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Knowledge Transfer in Higher Education Institutions Focused on Entrepreneurial Activities of Electronic Instrumentation

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Abstract: Although society, governments and the business sector are increasingly demanding that Higher Academic Centers translate their innovative potential into products and services that affect society, little is known or done about the entrepreneurial skills that both lecturers and students need in the context of electronic engineering academic degrees. Inevitably, the fact that some teachers lack certain skill sets will have a negative impact on some students' professional careers. This article demonstrates a range of initiatives in knowledge transfer which have been carried out over more than 30 years by the university research team making the proposal. Such initiatives have allowed the integration of, not only creative thinking, but also other skills differing from traditional teaching and which can help students to successfully compete for jobs requiring higher qualifications. Following the methodology of a case study within the framework of the Polytechnic University School of Vilanova i la Geltrú (EPSEVG) of the Polytechnic University of Catalonia (UPC), the novelty of the research lies in its focus on the results obtained. In the 1990s, entrepreneurial initiatives encouraged the creation of reference laboratories and the teaching of innovative subjects in the field of virtual instrumentation. Years later, this teaching activity would be complemented by the launch of lines of research/technology transfer. It should be noted that, in its initial stages, this entrepreneurial trajectory was characterized by limited material and human resources, but thanks to the discovery of little-explored areas of activity (niches), opting for working in cooperation networks (science-technology symbiosis), and the entrepreneurial profile of the members of the research team, it has been possible to gain a space in the research/development of marine technologies in the national and European context, as stated in the text. This empirical research has contributed significantly to shaping a new degree in Marine Sciences and Technologies. Likewise, the results of this study reveal that a significant number of electronic engineering students have acquired entrepreneurial skills by engaging in teaching and research and development activities in different Higher Academic Centers.

Keywords: higher education; electronic instrumentation; virtual learning instrumentation; thinking skills; entrepreneurship; science-technology symbiosis; marine technology

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Citation: Del Río Fernández, J.; Gomáriz Castro, S.; Olivé i Duran, J.; Mànuel Làzaro, A. Knowledge Transfer in Higher Education Institutions Focused on Entrepreneurial Activities of Electronic Instrumentation. *Knowledge* **2022**, *2*, 587–617. https://doi.org/10.3390/knowledge2040035

Academic Editor: Sharifu Ura

Received: 10 August 2022
Accepted: 4 October 2022
Published: 7 October 2022

1. Introduction

Engineering problems cannot be solved without applying knowledge. But what is knowledge? Each academic discipline (Psychology, Business Research, Science Education, etc.) formulates their concepts of knowledge, knowledge management and knowledge transfer in different ways, depending on the context. Thus, the definition given by the Collins dictionary, "Knowledge is information and understanding about a subject which a person has, or which all people have", was adopted. In the literature reviewed, different taxonomies appear that specify various kinds of knowledge. Some authors tell us that such taxonomies are not based on the relationship between epistemology and research methodology [1]. For this reason, the role played by differences in methodologies in the creation of the field of knowledge development is not clear. Based on existing taxonomies, it is not possible to criticize the research from a methodological point of view [1]. Bloom's taxonomy is perhaps the most relevant and most used educational methodology among educators from different areas of knowledge [2]. Using Bloom's taxonomy, some authors have made very specific contributions to try to develop a new taxonomy of engineering learning under the concept of an integrated learning system by combining theoretical classes with the appropriate computer tools [3]. In computer science, the use of Bloom's taxonomy has been proposed for learning programming and evaluating student activity [4]. However, the frequency of difficulties in its use, as well as the great variety of causes and proposed solutions, make it difficult to find clear lines of action that facilitate the use of Bloom's taxonomy for lectures; this is largely because the concepts are sufficiently general to be useful in any area of human knowledge, but it does not adapt cleanly to the teaching of Technology [3,4].

Knowledge management is a popular concept among many disciplines represented in higher education institutions. However, the reviewed literature shows that the concept is more widely used by the business sector than by higher education institutions [5]. Knowledge management is often related to obtaining information, human resource management and innovation, intellectual property, the measurement of intellectual capital, technological aids, cultural changes and new forms of work organization. Knowledge management applied to higher education institutions is becoming a topic of interest for academics, although due to its special conditions, it has basically been limited to bibliographic reviews applying techniques of analysis and interpretation of the content of scientific documents found in various databases. In the literature consulted, it is concluded that research on this topic is in an embryonic stage, with high levels of heterogeneity, while remaining fragmented and loosely focused [6].

Knowledge transfer refers to the sharing or dissemination of knowledge, and to providing inputs to problem solving. Part of the consulted literature focuses exclusively on the University-Enterprise relationship [7], but knowledge transfer is a broader concept, and the broader notion is the one that we will follow in this work. As public-funded organizations, higher education institutions (HEIs) have an obligation to transfer knowledge, with the involvement of their stakeholders, a category which includes the business, industrial and education sectors, as well as society at large [8]. Knowledge transfer (KT) has become one of the core missions of HEIs, which are expected to create knowledge assets by conducting research and development activities and primarily transferring the knowledge acquired to their recipients, i.e., students. Improving KT not only enhances the international competitiveness of the higher education sector but also augments its research capacities through feedback from knowledge stakeholders. Despite an increasing emphasis on KT within HEIs, not enough attention has yet been paid to how such knowledge can be effectively transferred to stakeholders and recipients.

This article starts from the premise that the university must have three missions: teaching, research, and service to society. In other words, it should transform society with the transfer of knowledge in order to meet present and future challenges. To do that, we need to train people (teaching) as well as generate new knowledge (research) and share this knowledge with the rest of society, through the exchange of knowledge for innovation [9].

The industrial policy landscape has changed profoundly in recent decades. Today, the competitive environment of companies depends greatly on knowledge. Thus, industrial policy focuses primarily on the transition to an innovation-based economy as the main driver of economic growth. This commitment stems from the goals set at the Lisbon European Council of 2000 [10]. The need to move towards a new growth model, one based on knowledge and innovation, requires a strong commitment from the institutions responsible for the task.

It is a fact that industrialized countries place more importance on research and innovation than do developing countries; countries among the latter tend to consider manufacturing and maintenance to be the most important factors in education. Economic development is therefore a key factor, as it greatly determines the type of industry a country has and, therefore, the economic policy of the government and the educational profile of its universities. Thus, in addition to the traditional role of universities in providing high-quality professionals with excellent scientific knowledge, society requires greater attention to knowledge transfer itself. While R&D spending (% of Gross Domestic Product (GDP)) in the EU-27 has been rising steadily over the years, in the case of Spain it has been declining (Table 1).

Table 1. Internal R&D expenditure (% GDP) 2010–2019 [11].

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
EU (27)	1.97	2.02	2.08	2.08	2.1	2.12	2.11	2.15	2.18	2.23
Spain	1.36	1.33	1.30	1.28	1.24	1.22	1.19	1.21	1.24	1.25

Given that employability is on the agenda of European universities, this leads to a closer link and a greater sense of shared commitment between universities and the world of work [12]. Students are becoming more and more interested in the set of differentiated skills that can be useful for them in obtaining a skilled job. In the same vein, we find the demands of the labor market: we want graduates who are professionals and specialists, but not necessarily socially engaged. When university institutions focus only on educating students for employment, they generate an increase in economic benefit to the detriment of intellectual capital. However, we should not exaggerate; the university should train students with the ability to find work, but not train them in the specific skills required by the labor market, as the main function of the university should not be this reduced training, but rather the human, social and integral development of the student [13]. This goal includes an ethical awareness of the importance of the social implications of technology [14]. In this line of actuation, and following a case study methodology, this paper will present the different activities carried out by a group of university professors. First, the electronic instrumentation engineering training will be assessed in the context of the relationship between the university and industries, then the resulting research and technology transfer is discussed. In all the SARTI activities, the main objective was building a research team, including lecturers, technicians and students.

To provide a framework for the evaluation and analysis of the complex and holistic activities of SARTI, a qualitative methodology based on case study seems particularly suitable for the purpose of the research. A case study will describe in depth the data related to SARTI's teaching-research activities. The case study, by collecting the different data sets, obtains a deeper insight into knowledge transfer than would be obtained using only one type of activity, teaching or research. Despite the growing amount of entrepreneurship education studies in recent years, much remains to be unveiled on how entrepreneurship should actually be taught in the classroom. There is a knowledge gap between the teaching practices in electronic instrumentation and the theoretical development of both the entrepreneurship and the general teaching fields. To contribute to this debate, this study describes the characteristics and outcomes of the SARTI research group.

At the end of the 1990s, the Remote Acquisition and Information Processing Systems research group (SARTI-UPC) was created at the UPC (Universitat Politècnica Catalunya), a group made up of professors from different departments who teach at the EPSEVG (Escola Politécnica Superior Enginyeria Vilanova i la Geltrú). Since electronic instrumentation was the topic of academic experience of the researchers who led the group, the research/transfer technology area of interest focused on the development of instrumentation and environmental sensors for industrial and scientific applications.

SARTI-UPC needed to be a research group with recognition from academic institutions and administrations, and with strong international ties. To this end, the authors of this paper have carried out a series of actions over more than thirty years, which can be framed in three periods of time. The period of 1990–1999 was characterized by the remodeling of the EPSEVG building, the establishment of state-of-the-art teaching laboratories, and recognition by the University as a faculty of research. The authors of this paper during this period were the EPSEVG's management team. The period 2000–2007 was marked by the creation and implementation of the Vilanova i la Geltrú Technology Center and the obtaining of different accreditations/certifications for research and technology transfer. Finally, the last period, from 2007 to the present day, was marked by the design, construction and commissioning of the OBSEA (Expandable Seafloor Observatory) submarine observatory [15] and the different fields of research and teaching (a new bachelor's degree in Marine Sciences and Technologies) linked to research in marine technologies.

2. The University Context where Knowledge Transfer Takes Place

The EPSEVG is located in Vilanova i la Geltrú (Barcelona), a city of 70,000 inhabitants with a strong maritime tradition, and the capital of the Garraf county. The Garraf coast is an area declared a Site of Community Importance (SCI), a Special Protection Area for Birds (SPA), and a part of the Natura 2000 Network.

The history and trajectory of the UPC and the EPSEVG did not go hand in hand until the creation in 1972 of the University, at the time named the Polytechnic of Barcelona (General Education Law 1970)]. Coinciding with the start-up of the Pirelli factory in Vilanova i la Geltrú, the EPSEVG was created in 1901 as the Escola Superior d'Indústries.

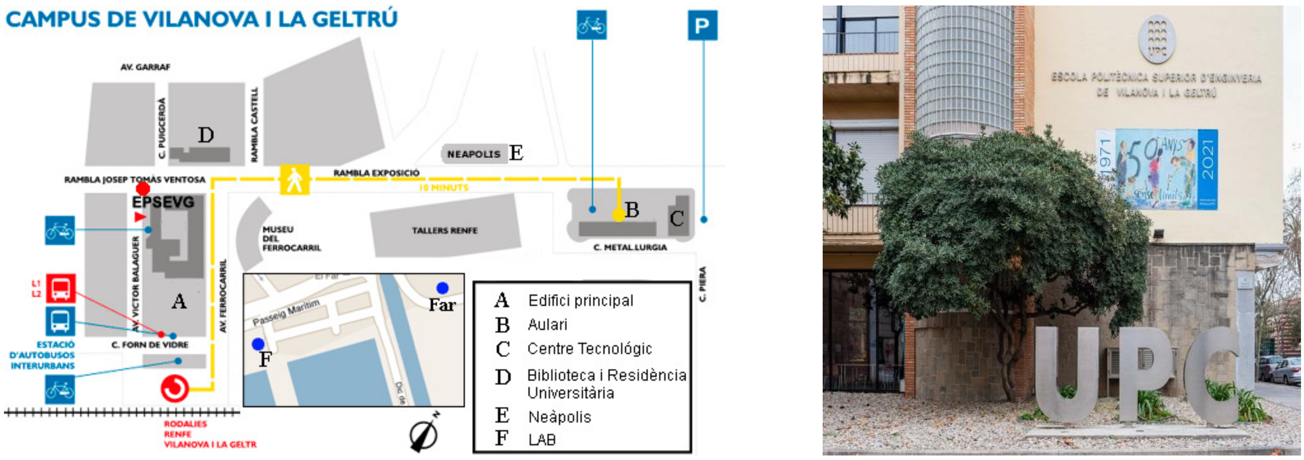
Prior to the introduction of the European Higher Education Area (EHEA), degrees in Engineering Schools in Spain were of two types: Technical Engineering (three years, equivalent to a bachelor's degree) and Higher Engineering (five years, equivalent to a bachelor's degree and a master's degree). At its inception, the EPSEVG had a mission to train intermediate level technicians (three years), in order to meet the needs of local companies for technicians with solid training. The first problem that arose was finding space for its location. It was first located in a building in the Plaça de la Vila (the town hall square) and later, in the 1959–1960 academic year, it was relocated to a site opposite the railway station.

The teaching was carried out in poor conditions, with an almost total lack of resources. The building, furniture and classrooms were in a state of decay, and old; there was a lack of offices for teachers, unsafe physics and chemistry laboratories, a small library with a minimal bibliographic collection, and poorly equipped mechanical and electrical workshops. The building has undergone multiple extensions over the years, mostly due to a lack of planning, as the expansions have been linked mainly to the number of students enrolled in the various academic degrees taught by the center. It is worth noting that the sudden increase in students, from 460 in the 1983–1984 academic year, to 770 in the 1984–1985 academic year, coincided with the start of degrees in Technical Telecommunication Engineering, a figure increasing to 3330 in the 1994–1995 academic year. The School became a center covering the excess demand of Barcelona, hampered by many shortages of the equipment and services that would usually correspond with its academic level.

An important date, one which would define the later structure of the Spanish University, is the publication in 1983 of the Law of the University Reform (LUR). Until 1983, the teaching activity was carried out in Engineering Schools and Faculties by the faculty chairs. The LUR establishes the areas of knowledge that encompass different disciplines and creates the departments that bring together the teachers who teach these disciplines. Within this matrix structure (Teaching Centers-Departments) in the Spanish University, different situations have occurred, such as departments with teaching on a single campus and those with teaching on different university campuses. At the UPC, the latter option is the most common situation. However, it is also possible that the discipline may be shared by more than one department. It is therefore a diverse scenario, where each subject can be linked to different areas of knowledge with departments behind them. These teaching needs will determine the hiring of teachers, which is the main source of incorporation of staff funded by the University budget.

For the LUR, those Technical Engineering Schools which were not newly created, such as EPSEVG, presented a unique situation due to their particular conception of technical education. Laboratories and workshops were devoted only to the training practices of students and only sporadically to essays and services for industry. The academic training of most teachers was limited to a Technical Engineering degree (three years), which was the minimum required by law at the time. Very few graduates (five years) and no doctors were part of the faculty. The profile of the university professor was dedicated exclusively to teaching, which was the primary criterion for hiring in Spanish universities in the 1980s.

Until the entry of the LUR, no research was conducted in Technical Engineering Schools. Therefore, many doubts had to be overcome before the full integration of the EPSEVG into the University. In order for the EPSEVG to have a certain weight within the University and not be seen as a burden, it was necessary to act. Thus, the period from 1990 to 1999 was characterized by the involvement of the authors of this paper in the management of the EPSEVG. As a result of the efforts made to present the case to the UPC rector's team, new buildings funded by the European Regional Development Fund (ERDF) were set up in the 1994–1995 academic year: namely, a new classroom, a new library, and hall of residence. At the same time, a thorough remodeling of the building in the station square was carried out. The Vilanova Campus was already beginning to incorporate some characteristics of the university, with the exception of spaces for research and technology transfer (Figure 1).



(**A**) (**B**)

Figure 1. (**A**) Campus de Vilanova i la Geltrú. (**B**) EPSEVG main building.

3. Company-University Relationships in the Engineering Training

Pursuit of excellence is one of the main goals of all HEIs (higher education institutions); the accreditation procedure may help to achieve this objective. Accreditation, a powerful tool of quality assurance, is used to assess the national system of higher education. Accreditation is considered to be an indicator of quality, one which ensures that an accredited institution/program has undergone a rigorous process of external peer evaluation based on predefined standards and principles and that it complies with the requirements [16]. The accreditation body can be of different types [17]: it may be a governmental organization, a professional engineering institution, an independent accreditation board (e.g., ABET-Accreditation Board for Engineering and Technology [18]), etc. The National Agency for Quality Assessment and Accreditation of Spain, ANECA [19], is an Autonomous Body whose aim is to provide external quality assurance for the Spanish Higher Education System and to contribute to its constant improvement through evaluation, certification and accreditation [20]. The different degrees and postgraduate courses offered at the EPSEVG of the UPC meet the ANECA criteria, which, like similar accreditation bodies, places minimal emphasis on professional skills.

Twenty-nine European nations signed the 1999 Bologna Declaration, which empowered them to set up a zone for the European Higher Education Area. The purpose of this accord was to fortify the coordination of the university and professional training into one body. Without doubt, there has been a requirement for higher education institutions to figure out how to implement the manner in which they guarantee that their students have certain abilities that are required in the active job market [21]. For institutions that meet accreditation requirements, academic programs are typically highly structured and sequenced, limiting students' ability to enroll in elective courses or participate in extra-curricular programs, particularly if they wish to complete their programs in four years. In addition, it should be noted that many engineering faculties lack experience with or interest in delivering entrepreneurial concepts or activities to students [20,22].

The educational goal of engineering training is to graduate as a good professional as possible, one with the knowledge and skills needed to succeed in today's highly competitive world. UNESCO has proposed that the vision of education for sustainable development is a world where everyone has the opportunity to benefit from a quality education and learn the values, behavior and lifestyles necessary for a sustainable future and a positive transformation of society [23].

The employability of university students and graduates has become a key goal of institutions, governments, and the private sector, one fostered by the Bologna process. Traditionally, Spanish universities have paid little attention to either the employability or the transition to the labor market for students and graduates. The most common ways to find a job are usually through personal and family contacts and over the internet, with graduates generally making less use of public employment services and job boards. There are three key issues for employability: language level, international mobility experiences [24] and work experience (if possible, abroad). These three aspects can be significantly improved by being part of a technological research and development group, such as the SARTI group.

The fact that employment rates are higher where there is a better level of education in the population is plain from information available in the public domain. Objectively, 36% of graduates from Spanish universities work in a position below their level of qualification, 13 points above the EU-27 average [11,25]. Given the lack of suitable job opportunities for their profile, engineering graduates cover the lack of vocationally trained technicians. In 2020 according to data from the State Public Employment Service (SEPE), 32% of contracts signed in Spain with university graduates were for positions that were not linked to their qualifications [25]. Although vocational training (within secondary education) is a key element for economic recovery and for the generation of quality jobs, in 2020 only 17% of these unemployed young people had received vocational training qualifications, despite the fact that youth unemployment in Spain was at 34%.

The current successful experience of Dual Vocational Training, especially in countries such as Germany and France, has had a positive impact on employment, and so now we are now proposing the implementation of dual university training [26]. We are aware that this could increase the ratio of university graduates occupying posts more suited to vocational training technicians and thus reinforce negative perceptions of work-based learning, as it could be interpreted as representative of the cheaper and less prestigious end of higher education. Such a situation is very familiar in university centers such as the EPSEVG, which established itself as a Technical Training school (Escola Superior d'Indústries) with an original mission to train intermediate-level technicians, but which is now training university graduates. For this reason, the creation of external liaison instruments, such as university-company relations committees is essential, in order to closely monitor students in both company and classroom environments. Unfortunately, not all companies have effective monitoring.

The proposal of an active learning approach positively influences and strengthens student/faculty relationships as faculty members share their engineering experience with students. Implementing active learning into the traditional engineering classroom is challenging for the faculty, but it offers the opportunity to teach engineering principles in a hands-on format. Therefore, it is important to understand the nature of active learning, the empirical research addressing its use and how teachers must make the necessary paradigm shift in Electronic Engineering education to prepare students for future challenges. Under the case study approach, in this section we will examine the activities carried out by the SARTI group in different aspects of Company-University relations in the training of engineering students.

3.1. Company University Knowledge Transfer Process

Universities cannot ignore the world of work, and this means making the specific demands of the economic sectors and those of academic training (basic, transversal and generalist), compatible with each other. The transfer of knowledge from higher education to business is very beneficial, because it leads to innovation and regional development. Unfortunately, this is often a difficult process, as universities and companies are different institutions, both in terms of their goals and the way they generate knowledge. Nonetheless, business cooperation is very important in the context of knowledge transfer, where students can learn about the various activities of the associated companies and participate in their projects. This participation can be structured at different levels: combining undergraduate research and industrial practice, establishing the framework of agreements, project-oriented learning, and lifelong learning. The different parts of the knowledge transfer process (the student, the company, and the university world) will achieve a number of benefits, such as:

- Support for the teaching process through real-world experience;
- Enhancement of job skills and entrepreneurship;
- Development of teamwork skills;
- Development of links with industry that can encourage future collaboration;
- Active involvement of the company in the research process, rather than as a consumer;
- Teacher-directed student research in areas of student interest;
- Improvements to industry-funded teaching laboratories;
- Ongoing training programmes with the participation of teachers and industry staff.

3.1.1. Combining Undergraduate Research and Industrial Practice

University graduation brings about a change in the day-to-day lives of students, with the subsequent entrance into the job market. To facilitate this transition, prior knowledge of the business world is very useful. Rather than the practical application of knowledge, the focus is on starting a phase of learning about the processes and projects being developed in the company. In-company internships in Spain are regulated by the Educational Cooperation Agreements for a certain period and level of commitment defining the objectives in the work plan annexed to the agreement. Following academic standards, this process must be closely monitored by the university, so that the student receives the appropriate training from the company [27].

University-business education collaboration agreements are more than just internships in a work environment. They must provide additional added value based on the shared effort between the university and the company, and allow for:

- The establishment of reference frameworks for the analysis of labor market needs, the definition of skills and continuous professional development;
- An outlining of the pedagogical component of the university-company collaboration and the real contribution in terms of competence-based training;
- The promotion of entrepreneurship education as an important element of curricula reform;
- The development of training materials and courses for the needs of the corresponding sectors.

Quality control of education will be effective if, and only if, the actions offered ensure that the expectations of students and the world of work are met [23].

One of the aims of SARTI-UPC has been to promote the use of the School's laboratories and spaces through collaboration agreements with external companies. Thus, as a result of the School's collaboration in the preparation of seminars with leading companies in the instrumentation sector (Agilent Technologies, National Instruments, among others), an option of Final Degree Projects (PFC) was launched in companies, using instrumentation control tools [28]. From 1995 these collaborations were reinforced with the start-up of the Commission on University-Company Relations, given charge of monitoring and tutoring the activities that students could do in companies as part of their education and training. The increase in collaboration with companies is shown in Table 2. In the 1998–1999 academic year, 231 students participated, representing 21.8% of the graduates of that academic year. There were 155 participating companies, 95 of which were involved for the first time. As a result of the academic offer over the last fifteen years, the number of students on the Vilanova campus has stabilized at around 1500, and the number of educational cooperation agreements has remained at around 200.

Table 2. Educational cooperation agreements for the years 1989/90 to 2020/21.

Course	**2020/21**	**2019/20**	**2018/19**	**2017/18**	**2016/17**	**2015/16**	**2014/15**	**2013/14**	**2012/13**	**2011/12**
No Agreements	163	231	253	294	311	257	208	129	111	143
Course	**2010/11**	**2009/10**	**2008/09**	**2007/08**	**2006/07**	**2005/06**	**2004/05**	**2003/04**	**2002/03**	**2001/02**
No Agreements	125	138	160	134	189	254	216	205	238	255
Course	**1998/99**	**1997/98**	**1996/97**	**1995/96**	**1994/95**	**1993/94**	**1992/93**	**1991/92**	**1990/91**	**1989/90**
No Agreements	231	219	158	106	78	51	19	50	18	6

3.1.2. Framework Agreements, Strategic Alliances

Another scenario of collaboration between academia and industry that supports knowledge transfer is the strategic alliance (framework agreement). These are lasting cooperation agreements between organizations based on reciprocity, with goals focused on the commitment and resources of each partner. Strategic alliances are driven by a greater efficiency than can be achieved with the company's own financial resources, or by the need to learn and expand the company's knowledge base and skills. They might also derive from previous relationships that provide a basis for the ability to work together [29]. Such collaboration involves: improving business profitability (economic theory); increasing the competence base to address similar future problems (learning theory); configuring future expectations in similar collaborations (social media theory) [28].

Within the framework of strategic alliances, another way of focusing on the process of knowledge transfer is the in-company project. This scenario focuses on a business problem that a group of students, under the direction of a teacher, have to solve. We move from individual collaboration in the case of educational cooperation agreements to group work in in-company projects. It is a method of knowledge transfer that takes advantage of the synergy between research and teaching as fundamental domains of academic work.

In the period 1990–1999 in EPSEVG, the teaching laboratories of electronics and other specialties lacking advanced equipment were modernized. In 1994, the Instrumentation and Control Laboratory was set up with ten workstations, equipped with a networked computer with a GPIB (General Purpose Interface Bus) controller, multimeter, oscilloscope, function generator, power supply, data acquisition card (A/D and D/A) and, at the serial port, a controllable PLC. All the equipment was under LabVIEW (National Instruments) and HPVEE (Agilent) program control. With this equipment and some more unique ones, under the concept of virtual instrumentation [30], different milestones were achievable:

- Framework agreements: Agilent Technologies and National Instruments Certified Instructors;
- Electronic Instrumentation talks in economic/industrial sectors (12 in the period 1994–1999);
- Renesas Electronics Corporation University Programme Membership from 2007;
- Industrial instrumentation and control projects with the participation of students in the work team (Lear Corporation, Pirelli Cables and Systems, etc.);
- European Project Semester (EPS) [31];

- In 1995, a team of three teachers and four students designed a line of low-cost GPIB equipment for Promax Test & Measurement, SLU [32–34];
- UPC Teaching Material Development Awards: 1995, "Virtual Instrumentation for Processed Acquisition and Signal Analysis"; 1997, "A virtual environment for experimentation";
- Books: *Labview* (ISBN-978-84-9281-268-4 2011, ISBN-84-9732-391-2. 2005, ISBN-84-283-2817-X 2001, ISBN-84-283-2339-9. 1997); *Virtual Instrumentation* (ISBN-84-8301-473-4 2001, ISBN-970-15-0777-0 2002); *Solved Instrumentation Problems* (ISBN-84-283-2141-8 1994).

As an interdisciplinary field, electronic instrumentation has become a philosophy that supports new ways of thinking, synergies of interdisciplinary knowledge, work and practices, and new skills and innovation. Currently, electronic instrumentation, due to its characteristics, can be included under the umbrella of ICT (Information and Communication Technology) and in a more general way linked to STEM (Science, Technology, Engineering and Mathematics) [25]. In 2019, according to Eurostat information, the ratio between university graduates (first degrees, master's degrees and doctorates) and the population aged 20 to 29 (in thousands) reached a value of 67.3 in Spain, below 68.9 in the EU-27. Of ICTs, the Spanish percentage is the fourth lowest of 27. It is also relevant to point out that the ratio between university graduates in STEM areas and the population aged 20 to 29 fell in Spain in the period 2013–2019, while it grew across the European Union.

Therefore, the commitment that SARTI-UPC has made from the beginning to the offer of teaching and research around electronic instrumentation is a small contribution to increasing the statistical percentage of Spanish studies in ICT.

3.1.3. Project-Oriented Learning

Without the environmental pressure of the business world, and as a prelude to the Educational Cooperation Agreements and the in-company projects, project-oriented learning is proposed. Within university facilities, project-oriented learning is introduced with the aim of improving the development of skills such as creative and critical thinking, which are essential for the development of student teamwork. Project-based learning gives students the space to express their ideas, discuss the ideas, have fun, interact, and raise concerns and questions. It is a methodology that encourages the effective participation of students by bridging the gap between theory and practice, and one where the teacher must facilitate, update and guide the learning process (the engineering dialogue) [35] by considering a number of goals:

- The facilitation of student interaction by helping to discover new situations and ways of solving new real-life problems with innovative solutions;
- The promotion of the ethics of engineering and social involvement of engineers;
- Design-based research and cooperative engineering;
- The development of a set of experiments integrating the necessary knowledge and skills as an interdisciplinary field;
- The understanding of the role of experiential learning in gaining practical experience and stimulating thinking skills;
- The development of a student-centered approach, involving students in the learning process.

Topics such as electronic instrumentation are very suitable for developing project-oriented learning. Electronic instrumentation focuses on the interaction of interdisciplinary knowledge, work, practices, skills and innovations, thus building thinking skills. Within this concept, three areas have been the most relevant teaching initiatives carried out by the SARTI-UPC group: the introductory course in Technical Engineering Studies, final degree projects framed within research, and the joint participation with different universities in the framework of the Leonardo and Erasmus European projects.

Before entry into the European Space of Bologna project and prior to the studies of technical engineering, the possibility of carrying out an introductory engineering course optative was introduced into the academic programming of the first semester (October–February) of the 1998–1999 to 2002–2003 courses. The content was structured in the design of a product carried out by a group of students, one following the guidelines of the top-down design in electronic instrumentation, integrating different fields of knowledge and some existing partial solutions in order to develop the proposed product.

The Instrumentation and Control Laboratory was the embryonic home of future research activities, which began with the completion of a series of final degree projects among groups of students and coordinated by the professors of the electronic instrumentation subjects under the concept of virtual instrumentation, and in the research line of the characterization of different designs of static DC/DC converters. In the period 1994–2000, 102 final degree projects were carried out in Electronic Engineering.

European experiences such as Leonardo da Vinci/Erasmus Summer School fall within the remit of the university consortium: Lifelong Learning Programme DGE AC/30/07 2007/C 230/05, Marine Technology Instrumentation, Erasmus Intensive Programme 2013-1-ES1-ERA10-74536,], 13th Summer School on Distributed Data Acquisition Systems, and accelerating transition towards Edu 4.0 in HEIs 2020-1-HR01-KA203-077777.

3.1.4. Lifelong Learning

The current changing situation in the political, economic, labor and business fields makes continual learning and adaptation to new realities essential, in a manner far beyond formal education. Nonetheless, there is a risk of knowledge quickly becoming out of date, leaving the individual unable to adapt, participate, and interact in a constantly changing world. [12]. Therefore, continual and lifelong learning, whether in the world of work, or in personal life, is essential, as it provides the tools needed to cope with the rapid changes that characterize today's societies [28].

Given the distinctiveness of the Garraf-Penedès (Barcelona) counties, and within a global framework of service to society, a modern infrastructure such as the Instrumentation and Control Laboratory, with the remodeling and new buildings built on the Campus of Vilanova i la Geltrú, as shown in Table 3, allowed the realization of a series of Lifelong Learning courses.

Table 3. Lifelong learning: number of courses and hours, as allocated among In Company, LabVIEW, and European Social Fund. (Total 21,979 h.)

Period	No LabVIEW	Hours	No InCompany	Hours	No Social Fund	Hours
1989–1999	0	0	1	30	8	3250
2000–2007	12	248	12	260	25	9470
2008–2021	57	1239	15	450	31	7032
Total	69	1487	28	740	64	19,752

In 1993, the first European Social Fund grant was awarded for the "Instrument Control Specialist Technician" course for a maximum of 18 students. SARTI-UPC Collaborating Centre with census number 427 from 1993 to 2019 has carried out 19,752 h of practical training in 64 courses with the collaboration of the most relevant and representative companies in the ICT sector. This has allowed the employment of students as specialists in advanced techniques of instrumentation and programming of electronic devices

Additionally, there have been a number of in-company training agreements carried out, e.g., CAN bus, microcontrollers, marine technologies, acquisition systems, automata, databases, programming languages.

A training agreement with National Instruments for LabVIEW users was also taken up.

3.2. The Risks of Knowledge Transfer University-Company Process

University-company interaction is a working method that allows students to have a much more authentic practical experience than that within a purely academic exercise [29]. Based on the experience gained, we can see that there are critical factors that determine the success of university-company relations. Some are linked to students and others to the company, teachers, and the inflexible structure of curricula and/or academic infrastructure [28]. For example:

- A lack of preparation by the company to participate in the planning of the cooperation;
- Preparation time is longer than usual in traditional teaching;
- Extra work by teachers, with no definition of incentives that recognize the activity;
- In general, teachers without industrial or research experience;
- A danger of student detachment from the project, affecting teacher credibility and the company's view of the university, conditioning future relationships;
- In order to ensure a responsible, proactive involvement with an adequate level of expectation, the group of students must be homogeneous and with basic knowledge [28];
- A lack of resources and support at the university for interaction with the company.

It is not an easy task for teachers to renew their teaching methodology to ensure a high level of knowledge transfer [23]. In order to overcome some of the risks mentioned, some of the possible solutions would be [28,36]:

- Encouraging project-oriented learning in academic curricula;
- Making academic schedules and/or curricula more flexible in a short period of time;
- Promoting teacher training activities focused, among others, on entrepreneurship education.

For a society interested in training academic researchers in the field of entrepreneurial skills, it would be prudent to invest on three levels [37]:

- Systems level: participation in business plan courses, interaction with incubators and OTT (Technology Transfer Office);
- Institute level: entrepreneurship education (1) technical knowledge of business, management and organization; (2) acquisition of skills and competencies, and (3) an experiential approach;
- Individual level: the academic researcher is motivated primarily by curiosity and personal recognition.

SARTI-UPC in the 90s was the management team of the EPSEVG, achieving the revitalization of the spaces of a century-old School of Engineering and turning it into a university center. In order to increase the entrepreneurial capacity of its members, it was proposed to develop research and development capabilities. With this objective, the design and construction of a technology center was the next challenge faced by the authors of this paper.

4. Research and Technology Transfer, Tools for Knowledge Transfer. Building a Team

In general, companies are interested in applied research, that is, research whose ultimate goal is the generation of knowledge which is exploited productively or commercially [38]. Companies have based their success primarily on good technology management and purchasing, but less so on innovation and technology development. For many companies, training and research are considered as expenses and not as investments. Thus, training to be a doctor who accredits an engineer to carry out research tasks alone cannot be said to be especially valued by companies in our area. A Ph.D. status is essential for a university career but seems to have little influence on promotion within a company.

In this section we will provide an overview of the research in our immediate environment (Catalonia). The following are the research activities of the SARTI group, many of which are characterized by the involvement of students' final master's degree courses at the School.

4.1. Research in The Autonomous Community of Catalonia (Spain)

Research (the development of new products and methods of production, management or service) and technological innovation are the pillars of the scientific and technical progress of society and, consequently, among the foundations of what is called progress.

The most developed companies have been shown to be those devoting the most effort to R&D (Research and Development).

The process of the globalization of the economy has led to the decline and sometimes to the disappearance of certain technologies, and it seems that the trend is for Catalonia to be a service economy. Manufacturing has gradually moved into the hands of foreign companies that do not require research and development engineering, but rather demand engineers in production chains, quality control and organization.

It should be remembered that in Spain, until the mid-eighties, there was a total absence of policies that would allow research in any field of knowledge. It is also at this time that Spanish universities, and also polytechnics, begin to professionalize and employ full-time staff with the ability to carry out R&D activities. This explains the gap between our universities and those of other European countries around us.

RIS3CAT (Research Innovation Strategies for Smart Specialization Catalonia) is Catalonia's response to the European Commission's demand that European Union states and regions develop research and innovation strategies for smart specialization tailored to their potential for innovation [39]. Within this strategy, the R&D&I Units in Catalonia are structured around six lines of action:

- Universities: twelve public and private universities; Fifty-two University Research Institutes; One hundred and eighty-seven Colleges and University Schools;
- Research Centres: thirty-nine participated in by the Generalitat de Catalunya and seventeen by the Consell Superior d'Investigacions Científiques (CSIC);
- Large infrastructures: eleven Singular Scientific and Technical Infrastructures (ICTS);
- Hospital institutions: nine Teaching and research support institutions in hospitals;
- Technology transfer: sixteen Science and Technology Parks; TECNIO Network, agents located in Catalan universities offering a wide range of technologies;
- Networks and research groups: seven R&D networks of collaboration among research groups; One thousand seven hundred and forty-four Research Groups with the recognition of the Generalitat de Catalunya (SGR).

4.2. Research Activities Carried out by the SARTI-UPC Group

All the activity developed in the Instrumentation and Control Laboratory, in the main characterized by research linked to the results of the project-oriented teaching activity, generated the publication of several different doctoral theses carried out entirely within the campus facilities of Vilanova, thus breaking with the dependence on Barcelona. A significant fact was the recognition, in 1997, by the UPC of the research sub-field "Characterization of signal and power processors" within the Department of Electronic Engineering of the UPC. In 2002, the UPC's research fields were restructured and renamed "Remote Acquisition and Information Processing Systems". And, finally, in 2004, the Governing Council of the UPC approved the constitution of the research group "Remote Acquisition and Data Processing Systems", registered in the first catalogue of research groups of the UPC. SARTI-UPC is a multidisciplinary research group formed by researchers from the departments of Electronic Engineering, Applied Mathematics IV, Fluid Mechanics, Mechanical Engineering, Chemical Engineering, and Physics and Nuclear Engineering at the UPC.

List of the most relevant research activities of the SARTI Group:

- Creation of the Vilanova Technology Centre 18 January 1999; Neapolis Building Extension 2007;
- Organization and scientific committees of international congresses:
    - Marine Technology (Martech). Vilanova i la Geltru (2005, 2007, 2009), 2011 Cádiz, 2013 Girona, 2015 Cartagena, 2017 Barcelona, Oporto 2018, Vigo 2020 [40];
    - The Annual Seminar on Industrial Electronic Automation and Instrumentation SAAEI (Matanzas-Cuba 2001), Scientific Committee 1994–2002;
    - Oceanographic Instrumentation: Mediterranean Campus 1998, 1999, 2000;
    - Vilanova Marine Science/Robotics Meeting (Vilanova i la Geltru), 2010;

    - Midwest-IEEE Circuits and Systems MWSCAS2006, Puerto Rico (USA) 2006;
    - The 19th Symposium IMEKO TC 4, Barcelona, Spain 2013;
    - XIX Fundamental and Applied Metrology; IMEKO World Congress 2009, Lisbon;
    - The International Conference on Electrical & Power Engineering, 2004, 2006, 2008, 2010;
- Member of the IEEE Society. Oceanic Engineering, Signal Processing, Instrumentation and Measurement, Education Power Electronics, Computer; Communications;
- Journal Evaluation: Transactions on Instrumentation and Measurement, Transactions on Circuits and Systems, Transactions on Mechatronics, Sensors, Measurement, Journal of Offshore and Polar Engineering, etc.;
- Project evaluator: National Agency for Evaluation and Prospective (ANEP) Ministry of Science and Technology (Spain); Agência de Inovaçao, S.A. (ADI) Portugal, VQR 2004–2010 National Agency for the Evaluation of Universities and Research, Italy; Agency for the Management of University and Research Grants Generalitat de Catalunya;
- Part of the proposal for large infrastructures Spain; MARHIS-Integrated Coastal Infrastructures for Experimentation and Simulation (iCIEM) [41];
- The Generalitat de Catalunya recognizes research groups that are characterized by the quality of their research work and the dissemination of knowledge and results to the society; one of them is SARTI in the marine field [42], and is present in four areas of R&D&I action recognized by the Government of Catalonia:
    - Member of the TECNIO Network. Network of Technological Innovation Centres (2001) [43];
    - Of the seven existing networks, it is a member of the Catalan Network for Blue Innovation BlueNetCat, creating an interdisciplinary ecosystem of transfer and innovation, and acting as a bridge with the quadruple propeller to improve the competitiveness of the innovation sector in the Blue Economy in Catalonia [39];
    - Recognition as a research group of the Generalitat de Catalunya. 2017SGR0371, Remote Data Acquisition Systems and Information Processing in the Marine Environment (SARTI-MAR), 2017SGR0757 Renewable Marine Resources.

The funding obtained from competitive appeals by SARTI for the development of research projects can be seen in Table 4, and productivity in research is shown in Table 5 [44].

- Twenty-six European grants: HORIZON 2020 (2014–20) (nine). VII European Union Framework Programme 2007–2013 (five), VI European Union Framework Programme (one), FP5-IST 1998–2002 (six), Leonardo/Erasmus Programme (three), Fishing activity (two);
- One hundred and ten grants from the Spanish state: access to large facilities (sixteen), National Plan for Scientific Research, Development and Technological Innovation 1989–99 (sixteen), 2000–2007 (forty-three), 2008–2011 (eighteen), 2013-2016 (eleven), 2017–2020 (six);
- Twenty-seven grants from the Generalitat de Catalunya: PIR2002 (four), IV Plan for Research and Innovation in Catalonia (PRI). 2005–2008 (eight), (PRI). 2010–2013 (ten). (RIS3CAT) (five);
- Fourteen grants from other institutions: Biodiversity Foundation, Higher Council for Scientific Research, Directorate General of Fisheries, Colciencias, International Cooperation Ministry of Foreign Affairs, among others.

SARTI-UPC is a research group located in a peripheral city far from the central services of the university in Barcelona. The group started from scratch, and there was no support from senior researchers, nor were there previous lines of created research. It was necessary to create a material infrastructure and provide it with technical personnel resources. The group is an autonomous research group without dependence on the groups located in Barcelona; this dynamic means that entrepreneurial skills are acquired and transmitted, with the collective making a niche for itself in the national and European context, as the tables [4,5] show. In this section the research accreditations granted by the Catalan administration have been shown.

Table 4. Number of competitive projects with funds awarded to SARTI-UPC.

	Spanish State	Great Facilities	Generalitat	Other Institutions	European	Total
1990–1999	16	13	0	6	1	36
2000–2007	43	3	4	3	8	61
2008–2020	35	0	23	5	17	80
Total	94	16	27	14	26	177

Table 5. Scientific productivity of the SARTI-UPC group.

Period	Publications	Ph.D. Thesis	Patents
1990–1999	426	7	0
2000–2007	655	6	2
2008–2020	732	18	6
Total	1813	31	8

4.3. Creating a Research Infrastructure

It was necessary to find an area of interest in which to focus the research, to look for a niche not covered by the research activities of other groups. The niche provides a competitive advantage determined not only by the quality of research, but also by the options that derive from an appropriate environmental analysis, such as the scientific and social relevance of research topics, and the application of new technologies which result in a new breakthrough by developing collaborations with other groups in different fields of knowledge (networking). And, following on from this, some of the points to consider when focusing the research on the marine environment were:

- The port of Vilanova i la Geltrú; by economic activity, the year 2020 is the second of the ports managed by the Generalitat de Catalunya (Figure 2);
- The fishing fleet based in the port of Vilanova is one of the largest in Catalonia and by number of catches is the first port in Catalonia [45];
- The seabed plays a key role in balancing our biotic ecosystem, with great ecological and productive value; aside from its location in the "Costes del Garraf", the Vilanova Campus is also located in the metropolitan region of Barcelona, so the pressure to which it is subjected is very high; this proximity, however, is a double-edged sword: an ecologically valuable and well-managed space can lead to a better quality of life for a large population;
- On 14 May 2001, a framework collaboration agreement (Tecnoterra Associated Unit) was established with the Consejo Superior de Investigaciones Científicas (CSIC), through the Institutes of Earth Sciences and Marine Sciences.

Therefore, the SARTI group decided to focus its research activities mainly on the marine environment. Research in Seawater Acidification, Marine Species Biology, Seismicity, Interoperability, Robotics, and Environmental Energy Capture, among others, have become intensified areas of work with the launch of the Expandable Underwater Observatory (OBSEA).

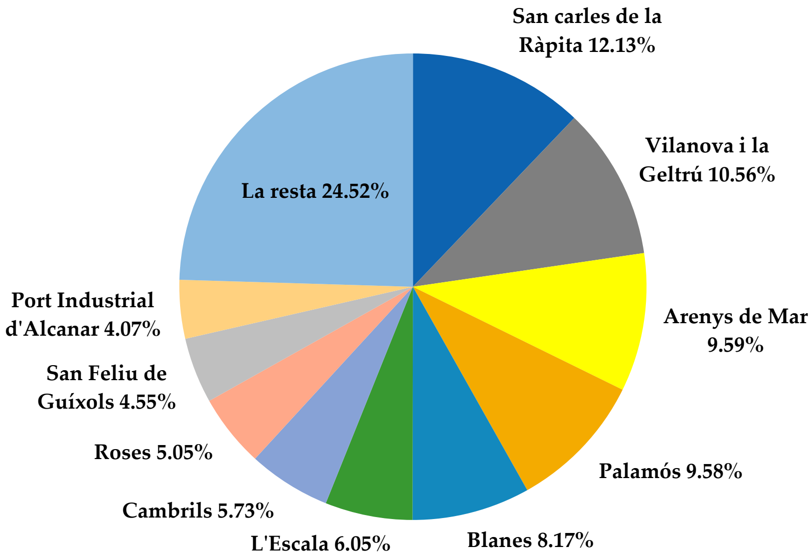


Figure 2. Economic activity of the ports of Catalonia, year 2020 [45].

At the end of 2007, as part of the ESONET Network of Excellence [46] of the VI Framework Program, the building of research infrastructure in the marine environment within the Costes del Garraf area was proposed. This proposal became a reality on 19 May 2009. OBSEA, the first wired underwater observatory in Spain, and one of very few in Europe, was installed by SARTI-UPC four km from the coast of Vilanova i la Geltrú (lat. 41°10′54 87′′ N; Long. 1° 45′8 43′′ E) and at a depth of 20 m (Figure 3), connected to the ground station by mixed fiber-optic cable and power line. The launch of the observatory was made possible by the participation of some companies in the telecommunications sector (Telefonica, Dycec, Abengoa, and Tyco Telecommunications) and others in the industrial sector (Prysmian and Stecma). These were companies that had never been involved in the development of this type of marine technology, but through previous relationships with the research group became involved in the project. The collaboration of these companies and the funds obtained from different appeals for competitive aid, made it possible to set up an infrastructure that has been operational for more than twelve years.

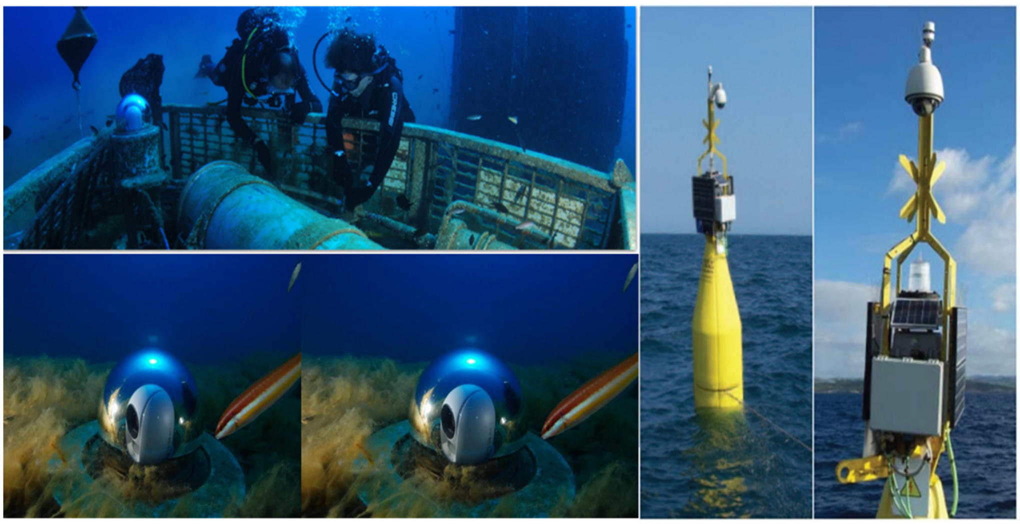


Figure 3. Photographs of the installation of the OBSEA wired observatory and the surface buoy: Divers performing maintenance operations; azimuth view of the position of the observatory with respect to an artificial biotope; detail of the underwater camera; surface buoy.

OBSEA is a modular underwater infrastructure, expandable and adaptable to different configurations, that supports the incorporation of different sensors [15]. It is an easily accessible laboratory that allows testing and the incorporation of new technologies that will later be located at great depths.

The scientific objectives of OBSEA are to obtain and manage the data necessary to promote efficient decision making in the conservation and integrated management of the seacoast. Continual sampling is performed, with intervals ranging from a few seconds in real time to long time series that allow a better and greater knowledge of the dynamics of environmental processes, evolution of ecosystems, natural hazards, etc.

The OBSEA infrastructure is part of a European collaboration project for the future installation of a European network of laboratories and underwater platforms considered within the European Strategy Forum for Research Infrastructures (ESFRI) Roadmap, as a European infrastructure of enormous strategic interest EMSO (European Multidisciplinary Seafloor Observatories FP7 Infrastructures-2007-1). This type of infrastructure is similar to that being developed in other countries, such as the Canadian American network NEPTUNE (North-East Pacific Time-Series Underwater Networked Experiments) or the Japanese network ARENA (Advanced Real-Time Earth Monitoring Network in the Area).

In addition, the OBSEA infrastructure is a fundamental tool in the exploration of the future biological reserves of the Catalan coast, especially in matters related to the location of landers, vehicles, underwater communication, species tracking etc.

4.4. Catalan Technology and Knowledge Transfer System

Today, in the information and knowledge society in which we operate, it is beyond doubt that the productivity and competitiveness of companies is closely related to their innovative activity and their ability to incorporate new technologies [47]. This increasingly requires public universities, as new drivers of regional innovation, to exploit, transfer and commercialize their knowledge. This process of transferring knowledge and research results from the public to the private sector is called technology transfer [48]. We need to become an entrepreneurial university [37].

ACCIÓ [43] is the agency of the Generalitat de Catalunya for company competitiveness and is the public reference point for contribution to the transformation of Catalan companies. It coordinates the worlds of science, technology and business, with the support of the public administration. In this way, the aim is to align the strategies and take advantage of the full potential of each, so that the existing knowledge and technology in the scientific world is used by companies and serves as a basis for creating new products and services demanded by the market. This is the process we call technology transfer [49].

There are two basic ways to transfer technology and knowledge from the scientific world to the business market:

- Technology Push: The starting point is the new knowledge and new technologies that have been developed in the scientific world and for which there is no clear demand in the business market. The way to bring this technology to market is through the creation of a new company (spin-off) or through the creation of patents for later marketing. In this case, it is the invention that seeks a market.
- Market Pull: There are companies that want to develop specific Research, Development and Innovation (R&D&I) projects or are aware of the need to innovate and are looking for support to define an innovation strategy or to identify concrete improvements in their current business systems [48]. This is a vision that starts with a problem that needs to be addressed.

4.5. Technology Transfer Offices

The main institutional mechanism that facilitates and enables the transfer of university technology is the Office of Technology Transfer (OTT). Successful OTTs are managed as companies, by people with a business mindset [50], experience in the world of research (often with a Ph.D.), and in the business environment [48]. There is a common denominator behind all the resources of the OTT: the people. In this sense, a combination of ability (knowledge) and behavior (attitude) is needed [50,51].

The OTT at the UPC adopts the name of Centre de Transferéncia de Tecnologia (CTT). CTT manages the main source of funding for research at the University: grants from the European Framework Program, the Spanish National R&D Plan, and the various research programs of autonomous governments, foundations, etc. In this role, the activity of the CTT is basically to advise the researcher in the administrative application process and to manage the expenditure and the subsequent justification of the resources obtained. From this point of view, CTT acts as the administrative office of the research, and does not evaluate the results. Thus, in response to the needs of university-company interaction at the UPC, different tools have been launched: the Technological Centre of the Universitat Politècnica de Catalunya (CIT UPC), Emprèn UPC programme [52], and UPC PARK.

4.6. SARTI Actions in Technology Transfer

With funds obtained from the Operational Plan for Objective 2 Area of Catalonia 1997–1999, from the European Regional Development Fund (ERDF), Vilanova i la Geltrú City Council and the UPC signed an agreement to create the Technology Centre on the Vilanova Campus. The Technology Centre was created to encourage and promote technological innovation in companies by facilitating access to new technologies and industrial processes. In order for the building to be equipped with basic equipment, the authors of this article applied for a grant through the ATYCA appeal of the Spanish Ministry of Industry and Energy for the periods 1998 and 1999. By 2000, SARTI was already an active group in research and technology transfer, and thanks to the launch of the Technology Centre, it was located within the Centre's facilities, occupying 50% of its space. A whole process of accreditation and certification of their activities for approval by the regional and national public administrations then started.

The Innovation Plan 2001–2004 of the Generalitat de Catalunya focused on raising awareness of the productive fabric of the importance of innovation and on encouraging the transfer of knowledge from universities to companies through the creation of the Network of Support Centers for Technological Innovation (Xarxa d'Innovació Tecnològica XIT). The aim of this network is to boost the market for R&D outsourcing and drive the transfer of technology from universities to companies. In 2001, SARTI was recognized as the Centre for the XIT, receiving TECNIO accreditation, which has since been renewed [43]. Table 6 shows the projects and services carried out by SARTI, of which eight agreements and twenty-one services have been carried out in the period 2004–2021 on behalf of the CSIC and within the framework of the Tecnoterra Associated Unit (science-technology symbiosis).

Table 6. Number of projects, services and training programmes developed by SARTI.

Period	Projects & Services	Agreements Framework	Training	Total Transfer Actions
1990–1999	28	0	1	29
2000–2007	145	7	12	164
2008–2020	690	16	15	721
Total	863	23	28	914

Activities carried out by SARTI, apart from the TECNIO accreditation [43], have met recognition or quality certification/accreditation standards:

- From 2005: Metrology Laboratory, ISO/IEC 17025 ENAC accreditation (ISO/IEC 152/LC375); the creation and equipment of the metrology laboratory is fundamental in the quality of teaching of electronic instrumentation;
- From 2004: ISO 9001: 2015 certificate issued by Det Norske Veritas for the field of Electronic Design, Computer Applications, Environmental Studies, Management of Business and Occupational Training in Computer and Electronics;
- 2005: ADEG Award (Associació Empresaris del Garraf-Penedès) for Quality;

- Access to the scientific infrastructure of the SARTI group through the Scientific and Technical Services of the UPC.

4.7. Activities Carried out for the Dissemination of the Research Activities Marketing Plan

There is room for the growth of internet technologies applied to instrumentation and intelligent sensor systems with an application to research, industrial and productive fields. This line of activity, which offers a set of technical solutions, must be presented in an attractive way. This is the marketing plan, supported with graphic and audio-visual material of different formats, which makes visible the different activities and services the group carries out:

Support material:

- Design of logos and stationery (Figure 4);
- Brochures with detailed definition of products and services:
    - Design and printing of the general SARTI services leaflet;
    - NICI National Instruments Certified Instructors;
    - Specific equipment services: seismometer, observatory, fishing technologies etc.;
- Generic web pages and web of marine activities: www.cdsarti.org www.obsea.es;
- Social networks (accessed on 1 October 2022).
    - https://www.facebook.com/OBSEAsarti (accessed on 1 June 2022);
    - www.youtube.com/user/cdSARTI (accessed on 1 June 2022);
    - https://twitter.com/OBSEAsarti (accessed on 1 June 2022);
    - https://www.instagram.com/obsea_observatory/ (accessed on 1 June 2022);
- Corporate video of promotional presentation with relevant features of capabilities, products and services;
- Videos of different individual projects;
- Small gifts with logo: pens, USB, t-shirts, balloons for children, CD-temperature sensor etc.;
- Promotion in the press: For example, the launch of the observatory in July 2009 took place in the school's auditorium, a news item covered in forty-eight print newspapers and twelve online: regular press releases; regional, local, national TV interviews.

Science dissemination activities:

- Organization of research events: workshops, conferences [40], presentation days;
- 1070 presentation of work at congresses: Instrumentation and Measurement Technology Conference, American Geophysical Union, IMEKO World Congress, Sensors Applications Symposium, OCEANS MTS/IEEE, Autonomous Underwater Vehicle Conference, Midwest Symposium on Circuits and Systems, Sensors, IEEE Industrial Electronics Society, World Conference on Marine Biodiversity, etc.;
- 93 books and book chapters: Subsea Optics and Imaging ISBN-13: 978-0857093417, Biorhythms Challenge to Deep-Water: Cabled Observatories Video-Solutions 2012 ISBN 9781439889985, Simulation of Bottom Trawl Fishing Gears 2007. ISBN 9780415455237, Ocean Bottom Seismometer 2012 ISBN: 978-3-659-05449-5, Impulse Signal 2011 ISBN: 978-3-8465-7358-7;
- 505 journal articles: *Sensors*, *Analytica Chimica Acta*, *Transactions on Instrumentation and Measurement*, *Measurement*, *Journal of Oceanic Engineering*, *Acta Imeko, IEEE Access*, *Transactions on Power Electronics*, *Aquatic Mammals*, *Frontiers in Marine Science*, *Transactions on Signal Processing*, *Journal of Signal Processing Systems*, *Physics of Fluids, Sea Technology*, *IEEE Sensors Journal*, *Ocean Engineering*, *Remote Sensing*, etc.;
- Edition Instrumentation Viewpoint Open Access Newsletter ISSN 1697-2562 (21 numbers 861 articles). *Instrumentation Viewpoint* is a periodical publication that aims to teach the activities that take place within the research group SARTI and other research groups working within the same thematic areas [53];
- Organization and teaching of summer courses;

- Organiser of the Technological Innovation Awards 2007: ICT category and Mechanics category;
- Identification of and attendance at art sector fairs such as Oceanology International;
- Databases of marine parameters with public access (OceanExpertEMODnet [54], Emso);
- Development of scientific tools for citizenship.

Figure 4. SARTI promotion and dissemination material.

There is a decrease in native species and an increase in new (invasive) species, due to climate change. The OBSEA submarine camera, together with recorded data from the other measuring equipment located in the observatory, provides valuable information for conducting studies on the evolution of marine fauna. The identification activity consists of a web application where the observer can easily identify the species observed on the computer screen (Figure 5), captured by the underwater camera. The image is captured with a simple click, and subsequently identified from the database of species previously acquired and registered by CSIC and SARTI researchers. This information provided by the observer will be stored for later statistical treatment, and participating citizens can see that their contributions generate a result within scientific studies [55].

Figure 5. Website for the identification of marine species with OBSEA.

To carry out this activity in a systematic way and to cover all schools in a geographical area, the Garraf Pedagogical Resource Centre of the Department of Education of the Generalitat de Catalunya was contacted. A working group of primary and secondary school teachers was set up to develop a series of teaching units. In this way, students in the intermediate and advanced training cycles in the subject of the natural environment can get to know better and interactively one of the most important elements of the coastal landscape: the sea (living beings, salinity, temperature, quality of the water, etc.). They are also introduced to the scientific-technological world and motivated to understand more. Guidelines are provided for conducting good observation in the case of the younger children, and for working on the recorded environmental data in the case of the older students [56] (Figure 6).

Figure 6. Work by students in the fourth year of Primary Education at the Els Costerets school in Sant Pere de Ribes (Barcelona). Panel made with cut-out drawings based on OBSEA videos and photos.

In CosmoCaixa (Barcelona) the exhibition "The Mediterranean. Our Sea as you have Never Seen it" was held from December 2013 to December 2014. The aim of this exhibition was to make the Mediterranean Sea known to the public from different points of view, such as scientific understanding, the richness of biodiversity, Mediterranean culture, and research for sustainability. The exhibition featured an interactive section dedicated to OBSEA, from which you could learn what an underwater observatory is, access the different equipment that is part of the platform, and capture live camera images.

5. Analysis of the Results of a Trajectory

This section shows the results of the knowledge transfer achieved through a series of initiatives over more than thirty years of teaching, research and technology transfer.

5.1. Conditioners in the Functioning of a Research Group. Human Resources

To carry out the research tasks, a series of material (space and equipment) and human resources are needed. This is how they were achieved:

- Occupied spaces: 50% of the Vilanova i la Geltrú Technology Centre (CTVG). New laboratories in the expansion of the Neàpolis-CTVG building (2007). Robotics laboratory at the Besòs Campus of the UPC (2014);
- Co-financed equipment: obtaining a series of infrastructure grants. ATYCA Ministry of Industry and Energy (1999), PIR2002 (2004) and PEIR2005 (2005) Generalitat, PCT-310100-2005-2, PCT-310100-2006-3, PCT-310100-2007-1 Ministry of Education and Science (MES);
- Human resources: the members of the research group are university lecturers. This involves devoting an important part of the day to undergraduate/master's/doctoral teaching tasks, time to research management, and, as we have already mentioned, to the management tasks of the School. In this way, the time that can be spent on research and technology transfer projects is limited, except for periods of research intensification achieved in public appeals (Table 7).

Table 7. Periods of intensification in research of SARTI teachers.

Period	Entity	Grant Type	No
2000–2007	MES	Teacher mobility (UK)	1
	UPC	Sabbatical academic year 2003 (Institute of Marine Sciences -CSIC)	1
	MES	Intensification Research programme I3. 3 years	1
2008–2020	UPC	Agreement 140/2009 Governing Council Support for Technological Innovation	1
	UPC	Sabbatical academic year 2013 IGN (National Geographic Institute).	1

Therefore, to carry out the projects and keep the laboratories operational, it is necessary to have staff who are fully dedicated to research, whether as researchers, laboratory technicians, or fellows. To date, the technical research staff are not linked to the staff included in the general budget of the University, so these needs must be covered with public and private funding from the projects developed by SARTI. For example, the percentages of expenses for the period 2001–2013 were: Staff 51.4%, Suppliers 35.4% and Overheads 13.25; personnel costs, arising from the launch of the Technology Centre and the OBSEA submarine observatory, is the most important category, thus conditioning the need for maintenance and acquisition of new equipment. The overhead expenses do not include the part corresponding to the overheads of public projects received directly by the CTT (the office of technology transfer) from the corresponding public entity.

The financial application of the CTT does not show the sum of all the expenses/income of the research groups. There are some that go directly to the economic and personnel services of the University. Tables 8 and 9 show the 15 co-financing grants obtained from public appeals for the hiring of research support technicians.

Table 8. Co-financing for the hiring of research support technicians.

Period	Entity	Grant Type	No
1990–1999	UPC	UPC Strategic Planning Impulse. (1999)	1
2000–2007	MES	Technical support staff (PTA)	6
	Generalitat	Qualified research technical support staff (PQS)	3
2008–2020	MES	Technical support staff (PTA)	4
		Promotion of youth employment in R & D & I	1

Table 9. Collaboration in the training of Master's/Ph.D. students.

Period	Entity	Grant Type	No
2000–2007	MES	Master's students' collaboration in research projects	2
		Research staff training (FPI)	2
2008–2020	MES	Master's students' collaboration in research projects	2
		Research staff training (FPI)	2
		University staff Training (FPU)	1
	European community	Post Doc Marie-Curie	1
		Underwater Vision Project: a learning environment	1
	Generalitat	Industrial Ph.D.	1
		Researcher training (FI)	3
	UPC	Ph.D. university-company collaboration	2

Entrepreneurship provides an open and transformative space to generate knowledge through research, education, and innovation in the service of society. In this environment of knowledge transfer, several students, mostly from the Vilanova campus, joined the research group over the years. From 1995 to 2020, there have been sixty-six contracts managed by the CTT, many of which have been extended for several years. Of these research support fellowship contracts, over time some have gone on to obtain technical contracts linked to research projects, while others have become doctoral students at the UPC or other universities, subsequently moving on to become researchers and teachers. In addition to the research support fellows via CTT contracts, and without having previously gone through CTT fellowship status, others have also been directly incorporated, such as (32): technical staff, doctoral students, Industrial Ph.D. or Erasmus and IAESTE exchange fellows (Table 10).

Table 10. Year 2021. Types of hiring of SARTI staff.

Personal Profile	From CTT Scholarship	Directly Incorporated	Total	Year 2021 Situation
Technicians	19	15	34	7
Lecturers	6	0	6	2
Ph.D. students	5	3	8	3
Postdoc/researchers	6	0	6	2
Graduates	28	0	28	0
Erasmus/IAESTE Exchange Fellows	0	14	14	3
Year 2021	2	0	2	2
Total	66	32	98	19

The rules of the projects of the National Plan of the Spanish Ministry of Education and Science condition the association of researchers with a single project over three or four years. With about twelve university teachers in the research group, it is quite difficult to cover the costs of staff hired through this funding channel. At the same time, an increase in projects increases the workload of projects already underway, causing saturation in the work team. It is an impossible situation. Table 11 shows the trend over the years, where the contributions derived from the transfer of technology with companies have decreased, either due to the increase in projects with public funding or as a result of the different periods of economic and health crises since 2008. There is also a decline in income from lifelong learning. We also note that the contributions of the Generalitat were more significant in the period 2000–2007 for the accreditation of technology transfer TECNIO. Finally, there is the sharp increase in European revenue from projects linked to the OBSEA observatory.

Table 11. Distribution of the source of SARTI financial resources.

Period	Spanish Government	Generalitat	SOC *	Europa	UPC	Company
1990–1999	2.33%	0.00%	31.02%	0.00	3.70%	62.95%
2000–2007	27.23%	8.89%	19.96%	0.00	0.39%	43.53%
2008–2020	32.61%	4.31%	8.83%	28.31%	0.51%	25.43%

* SOC: Catalan Employment Service, Generalitat de Catalunya.

5.2. Networking a Way to Improve the Transfer of Knowledge

Many of SARTI research activities have been made possible through networking with national and international research centres and groups. Some of the collaborations have been:

- With other UPC research groups (work congress 1070 articles and 183 projects);
- Using equipment designed by SARTi, agreements have been made with public entities: Meteorological Service of Catalonia, Geological Institute of Catalonia [57], Colls-Miralpeix Consortium, among others;
- National University Networks: Marintech. Marine Instrumentation-Technologies. CTM2015-68804-REDT Automation and Robotics in the Maritime and Oceanic Industries;
- First Spanish Committee of Oceanographic Observations;
- Integrated actions with universities in Portugal and France HP2006-0131, PT2009-0080;

- Erasmus exchange of students and teachers (1990–2000 in Ireland and Romania, 2000–2007 in the Netherlands, Puerto Rico, Italy and France, from 2007 eighteen stays in Portugal, Germany, Italy, Poland, France);
- European projects Leonardo, Erasmus, Summer Schools, etc.;
- Consortia in different European projects (9) from 2005 with European Seas Observatory Network FP6-2005-Global-4-ESONET 036851-2;
- European Research Infrastructure Consortium (ERIC) European Multidisciplinary Seafloor and water column Observatory (EMSO) [54];
- Collaborations with international centres: Ifremer (France), Monterrey Bay Aquarium (USA) [58], Jacobs (Germany) etc. MBARI Summer Internship (2010, 2014, 2017) and 2021 post doc Marie Curie;
- Smart Ocean Sensors Consortium [58] Open Geospatial Consortium (OGC);
- Development Cooperation Centre UPC years 2001, 2002, 2003, 2004 Matanzas Cuba
- Doctoral theses in collaboration: ISEN-Brest (France), IST-Lisboa (Portugal), ICM-Barcelona, IGN-Madrid, Universitat Publica Navarra (Spain), in company (Prymian, Monocrom, etc.);
- Establishment of an international group in underwater vehicle technologies (15–16 November 2010);
- Centre Tecnològic del Mar-Fundació CETMAR Silence project.

5.3. Bachelor's Degree in Marine Sciences and Technologies

UNESCO has proclaimed the period 2021–2030 as the "Decade of Ocean Sciences for Sustainable Development", with one of the goals being to restore marine ecosystems. The SARTI group is one of the few in Spain with experience in the design, development, and implementation of marine technologies. This entrepreneurial experience of research and technology transfer, from the 2020–2021 academic year, is completed from an educational point of view, with the four-year degree in Marine Sciences and Technologies, taught jointly with the UPC School of Civil Engineering (ETSECCPB) in Barcelona. Until this year, all the academic activity of the group linked to the marine environment had resulted in doctoral studies and optional master's degree modules at the UPC Campuses in Vilanova, Barcelona and Besòs (PECT Coast Besòs Sustainable Territory).

- Doctoral programme in the Department of Electronic Engineering;
    - *The use of Seabed Seismometers (OBS) for Knowledge of the Earth's Crust* (2001–2004);
    - *Electronic design techniques applied to the measurement of marine parameters* (2003–2006);
- Teaching on master's and undergraduate degrees;
    - Oceanographic and aerospace instrumentation systems (2006–2013);
    - Degree in Marine Sciences from the University of Barcelona (UB) (2019–2021).

In courses such as the Degree in Marine Science and Technology, part of the teaching and learning activity must carried out in the marine environment itself (the field of Marine Technologies). By economic activity, for the year 2020, The Port of Vilanova is the second most important of the ports managed by the Generalitat de Catalunya [45]. The location of the School in a city with this infrastructure and proven research experience, is ideal for conducting these courses. These courses were verified by the Agency for the Quality of the University System of Catalonia (AQU), who implemented a quality control system guaranteeing the process of design, implementation and development of studies adapted to the European Space of Higher Education (EHEA), through the AUDIT project of the National Evaluation Agency (ANECA).

5.4. Indicators Research Activity and Technology Transfer in the UPC Context

However, SARTI is a small research group outside the core of the University. In this last section we want to show the weight of the activities of the research group within the UPC. SARTI is one of fourteen TECNIO (Generalitat de Catalunya) accredited UPC research groups. To convey an idea of its contributions to research and technology transfer within the UPC, we will use the indicators PAR (Research Activity Points) and PATT (Technology Transfer Activity Points). These are regulations approved by the UPC Governing Board in 1989 and 1995, respectively [59].

We have already indicated that the activities of the research group have been recognized by the UPC since 1997 as a sub-field of research within the Power Electronics research field of the Department of Electronic Engineering (EEL) of the UPC. In the period 1997–2002, SARTI's contributions already accounted for 29.2% of the Power Electronics research line. Table 12 shows the contributions of PATT points. Prior to 2002, PATT points were not visible in the SARTI group, as they were included in the activity of the Department of Electronic Engineering.

Table 12. Comparison of SARTI PATT points with those of the UPC in the period 2002–2019.

Period	PATT UPC	PATT SARTI	Ratio SARTI & UPC	PATT SARTI Per Year
2002–2007	409,829,705	3,410,642	0.8	592,357
2008–2019	830,072,764	14,553,035	1.8	1,323,003

Table 13 shows the research activity points of the University, the SARTI group and the EPSEVG (the last column shows the average value PAR/year). The increase in PAR points between the periods analyzed is observed; Table 13 shows the comparison in percentages for three periods where the increase is observed when the Vilanova Technology Centre is set up and is maintained in the following period. With regard to the EPSEVG, in the period 2008–2019 the level of SARTI contributions continues to increase significantly.

Table 13. PAR points: UPC, SARTI, and School for the period 1996–2019.

Period	PAR UPC	PAR SARTI	PAR EPSEVG	PAR SARTI/Year
1996–1999	91,361.67	209.50	3001.35	52
2000–2007	319,401.51	1268.99	12,039.33	159
2008–2019	859,923.29	4078.91	22,898.87	371

The reports of the Governing Council of the UPC consider the level of activity following some assessments shown in Table 14 [59]. The assessment of SARTI activity, in PATT points, is very high in the three time periods considered. For PAR points, it is very low in the initial period 1996–1999, medium in the period 2000–2007, and very high in the last period 2008–2019. In the context of the Polytechnic University of Catalonia, this section has shown the optimal level of research and development achieved by SARTI-UPC.

Table 14. Assessment table of the PATT and PAR points at the UPC, year 2003 and following.

	PAR	PATT
Very low	0 to 101.03	0 to 62,256
Low	101.03 to 148.22	62,256 to 132,758
Medium	148.22 to 218.16	132,758 to 294,948
High	218.16 to 337.82	294,948 to 569,269
Very High	More than 337.82	More than 569,269

6. Discussion Section

In the introduction to this paper, we stated that the University has three missions in knowlege transfer: teaching, research, and service to society. Only in this way can the complex problems and challenges of the future be addressed. If the missions are separated, teaching becomes merely technical training [13], instead of an education for freedom and responsibility, regardless of the work or role carried out in society [60].

This work has not sought to present details of the results of the research projects, publications that can be accessed through the websites of the research group and/or the

UPC [44]. The objective of the article has been to show the different facets of a research group (teaching/research/technology transfer) and the tools used to fulfill the mission of improving the transfer of knowledge to society.

At the Vilanova Campus in the 1990s, resources did not exist, and the only possibility of carrying out research was to be linked to existing groups on the UPC Barcelona campuses. In a first phase, equipment and infrastructures were put into operation under the umbrella of teaching electronic instrumentation, and a first core of researchers was created with recognition from the University as a research sub-field based in Vilanova (1990/99). Subsequently, research and transfer facilities were set up with the construction of the Technology Centre building, the obtaining of a series of quality certifications and accreditations, and the formation of a part of a network of centers, with the recognition of public administrations. A framework collaboration agreement with the CSIC was established in 2001, and has since generated an important symbiosis of science and technology. And finally, the OBSEA submarine observatory, an infrastructure that was not bought as a turnkey system, was designed, built and installed by SARTI. This infrastructure allows for participation in different national and European consortia (2008–present). The last step in this trajectory has been the creation of university studies linked to the research field (Marine Sciences and Technologies). This is illustrated as a brief summary of the trajectory in Table 15.

Table 15. Brief summary of trajectory.

Revitalization of Spaces of a Century-Old School with the Aim of Becoming a University Centre
• New spaces. Classroom building, student residence, library. • In laboratories: centralization of management and new laboratory. “Virtual Instrumentation.”
Design and implementation of research infrastructure
• Technology Centre building with high performance equipment • Marine observatory
Developing autonomy in research and technology transfer
• 1990–1999 dependent on Barcelona. SARTI self-governing since 2000 • Associated Unit to CSIC. Science and Technology Symbiosis • Training of research staff • Evaluation of technology. Certifications-Accreditations Quality • Internalization and networking actions
University teaching in the field of marine instrumentation-technologies
• Degree in Marine Science and Technology. Field of Marine Technologies.

Generating and exchanging new knowledge are essential processes in higher education. Although evolving, the standard profile of a university lecturer today is still mainly that of a researcher who has completed their doctorate at the same university and has taken up a teaching position. Their future activity will be to teach master’s level degree classes based on obsolete content, and to devote a minimum amount of time to publishing in academic journals. They will only be interested in investing in the development of personal entrepreneurial skills if the academic environment offers support and recognition [61], which, however, is not the current situation. In the university-society knowledge transfer, a series of points should be considered in order to achieve success in the development of a research team. Based on our experience, Table 16 shows some points to consider for the development of a research team.

Table 16. Some points to consider for the development of a research team.

Situation	Effect
• measuring the success of a researcher only by the factor h [62]	not valuing the development of entrepreneurial skills
• the academic environment does not offer support for, or recognition of, the development of personal entrepreneurial skills	lack of entrepreneurial culture
• entrepreneur is probably self-taught with previous experience in the business world	knowledge of management, communication skills, business coaching is needed
• the university has few qualified human resources for management and consulting in university-business relations	researchers' constant investment in effort and time
• the research activity basically responds to the personal initiative of the researcher	loss of collective synergies in strategic lines of research
• volatility of the research project: it starts and ends	there is no continuity in the search
• funding only to develop a project	there is no fundamental funding for research groups
• Not being part of a multidisciplinary team. Not working in collaboration with other research groups	Poor knowledge transfer
• insufficient number of teaching and research staff	conditions the success of the research: precariousness
• low presence of technical staff in universities	conditions the success of the research
• small-scale economic projects	solution with teaching infrastructure
• singular lines of research	conditioned by large infrastructures
• lack of certifications and accreditations	the level of quality contrasted is shown
• the creation, equipment and accreditation of a metrology laboratory	In the topic area of instrumentation, anincrease in the quality in teaching/research/technology transfer
• actively participate in Lifelong learning courses	This allows the update of the study plans

The different knowledge transfer activities of SARTI-UPC presented in the previous sections, despite difficulties in obtaining funding, have made it possible to contribute to academic research and entrepreneurship on a small scale. It has also opened windows to prepare electronic engineering students for their futures by training in a research team. Table 17 presents a summary of some of the latest active projects, the ongoing nature of which ensures continuity in the activities of the research group.

Table 17. Currently active research projects with funding for competitive public calls [44].

Name of the Project	Initial Date	End Date
• Geosphere Infrastructures for Questions into Integrated Research; Geo-INQUIRE.	2022	2026
• Enabling research infrastructure services for better use of imaging data to address challenges in thematic research areas.	2022	2026
• Gemelo digital photovoltaic solar power plants; Girasol.	2022	2023
• Metrology for Integrated Marine Management and Knowledge-Transfer Network.	01/04/2021	31/03/2025
• Joint European Research Infrastructure of Coastal Observatories: Science, Service, Sustainability.	01/02/2020	31/01/2024
• Environmental Research Infrastructures building; Fair services Accessible for society, Innovation and Research.	01/01/2019	31/12/2022
• Multi-purpose/Multi-sensor Extra Light Oceanography Apparatus	01/12/2017	28/02/2022
• Underwater acoustic systems for monitoring the spatial behavior of species; SASES.	01/01/2019	30/09/2022
• Long Duration Platform for the Observation of Marine Ecosystems	01/12/2021	30/11/2024
• Joint effort between biology and technology to monitor and recover species and ecosystems impacted by fishing; multiparametric observation platforms.	01/09/2021	31/08/2025

7. Conclusions

It is important for a new university lecturer to find a topic on which to develop knowledge transfer which, if possible, is different from that of other research groups at the same university. This will, in all probability, be difficult at the beginning, due to the lack of human resources and equipment. Feasible activities will have to be found to launch the knowledge transfer entrepreneurial agenda that combines the three missions of the university: teaching, research, and technology transfer in the medium/long term.

Taking as a reference the three missions of the university, this work has been carried out by a research team following a case study methodology [63–65]. This paper has covered the over 30-year trajectory of SARTI-UPC in teaching-research and technology transfer in the Catalonia-Spain-Europe territorial context. The trajectory began in the teaching of electronic instrumentation in the context of structured knowledge transfer at different levels: combining undergraduate research and industrial practice, establishing the framework of agreements, project-oriented learning, and lifelong learning. Subsequently and in parallel, research and technology transfer activities were developed in the field of electronic instrumentation, to later specialize in marine technologies that have generated the creation of new engineering degrees.

More than thirty years of entrepreneurial experience in the transfer of knowledge on the University Campus of Vilanova i la Geltrú have allowed the incorporation of a significant number of students in the process of the evaluation of real-life problems (Table 10), thus building creative thinking as a cognitive process that leads to innovation [66,67]. This whole trajectory has been made possible because a series of activity niches have been found. Firstly, the commitment to graphic programming for instrumentation control (LabVIEW programme and GPIB instruments), and later, marine technologies. These two points have been crucial. Achieving a niche in the context of marine technology research has been possible thanks to the location of the EPSEVG in a coastal town, and the science-technology symbiosis with the Institute of Marine Sciences and other research centers of the CSIC (Section 4.3).

The research team has carried out many activities, and in this article, we have tried to detail an entrepreneurial focus in degree studies from its outset. There is no better way to say what needs to be done in knowledge transfer, than to show how it has been done: setting up laboratories, civil infrastructure construction, magazine editing, biannual organization of scientific conferences, creation of databases of environmental parameters, marketing plans, quality accreditation ISO, etc. This entrepreneurial trajectory has shown us the desirable characteristics an academic staff should possess, including perseverance, the attitude to achieve an objective, the ability to identify opportunities and motivation, among others [68,69]. Universities should involve their academic members in all knowledge transfer practices to strengthen their effectiveness and quality [70–72]. Table 16 shows some points to consider for the development of entrepreneurial skills in the standard profile of a university lecturer.

In terms of strengthening graduates' professional outcomes, Section 3 (Company-University Relationships in Engineering training) has shown the trajectory of SARTI in the teaching of electronic instrumentation at different levels: combining undergraduate research and industrial practice, establishing the framework of agreements, project-oriented learning, and lifelong learning by developing skills such as analysis, synthesis and evaluation of information, and enabling the development of critical thinking, teamwork and decision making. The case study presented here does not provide general solutions, but rather specific data to reflect on, analyze and promote the finding of possible solutions to a given problem. It does not offer the students solutions, but allows them to generate them. By leading students to the generation of alternative solutions, it allows them to develop creative ability and the capacity for innovation, and it represents a resource to connect theory with real practice [73]. University-business interaction is a working method that allows students to have a much more authentic practical experience than would be had in a purely academic exercise [74].

No survey was carried out on the students involved in order to test the effectiveness of the employability of these activities. Table 2 (Educational collaboration agreements) and Table 3 (Number of continuing training courses) show a significant number of activities which companies value highly, and which have facilitated the employability of students. Also, in order to improve University-Company relations and based on the experience gained, Section 3.2 introduces some critical factors that determine the success of the University-Company relationship.

As with all research, this study has limitations, some of which are highlighted. The case study focused on the results of a specific trajectory of a research group, which limits the generalization of these results. It would be interesting to compare the effects of different proposals using matching techniques. A comparison using two control groups of students, one that attends the SARTI entrepreneurship activities and the other that does not, would also be of interest. This would allow the research to assess the impact of the case study more rigorously [75]. The application of research methods such as interviews (qualitative) or questionnaires (quantitative) [76]) could help ensure a better understanding of the topic. However, because of the nature of questionnaire research, it is not suitable for deep understanding, as many individual aspects remain hidden [77]. Another limitation of the study is related to the consideration of the gender perspective [78]. For this case study, the differences between male and female students have not been considered, so they could be taken into account for future lines of research.

Author Contributions: Conceptualization, J.O.i.D. and A.M.L.; methodology, A.M.L., J.O.i.D. and S.G.C.; validation S.G.C. and J.D.R.F.; writing—original draft preparation, A.M.L., J.D.R.F. and J.O.i.D.; writing—review and editing, J.D.R.F. and A.M.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting the reported results can be partially found on the different UPC websites.

Acknowledgments: A thanks to all the researchers and advisers who have been involved in the creation and development of the SARTI research group for over 30 years. A special thanks a Rosa Gonzàlez-Casas for the work by students in the 4th year of Primary Education at the Els Costerets school in Sant Pere de Ribes (Barcelona).

Conflicts of Interest: The authors declare no conflict of interest.

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