Mexico was institutionalized through its inclusion in institutional strategic plans and the establishment of international relations offices (Bustos and Crôtte, 2018). However, beginning in 2018, this process faced a series of setbacks due to the arrival of a new austerity-driven government and the outbreak of the COVID-19 pandemic. As a result, funding for international scientific cooperation and mobility scholarships in postgraduate studies was discontinued (Díaz, 2020; El Financiero, 2020). Furthermore, the structures for evaluating and accrediting the quality of postgraduate programs were transformed with the introduction of the National Postgraduate System<sup>2</sup> (SNP), which directs training processes towards the comprehensive development of scientific communities (National Council of Humanities, Science and Technology [Conahcyt], 2020). In summary, educational policies that once promoted internationalization are currently in a state of uncertainty, underscoring the reliance on public funding and the urgent need to diversify sources of support to sustain effective international education.

In the state of Sonora, the development of postgraduate programs has shown a sustained growth trend, establishing the region as a leader in postgraduate education (Rodríguez et al., 2010). By 2021, the PNPC recognized 56 postgraduate programs in Sonora, the majority of which were offered by the Universidad de Sonora (Unison). These programs aim to meet international standards by fostering partnerships with foreign institutions; however, this process has been characterized by uncertainty regarding government support.

In the context of profound changes and emerging challenges, the present study focuses on analyzing the reconfiguration of internationalization in the postgraduate programs at that achieved “Consolidated” or “International Competence” status in the PNPC during the period 2018-2022. The research addresses the following questions: What organizational

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<sup>2</sup>Mexico's National Council for Science and Technology (Conacyt) has transitioned from the National Program for Quality Postgraduate Studies (PNPC) to the National Postgraduate System (SNP). This change, initiated in 2021, [aims to align](#) the evaluation and accreditation of postgraduate programs to the country's [evolving](#) realities. [Unlike](#) the PNPC, [the SNP](#) emphasizes qualitative and [socially relevant](#) criteria, [revises](#) classification categories, updates the evaluation process and scholarship criteria, and [promotes](#) international collaboration with a focus on [addressing](#) national [challenges](#). This transition has [sparked](#) debates [within](#) the academic community and reflects a [broader](#) shift in Mexico's scientific and educational policy, aligning postgraduate [education](#) with the country's development priorities and social needs. The implementation of the SNP [is ongoing](#), with [continuous](#) adjustments [being made](#).

characteristics have facilitated the institutionalization of international activities in postgraduate programs? What are the predominant internationalization strategies in the analyzed postgraduate programs? How have recent transitions affected the international scientific work of these programs? And which strategies have been adjusted to ensure the continuity of their activities?

Answering these questions is essential for achieving the objective of providing a comprehensive and critical analysis of how Unison's graduate programs have reconfigured their global strategies in response to recent restrictions. It will also enable us to identify factors that could enhance the resilience and competitiveness of these programs in a globalized and increasingly challenging context.

## Materials and methods

This research adopted a rigorous case study design, following the methodological framework of Yin (2018), to examine the reconfiguration of internationalization in SNP postgraduate programs. This approach was chosen for its effectiveness in exploring complex phenomena within their real-world context, facilitating a detailed and holistic understanding of the dynamics and processes involved (Merriam & Tisdell, 2016). The study was grounded in a social constructivism perspective (Creswell & Poth, 2018), employing an inductive framework to interpret the experiences and realities of the participants, ensuring a nuanced and contextualized understanding of their perceptions and experiences.

Participants were selected using strategic purposive sampling (Patton, 2015), aimed at including individuals with in-depth knowledge and experience of the internationalization processes in Unison's postgraduate programs during the period 2018-2022. 15 key participants were chosen: coordinators, members of the Basic Academic Core and the Complementary Academic Core. Directors and former directors of the Unison Teaching, Research and Postgraduate Support Directorate (DADIP) also participated. The informants had a minimum of five years' experience in postgraduate programs and significant exposure to international academic environments. These methodological decisions were based on the recommendations of Deardorff (2006), who underscores the importance of international experience in gaining a deep understanding of internationalization processes.

Data were collected through semi-structured interviews, selected for their ability to provide flexibility and depth in exploring participants' experiences (Brinkmann & Kvale, 2015). The interview guide was meticulously developed, drawing on the dimensions of

internationalization proposed by Knight (2004), and adapted to the different types of informants. It addressed three main categories: characteristics of SNP programs, institutional context, and perceptions about internationalization strategies and their adjustments. Interviews were conducted either in person or via online platforms such as Zoom or Microsoft Teams, depending on participants' preferences and the restrictions imposed by the COVID-19 pandemic (Lobe et al., 2020). This approach facilitated a detailed and nuanced understanding of the perceptions and experiences of key actors involved in the internationalization process.

In addition to the interviews, a comprehensive documentary analysis was conducted to complement and contextualize the findings. This analysis included a review of institutional documents, evaluation reports and strategic plans. It provided valuable insights into how institutional policies and available resources have influenced the reconfiguration of the internationalization in graduate programs.

The documents reviewed included institutional development plans, which provided information on long-term policies and strategies for the internationalization of postgraduate programs; annual reports, which offered detailed data on the programs' progress and challenges; university laws and regulations, which offered a legal and regulatory framework for internationalization; university statutes, which clarified the organizational structure supporting these activities; study plans for the postgraduate programs, constitutive acts, logbooks of the academic colleges and reports of pioneering members, which provided insights into the historical background of each program and the factors that have facilitated its institutionalization.

The evaluation and accreditation documents included internationalization indicators published by the postgraduate programs, which provided specific metrics to assess the effectiveness of the implemented strategies, as well as external evaluations by Conahcyt, which offered an objective evaluation of the quality and international reach of the programs. Official communications from Unison were also analyzed, containing relevant announcements and updates, alongside the CVs of coordinators and members of the Academic Core, which offered insights into their academic and professional qualifications – essential for understanding their roles and capabilities in managing internationalization. Additionally, Conahcyt's reference frameworks helped align the postgraduate programs with the national and international standards, thereby strengthening internationalization initiatives. Further, queries were made regarding productivity at Unison through Web of



Science. These documents provided essential contextual data for the analysis and helped validate the information obtained from the interviews.

The validity and reliability of the study were strengthened through data triangulation (Denzin, 2017), combining interviews and documentary analysis to ensure a comprehensive and robust understanding of internationalization processes. Triangulation was carefully designed to contrast and verify the data collected (Flick, 2018). This methodological approach ensured a thorough interpretation of the data and helped mitigate potential biases in the findings.

Data analysis was carried out in an iterative and inductive manner, adhering to the rigorous principles of thematic analysis outlined by Braun and Clarke (2006). MAXQDA22 software was used to organize and code the data (Woolf et al., 2015). The coding process unfolded in three stages: open, axial, and selective coding (Corbin & Strauss, 2015), which facilitated the identification of emerging patterns and the development of robust, well-founded conceptual categories, thereby providing a comprehensive and nuanced understanding of the internationalization processes.

The research procedure was conducted in accordance with strict ethical protocols, ensuring informed consent from all participants and guaranteeing confidentiality of their information, in line with ethical guidelines for qualitative research (Guillemim & Guillam, 2004). This ethical and reflexive approach not only safeguarded participants' rights, but also enhanced the credibility and legitimacy of the study. In summary, the methodology employed provided a detailed and nuanced understanding of the factors influencing the reconfiguration of internationalization in postgraduate programs at Unison, thereby making a significant contribution to the existing literature on the internationalization of higher education in specific contexts (De Wit et al., 2015; Hudzik, 2015).

## Results

The results are presented based on data collected through semi-structured interviews and documentary analysis, organized into four sections. The first two sections describe the organizational characteristics that facilitated the establishment of postgraduate programs at Unison. The third section outlines the internationalization strategies regularly implemented prior to the period of change. Finally, the fourth section analyzes the impacts of the transitional period and the adaptations made by postgraduate programs.

## **Institutionalization and Internationalization of Postgraduate Studies in Physical Sciences and Materials Sciences at Unison**

The development of postgraduate programs in Physical Sciences and Materials Sciences at Unison resulted from significant interactions between local and international actors, positioning the institution as a leader in these fields. This process not only fostered scientific and technological advancement but also led to a substantial transformation of academic standards and regional expectations. Additionally, it enabled the university to integrate more firmly into the international scientific community, aligning itself with global trends in higher education and research.

The analysis of historical background and interview testimonies suggests that the consolidation of these postgraduate programs emerged from the aspirations of young academics committed to research. This effort culminated in the establishment of research centers in Chemical-Biological Sciences and Exact Sciences and Engineering, thereby laying the foundations for the institutionalization of postgraduate programs. This development took place in a context marked by interinstitutional competition and reliance on national policies and external resources. The efforts of these academics set a precedent for future generations and contributed to the institutional strengthening in key scientific areas.

In the field of Physical Sciences, the inclusion of this discipline in the curriculum of the School of Advanced Studies in 1964 sparked a growing demand for specialized professionals. However, the initial program lacked a strong research focus, prompting many graduates to pursue postgraduate studies abroad. Upon their return, these academics made significant contributions to teaching and research at the university, culminating in the establishment of the Department of Physics in 1976, a key milestone in the consolidation of the institution's scientific endeavors (Castañeda Medina, Pedroza Montero & Barboza Flores, n.d.). This initiative not only enhanced the quality of education, but also facilitated the university's integration into national and international research networks.

The professors leveraged the international collaboration networks established during their studies, forging alliances that contributed to the internationalization of the program. The incorporation of advanced techniques and participation in collaborative projects enhanced the department's competitiveness and improved the training processes. Notably, partnerships with foreign institutions provided not only material resources but also valuable knowledge, which facilitated the ongoing modernization of both pedagogical approaches and research methodologies.

In the field of Materials Sciences, the need to explore new materials led to the establishment of the Center for Research in Polymers and Materials (CIPM), with the support of Eng. Gabriel Ibarra Félix and the collaboration with the University of Guadalajara. This project also received backing from the Japan International Cooperation Agency (JICA), which provided funding and infrastructure to support the technological development of the institution (Jara Rivera, 1991). These partnerships reflected a commitment to strengthening strategic areas of materials research, ensuring access to cutting-edge equipment and specialized technical training, which facilitated the generation of knowledge applicable to industrial sectors.

The arrival of young researchers intensified scientific activity in both disciplines, drawing on the professional networks established during their postgraduate studies. A pivotal moment in this development was the collaboration with Dr. Ariel Valladares Clemente, leader of a SEP program designed to promote research in peripheral regions of the country. During a visit to Unison, Dr. Valladares encouraged the departments of Physics, Mathematics and Chemistry to submit research proposals, offering his support for their initiatives (Rodríguez Mijangos, 2015):

Upon assuming my position here, Dr. Valladares contacted me and requested that I organized meetings with the rector and other relevant officials to promote emerging programs in higher education that supported scientific research and graduate studies (Informant 12, PCF).

This institutional support, combined with the backing of the academic community, was crucial in strengthening research programs and establishing the Unison Physics Research Center (CIFUS) in 1977, thus laying the foundations for a robust research group capable of securing funding from SEP and Conahcyt. Moreover, this collaboration fostered a culture of innovation that extended beyond the Physical Sciences, encouraging participation in funding calls and the dissemination of knowledge through international publications and conferences.

In parallel, the School of Chemical Sciences developed research lines in food sciences, which led to the establishment of the Food Research Coordinating Centre (CCI-Alimentos) and, in 1982, to the approval of the master's degree in Food Sciences and Technology (Department of Food Research and Postgraduate Studies [DIPA], 2022). These developments demonstrated Unison's capacity to diversify its areas of specialization and address local needs in applied scientific research, thereby enhancing the technological development capabilities of the region.

In the area of Physics, Dr. Eugenio Cetina Vadillo played a crucial role in the articulation of the Master of Physical Sciences (MCF) in 1984, with the support of Dr. Jorge Andrés Flores Valdés, a representative of the SEP: *“Dr. Cetina played a key role in administration, with the decisive support of leaders... Eugenio, Ariel Valladares, and Dr. Jorge Flores must be recognized for their decision to support the creation of the MCF”* (Informant 12, PCF).

The MCF was designed to train high-level educators and researchers, fostering the publication of articles in international journals and the presentation of papers at conferences, thereby positioning Unison on the international stage (Colegio Académico de la Universidad de Sonora, 1995). The training of these academics had a positive impact not only on the generation of new knowledge, but also on the quality of the teaching, creating a virtuous circle between teaching and research. The consolidation of CIFUS represented a structural transformation at the university, as it introduced international standards for the human resource training, positioning Unison within a broader and more diversified scientific community. This shift established a rigorous research culture that would underpin new programs and areas of study. The adoption of these practices prompted the university to integrate more rigorous standards and procedures, thereby enhancing the quality of its academic programs and increasing the international relevance of its research.

Similarly, the strengthening of the CIPM was facilitated by the arrival of international researchers who trained future faculty members and by collaborations with foreign institutions, particularly with the support of JICA. This collaboration enabled the creation of a postgraduate program that integrated applied research and advanced training. As one informant noted: *“I joined as a professor because during my doctoral study, we all had the responsibility of teaching at the undergraduate level... we started to form part of the core group of postgraduate professors once we graduated”* (Informant 6, PCM).

These pioneering programs expanded through international collaborations and institutional support, ensuring the high-quality development of human resources. The evolution of these postgraduate programs reflects not only the growth of academic capabilities but also their integration into a broader network of scientific collaboration. Despite the challenges, these programs have established a model for researcher training and internationalization that continues to endure and contributes to the advancement of knowledge in their respective disciplines.

In summary, the development of postgraduate programs in Physical Sciences and Materials Sciences at Unison exemplifies a successful model of internationalization, grounded in collaborative networks and advanced training. These achievements have laid the foundations for the consolidation of new initiatives and the university's integration into the global scientific community.

### **Emergence of Internationalization in Unison Postgraduate Studies**

The internationalization of the postgraduate programs in Physical Sciences (PCF) and Materials Sciences (PCM) at Unison evolved throughout the 1980s, following distinct trajectories, but sharing common objectives aligned with international standards: consolidating academic quality and enhancing research through a global perspective. Below we analyze how each program pursued its path toward internationalization.

The internationalization of the PCF began in the late 1970s, driven by faculty members returning from abroad, such as Dr. Marcelino Barboza Flores. In 1976, Dr. Ariel Valladares Clemente encouraged his colleagues to develop projects with government support, which enabled the Physics Department to acquire resources for equipment and hire new faculty members. As an informant noted: *“That is how it all began between 1976 and 1980, and the results were very positive. We received support from the UNAM Physics Institute and were able to hire new researchers, many of whom had been trained abroad”* (Informant 12, PCF).

The establishment of the Physics Department in 1976 allowed resources to be directed towards research. During the 1990s, the PCF further consolidated its internationalization with the support of Conahcyt's Patrimonial Chairs, which facilitated the arrival of researchers from countries such as Brazil, Japan, England, Russia, the United States, and Spain. One informant recalls how international collaboration became a central strategy from the outset of the PCF, citing the visit of the Nobel Prize Laureate in Physics, Abdus Salam, in 1986:

When I was pursuing my degree, Dr. Barboza had just returned from his PhD and brought a Nobel Prize winner in Physics. Wow! I mention this to illustrate the kind of activities that were encouraged back at that time. From an early age, we were exposed to a wide range of possibilities (Informant 11, PCF).

These activities positioned the PCF within the international arena and promoted the mobility of students and academics. From 1991 onwards, students actively participated in international research stays and conferences, enhancing the visibility of the department's

research. As one informant explained: *Our students have travelled the world presenting their research, which strengthens scientific collaboration. When an academic is unable to attend, students step in to represent them* (Informant 12, PCF).

The PCM, on the other hand, began with a close collaboration with JICA, which facilitated the establishment of the CIPM in 1981. This partnership provided advanced equipment and enabled the arrival of researchers such as Drs. Takeshi Ogawa and Motomichi Inoue, who played a pivotal role in the training of both faculty and students:

The arrival of Drs. Ogawa and Inoue completely transformed our situation. Not only did they provide us with the necessary equipment, but they also trained us to become researchers and educators. They introduced a new approach that was focused on applied research and international collaboration, which was a departure from our previous experience (Informant 7, PCM).

Collaboration with Japan enabled the implementation of an *internationalization at home strategy*<sup>3</sup>, directly integrating international experience into its operations. This partnership proved especially valuable given the financial constraints of the time: *“JICA contributed not only equipment but also personnel and training, which were essential for the establishment of the center in 1981”* (Informant 6, PCM).

Both programs adopted distinct strategies to achieve internationalization. The PCF focused on a "collaborative and diversified" approach, prioritizing the recruitment of international talent and the organization of scientific events. In contrast, the PCM pursued a "structured" strategy, centered on collaboration with Japan and supported by JICA, which facilitated the transfer of knowledge and the integration of international researchers. Both strategies contributed to the academic and scientific consolidation of the programs, establishing them as benchmarks in their respective areas. While the PCF benefited from a range of international influences, the PCM developed a more focused collaboration, demonstrating that internationalization can take different forms, each adapted to its specific context.

In summary, the distinct internationalization strategies of the PCF and PCM not only enhanced Unison's academic and research quality, but also established a solid foundation for future advancements in the international arena. This experience underscores that flexibility

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<sup>3</sup>This strategy refers to the integration of international experiences within the local environment of the institution (Knight, 2004).

in internationalization strategies can lead to long-lasting and significant impacts across diverse academic contexts.

### **Internationalization strategies**

Internationalization is a critical component in evaluating the quality and competitiveness of academic programs. In the global context, it is achieved through practices such as academic mobility, collaborative scientific production, and participation in international events. Both the PCM and the PCF have adopted different strategies; however, the outcomes have been uneven due to structural challenges, including the inconsistent of policies, lack of sustainability, and unequal access to opportunities.

At the PCM, international student mobility, particularly at the doctoral level, is a key institutional strategy. According to DADIP reports (2023), destinations include countries such as the United States, France, Italy, Japan, and Spain. This mobility is mandatory, in accordance with Conahcyt standards. Specific agreements, along with informal arrangements, often facilitated through personal connections of academics, enable this mobility. Informant 4 of the PCM emphasized that the institution encourages students to seek international experiences for both academic and personal development. However, the mandatory nature of mobility does not guarantee a positive impact, as the lack of mechanisms for transferring acquired knowledge to the local context diminishes its effectiveness. In this regard, internationalization represents a valuable experience, although its impact at the institutional level remains limited.

Unlike the PCM, at the PCF, mobility is not mandatory and largely depends on the initiative of faculty members and the interest of students. One academic remarked: “*Student mobility depends primarily on the interest of the thesis advisor and not on a coordinated institutional policy*” (Informant 15, PCF). This lack of formalization results in significant disparities in access to international experiences, creating unequal opportunities for students based on the network of contacts of their thesis advisors. While there are examples of success, the absence of a robust institutional support policy limits the positive impact that mobility could have on students’ academic and professional development.

Since 2017, PCM has succeeded in attracting international students, primarily from Colombia and Cuba. According to enrollment reports, these students have come to represent up to 17% of new admissions in some years. This achievement is seen as an indication of the program’s growing prestige. However, limited resources and inadequate infrastructure to

accommodate these students have posed challenges to the sustainability of this strategy. As one PCM professor noted: *“The presence of international students should be complemented by mentoring programs and cultural activities, but the lack of resources significantly limits what we can do”* (Informant 8, PCM).

The PCF, on the other hand, has faced greater challenges in attracting international students, despite efforts to enhance promotion of the program. As one professor remarked: *“They don't do any advertising. How is it possible that, despite Conahcyt's request for an increase in international students, they didn't make any visits?”* (Informant 12, PCF). The lack of a structured promotional strategy and a coordinated efforts has hindered the PCF's ability to attract international students. Moreover, reliance on individual initiatives has proven insufficient to overcome the language and cultural barriers faced by foreign students.

Participation in international academic events is an essential component of internationalization in both programs. At the PCM, both students and faculty actively engage in international conferences, with financial support provided by the University and external programs. For example, at the 2023 Biennial Colloquium on Materials Sciences, Unison reported that 108 scientific posters produced by PCM students were presented. This participation underscores the commitment to enhancing international visibility and reflects a clear institutional policy of supporting academic training within a global context.

As with the PCM, participation in international events is also valued at the PCF; however, it largely depends on the interests and resources of individual academics. Informant 10 of the PCF noted that the events held at Unison aim to connect students and faculty with international experts in the research areas developed within the Department. However, the absence of formal funding and a clear policy to promote participation in international events limits the PCF's capacity to build meaningful networks and establish valuable contacts.

At the PCM, PhD students are required to publish at least one article in a high-impact, indexed journal before graduation. This requirement has resulted in a high percentage of publications in first- and second-quartile journals. While it enhances the program's international competitiveness, it also imposes significant pressure on students to advance their research.

At PCF, scientific production largely depends on the thesis supervisor and personal resources. Although the program's regulations encourage publication in high-impact journals, the lack of structured institutional support limits publication opportunities for many students. As one professor explained: *“The involvement of professors is crucial in the*



*scientific development of students, but without adequate support, it is difficult to maintain a consistent publication output"* (Informant 11, PCF).

The PCM has established formal collaborations with programs and institutions, such as JICA in Japan, which has facilitated student mobility and joint scientific production. However, these collaborations are largely driven by personal initiatives by academics, which limits their scope and sustainability. As one professor noted: *"When I was in France or the United States, there were so many seminars that I had difficulty choosing"* (Informant 4, PCM). This statement highlights the potential of these collaborations but also underscores their lack of institutionalization.

At the PCF, international collaborations have been primarily developed through personal networks. While these initiatives have been proven beneficial, their impact and sustainability are limited and are constrained by the lack of formalization and coordinated follow-up. *"Many graduates have secured postdoctoral positions at reputable institutions, but this is more a result of their individual efforts than of coordinated institutional support"* (Informant 12, PCF).

The Unison Directorate of Support for Linkage and Dissemination notes that in this postgraduate program, specific cases have arisen in which formal agreements were established, such as with the University of Kansas and CERN. However, these agreements have limited scope, benefiting only a small proportion of the student population.

In summary, the internationalization strategies implemented by the PCM and the PCF have yielded significant, though uneven, progress. While the PCM stands out for the institutionalization of key practices, it faces challenges related to limited resources and the pressure placed on students. In contrast, the PCF, which relies on individual initiatives, underscores the need for formal policies that promote a more equitable and sustainable process of internationalization.

## Structural Fragilities and Adaptation in the Postgraduate Courses of Physical Sciences and Materials Sciences in the Face of the Pandemic and Political Changes

Higher education and scientific research in Mexico are undergoing profound transformations, further intensified by recent political changes and the impact of the COVID-19 pandemic. In this context, the structural weaknesses and adaptations of Unison's graduate programs in Physical Sciences and Materials Sciences are examined, with a particular focus on funding, academic mobility, and scientific productivity.

Since 2018, the restructuring of Conahcyt's funding policies and the cancellation of scientific projects trusts have led to a drastic reduction in the resources available for graduate programs. The data are compelling: according to Unison's annual reports (2024), in the Departments of Physics Research (DIFUS) and Polymer and Materials Research (DIPM)—where the PCF and PCM Programs are affiliated—have experienced a significant decline in projects funded by external sources, primarily from Conahcyt. Table 1 presents a comparison between the five-year periods of 2013-2017 and 2018-2022.

**Table 1.** DIFUS and DIPM scientific research projects funded by external sources 2013-2022

Quinquennium	DIFUS		DIPM	
	Approved projects	Total amount financed	Approved projects	Total amount financed
2013-2017	18	\$42,942,274.00	13	\$31,278,956.00
2018-2022	3	\$4 769 798.72	8	\$11,433,118.70

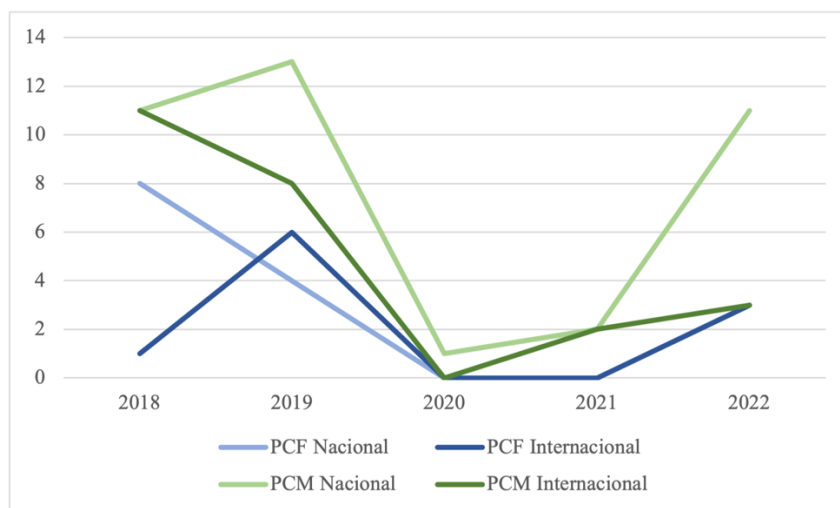
Source: Prepared by the authors based on Unison annual reports (2024).

According to testimonies from academics, the lack of financial support has directly impacted research activities. Informant 10 from the PCF noted: *"Federal resources could not be used to purchase equipment or anything that required inventory... If the resources from PROMEP and the federal budget have already been exhausted, there is no way to renew or maintain the equipment."* This type of restriction has created uncertainty about the continuity of research, with the persistent threat that laboratory equipment will become obsolete.

Regarding academic mobility, the pandemic caused a significant disruption in both programs, although with different dynamics. At the PCF, student mobility fell to zero in 2020 and 2021, making an unprecedented decline that not only impacted student training but also jeopardize the program's network of international collaborations. In contrast, the PCM

managed a partial reactivation in 2021, primarily at the doctoral level and with national destinations (Fig. 1). While this reorientation was pragmatic, it compromised the quality of the international experience and hindered the development of global collaboration networks. Furthermore, this situation limited access to cutting-edge technologies and methodologies typically available only at international institutions, thereby restricting the academic development of students.

**Figure 1.** 1Degrees in Physical Sciences and Materials Sciences 2018-2022



Source: Prepared by the authors based on DADIP reports (2023).

On the other hand, informants also highlighted the decrease in participation in international events. As an alternative, virtual events were utilized. One informant noted, *“The first meetings were virtual... we all have collaborators in other locations, and if you invite them, they do participate, especially in this format (virtually), as it was easier to involve them”* (Informant 10, PCF). While these events allowed for the continuation of scientific communication, the reduction in face-to-face interactions limited opportunities for informal discussions on complex issues between researchers and students, which, in turn, affected the development of new ideas and projects.

Regarding scientific productivity, changing dynamics are evident. According to data from Web of Science (2024), Unison's publications in the research areas of Physics and Optics (the primary research areas in the PCF) and Materials or Polymer Sciences (the primary research areas in the PCM) have shown a general decline over the study period. While there appears to have been a brief recovery in Physics in 2021, Materials Sciences experienced 32% decrease in publications between 2019 and 2022 (Table 2).

**Table 2.** Productivity of the University of Sonora in specific areas 2018-2022

Year	Publications by area	
	Physics and Optics	Materials and Polymer Sciences
2018	80	62
2019	155	81
2020	143	66
2021	150	68
2022	101	55

Source: Prepared by the authors based on data obtained from Web of Science.

At PCF, informants highlight that the decline in international collaborations results not only from a lack of funding but also from the aging of the academic staff, which limits the generation of innovative knowledge. One informant noted: *“My international collaborations have decreased because we have gotten older... what I do now is survive with two or three studies here, advising students”* (Informant 12, PCF). This aging process translates into a lack of renewal in ideas and approaches, thereby restricting the ability of the programs to remain at the forefront of their respective fields of study. Furthermore, the shortage of new, young talent diminishes the program’s capacity to adopt emerging technologies and innovative methodologies.

While the PCF exhibits structural inertia that complicates adaptation, the PCM has made efforts to develop dynamic capabilities, such as seeking external funding. However, these initiatives are not part of a comprehensive strategy. As some informants explained, *“Sometimes we have to pool our resources between professors to pay for the maintenance of the equipment... the most important thing is the resonance equipment because is costly and sometimes there are no resources”* (Informant 9, PCM); *“At Conahcyt, it is difficult to secure resources... We receive very little funding from the Department, and we have to use it efficiently. In the Division I have just submitted a project, and we also want to submit it to a European foundation”* (Informant 7, PCM). This lack of strategic planning is further reflected in the difficulty of establishing alliances with industry and other stakeholders. The search for external resources has been sporadic and reliant on personal contacts, which does not ensure long-term financial stability.

Regarding the collaboration networks reflected in publications, Web of Science data indicate a trend of declining partnerships with international institutions, while national collaborations have remained stable. The lack of resources for international mobility and the

reliance on government funding have constrained the program's ability to establish new strategic alliances with foreign institutions. One example of this is the cancellation of the Thematic Networks, which previously facilitated the integration of knowledge and skills and, in some cases, led to internationalization activities, as noted by an informant from the PCF:

Previously, individuals were able to organize their own thematic meetings, and support was provided for these initiatives. One of the first actions taken by Conahcyt was the cancellation of this support... Consequently, resources for holding annual meetings have become increasingly scarce. In the past, we organized competitions for students to undertake internships in foreign laboratories; however, there is now less funding available (Informant 14, PCF).

The lack of such support has led to a form of isolation that not only impedes the capacity to generate innovative knowledge but also diminishes the international visibility of the programs, which is crucial to attract talent and securing external funding. This isolation restricts participation in international collaboration networks and limits opportunities to access cutting-edge technologies and methodologies. Furthermore, the absence of a clear strategic vision for the future of postgraduate programs in Physical Sciences and Materials Sciences presents a significant challenge. Although some academics have made efforts to adapt by seeking alternative funding and establishing local alliances, these initiatives have largely been insufficient to address the structural challenges facing the programs. Institutional rigidity and the lack of proactive strategies to diversify resources and expand collaboration networks further exacerbate this situation.

In conclusion, the dependence on government funding, the lack of faculty renewal, and the absence of comprehensive strategies have hindered the adaptability of Unison's graduate programs. To ensure their sustainability and competitiveness, it will be essential to implement strategic changes, including the diversification of resources, the modernization of infrastructure and the establishment of national and international collaborations.

## Discussion

The reconfiguration of the internationalization strategies of Unison's PCF and PCM programs, in response to the conditions imposed by the pandemic and recent federal policies,



reveals complex patterns that both align with and extend existing findings in the field of higher education internationalization. This analysis focuses on three key dimensions: internationalization practices, adaptive capacity, and the implications for the sustainability of graduate science models.

Regarding the impacts of crises on internationalization practices, the specialized literature identifies several common trends in the educational field. The drastic reduction in student mobility, especially within the PCF, aligns with global trends highlighted by Jensen et al. (2022) and Gacel-Ávila (2022) in their studies on the effects of COVID-19 on international and Latin American higher education, respectively. This finding underscores the vulnerability of traditional models of internationalization, which relies heavily on physical mobility –an issue that, according to de Wit and Altbach (2021), requires urgent reconsideration in the post-pandemic context.

The adoption of virtual formats for academic events in both postgraduate programs aligns with the *internationalization at home strategy* proposed by Beelen and Jones (2015), who argue that institutions can and should develop internationalization processes that do not rely exclusively on physical mobility. Gacel-Ávila and Vásquez-Niño (2022) highlight that, in Mexico, most HEIs adopted this strategy during the pandemic. These actions, despite their intention to be more inclusive for the university population, may exacerbate inequalities related to digital infrastructure. Additionally, Sohrabi et al. (2021) critique that these initiatives for limiting the opportunities for informal interactions and collaboration among experts in the field.

Regarding adaptive capacity, the PCF demonstrated resilience by maintaining high-level international collaborations, such as its partnership with CERN. This aligns with Knight's (2004) concept of *institutional-level internationalization*, which refers to the implementation of proactive internationalization strategies across the entire organization. However, the financial vulnerability revealed by the decline in approved projects underscores challenges in sustaining internationalization strategies in resource-constrained environments, particularly in developing countries (de Wit et al., 2015). In contrast, the PCM'S more conservative approach, which preserves established collaborations but with limited geographic diversity, reflects the adaptive responses identified by Altbach and de Wit (2015) during global crises. This disparity in the responses of both programs illustrates the complexity of internationalization within different institutional contexts, a phenomenon that Gacel-Ávila (2012) has also observed in the Latin American context. Furthermore, the

complexity and speed of these adaptive processes can be attributed to the organizational culture of each program, shaped from its inception (Nauffal and Nader, 2022). In this regard, both postgraduate programs have developed established traditions in types of collaborations and funding mechanisms, meaning their adaptations are varied and occur at different paces.

In this context, the sustainability of the postgraduate science model and, the critical reliance on government funding observed in both programs reflect what Gacel-Ávila (2012) identifies as a common challenge in the internationalization of higher education in Latin America. This reliance, which constrains institutional autonomy, is a recurring theme in the literature on internationalization in resource-limited environments, as noted by de Wit et al. (2015). The decline in scientific productivity aligns with Altbach and de Wit's (2015) observations regarding the disproportionate impact of global crises on institutions the periphery of the global higher education system. This finding underscores the need for more resilient and adaptable internationalization strategies, a topic explored by Gacel-Ávila and Rodríguez-Rodríguez (2018) in the Latin American context.

The reconfiguration of the internationalization of postgraduate programs at Unison reveals a complex interplay between institutional resilience and vulnerability, which both aligns with and expands previous findings in the field of higher education internationalization. While examples of innovative adaptation are evident, significant structural fragilities also surface, raising concerns about the long-term sustainability of the current model. These findings correspond with Gacel-Ávila and Rodríguez-Rodríguez's (2018) analysis of internationalization in Latin America, which underscores the need for more comprehensive and sustainable strategies. They also reflect de Wit and Altbach's (2021) observations on the necessity of rethinking internationalization models in the post-pandemic context.

The findings highlight the importance of developing theoretical and practical frameworks that are more attuned to the realities of institutions in the global academic periphery, i.e., higher education institutions located in regions with limited access to global resources. Future research could focus on designing practical and adaptable strategies for peripheral institutions to enhance their internationalization efforts, increasing their resilience to global crises.

## Conclusions

The internationalization of higher education has been crucial for institutional progress and the development of highly competitive human capital in a global market. In the current era, characterized by the health crisis and political transitions, scientific postgraduate programs in Mexico have undergone significant reconfigurations. This study identified three main areas of impact: the effect on core practices such as mobility and collaborative research; the vulnerability of programs due to reliance on public funding; and the need to strengthen sustainable strategies to ensure their continuity. The results emphasize critical areas that must be addressed to ensure the sustainability of graduate programs, including faculty renewal, diversified funding, and the consolidation of international collaboration networks. This entails several challenges, such as designing strategies for faculty renewal through national and international recruitment initiatives; diversifying funding sources through partnerships with industry, private foundations, and multilateral programs; and strengthening international collaboration networks through formal agreements and academic mobility. Although the results of this study are not generalizable, they offer valuable insights into the challenges facing scientific postgraduate programs in Mexico. Future research should focus on exploring innovative strategies to overcome these challenges and ensure sustainable and equitable internationalization.

### **Future lines of research**

The results of this study highlight key areas that require further attention to strengthen the internationalization of higher education. The following lines of research address these challenges and aim to respond to the needs identified in the current context:

1. Robust and flexible strategies for peripheral institutions.

To conduct in-depth examination of how peripheral institutions can develop international strategies that are both robust and flexible, enabling them to respond effectively to global crises while advancing their institutional development goals and knowledge generation objectives.

2. Alternative financing and collaboration models.

To investigate models of international collaboration that reduce the dependence of graduate programs on government funding, exploring alternatives such as public-private partnerships and South-South collaboration networks.

3. Long-term impact of virtualization.





To analyze the long-term effects of virtualization, implemented during the pandemic, on internationalization practices, evaluating its potential to democratize access to international experiences and its effectiveness in comparison to traditional models of physical mobility.

4. Strategies for the renewal and attraction of academic talent.

To examine effective strategies for the renewal and rejuvenation of the academic staff in postgraduate programs, focusing on aspects such as the intergenerational transfer of knowledge and the attraction of international talent.

5. Development of institutional dynamic capacities.

To explore how institutions can develop dynamic capabilities to adapt to rapid changes in the global academic environment, focusing on the integration of new technologies and innovative pedagogical approaches.

6. Policies for an equitable and sustainable international dimension.

To investigate the role of national and institutional policies in promoting more equitable and sustainable global education, focusing on how these policies can address inequalities in resources, infrastructure, and opportunities between institutions and regions.

Exploring these lines of research will not only enhance our understanding of the current state of internationalization but also contribute to the development of practical solutions that foster a more equitable, sustainable, and resilient higher education system.

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