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Novus Projects: Innovative Ideas to Build New Opportunities upon Technology-Based Avenues in Higher Education

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Abstract: This study describes a funding initiative that promotes educational innovation in a higher education institution in Mexico. This initiative, known as Novus, and carried out at Tecnologico de Monterrey, encourages professors to present educational innovation proposals by funding and monitoring research projects that promote student learning and competencies. These projects are based on digital technologies and pedagogies developed on the 26 campuses distributed throughout the country. This article presents a case study in which the historical data of Novus projects from 2012 to 2021 are reviewed. The results show that using digital technologies in these projects has favored more than 65,000 students on more than 1700 courses and the 1000 professors who teach these formative experiences. In addition, there are similar initiatives, especially in Latin America; however, they are still too few to contribute to improving student learning in an unprecedented time. Due to the COVID-19 pandemic, the digital transformation of educational institutions has been accelerated, with many challenges and obstacles. Therefore, showing the result of initiatives that favor the professionalization of teachers through technological projects based on evidence will illustrate the possibilities for higher education to develop these experiences. This study aims to communicate the main ideas and findings that originated in the projects created with this initiative and to show how these experiences have impacted the teaching-learning processes of university students through the innovation proposed by teachers. The dissemination of these results can generate interest so that other institutions understand the benefits of this initiative and can continue to generate new opportunities for these contexts.

Keywords: educational innovation; higher education; evidence-based research; Mexico

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1. Introduction

Traditional education is being transformed, and this has undoubtedly been true for the past two years, due to the contingency caused by the SARS-CoV-2 pandemic. New technologies and pedagogies are being adapted to the teaching-learning processes, and educational researchers are analyzing how these innovations affect student learning [1]. Technologies and practices such as artificial intelligence, learning analytics, open educational resources, and tools that favor hybrid learning models have been the trends of the past year, according to the Horizon Report 2021, and will continue to be, especially in the post-pandemic stage [2]. However, these trends do not apply equally to all countries.

In Latin America, there are challenges for digital transformation and educational innovation initiatives in higher education environments. In this regard, Ramírez Montoya [3] conducted a study with universities in ten Latin American countries and found that although they have had to adapt to the new requirements of digital transformation, there are still challenges to overcome, mainly related to virtualization, training, infrastructure, connectivity, and open education, as well as educational innovation related to new processes, products, services, knowledge, and research. These findings agree with a systematic literature review (SLR) in which the author analyzed the results of the implementation of innovations based on Information and Communication Technologies (ICT), and it was

found necessary to continue with teacher training, reduce technological barriers and incorporate new tools that increase the interest and motivation of students [4]. Hence, initiatives promoting digital transformation and educational innovation based on digital technologies and pedagogies are necessary to overcome universities' challenges.

In this way, more and more institutional leaders worldwide are focusing on developing educational innovations [5,6] based on the need to improve student learning [7]. To achieve this, teachers must be familiar with innovative educational strategies and resources that favor active student learning [8,9]. However, teachers' development of these strategies is hindered significantly by access to materials and resources [10]. Therefore, one way to reduce these difficulties is to include research activities in teaching environments that include financial support [11].

One of these initiatives is the Novus grant, developed by the Institute for the Future of Education (IFE) at Tecnologico de Monterrey in Mexico. Novus aims to position educational innovation research as a means for faculty development, the improvement of the teaching-learning process, and the construction of the future of education [12]. To achieve these objectives, the initiative provides institutional resources to finance faculty-proposed educational innovations and as methodological support to correctly assess the impact of these innovations on student development.

According to the literature, the implementation strategies and the results of the initiatives that provide funds to promote teaching innovation are not very often disseminated. Therefore, it is necessary to understand them better to enhance the development of educational projects based on research on innovations in higher education [13,14]. Disruptions to the future of work and learning such as technological advancements, longer life spans and careers, geopolitical shifts, and pandemics, among others, demand efforts to ensure the continued value and relevance of education. The IFE purpose is to generate, transfer and disseminate applicable knowledge on educational innovation connecting diverse perspectives across regions, seeking disrupting solutions for the future of higher education and lifelong learning.

For this reason, this study aims to present the results of the Novus fund as an initiative to promote evidence-based educational innovation and research. According to Davies [15], evidence-based research seeks to establish solid evidence that will allow future research in the educational field to continue with scientific validity, high quality, and practical evidence. It is essential to make these results known to build new opportunities and contribute to the Latin American context with examples of educational innovations promoted by the institution and whose model could be replicated in other contexts. To achieve the research objective, we seek to answer the following questions: (1) what has been the geographical distribution of the projects? (2) what are the technologies used? (3) how many students and courses have been impacted? (4) what has been the impact on the faculty? and (5) what is the impact on publications and international awards?

1.1. Digital Transformation in Universities

Digital transformation has become a challenge for universities, which have attempted to integrate new technologies into the traditional way of teaching classes for several decades. This digital transformation aims to form 21st-century competencies in students to improve the quality of education in the face of the challenges imposed by the so-called fourth industrial revolution [16]. Digital transformation is defined as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" [17] (p. 118). In universities, this transformation involves the integration of new technologies and changes in organizational culture to enable the implementation and management of the digital university [18,19]. However, achieving an adequate integration of these changes into educational institutions faces important challenges.

To meet the digitization challenges, institutions must develop an organizational culture that promotes innovation. According to UNESCO [20], digital transformation in

educational institutions is an ongoing process that requires leadership and commitment to succeed; also, it is necessary to have a clear vision, support change, develop talent, and engage in investment. This leadership must also be accompanied by a people-centered and technology-based strategy [21]. Both the professor and the development of skills in students can facilitate the digital transformation, making teaching-learning more flexible and favoring lifelong learning [22,23]. Moreover, the teacher's perception of how to teach with technology [24] and carry out research that allows the scientific evaluation of the results [25] is fundamental for the successful implementation of educational technology. Hence, the digital transformation process must favor the development of digitization strategies for these educational actors.

To analyze the results of digital transformation initiatives in Latin American countries, a review conducted in the Scopus database showed that few studies had been conducted in the Latin American region. When searching for results that included the keywords "digital transformation", "Latin America", and "universities", 13 studies were found in the period from 2017 to 2021: five were from Mexico, two from Colombia, two from Ecuador, and one from each of these countries: Argentina, Panama, Paraguay, and Uruguay [26]. The institution that published the most was Tecnologico de Monterrey, with three publications.

Some of these studies discussed the progress in the digitalization of universities and the main challenges to reaching higher levels of maturity. A study by Serna Gómez et al. [27] mentions that digital transformation in educational institutions in Latin America is in the early adoption phase. Although there are some successful cases in this region, such as those at the top of the academic rankings, the authors conclude there are still challenges related to resistance to change, organizational culture, and hierarchical governance. Evidence of progress in this transformation includes classes using collaborative virtual reality at the Tecnologico de Monterrey, the use of robots in research at the Universidad Autónoma de México and advice to students at the Universidad de los Andes in Colombia, the use of artificial intelligence at the Universidad del Norte de Barranquilla, and the use of blockchain at the Universidad Provincial del Sudoeste de la Provincia de Buenos Aires, Argentina.

When it comes to the reality of digital transformation, another study concludes that there is a gap between universities and within countries. The authors analyzed different degrees of maturity in adopting technologies in five countries, Argentina, Brazil, Chile, Mexico, and Peru, and compared universities of different sizes and sectors. The results showed that in the case of public institutions, they have more significant obstacles to using technologies because they face higher levels of uncertainty and complex bureaucratic systems [28]. However, in the case of private universities with large budgets, they do not present a problem with the effective use of technological resources and can achieve greater maturity in digital transformation, although they do present a problem in covering huge populations. Furthermore, according to these authors, in Latin America, there are still deficiencies related to internet access, infrastructure, organization, the development of digital skills, and digital training.

Digital transformation is a fundamental element for achieving better economic and social development conditions within the industry 4.0 economy and the fourth industrial revolution. Indeed, digital transformation allows the generation of innovation opportunities for the region [29]. However, authors such as Argüelles Cruz et al. [30] state that there is still work to be done in Latin America to achieve this transformation and recommend that governments generate public policies aimed at the education sector, fostering the integration of new technologies and the application of innovative solutions that promote new models and ways of participating in the knowledge society. Initiatives along these lines will be of great importance to achieving the development required by Latin American countries.

1.2. Educational Innovation and Impact on the Institution

Educational institutions must face the requirements of the knowledge society and adapt to a modern world where change is a constant. Hansen [31] argues that this change needs to come from the classrooms, classes, and the university itself, where solutions can

be sought to the problems and can meet students' needs. This process implies a change in the way teaching is practiced and suggests the role of the teacher must change to include the formulation of simulations and proposals that allow the testing of the competencies of students through robust and complex tasks [32]. Therefore, the focus should be on developing innovation competencies, new methods, and resources integrated into the teaching planning to help students acquire the necessary skills for the knowledge society [33]. This process also implies being open to incorporating innovations in educational practices, mainly when technologies mediate the learning environments.

In recent years, the integration of ICTs in education has increased. Many higher education institutions (HEIs) strive to invest in digital technologies to support the teaching and learning processes and curricula [34]. The interest in promoting innovative proposals in teaching and learning processes aims to better prepare graduates for the labor markets, which require skills and competencies that adapt to their needs [35]. Educational innovation is any dynamic change that seeks to improve educational processes and measure results, both participant satisfaction and educational performance [36]. This measurement of results will depend on how the change intended permeates within the educational context in which it is developed.

The results of educational innovations need to be measured and evaluated to determine their outcome and impact on student learning. Furthermore, with the expansion in ICTs in all educational modalities, research on their effectiveness in teaching and learning processes is growing [37]. According to the OECD [38], taking advantage of innovation motivated by technological advances favors the availability of resources and the skills for their use. The role of the teacher is also acquiring new functions, which requires appropriate professional development [39]. However, identifying the use of research findings in teachers' practice and then assimilating it is a high-level skill that is not developed to a significant level during teacher training [40]. The dialogue between researchers and educators allows an educational practice oriented to the school's needs.

Pedagogical and technological trends in education and their potential for improving educational processes have been the subject of study by several organizations. One of them is the case of the Horizon Report, which, since 2004, has held discussions with expert panelists to determine the trends for the coming years. The report presented for the year 2021 shows that the rapid changes of the past year have forced institutions to move teaching and learning operations online, making digital technologies indispensable for education [2]. This year, the main technological trends are artificial intelligence, hybrid and blended course models, learning analytics, micro-credentials, open educational resources, and quality online learning. The evaluation of these practices was based on the consultation on their usefulness in addressing issues of equity and inclusion, their potential to have a significant impact on learning outcomes, the risks, the level of funding required to implement them, faculty receptivity, and their importance to institutions.

In Mexico, Tecnologico de Monterrey consulted innovative teachers and professors on the main trends in pedagogy and technology. Through a Delphi method, teachers evaluated each trend's present and future impacts on their classroom practice, and 26 trends in pedagogy and 19 trends in educational technology were identified [41]. According to this study, challenge-based learning, competency-based education, flexible learning, gamification, and project-based learning are the main pedagogical trends. Technological trends include adaptive learning, social networks, collaborative environments, mobile learning, big data and analytics, and massive open online courses (MOOCs).

Internationally renowned educational institutions recognize the importance of educational technology and technology-derived educational innovations. Table 1 shows that each of the five universities at the top of the QS World University Rankings [42], the annual publication by Quacquarelli Symonds, has at least one initiative that systematically finances educational innovations proposed by professors, with two of these institutions having not one, but up to four initiatives financing educational innovation and technology. In Latin America, authors found initiatives for most of the top five universities in the rank-

ings. Universidad de Buenos Aires and Universidad Nacional Autónoma de México have funding initiatives for educational innovations. Tecnologico de Monterrey and Pontificia Universidad Católica de Chile each have their own initiative but are also working with Universidad de los Andes (QS Rank: 236) in a joint initiative called Novus La Triada. The authors could not find a similar initiative for Universidade de São Paulo but attribute it to a language barrier.

Table 1. Educational innovation grants in the Top 5 universities and top 5 Latin American universities according to the QS World University Rankings 2022. Adapted from [42].

Institution	QS Rank	Region	Name	Starting Year	Source
Massachusetts Institute of Technology	1	World	J-WEL Grants in Higher Education Innovation	2017	https://jwel.mit.edu/j-wel-grants-higher-education-innovation-2021 (accessed on 6 August 2022).
Massachusetts Institute of Technology	1	World	J-WEL Grants in pK-12 Education Innovation	2018	https://jwel.mit.edu/pk-12-innovation-grants (accessed on 6 August 2022).
Massachusetts Institute of Technology	1	World	J-WEL Workforce Learning Innovation Research	2020	https://jwel.mit.edu/workforce-learning-grants (accessed on 6 August 2022).
Massachusetts Institute of Technology	1	World	d'Arbeloff Fund for Excellence in Education	1999	https://registrar.mit.edu/faculty-curriculum-support/education-initiatives-funding/darbeloff-fund-excellence-education (accessed on 6 August 2022).
University of Oxford	2	World	Summer of Innovation	2015	https://blogs.it.ox.ac.uk/innovation-challenges/summer-of-innovation/ (accessed on 6 August 2022).
University of Oxford	2	World	Higher Education Innovation Fund (HEIF)	2018	https://re.ukri.org/knowledge-exchange/the-higher-education-innovation-fund-heif/ (accessed on 6 August 2022).
Standford Medicine	3	World	The Stanford School of Medicine Tuition Revenue Sharing	No information	https://med.stanford.edu/tuition-revenue-sharing/innovation-funding.html (accessed on 6 August 2022).
University of Cambridge	4	World	Cambridge Technology-Enabled Learning Prize 2021	2019	https://www.cambridge.org/core/cambridge-technology-enabled-learning-prize-2021 (accessed on 6 August 2022).
University of Cambridge	4	World	Teaching and Learning Innovation Fund (TLIF)	No information	https://www.cctl.cam.ac.uk/newsletter/teaching-grants (accessed on 6 August 2022).
University of Cambridge	4	World	The Pilkington Prize	1994	https://www.cctl.cam.ac.uk/pilkington-prize (accessed on 6 August 2022).
University of Cambridge	4	World	Student-Led Teaching Awards (SLTAs)	No information	https://www.cambridgesu.co.uk/yourvoice/projects/student-ledteachingawards/ (accessed on 6 August 2022).

Table 1. *Cont.*

Institution	QS Rank	Region	Name	Starting Year	Source
Harvard University	5	World	Operation Impact	2018	https://www.operationimpact.net/funding (accessed on 6 August 2022).
Harvard University	5	World	Spark Grants	2013	https://innovationlabs.harvard.edu/spark-grants/ (accessed on 6 August 2022).
Harvard University	5	World	i3 Innovation Challenge	2006	http://tech.seas.harvard.edu/harvardi3 (accessed on 6 August 2022).
Universidad de Buenos Aires	69	Latin America	UBANEX	2014	https://www.uba.ar/#/ubanex (accessed on 6 August 2022).
Universidad Nacional Autónoma de México	105	Latin America	Programa de Apoyo a Proyectos para Innovar y Mejorar la Educación	2019	https://dgapa.unam.mx/index.php/fortalecimiento-a-la-docencia/papime (accessed on 6 August 2022).
Universidade de São Paulo	121	Latin America	None found	–	–
Pontificia Universidad Católica de Chile	135	Latin America	Novus Tríada	2019	https://latriada.tec.mx/es (accessed on 6 August 2022).
Pontificia Universidad Católica de Chile	135	Latin America	Fondo para la Mejora y la Innovación en la Docencia	2013	http://fondedoc.uc.cl/ (accessed on 6 August 2022).
Tecnologico de Monterrey	161	Latin America	Novus Tríada	2019	https://latriada.tec.mx/es (accessed on 6 August 2022).
Tecnologico de Monterrey	161	Latin America	Novus	2012	https://novus.itesm.mx/ (accessed on 6 August 2022).

1.3. Context

Tecnologico de Monterrey is a private, non-profit Mexican university founded in 1943. It has twenty-six campuses throughout the country and eighteen international branches and offices around the world.

More than ninety thousand students are in the three levels of Tec de Monterrey's educational offerings: high school, professional careers, and graduate programs. These levels are usually referred to as Preparatory, Professional, and Postgraduate, respectively. In addition, more than ten thousand professors work in the various areas of study offered by the university: Engineering; Information Technology; Business; Health Sciences; Architecture, Art and Design; Humanities and Social Sciences at the Professional level. The academic year of this university is divided into two semesters: the first semester begins in August and ends in December. The second one begins in February and ends in June.

In terms of rankings, Tecnologico de Monterrey is located in the top three of the best universities in Latin America, according to the QS Latin America Rankings 2021 [42]. In Mexico it is number two, according to the QS World University Rankings 2021. In addition, in terms of employability it is in the top 40, according to QS Employability Rankings 2020 [43].

Finally, it is worth mentioning that research is an essential activity for this university. "For Tecnologico de Monterrey, research is a strategic activity. Scientific knowledge is the engine that generates innovative solutions for the economic, social, and environmental development of our country" [44]. Tecnologico de Monterrey stands out for research in biotechnology, health, sustainable development, mechatronics, nanotechnology, business, and the manufacturing industry [45].

1.3.1. Tec21 Educational Model

In the year 2013, ITESM began to evolve towards a new educational model: The Tec21 Model. Its objective is "to provide comprehensive training and improve the competitiveness of students in their professional field through enhancing the skills of the coming generations to develop the required competencies that will enable them to become the leaders who face the challenges and opportunities of the 21st century" [46] (p. 6).

The Tec21 Model is unique globally, with a pedagogical basis in Challenge-Based Learning (CBL). A challenge is "a life experience designed to expose the student to an engaging and challenging situation in their environment" [47]. Student learning is centered on the student's relationship with their teacher and with the environment. Students develop disciplinary and transversal competencies by resolving challenges linked to real problems and demonstrating their mastery through various evidence of learning. In the model, competency is "the conscious integration of knowledge, skills, attitudes, and values that allow successfully facing both structured and uncertain situations" [46] (p. 6). Disciplinary competencies point to the capabilities focused on the course and study area chosen by the student. On the other hand, transversal competencies are the capabilities "indispensable to be a transformational leader in any environment in which the student develops" [44].

Within the Tec 21 Model, there are two essential elements: personalization and flexibility. As shown in Figure 1, students acquire the fundamentals of the area, learn about related careers, and confirm their career choice. Subsequently, they concentrate on more focused challenges where they develop the core competencies of the career and broaden their university experience. The student's interests, passions, and plans strengthen their competencies through various concentrations, internships, and certificates available. Another vital element is the faculty profile, which creates active learning environments and finds in the challenges a trigger for the formation of disciplinary and transversal competencies to guide the student to transfer that knowledge to real contexts. In addition, they work in a multidisciplinary and updated manner with links to their professional practice.

Figure 1. Route to be followed by the student in the Tec21 Model [44].

1.3.2. Novus

This initiative is responsible for funding and providing methodological support to professors at Tecnologico de Monterrey who have an educational innovation project.

This initiative issues a call for proposals at the beginning of each academic year and is aimed at any member of the Educators and Mentors Community of Tecnologico de Monterrey. Since 2020, it has been established that the minimum number of participants in each proposal must be two members: one faculty member will represent the team as

the "Project Manager", although any other collaborator or invited member is expected to collaborate with the preparations, implementation, and impact measurement for the proposed project. In the case that a selected project manager does not have a permanent contract with the institution, they will need to include at least one permanent-contract faculty member willing to manage the budget, as these contracts are active all year, and the budget will not be limited to academic periods.

All proposals are then revised by a committee of experts in educational technology and innovation projects. Each proposal is reviewed by three people, using an in-house scoring rubric developed for the initiative. Evaluators also leave a yes/no final recommendation to fund. After the evaluation process, the Novus team selects those that score higher in the evaluation rubric and have at least two positive recommendations. The number of selected proposals varies over the years, but generally 50 and 150 projects are funded each year (L. Peña, personal communication, 20 July 2022). The selected proposals from the 2021 call will benefit institutional resources in the range of USD 1000 to USD 15,000, depending on what was requested by each project at the time of application. Novus contestants receive the selection results via email during August, but resources are not allocated until January of the following year and are active for 18 months, which is the amount of time a Novus project is expected to be implemented and its impact measured.

Novus aims to find innovative proposals "designed to solve a problem in the teaching-learning process (with emphasis on learning) or the process of leadership training and student development" [12]. It is worth mentioning that the proposed projects must be aimed at innovation for one of the three academic levels of ITESM (High School, Professional, or Postgraduate). Proposals can be cross-cutting, i.e., directed at two or three levels, or they can be a Student Leadership and Training project. Currently, the team that manages this initiative consists of the Operational Coordinator, Academic Coordinator, Experimentation Mentor, and Experimentation and Impact Measurement Leader.

2. Methods

The research followed a case study methodology with a qualitative approach [48]. This methodology allows inquiry into a particular case to understand a specific issue [49], and researchers can explore data from multiple sources such as documents and reports [50]. This case study sought to describe the impact of the Novus grant on the development of technology-based educational innovations proposed by professors to conduct evidence-based research. The authors selected the case to highlight the importance of learning about initiatives that promoted ICTs in education and could be disseminated in other contexts, especially in Latin America, where their use is still developing. For this purpose, we conducted an in-depth analysis of the available data on this initiative.

Past Records

We searched records thoroughly, including the final reports on every Novus generation from 2012 until 2019. The report on the 2020 generation was also included, despite projects still running at the time. Data obtained from records included the project leader's information (name, institution ID, e-mail, campus) and the educational technology used. We crossed full participant information of records from 2018 to 2020 with internal faculty databases to obtain gender, educational level, and contract type for participating faculty members. The same 2018–2020 records were consulted to obtain the number of declared impacted students and courses.

In addition, we conducted a Scopus search to determine the number of indexed scientific publications derived from Novus projects and crossed them with participation data for Novus entries in the QS Reimagine Education Awards.

3. Results

The following are the results found in the Novus project databases from 2012 to 2021. These results have been organized according to the research questions above, under the

following sections: (1) the distribution of projects, (2) educational technologies used, (3) the number of students and courses impacted, (4) the impact on faculty, (5) the impact on publications and international awards.

3.1. Distribution of Projects

The Novus grant has funded 933 projects in the last ten years (Figure 2). Figure 2a shows the distribution across the different Mexican states, which shows most grants (168) awarded to the Monterrey area campuses, which include the Monterrey campus, two graduate schools, and five high school campuses; Colima is the campus with the least amount of grants awarded so far (1). Figure 2b shows the number of Novus projects granted institutional resources each year. Since 2012, this number has been increasing, with 2019 reflecting the latest changes made in order to focus on accepting projects grounded on published evidence, and 2020 reflecting the impact of the COVID-19 pandemic.

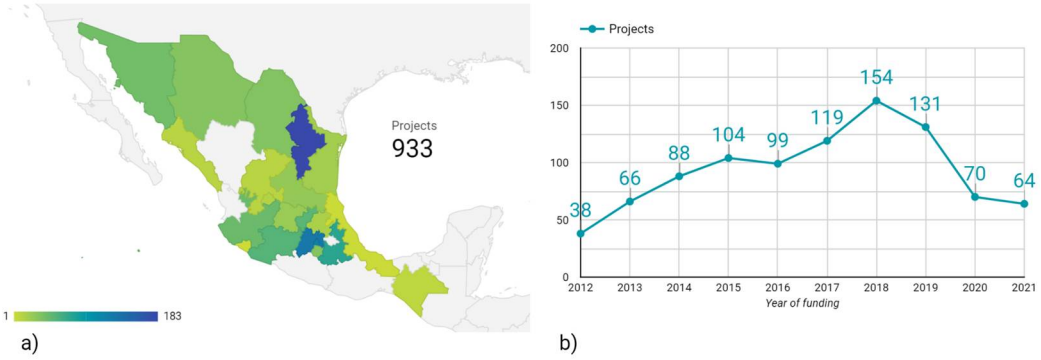

Figure 2. Total Novus projects accepted for funding: (**a**) distribution by state/campus, (**b**) distribution by generation (year accepted).

Of the total projects that the Novus grant has funded, 485 (52%) were led by professors at the School of Engineering and Sciences, 122 (13.1%) by High School teachers, 104 (11.1%) by professors of the School of Business, 71 (7.6%) by professors of the School of Humanities and Education, 52 (5.6%) by professors of the School of Architecture, Art and Design, 39 (4.2%) by professors of the School of Medicine and Health Sciences, 17 (1.8%) by professors of the School of Social Sciences and Government. The leaders for the remaining projects (4.6%) could not be linked to one school using the current faculty databases.

3.2. Educational Technologies

The Novus initiative has served as a gateway for teachers and professors to test a great diversity of educational technologies, as shown in Table 2. In this sense, the initiative works as an organizational learning tool to understand the trends and preferences of the professors in terms of educational technology and the challenges faced in the classroom. Implementation of extended realities is the most prevalent of educational technologies. Out of 132 projects (14.15% of the 933 projects), 55 projects (5.89%) implemented virtual reality, while teachers implemented augmented reality in 35 projects (3.75%) and 360-video immersive experiences in 25 projects (2.68%), and 17 projects (1.82%) used mixed reality in the learning experience. The development and use of web platforms and mobile applications were recorded in 131 projects (14.04%), with 88 projects developing a web platform (9.43%), and the remaining 43 projects developing a mobile app (4.61%).

Table 2. Educational technology used in the different Novus projects, 2012-2020.

Technology	PROJECTS	%
Extended realities	132	14.15%
Web or mobile app	131	14.04%
Artificial intelligence	91	9.75%
Virtual and remote laboratories	63	6.75%
Maker movement	59	6.32%
Robotics	58	6.22%
Telepresence	48	5.14%
Video tutorials	29	3.11%
Internet of things	25	2.68%
Neurocognition	18	1.93%
Educational software (license)	17	1.82%
Ebook	12	1.29%
Collaborative learning through social media	11	1.18%
Smart classrooms	10	1.07%
MOOC	8	0.86%
Video games	8	0.86%
Wearable technology	7	0.75%
Haptic technology	4	0.43%
Hologram	3	0.32%
Blockchain	2	0.21%
Telescopes	2	0.21%
Projection mapping	1	0.11%
None	194	20.79%
Total	933	100%

A total of 91 (9.75%) implemented artificial intelligence to support the learning or teaching process: machine learning in 35 projects (3.75%), adaptive learning in 32 projects (3.43%), and data analytics in 24 projects (2.57%). Virtual and remote laboratories were implemented in 63 projects (6.75%). A total of 59 projects (6.32%) took a Do-it-Yourself approach to their learning experiences. Finally, 58 projects (6.22%) dealt with the design, construction, and operation of robots, and thus were classified as Robotics. Other interesting technologies that were implemented in the Novus projects were the Internet of Things (IoT; 25 projects, 2.68%), Neurocognition (18 projects, 1.93%), the development of eBooks (12 projects, 1.29%), and Smart classrooms (10 projects, 1.07%). The least used technology, with one project, was Projection mapping, followed by Blockchain (2) and Holography (3). It is important to note that Novus also funds educational innovations that do not rely on educational technologies, as seen in 194 projects (20.79% of the total).

Figure 3 shows how the most common educational technology has been used in Novus projects over the years, in the past decade. Extended realities have been on the rise, even more so after the pandemic (Figure 3b). The development of web or mobile applications has been in decline, with popularity rising once again in the last two years (Figure 3c). Projects dealing with artificial intelligence had a slow surge until 2018 and then their popularity declined (Figure 3d); the authors attribute this to the difficulty, higher costs, and amount of work by developers that must be invested into the project. Virtual and remote laboratories had also been in decline until the pandemic, as can be noted in Figure 3e. Projects that involve a makers movement component (such as 3D-printing) (Figure 3f) have had a steady presence through the years. Finally, projects that aim to bring people together through technology have been in slow decline, even during the pandemic; the authors attribute this to communication platforms such as Zoom and MSD Teams being part of the "new normal".

Figure 3. Educational technology used in Novus projects from 2012 to 2021: (**a**) most commonly used educational technology for Novus projects, (**b**) extended realities, (**c**) web or mobile apps, (**d**) artificial intelligence, (**e**) virtual or remote laboratories, (**f**) makers movement, (**g**) telepresence.

Educational innovations that rely on technology have also become more common over time. As evidenced in Figure 4, the percentage of projects in which teachers and professors explored educational technology was lower than in recent years, especially after the pandemic. From 2019 onwards, educational technology has impacted 647 institutional courses and 15,927 students from high school to graduate education.

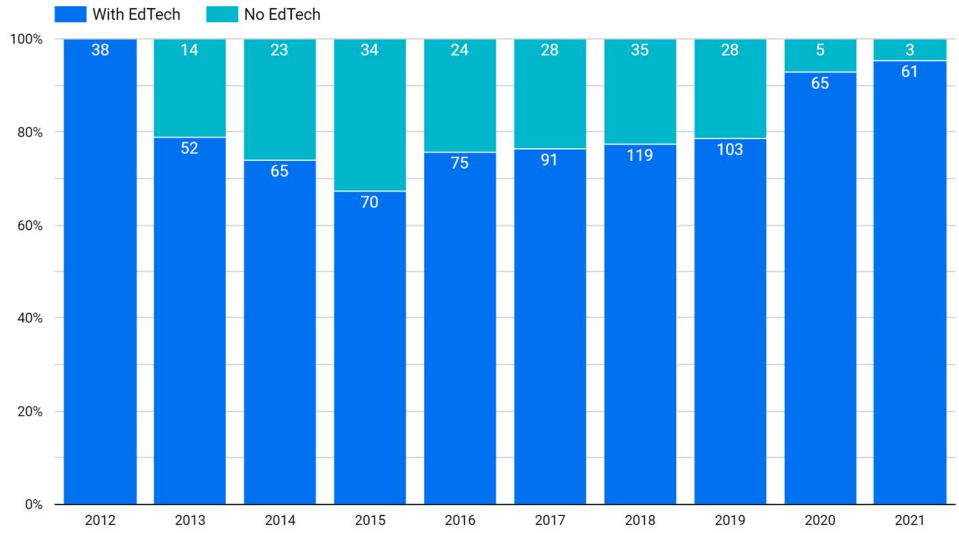

Figure 4. Percentage of Novus projects that use educational technology for all Novus projects in the last 10 years.

Novus projects have had a positive impact at different levels of the institution. Faculty members can implement educational innovations and conduct experiments to measure the impact of their ideas. The professors expressed the opinion that implementing a Novus project was their first experience with educational innovation, although room for improvement was mentioned regarding some operational processes [51]. It is expected that some degree of measuring impact is conducted for all implemented Novus projects. This allows non-researcher faculty staff to develop skills and competencies related to educational experimentation. Finally, should a project become licensable intellectual property, another team of experts will guide the faculty towards an entrepreneurship track.

Leadership in the institution has also benefited from Novus projects, thanks to the initiative serving as a testing ground for educational software, app development, and other educational technology that could be implemented in the learning experiences. Impact measurements were taken in terms of educational variables and indicators related to knowledge acquisition, skills development, or attitude assumption, which has led the initiative as a whole to be present in the institution's yearly Educational Innovation Report since its inception in 2018 (C. R. Garcia, personal communication, 11 March 2019); this is an institutional report that showcases educational innovation practices, and the state of their deployment and implementation at Tecnologico de Monterrey [52].

3.3. Number of Courses and Students Impacted

Since the initiative was initially focused on implementing technology in the classroom, not much was reported about impacted students, groups, and faculty during the initial years. Records from 2018 and onwards show that Novus educational innovations have impacted 33,280 students on 1017 institutional courses. Based on the ratio of projects to the number of impacted students and courses, the authors estimate that the Novus project has impacted more than 65,000 students and 1700 courses since 2012.

3.4. Impact on Faculty

Participant records from 2018 to 2020 show that 360 teachers and professors participated in 2018. In 2019, Novus started to allow the faculties to include people from outside

the institution, to promote collaboration with other educational institutions but also as a way of having proposals close the gap between the classroom and industry; this resulted in a total of 452 participants, with 408 being from the institution and 44 from other educational institutions, enterprises, and even non-governmental organizations. This was also observed for the 2020 generation: out of 245 total participants, 232 worked in the institution, and 13 worked outside Tecnologico de Monterrey. This decrease in the number of participants may be attributed to the beginning pandemic isolations world-wide. Finally, during the year 2021 and with faculty staff more used to working remotely, collaborations with other institutions almost doubled. This information can be seen in Figure 5.

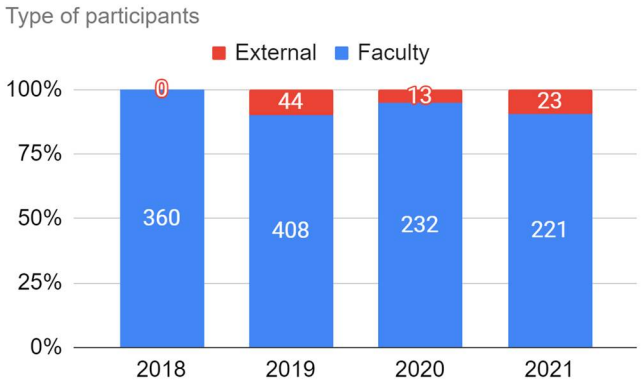

Figure 5. Types of Novus project participants from 2018 to 2021.

Women-led projects represented about 40% of the total, a trend maintained in all three Novus generations from 2018 to 2021 (Figure 6). Most participating faculties had a permanent contract with the institution, which is expected behavior. While temporary professors can participate in Novus projects, if they want to lead one, they also need to include a permanent-contract faculty member willing to manage the institutional resources. This is seen in Figure 7.

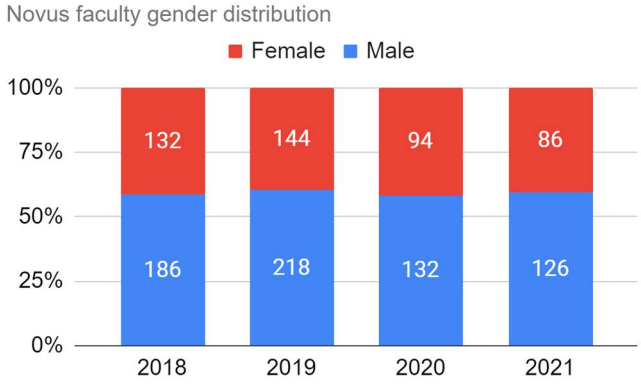

Figure 6. Novus projects participants by gender from 2018 to 2021.

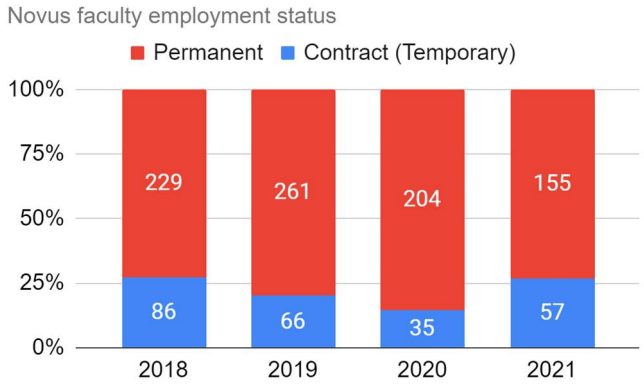

Figure 7. Novus projects participants by employment status from 2018 to 2021.

The minority of participating faculty staff do not have a graduate degree (Figure 8). This is also expected behavior, since staff are required to be of an educational level above the course level they are expected to teach (e.g., to teach a master's degree course, one must hold a doctoral degree).

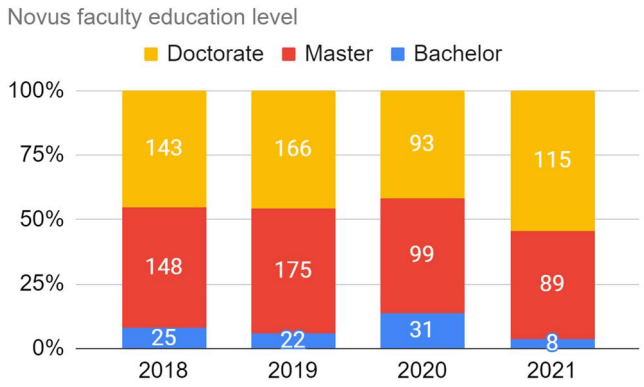

Figure 8. Novus projects participants by education level from 2018 to 2021.

Participating in the projects allowed the faculty to improve their competencies and knowledge related to educational innovation. In interviews with teachers and professors participating in the Novus initiative, they mentioned that in the beginning they did not know how to approach each phase of the design and development of a project. As one teacher commented, "*Participating in the project allowed me to acquire the knowledge I did not have before. I have learned to pay more attention to what works; as I evaluate it all the time, I can know what works from what I am implementing*" (Novus faculty Gen. 2017). All interviewees agreed that having the opportunity to carry out an educational innovation project allowed them to learn about processes usually managed by the higher tiers of an institution. As stated by another professor, "*Participating in the Novus project allowed me to reflect on my teaching practice and identify those students are changing. So, you have to be flexible, and you can connect with them through technology*" (Novus faculty Gen. 2016).

The professors also recognized that Novus participation allowed them to achieve greater international recognition through their participation in international competitions, as well as invitations as speakers at different workshops and conferences which they mention in their comments, "*Our peers have recognized our innovation, and we have obtained awards in QS Reimagine Education, we have also been invited to other countries to give workshops. The recognition is that we are showing how innovation can be achieved and the importance of the methodological design we use in our project*" (Novus faculty Gen. 2019). Another professor mentioned, "*Having publications helped me grow by receiving recognition from abroad. They sought me from another university to participate in a congress because they saw my expertise in the subject*" (Novus faculty Gen. 2013).

Additionally, participation in these activities allowed them to grow in their professional development. As one of the professors mentioned, "Participating in the Novus project gave me new opportunities. A year after finishing the project, I demonstrated experience in teaching innovation, so I got recognition to grow in my professional career, thanks to being attentive to innovate and experience what has served me for professional practice" (Novus faculty Gen. 2016). Another professor mentioned, "I have learned a lot, thanks to the participation in the projects I have learned research techniques, teaching techniques and how to include educational innovation in the discipline which has benefited my students, in my professional practice it does impact" (Professor Novus Gen 2017).

3.5. Impact on Publications and Awards Obtained

This extensive use of educational technology in Novus projects aims to develop a culture of evidence-based innovation among the faculty. Tecnologico de Monterrey has produced 565 papers on educational innovations since 2017. Novus-funded projects represent 21% of institutional publications, evidenced by a search performed in the Scopus database with the strings shown in Table 3. This number of publications, and thus the Novus initiative, have positioned Tecnologico de Monterrey among the world-leading universities in the field of educational innovation.

Table 3. Scopus search for scientific publications attributed to Tecnologico de Monterrey on educational innovations and those funded by Novus. Adapted from [26].

	Tecnologico de Monterrey	**Novus**
Scopus character string	TITLE-ABS-KEY ("educational innovation") AND AF-ID ("Tecnologico de Monterrey" 60007966) AND PUBYEAR > 2017 *	FUND-ALL ("NOVUS") AND AF-ID ("Tecnologico de Monterrey" 60007966) AND PUBYEAR > 2017 *
Article	200	50
Conference	344	65
Others **	21	1
Total	565	116

* Search query includes results from 2018 to 1 September 2022. ** Includes books chapters reviews, notes and editorials.

The accelerated growth in the number of publications originating from Novus projects in the last few years is striking. According to Scival [53], publications increased 167% from 2019 to 2021, due to the participants' commitment to publishing in high-impact journals and participating in conferences. The institution's publications have increased by 62% in the last 3 years, indicating the great impact that publishing Novus projects results has had on the faculty.

As shown in Table 4, 22.4% of the publications originating from Novus projects were produced in collaboration with international institutions such as the Massachusetts Institute of Technology, the Polytechnic University of Valencia, and the University of California at Berkeley, among others. Regarding citations, the publications total 335 and have a Field-Weighted Citation Impact of 1.05, which means the output is more cited than expected according to the global average [53]. The scholarly output of faculty members from Tecnologico de Monterrey (includes Novus faculty), the rest of the world, and from Novus faculty only from 2018 to 2022 is presented in Figure 9.

Table 4. Scholarly output funded by Novus from 2018 to 2022, by the amount of international, national, and institutional collaboration. Retrieved from SciVal with data from Scopus database using string query from Table 3. Adapted from [53].

Metric		Scholarly Output	Citations	Citations per Publication	Field-Weighted Citation Impact
International collaboration	22.4%	26	36	1.4	0.91
Only national collaboration	12.1%	14	41	2.9	1.86
Only institutional collaboration	62.9%	73	203	2.8	0.98
Single authorship (no collaboration)	2.6%	3	12	4.0	0.38

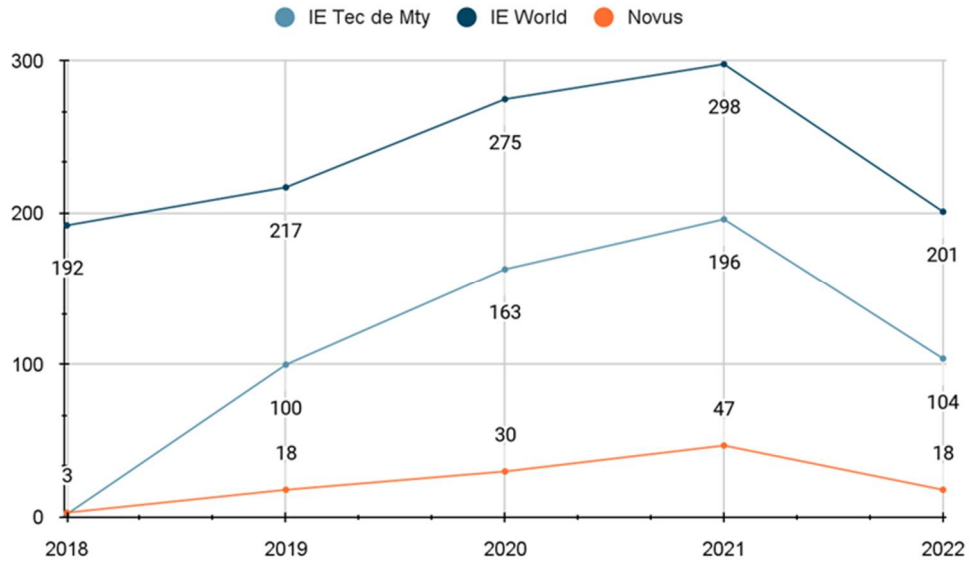

Figure 9. Scholarly output of faculty from Tecnologico de Monterrey (includes Novus faculty), the rest of the world, and from Novus faculty from 2018 to 2022. Retrieved from SciVal with data from Scopus database using string queries adapted from Table 3.

Novus projects have participated in international events and have received awards. For example, Novus projects have been internationally recognized during various editions of the QS Reimagine Education Awards, as shown in Figure 10. Examples of awarded projects can also be found in Table 5. These publications and the recognition at international events help showcase how faculty-led Novus projects use educational technologies to impact student learning and development.

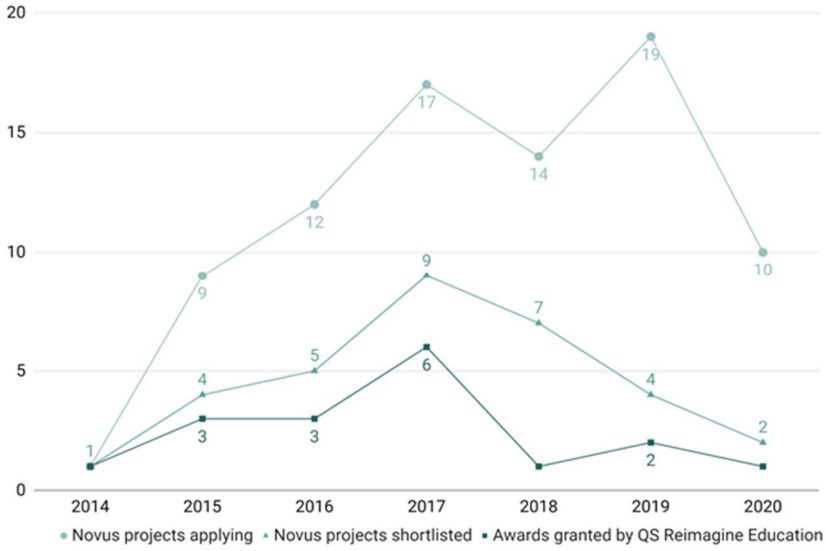

Figure 10. Novus projects participation in QS Reimagine Education Awards, adapted from [54].

Table 5. Examples of Novus entries for the QS Reimagine Education Awards, the year of Novus funding, the educational technology used for the projects, and the impact reported in scientific publications. Adapted from [54].

Year	Entry Name	Category (Award)	Novus	Technology	Description and Results	Reference
2016	Professor Avatar—Telepresence Model	Best use of ICT tools (Gold)	2012	Telepresence, holographic projection	Allows students in a distance-learning experience to "feel" the presence of the instructor in the classroom through human-scale holographic image, bi-directional audio, and video and autonomous movements of a remotely controlled robot. The experience has been deployed nationally, and since 2013 some courses have been taught using this Hologram Professor Model.	[55,56]
2017	Open Innovation Lab for Rapid Realization of S3 Products	Latin America Region (Gold), Engineering and IT (Gold), Hybrid Learning (Silver)	2018	Virtual reality, 3D printing	Provides innovative resources that support the exchange of knowledge and experiences during the innovation process of new product development. Its use in engineering courses as well as specific projects such as research summer boot camps, demonstrates the development of critical skills exposed in this work by challenging the students to adapt new forms of collaboration. As a result, several innovative products have passed from the divergence to the convergence of the idea, in most cases achieving the manufacturing stage.	[57]

Table 5. *Cont.*

Year	Entry Name	Category (Award)	Novus	Technology	Description and Results	Reference
2017	Touching Math: From concepts to reality through 3D tools	Natural Sciences (Gold), Latin America Region (Silver), Presence Learning (Bronze)	2012, 2015, 2017	Augmented reality, virtual and remote laboratories	Combines a platform that allows authorship, manipulation and visualization of geometric models of surfaces in a remote 3D environment, and a mobile application with two sections that allows the performance of different exercises and multivariable calculus operations to improve the mathematics teaching-learning process and enhance students' spatial visualization and orientation skills with the use of these 3D tools. Results show that students' final grades have increased, and the failure rate has decreased significantly.	[58]
2018	Lean thinking learning space (LTLS)	Hybrid Learning (Silver)	2015	Make movement	Presents a flexible and innovative physical space with all the real factors of a productive process, where the students are immersed in the experience and make decisions to create an efficient transformation with zero waste. Experimentation shows an increase of 29% in the level of attainment of the ability to design a system, component, or process to meet the desired needs within realistic limitations.	[59]
2019	Hands-on experience with Star Wars Robotics	Latin America Region (Silver), Engineering and IT (Silver)	2016	Robotics, 3D printing	Introduces first-semester engineering students to a robotics workshop as part of their introductory experiences in the initial semesters of Mechanical, Industrial, Automotive, Electrical, and Mechatronics programs. An in-house 3D printed droid was programmed by the students, with the aim of having practical applications for their studies from the very beginning. Results show students are engaged in the experience, and it helps them reaffirm their decision about studying an Engineering Major.	[60]

4. Discussion

This study sought to present the results of an initiative that promotes evidence-based research conducted by professors in a Mexican university. The results presented show the impact of this type of innovation on the digital transformation and local, regional, and global positioning of an educational institution, based on technology-based proposals. According to the literature, there are significant challenges for Latin American universities in digital transformation. The situation caused by the pandemic exposed the shortcomings they face, especially in terms of infrastructure, teacher training, and access to technological resources [3,4]. It was also found that the results of the initiatives that provide funds for research and experimentation by professors are little-publicized and not well-known [13,14]. Therefore, initiatives such as the Novus grant contribute to generating innovations that could allow these institutions to adapt to the knowledge society's requirements.

The institution's support of educational innovation initiatives can favor the quantity and scope of these professors' proposals, which strengthens a culture of innovation. This study shows that over the years there has been an increase in the number of innovation

projects favored by this initiative that involve different campuses within the country and are promoted by professors from different disciplines. These results are consistent with international organizations that indicate that investment and support for innovation favor digital transformation as a continuous process that benefits educational institutions [20,29]. Therefore, the efforts made to develop strategies that promote the use of technologies will be of vital importance to meet the needs of Industry 4.0 and the updating of educational institutions [16,21], especially in the context in which we find ourselves and in which Latin American universities are still in the early stages of the digital maturity process [27]. This digital transformation has also led to the development of new technology implementations.

Trends in higher education show an increase in the use of ICT-supported pedagogical strategies. This study shows that institutional support for educational innovation initiatives led by professors has led to the successful implementation of new technologies with impact inside and outside the institution. As can be seen, extended realities, robotics, virtual and remote laboratories, and artificial intelligence, among other emerging technologies, have been widely used at Tecnologico de Monterrey, thanks to the Novus initiative. According to reports related to new trends, all these technologies are booming, mainly because of the current situation with COVID-19, where it is indicated that the trends being implemented globally should be understood to bring them to particular environments [2]. In addition, it should be considered that funding for higher education is increasingly limited and requires more efficient use of resources to continue providing opportunities for professors to implement educational innovations and for students to work with innovative educational models.

Regarding the impact of the Novus grant to promote educational innovations, it was found that different actors have felt its effect. On the one hand, the number of students and courses impacted within the university has accelerated over the years; similarly, professors' interest in presenting new innovative proposals has also increased. In the case of faculty members, they can apply educational innovations and conduct experiments to measure the impact of their ideas, whereas non-research faculty members can develop skills and competencies related to educational experimentation. In addition, the extensive use of educational technology in Novus projects has contributed to developing a culture of evidence-based innovation among the faculty members. This finding supports what is mentioned by other authors who affirm the need to change the way of thinking about educational systems, adapt to new ways of learning using technology [22,23], and ensure that teachers/professors have a fundamental role in its effective implementation [24]. Hence, the efforts to favor this development through the Novus grant have generated greater visibility for the institution through the presentation of projects at international conferences, in academic publications, and in global competitions.

5. Conclusions

This case study presents the way that the Novus grant encourages educational technology use and evidence-based research by providing financial and methodological support to implement educational innovations and measure their impact within a structured scientific methodology.

As mentioned in the literature, the use of new technologies in education is still emerging, especially in the case of the Latin America region, where there are still infrastructure problems and a digital divide, due to the lack of adequate internet connections and appropriate and sufficient devices, as well as teacher training to carry out this task [3,30,34]. This situation has become more evident due to the contingency suffered in the last two years caused by the pandemic. We have to consider that changing the culture of the faculty is difficult, but even more so when talking about technology. In this sense, we emphasize the dissemination of the experience accumulated in Novus during these 10 years, in which the development of educational innovations by professors has contributed to detonating a culture of innovation in the institution and positioning it internationally. We share not only a Latin American point of view, but also an efficient ecosystem that

fosters continuous trial and error concerning educational innovations. We consider our contribution could help any institution seeking to empower the faculty staff, especially regarding educational technology.

The Novus grant has been working since 2012, granting funds to educational innovation projects proposed by professors. The use of technology has been relevant to making the institution visible as innovative, thanks to the projects positioned in international competitions and forums. Therefore, this work has demonstrated that a difference can be made in the context of HEIs thanks to the investment and leadership promoting faculty participation. As a limitation of this research, it is found that not all the data for all the years are available; however, work is being done to strengthen the information available to present increasingly robust data, a process that was started in 2019, in which the Novus grant strengthened the management tools to obtain information on the projects. The impact of Novus projects has been to support the international recognition of the institution; moreover, there is also an impact at the professional and personal level of the professors, through the development of competencies and greater involvement with the improvement of the teaching and learning processes, so for future research it will be important to identify this impact on the professional development within the faculty to continue strengthening this growth. In addition, it is important to continue to deepen the analysis of successful cases generated by these proposals and share methodologies that other institutions can use to generate similar proposals for future studies. We believe that this research may be of interest to presidents and directors of other educational institutions, especially in Latin America, so that they can learn more about this initiative and even generate other similar actions that promote digital transformation within their universities, as well as supporting professors to investigate the integration of ICT into the teaching-learning processes.

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