CESAER

ROLE OF UNIVERSITIES OF SCIENCE & TECHNOLOGY IN INNOVATION ECOSYSTEMS TOWARDS MISSION 3.1

TECHNICAL ANNEXES

LEUVEN, 5th OCTOBER 2018

TABLE OF CONTENTS

SURVEY INNOVATION ECOSYSTEMS

FIGURE 1. QUESTIONNAIRE STRUCTURE

UNIVERSITIES TECHNOLOGY TRANSFER ACTIVITY	SPECIFIC UNIVERSITIES TECHNOLOGY TRANSFER ACTIVITIES AND SCALE USED
Research Commercialisation	- TTO activities (IPR, licensing) (Likert 1-4) - Research results economic valorisation (Likert 1-4) - Improvement of the university ability to stipulate research contracts with industry (Likert 1-4) - Improvement of the university ability to stipulate research contracts with other public organisations (universities, research centres, science and technology parks) (Likert 1-4) - Research results IPR management (Likert 1-4) - Licensing management (Likert 1-4)
Academic Engagement	- **Collaboration with ecosystem actors (research centres, government, Venture Capitalists/Investment funds, industry) (Binary 0,1)** - **Collaboration with industry on technology development lifecycle (Binary 0,1)** - **Lifelong education with graduate members, scientists and industry members (Likert 1-4)** - **International Networking with companies (Likert 1-4)** - **International Networking with universities (Likert 1-4)**
Support to Start-up creation and growth	- Mentoring programmes for startupper (Likert 1-4) - Business plan competitions (Likert 1-4) - Incubators programmes (Likert 1-4) - Accelerators programmes (Likert 1-4) - University spin-offs management/mentoring support (Likert 1-4) - University entrepreneurship courses (Binary 0,1) - University labs available for students (Binary 0,1) - University mentoring programmes (Binary 0,1) - Space provision By University (Binary 0,1) - Competition with final prize Powered by University (Binary 0,1)
Funding support	- Funding support for technology development, start-up and spin-offs (Likert 1-4) - Innovation stage funded by Universities (Binary 0,1)
Entrepreneurship Education for Students	- Entrepreneurship education for students (Likert 1-4)
Entrepreneurial Climate within the university	- Entrepreneurship education for faculty members (Likert 1-4) - Assistance for finding investors (Likert 1-4) - Diffusion of an entrepreneurial culture (Likert 1-4) - training staff in commercialisation of technologies (Likert 1-4)

TABLE 1. GROUPING OF SPECIFIC UNIVERSITY TECHNOLOGY TRANSFER ACTIVITIES INTO SIX MAIN DIMENSIONS

SURVEY INNOVATIVE MINDSETS

The survey on innovative mindsets aimed to shed light on how innovative and entrepreneurial mindsets are being formed by S&T universities. It was conducted among CESAER Members in the summer of 2017 and obtained responses from 17 leading S&T universities.

The core questions of the survey were divided between the definition of concepts, activities (this survey only covered extra-curricular and not the adaptation of current curricular activity) and the support systems and enabling factors.

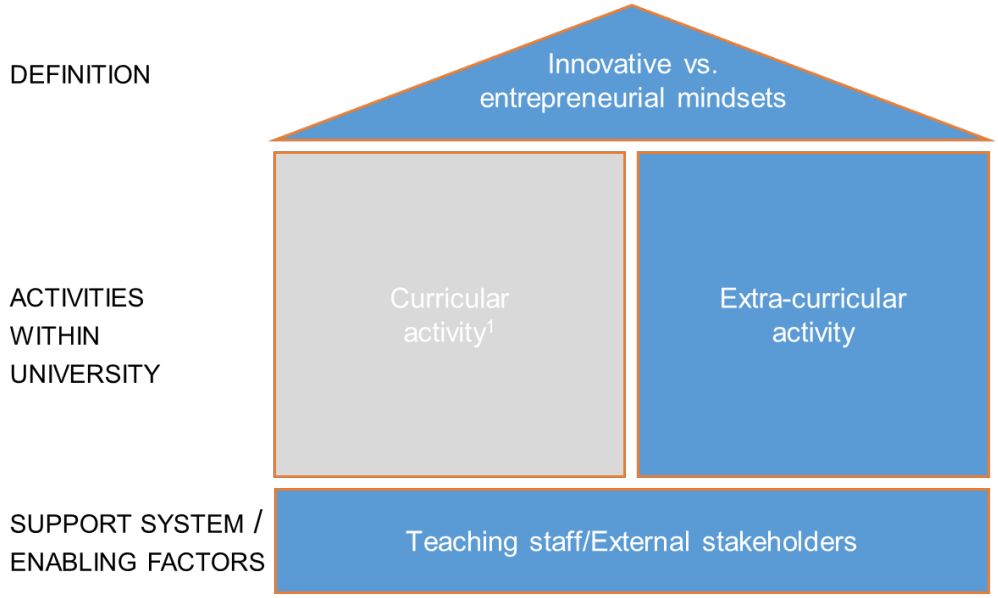


Illustration of concepts and activities dealt with in survey

This translates into the following dimensions of analysis:

- Understanding/interpretation of innovative and entrepreneurial mindsets
- Extracurricular offering
- Centre of entrepreneurship
- Incentives for students
- Involvement of teaching staff and external stakeholders

CASE STUDIES

KU LEUVEN[1]

INTRODUCTION OF UNIVERSITY IN ITS REGIONAL CONTEXT

KU Leuven is Belgium's largest university. Established in 1425 it is also one of Europe's oldest universities. It currently has about 57,000 students (of whom 17% are international students), some 12,000 university staff that are further complemented by an additional 8,000 University Hospital staff. The university is also associated with 5 university college clusters that make up an additional 50,000 students on several campuses in the Flemish region in Belgium. It is a comprehensive university encompassing 16 faculties that are organised into 3 groups: Science & Technology, Biomedical Sciences and Humanities & Social Sciences. Its research expenses amount to 475 million euro (2017 data).

UNIVERSITY STRATEGY ON INNOVATION AND ENTREPRENEURSHIP

KU Leuven is an internationally oriented research-intensive university, strongly embedded in both the local and European innovation eco-system. In order to leverage its impact on society, it has forged strategic partnerships with many actors (governments, public and private networks, individual companies, non-profit organisations, etc.). Examples of successful local collaborations are the establishment of regional science parks by KU Leuven together with local stakeholders and an active multi-stakeholder collaboration in a network managed by the local government[2] that focuses on health, food, logistics, cleantech, media and creative industry. Examples of successful European ecosystem collaborations are the the Eindhoven-Leuven-Aachen triangle or the Health Axis Europe partnership (including a.o. Copenhagen, Maastricht and Heidelberg University). KU Leuven is also actively engaged in several international networks, such as CESAER and LERU. These networks serve not only as meeting places to exchange best practices amongst peers, but also as places to think along with policy-making at EU level.

STRATEGY IMPLEMENTATION

Like many other universities, KU Leuven has materialised its strategy on innovation and entrepreneurship through the setup of a specialised Technology Transfer Office (TTO), called Leuven Research and Development (LRD). LRD was established in 1972, which makes it one of the oldest TTOs in Europe. As a result of its long existence and experience, LRD has become structurally embedded in the University's governance system while keeping the necessary level of autonomy in order to maintain its focus on its particular, entrepreneurial mission of supporting exploitation of research results. Driven by the excellent science from its

[1] Case study developed by Wim Fyen (Investment Manager of KU Leuven R&D and Co-Founder of Lcie), with the collaboration of the following KU Leuven staff members: Koenraad Debackere, Paul Van Dun, Rudi Cuyvers, Gert Trekels, Marrit van den Heuvel, Lucas Vanlaer.

[2] See: www.smarthubvlaamsbrabant.be/international/

faculty members, KU Leuven has consistently built an entrepreneurial climate amongst its researchers by exploiting research results via contract research, intellectual property licensing and spin-off creation. Currently, the university, through the support of LRD, starts about 2,000 new research collaborations per year, manages a patent portfolio of 565 active patent families and has so far created 124 spin-offs that employ some 6,700 employees (2017 data). More details on the historical evolution of these activities can be found in a study made by Science|Business[3]. As a result of these activities, KU Leuven has managed to obtain the title of Europe's most innovative university based on the Reuters ranking of 2016, 2017 and 2018.

In addition to these technology transfer activities, KU Leuven also actively supports entrepreneurship and innovation through several courses, events and workshops, some of which are organised in collaboration with partner organisations. Examples are a modular programme 'exploitation of research' where each year some 90 PhD students work in teams to develop a valorisation plan based on their own research, or specific workshops explaining the process of starting up a spin-out company, which includes guest lectures given by successful entrepreneurs.

The university has also set up several networks that bring researchers and business practitioners together on certain themes such as materials science, medical technology, food and nutrition, drug discovery, among others.

UNIVERSITY AS INNOVATION ECOSYSTEM INTEGRATOR

Based on the experience with research and technology transfer as demonstrated in the previous sections of this paper, it was decided in 2012, to start an initiative with the goal of creating an entrepreneurial culture throughout the entire university, including the student population. This led to the Lcie initiative[4] (the Leuven Community for Innovation driven Entrepreneurship). A particular characteristic of the Lcie initiative is that it is largely managed via a bottom-up approach with significant student involvement throughout its system of governance. In the context of Lcie, many entrepreneurial individuals (students, professors, researchers, etc.) started to take initiatives that support a university-wide innovative and entrepreneurial climate.

In order to leverage all this creative and human capital, a core Lcie team was set up and was embedded within the TTO (in order to provide it with the necessary autonomy within the university - a similar approach as has been adopted previously when setting up the TTO itself). This core team actively engages with entrepreneurial individuals in the university, thereby creating a university-wide entrepreneurial community. The activities of this core team can be roughly divided into 3 categories: i) improving entrepreneurial skills, ii) leveraging the community and iii) startup support.

[3] See G. Edmondson, Creating a virtuous circle in technology transfer - The case of KU Leuven (Science|Business Publishing), available from http://bastion.wum.edu.pl/wp-content/uploads/2015/08/Bastion-report-single-view-AUG4.pdf

[4] W. Fyen et.al. in Aalto A., Montonen L., (2016). Smart Cities in Smart Regions 2016: Conference Proceedings. Willman M. (Ed)., In: The publication series of Lahti University of Applied Sciences, part 27, Lahti University of Applied Sciences. URN:ISBN:978-951-827-264-2 (pp. 37-46).

1. Improving entrepreneurial skills

Over the last years, various KU Leuven faculties have introduced courses on entrepreneurship both in the Master and Bachelor level curriculum. To further build on and consolidate these initiatives at the faculty level, the University has created the Lcie Academy, which now manages a portfolio of entrepreneurship courses that can be followed leading to a certificate of entrepreneurship (requiring a minimum of a least 18 ECTS worth of courses). It is important to note is that the Lcie Academy is governed by an interdisciplinary steering committee.

In addition, the Lcie community has also started new initiatives that have become fully supported by the Lcie core team. As an intra-curricular example, students have created a new course 'Product Innovation Project'. In this project-based learning format, a multi-disciplinary team of students has to develop a solution to a given problem, delivering a prototype and business case. The concept was inspired by examples developed at Aalto and Graz and has been introduced at KU Leuven by motivated, entrepreneurial students. Starting with three faculties offering this course to their students, the concept has (after four years of operations) now been accepted in faculties. It is noteworthy that the faculty of engineering science has created a new course descriptor for PiP, allowing students to fully embed this project in their curriculum. This approach is now followed by several other faculties, clearly demonstrating the potential of bottom-up innovation initiatives within the university.

As an extra-curricular example, a modular inspirational concept known as the 'Learning Garages' has been implemented in the university whereby students are challenged to come up with a business case in the field of an emerging technology (e.g. Artificial Intelligence). This concept has been initiated by the Cronos Group - an IT integrator & innovator with focus on entrepreneurship - and one of the strategic partners of the Lcie network and implemented at KU Leuven as a test-case to support entrepreneurial behaviour with students of all backgrounds. It is noteworthy that a significant number of participants in this concept (at least one third) is affiliated with the group of Social Sciences and Humanities, indicating the potential to reach out to faculties that are not often easily associated with entrepreneurship and innovation. It also illustrates the power of strategic partnerships with external partners.

2. Leveraging the community

Within the Lcie community, several initiatives developed by the student community provide valued support for entrepreneurial projects. One example is IusStart, a legal clinic that has been started in 2014 by PhD students from the faculty of Law, whereby students provide legal advice for startups. At this point, the concept has been fully adopted by the faculty of Law in the form of a Master thesis for law students. At the quantitative level, every academic year, some 10-20 IusStart law students provide (as part of their Master's thesis) legal advice to 5-10 startups supervised by five PhD students and a similar number of law offices. Along similar lines, the 'TechStart' concept was initiated recently by PhD students from the engineering faculty, whereby engineering students provide technology advice to startups, thereby receiving ECTS credits.

3. Startup support

For those students who want to actively engage in entrepreneurship, the university provides support in the form of office/technical space at a dedicated incubator, as well as coaching and funding. The incubator is conveniently located on-campus and houses several startups, which – in line with the community approach – allows entrepreneurially minded students to engage directly with colleagues who have already started their company. As part of its further strategy, the university is also launching a fund to provide financial support for students in the early stages of their venture, in collaboration with the private equity company CVC and the university investment fund Gemma Frisius Fund Over the last three years, about 400 students (109 teams) have received some form of support. In total, the students who started new ventures have created more than 85 new jobs and have raised over 10 million euro in capital from a variety of sources (business angels, loans, venture capital, grants,…).

FUNDING STREAMS

The Lcie initiative is currently financed through a mix of funding sources. Starting with small structural funding from the TTO (including in-kind support via a part-time coordinator) and a yearly allowance of the local network of entrepreneurial startups (Leuven.inc, the funding base gradually increased thanks to the support from the local government in setting up the student incubator activities, followed by support from private sources. Currently, the annual budget is in the order of 200,000 euro (excluding in-kind “staff time” contributions) and is set to increase in the future. A survey amongst LERU universities indicates that a meaningful annual budget is typically in the order of 500,000 euro. It should contain structural (i.e. non-project based) funding to attract and maintain dedicated people and allow the adoption of a long-term vision and its execution.

VISION OF THE FUTURE

The impact that has been reached so far with the Lcie initiative clearly illustrates that a step-up in entrepreneurial culture is possible and results in a structural impact on the ecosystem. As far as entrepreneurship is concerned, many good ideas exist within the community (of students, researchers and professors). Hence, a supporting role of the university offers a good approach to leverage its entrepreneurial potential. Moreover, a large and motivated entrepreneurial student population is ideally placed to have a significant impact on the entrepreneurial culture of Europe’s future workforce. In this process, the university becomes even more embedded in the local ecosystem while the role and impact of structural partnerships (and structural support for maintaining these partnerships) diversify and increase. The result is an entrepreneurial win-win between our students and the other relevant actors in the ecosystem.

NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (NTNU)[1]

The Norwegian University of Science and Technology (NTNU) is the largest university in Norway with its main campus in Trondheim. Since its establishment in 1910, NTNU has been the leader in engineering education and even though the university today includes all seven faculties, the science and technology-orientation is still strong. NTNUs 2020-strategy clearly articulated that all students will get an introduction to entrepreneurship and innovation during their studies. NTNU not only strives to educate people with the skills and mindsets to act as change agents creating new businesses, but also contribute in existing private and public organisations. In 2013, a request from a major utility company, TrønderEnergi (https://tronderenergi.no/om-tronderenergi/english), called for closer cooperation with the university. This extended cooperation is primarily expressed through developing a method to engage more students in the region to work with innovation and entrepreneurship. This was to be a joint effort to include all NTNU students in the innovation ecosystem and bring to life more ideas at the regional and national levels. TrønderEnergi has a long history in supporting business development in the region, and view their support of student-driven start-ups as beneficial in several ways:

a. Facilitating new business growth in the region;
b. Facilitating more experience-based learning about entrepreneurial and innovation processes among students at the university;
c. Inspiring their own organisation to gain a mindset prepared for the revolutionary changes in their industry;
d. Marketing themselves as an attractive employer for highly competent talents.

Therefore, and in accordance with NTNUs goal of exposing all students to entrepreneurship and innovation, NTNU and TrønderEnergi decided to set up an initiative employing selected students with entrepreneurial experience to act as coaches for all students with a business idea. The objective is not solely to develop more start-ups in the region, as acknowledged that most start-ups fail in the early phase. Nevertheless, the entrepreneurial process offers unique learning regardless of whether the start-up is successful or not. In summary, NTNU offers an extracurricular and student-driven introduction to entrepreneurship and innovation to all students, building a community that shares ideas, inspiration and knowledge among students.

EXTRACURRICULAR ENTREPRENEURSHIP INITIATIVE: SPARK NTNU

Based on the above, in 2014 NTNU launched Spark NTNU, an extracurricular entrepreneurship initiative that offers free coaching in the entrepreneurial process to all students at NTNU. In general, extracurricular initiatives have been shown to complement curricular activities as they involve a broad population of university students (Passiante and Romano, 2016), allowing students to learn about entrepreneurship in a supportive environment (Pittaway et al., 2011). Extracurricular activities may also contribute to the entrepreneurship ecosystem at many universities (Wright et al., 2017). The core of Spark NTNU is coaching. Students with some entrepreneurial experience, for example from running their own start-up are coaching novice student entrepreneurs. At the time of writing, 17 students work as coaches

[1] Case study developed by Solvi Silset (Senior Advisor, NTNU Rector's Staff for Innovation).

in Spark NTNU. All university students with an idea they want to set to life are eligible for free coaching from Spark NTNU. There is an emphasis on ideas with a business goal and/or potential, but any idea or project is eligible to receive coaching. In general, student entrepreneurs that contact Spark NTNU have little or no prior experience with entrepreneurship or business development.

As of April 2018, Spark NTNU is coaching 70 active projects. In addition, Spark NTNU also hosts events such as "Join-A-Startup-Night" and "Thirsty Thursday" in order to reach out to even more students. Since its launch in 2014, Spark NTNU has been coaching over 350 projects. Taking into account the average team size of three students, this means that the initiative have supported more than 1000 students so far. Among the projects that have been supported, 35 are registered as "alumni", meaning that the projects have been turned into growing businesses and/or limited companies at a level beyond the mandate of Spark NTNU. Table below lists the niches in which the alumni start-ups operate within, which illustrates the diversity of projects within Spark NTNU.

Consumer Hardware / Appliances	2
Education Technology	5
Food & Fashion	3
Games	3
Health Technology	3
Industrial Solutions	9
Marketing (services, platforms)	3
Non-Profits	2
Social Media / Multi-Sided Platforms	4

Alumni projects from Spark NTNU categorised by niche

The fact that NTNU as a S&T university facilitates the creation of technology-based student start-ups and student start-ups that work in business-to-business markets solving industrial problems. This is a unique characteristic of the innovation ecosystem around NTNU.

INTEGRATION OF STUDENT INITIATIVES AND UNIVERSITY ACTORS

Engage is a centre of excellence in entrepreneurship education. Engage aims to ensure that the ability to identify new opportunities, the will to act upon these opportunities, and the knowledge to acquire the resources and skills needed to innovate for the better, become fundamental elements in all disciplines at the higher education level. Engage was founded in 2017, and is a consortium consisting of the NTNU School of Entrepreneurship, Nord University Business School, NTNU Experts in Teamwork, TrollLABS and Spark NTNU. In order to be awarded the status as a CEE, Spark NTNU and the other partners were evaluated by an international expert jury. Among the conclusions of the jury were; "The expert panel was particularly pleased to see the important position and roles of students and student organisations within Engage".

NTNU School of Entrepreneurship is a two-year Master programme in entrepreneurship where students create and learn through their own ventures as an integral part of their education. The vision of the NTNU School of Entrepreneurship is to develop the world's best business developers and enrols 35 students each year. A major part of the coaches in Spark NTNU are students at the NTNU School of Entrepreneurship.

FRAM NTNU is the students' shared hub for innovation and entrepreneurship. FRAM offers a place to host events such as presentations and competitions, meeting and lecture rooms, a

makerspace and a studio for audio and video recording and editing. It is governed by a group of student volunteers and is open to all NTNU students. Most of Spark NTNUs activities take place at FRAM.

Start NTNU is a student-driven organisation set up to promote entrepreneurship and innovation to students. While Spark NTNU focuses on students that have an idea they would like to pursue, Start NTNU aims to motivate and inspire students to create a business idea. They do this through hosting several large annual events sponsored by local and national industry actors. Start NTNU provides a recruitment area for Spark NTNU.

Furthermore, Spark NTNU engages with SMBs in the region, with local co-working spaces, such as DiGS and Work-Work, and Innovation Norway, the national support organisation for innovation and development of Norwegian enterprises and industry.

SUPPORT AND FUNDING

TrønderEnergi is the main funding actor for the establishment and operations of Spark NTNU. NTNU contributes by organisational resources for the day-to-day operation of the initiative. Engage provides funding for further development of Spark NTNU in terms of the methods applied and the dissemination of the Spark NTNU model to other universities.

RESULTS AND FUTURE VISIONS

Spark NTNU has built an awareness of student entrepreneurship at NTNU. Long-term impacts are: increased presence of entrepreneurship topics in many study programmes; increased motivation for entrepreneurship and innovation among students; and the promotion of the development of change agents for business and society, together with Engage.

On their side, TrønderEnergi has experienced a positive impact on their organisations ability to prepare for and handle change in the renewable energy sector. Spark NTNU has turned into a national model for developing student entrepreneurship, and, at the time of writing, five universities in Norway are collaborating with Spark NTNU to establish similar initiatives. The dissemination of the Spark NTNU model to other universities is one of the goals of Engage. In addition, at the time of writing, two large industrial actors are on-board as supporters of Spark NTNU, both finanically and through providing students with insights and opportunities in their respective industries.

REFERENCES

Passiante, G. and Romano, A. (2016), *Creating Technology-Driven Entrepreneurship*, Springer Nature, London.

Pittaway, L., Rodriguez-Falcon, E., Aiyegbayo, O. and King, A. (2011), “The role of entrepreneurship clubs and societies in entrepreneurial learning”, *International Small Business Journal*, Vol. 29 No. 1, pp. 37–57.

Wright, M., Siegel, D.S. and Mustar, P. (2017), “An emerging ecosystem for student start-ups”, *Journal of Technology Transfer*, Springer US, Vol. 42 No. 4, pp. 909–922.

POLITÉCNICO DI MILANO (POLIMI)[1]

With approximately 42,000 students, Politecnico di Milano (PoliMi) is the largest Italian university for Engineering, Architecture and Industrial Design and it is ranked as one of the most outstanding European universities in these fields (QS World University Ranking by Subject 2018: Engineering: 17th, Architecture: 9th, Design: 5th).

The university has seven campuses located in Milan and in other nearby Italian cities and it is organised into 12 departments, devoted to research and 4 Schools, devoted to education. Because of its nature as an S&T university, PoliMi has always earmarked the theme of innovation both within the university and with external collaborators, and holds significant potential in this area.

PoliMi's innovation strategy can be found in the University guidelines "*Politecnico di Milano*, in the achievement of its institutional goals, promotes the development of scientific knowledge, technology transfer and the exploitation of university research results. In particular it: a) promotes and organises the innovative research of the University, also in collaboration with other public or private partners; b) promotes the protection of the University's research results; c) economically enhances the results of the University's research, also through the technology transfer related to the University intellectual property."

The foundation of the University's innovation ecosystem are:

- High-quality research (attested by the various international rankings);
- A close relationship with the industrial world, highlighted by the volume of collaborations with companies and also supported by the capacity to make technological facilities available to businesses;
- A strong inclination to technology transfer and entrepreneurship: PoliMi was among the first universities in Italy to understand the importance of enhancing the innovation arising from its teaching and research activities.

PoliMi innovation ecosystem mainly relies in two operative structures: the Technology Transfer Office (TTO), that supports the development and transfer of intellectual property stemming from research results and activities (such as know-how, patents, designs, trademarks, software) and PoliHub, a startup district and incubator providing support to highly innovative startups operating in different fields of innovation. The TTO and PoliHub work actively in spreading the innovation and entrepreneurial culture inside the University. They build networks for the development of long-standing partnerships with other universities and research institutions, and work closely with other TTOs and incubator associations like NETVAL (the Italian TTO association), PNI CUBE (the Italian association of incubators and academic business plan competition) and others.

Alongside the collaboration with other innovation ecosystems, POLIMI has developed strategic partnerships with key external stakeholders from industry, consultancy firms and Italian associations to increase the value of the university's technologies and IP assets, and strengthen the innovation and technology transfer culture.

[1] Case study developed by Silvia Bianco (Valorisation and Research Services of PoliMi).

Over the last few years, the University invested more resources in the innovation strategy by implementing the following activities:

- Specific courses on innovation and intellectual property management addressed to students and external attendees like the I.PhD day, a one day workshop on Intellectual Property dedicated to the PhD student of Politecnico di Milano; Theorem, an awareness and training programme on intellectual property aimed at researchers and start-uppers; and a MOOC available on the Polimi Open Knowledge platform titled “Introduction to Industrial Property: patents, designs, trademarks”.
- Activation of a competence centre to guide companies, especially SMEs, in industrial digitalisation, that will carry out training activities and implement innovation and joint research projects in different target areas of the Italian Industry 4.0 strategy.
- Implementation of joint research centres for the creation of medium/long strategic partnerships with specific companies and the definition of common interests with the purpose of: orienting the basic research developed at the University and its application in industrial contexts; create joint observatories on technological evolution; facilitating the creation of joint research projects; and encouraging cooperation between researchers and companies also through joint laboratories.
- Organisation of specific idea scouting programmes like the Switch2Product (www.s2p.it) Innovation Challenge and Start Cup (http://www.startcupml.net/) aimed at the development of new technologies and/or the creation and consolidation of new companies.
- Awareness activities to implement the dissemination of innovative technologies and research results at national and international level through the participation at the conference target and market fair, using new social media applications and organising dedicated webinars. A new web platform www.plilink.polimi.it has been launched to strengthen the relationship with companies and their specific innovation needs.
- Definition of new processes for the evaluation of the innovations more oriented to the technologies’ applications and market areas. The innovation portfolio has been organised into six different technology areas with a consistent focus on industry related applications: energy efficiency, infrastructures; IT & automation, advanced materials, manufacturing technologies, health & medical devices, and design.
- Implementation of a dynamic technology transfer model (risk and revenue sharing) aimed at advancing the technology readiness level (TRL) through the involvement of different actors in the exploitation process, combining different expertise and investment capabilities and proposing a co-development in the industrial validation phase.

One of the main new structured initiatives aimed at creating innovation touch-points between key stakeholders and the university innovators is the Switch2Product: a call for idea competition organised by the TTO and PoliHub in collaboration with Deloitte Italy. The goal of the competition is to reward the best innovative solutions and entrepreneurial ideas arising from the PoliMi academic community, in order to facilitate the development of new technology, products, services and start-ups.

PoliHub has run the Switch2Product from 2010, but the involvement of the TTO and Deloitte in the 2017 edition brought important and novel developments to the competition structure:

- Corporate managers and experts from patent firms composed the jury for the selection of the projects.
- The teams of researchers got access to different kinds of support for the exploitation of their ideas according to the selection process: 60 selected teams had the chance to pitch their ideas to the companies, 24 finalists followed a boost programme during which they had the chance to meet with industry mentors and Deloitte experts, 15 winners followed an acceleration programme offered by Polihub.
- Five winners received a grant of €30,000 each from PoliMi aimed at developing an industrial prototype and validating the technology in the field.

The Switch2Product 2017 call brought considerable impact in terms of idea scouting, spreading of IP and start-up culture and the relationship with industries and inventors. The competition received 131 applications. The teams that followed the whole competition and won it are now creating new companies and/or collaborating closely with industrial partners to bring their technologies to the market. On the other hand, the teams that did not win but applied with great patentable ideas are now filing patents and applying for research development funding to advance their innovations further.

To better explain the Switch2Product operative process, we present one of the applications: the project PhononicVibes developed by a group of researchers at the Department of Civil and Environmental Engineering. PhononicVibes is a new technology that limits the propagation of vibrations, both elastic and acoustic, generated by traffic, machinery and industrial plants. PhononicVibes works thanks to specific periodic structures capable of controlling the propagation of waves, guaranteeing a three-dimensional isolation. When entering the Switch2Products the project was just a promising idea from a PhD thesis project and a handmade laboratory prototype. The TTO performed an accurate prior art analysis that led to two patent applications in order to protect the idea behind the product. During Switch2Product the team of researchers had the chance to get feedback from industry partners and PoliHub mentors, they developed a business plan to establish a spin-off and won the €30,000 grant for the in-field technology validation. With this grant, they found a partner that produced the first industrial prototypes and they have now started applying for funding and speaking with investors. They won two other technology competitions: the Italian Enviris award and the Innodriver competition from Regione Lombardia. PhononicVibes advanced very quickly in terms of technology readiness level (TRL) and the team is now speaking with the main Italian railway company for the first installation in the field.

Thanks to its proven successful impact, the Switch2Product competition has now become one of the core activities of the PoliMi innovation ecosystem, also attracting the interest of new well-known companies. The second edition opened in May and will end next September. The Rector decided to allocate an additional grant addressed to the funding of a disruptive technology. The Switch2Product itself and all the other activities concerning innovation are in part internally funded by PoliMi, which means that all the incomes from the exploitation of the technologies are then re-invested in research. Other funding sources come from: a) local, national and international authorities and institutions such as the EU, Ministries and Regions; b) companies and corporates that commission innovative research to the university.

The PoliMi vision for the future is to lead the Italian innovation ecosystem through the entrepreneurial exploitation of scientific knowledge and cutting-edge technologies to create economic impact at the local level as well as at the international scale. To do so, one of the main objectives in the upcoming years is the constitution of a tech-venture fund for early-stage investments in technology transfer and the implementation of new business synergies with corporates for technology and spin-off growth. This new fund goal should be intercepting the broader spectrum of S&T sectors of the university and reinforcing their innovation potential through investments to support the development of new high-tech companies. The venture will also become an opportunity for those Italian companies interested in financing the initiative and taking part in the programme, and foster the interaction between industrial and academic sectors.

POLITÉCNICO DI TORINO (POLITO)[2]

INTRODUCTION TO UNIVERSITY AND REGION

Politecnico di Torino was founded in 1859, formerly known as "School of applications for Engineers". In 2017, it ranked 33rd in the QS ranking in Engineering and 1st in "Graduate Employment Rate" in 2017 QS Graduate Employability. It provides teaching to approximately 33,000 students (of which around 15% are international students and about 800 PhD students). Politecnico di Torino (PoliTo) has always had strong relationships with its ecosystem, characterised by the presence of major players in the automotive, aerospace, telecom, food and textile industries (like FIAT (now FCA), Leonardo, Thales Alenia, General Electric, Comau, Magneti Marelli, Telecom Italia and Ferrero), as well as several SMEs which mostly belong to the supply chains listed above. PoliTo has several partnerships and research collaborations in place with large companies and recently invested in creating stronger links with SMEs as well.

UNIVERSITY STRATEGY ON INNOVATION AND ENTREPRENEURSHIP

Until 1999[3], the main activities of PoliTo related to innovation and entrepreneurship were (i) research collaboration with local industrial players and (ii) technical education (to students and industry members) through the provision of bachelor and master degrees, and post-degree programmes addressed to employees. PoliTo mainly adopted a "market-pull" approach, helping large companies to solve specific technical problems, exploiting existing competencies and eventually developing the basic technology for new products and processes (e.g. the common rail for diesel engines, some key parts of MP3 technology, etc.)

Almost 20 years later, PoliTo complemented these activities with an approach focused both on the exploration of new technological trajectories and the exploitation of existing technologies with industrial partners located in its region. Following the example of many other S&T universities, it established a Technology Transfer Office, a university-based incubator and a research centre on entrepreneurship and innovation, in order to strengthen collaboration with its relevant ecosystem. PoliTo created a new campus where large companies transferred their research activities that are closer to university research (i.e. GM has a research centre with 700 employees inside the PoliTo campus).

In order to both develop a critical mass and multi-disciplinary new research domains, in 2017 PoliTo created 11 cross-departmental research centres, with the specific objective to work on breakthrough technologies (such as additive manufacturing, photonics, power conversion, and autonomous vehicles) by mixing multiple disciplines and engaging firms and other relevant actors in the regional ecosystem. As a result, the role of PoliTo within its ecosystem is based on a dual strategy aimed at mixing technology-push and market-pull approaches according to two main pillars: (1) the generation and exploration of new knowledge for long-term innovation

[2] Case study developed by Emilio Paoluci (Full Professor at the Department of Engineering and Production Management and former Vice-Rector for Technology Transfer).

[3] In this year I3P, the university-based incubator, was founded which has been conducive to a profound transformation of the Turin entrepreneurial ecosystem. Colombelli, A., Paolucci, E., & Ughetto, E. (2017). Hierarchical and relational governance and the life cycle of entrepreneurial ecosystems. *Small Business Economics*, 1-17.

on new breakthrough technologies and (2) exploitation of available research results in order to drive economic and societal impact in the short to medium term.

POLITO AS AN INNOVATION ECOSYSTEM INTEGRATOR AND ITS VISION

PoliTo acts as an integrator in its knowledge ecosystem at different levels, putting together different actors. Being a knowledge generator, it promotes geographical proximity among players: large firms, with the objective to access the knowledge generated, and research centres clustered around PoliTo. The ecosystem as such favours the transfer of knowledge among the different actors, including PoliTo, by mechanism of “cross-realm transposition”, which is defined as a transfer of logic (ideas, models) between the different players in the ecosystem. In this context, PoliTo not only works with large multinational companies, but it also acts as a knowledge intermediary between local SMEs and large companies.

Furthermore, PoliTo is supporting the evolution from a traditional industrial setting, with FIAT at centre in a directive role, to a more sophisticated and technologically diversified system, which is today only partially linked to the local automotive production system and that has progressively been reshaped to include emerging businesses in new sectors.

Such activities will continue with further reinforcement in collaboration with the regional government. The vision for the future includes the creation of a so-called “Competence Centre” (PoliTo won a competitive national tender financed by the Minister of Economic Development), a collaborative space shared with large firms and SMEs to perform training and collaborative research on the key enabling technologies of Industry 4.0 (i.e. Internet of Things, Big Data, Additive Manufacturing etc.).

STRATEGY IMPLEMENTATION

In its statute and strategic plan PoliTo formalised the importance of transferring research results in multiple ways, in order to sustain the process of sharing knowledge produced from scientific and technological research. The Technology Transfer Office (TTO) and the university-based incubator (I3P) are key organisational structures in this vision.

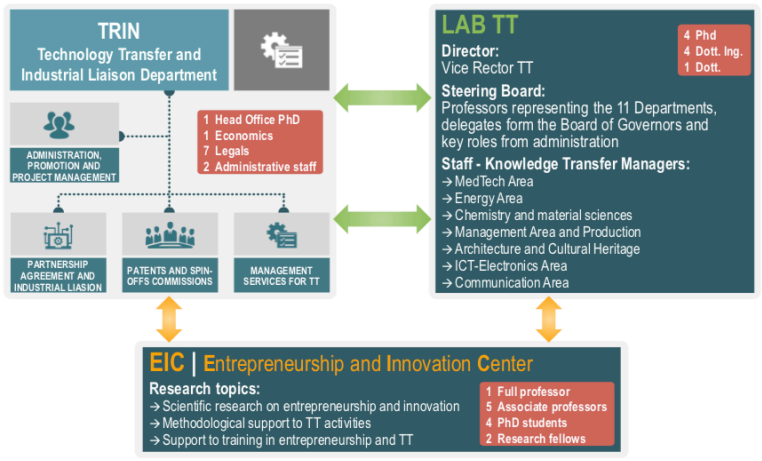
Today, the university's TTO performs six main activities (in collaboration with research departments) to foster innovation and entrepreneurship within the Piedmont economic ecosystem:

1. Research Commercialisation: it exploits the scientific results via formal mechanisms such as patenting, licensing, collaboration with Business Angels and VCs and creation of hi-tech spin-offs. With more than 601 registered patents and 51 spin-offs in the last 15 years, PoliTo is a leading university in Italy in this field. In around 50% of cases, patents are co-owned with companies or research centres and there is a growing number of licensee agreements with local companies and PoliTo spin-offs.
2. Support for technology development, hi-tech start-up creation and growth. This activity is performed jointly by the TTO and the university-based incubator. It includes both a "soft" and "hard" assistance through both mentoring programmes and networking on one side and funding support on the other side. The incubator was successful at introducing new companies: it was ranked 15th in the 2014 UBI global index and a recent paper[4] reveals that I3P was key for the creation of an entrepreneurial ecosystem in the Turin area. It organises networking events to connect incubated start-ups with potential investors and offers dedicated mentorship programmes. Regarding funding support, the university has recently launched a proof of concept (PoC) programme to improve the technology development process. This fosters the collaboration of researchers with local entrepreneurs and national VCs and BAs, and allow the TTO to reach a larger number of firms and have a larger impact. Today, PoliTo is the only university in Italy offering such programme, performing as a proactive investor addressing "the most critical phase in the innovation process, between invention and technology development when commercial concepts are created and verified, target markets are identified, and Intellectual Property (IP) may have to be developed. The PoC programme has two annual calls. A semi-quantitative analysis reveals that PoC was able to increase the technology readiness level of two stages on average, from around 3 to 5. It also created opportunities for new patent licencing and start-ups creation, proving how PoliTo was able to act as an integrator between research and industrial application. Last but not least, PoliTo created, with the support of Banca Intesa and the Ministry of Economic Development, a new national project (https://www.knowledge-share.eu/) aimed at collecting patents from most Italian universities and research centres. The objective of the project is to increase opportunities to commercialise market technologies developed by Italian universities and to establish a closer engagement with business actors.
3. Academic Engagement: knowledge transfer via informal mechanisms that include long term research collaboration programmes with large companies, consulting on intellectual property, international networking, research collaboration with SMEs, etc.

[4] Colombelli, A., Paolucci, E., & Ughetto, E. (2017). Hierarchical and relational governance and the life cycle of entrepreneurial ecosystems. *Small Business Economics*, 1-17.

4. Diffusion of entrepreneurial culture in the academic faculty, students, and start-uppers. PoliTo strategically invested in entrepreneurship education to foster an entrepreneurial mindset in students and young researchers. In this vein, it provides several entrepreneurship curricula programmes: optional courses to bachelor and PhD students in entrepreneurship and innovation. For example, from 2016, it hosts the European Innovation Academy, an intensive start-up competition in which international students, guided by renowned mentors and with sponsorship of multinational firms and international institutions, are challenged to transform their ideas into a tech start-up. From 2015, it offers, in partnership with CERN and the Agnelli Foundation, Innovation for Change, an entrepreneurship programme for PhD and MBA students with the objective to identify solutions to long-term challenges proposed by large companies. Very recently, it created a fab lab-like programme for bachelor students with specific liasons with SMEs.
5. Attraction of strategic investments from large companies to increase the impact of new technologies on the region.
6. Inclusion of SMEs by specific programmes co-designed with the local employers' associations and with Turin Chamber of Commerce. Such a focus was reinforced in 2015 with an array of programmes in collaboration with local industrial associations, other local actors, each offering specific tutoring and coaching services to realise product and/or process innovations in SMEs based on PoliTo's available research results. The overall objective is to bring to a broad number of firms the capabilities they need to innovate, through coaching and tutoring programmes that include high-level training in advanced technologies, consulting and IP services, and contact with PhD students.

In order to perform these activities, PoliTo changed the TTO organisational model (Figure 1): a new entity called TT LAB and a committee were added to support the activities of Technology Transfer Office (TRIN in Figure 1). In particular, such a committee performs as a liaison between the TTO and the "traditional" departments. Furthermore, the TTO, which also manages administrative and laws issues, is supported by the Entrepreneurship and Innovation Center, which provides the research and methodological support needed to perform technology transfer, informing policy and practice.



Structure of Tech

RWTH AACHEN UNIVERSITY (RWTH AACHEN)[5]

> "Politicians are waiting for digitisation concepts from universities. They are also very willing to support them. A good example is RWTH Aachen. Their rector has provided a boost that is now implemented by the whole university."
>
> General Secretary Dr. Meyer-Guckel of 'Stifterverband', a unique and renowned network of business, science, politics, and civil society that focuses on education, science, and innovation, in December 2016

RWTH Aachen University is the largest university of science and technology in Germany with currently more than 45,000 enrolled students. With a total budget of 948 million euros in 2017, which includes more than 454 million euros in project funds, RWTH Aachen University acquires the largest amount of third-party funding in Germany. It focuses on societal impact, scientific excellence, internationalisation, cooperation with research and industry partners, and innovative education, among others, as part of its strategy. As its excellent connection to industry has enabled the university to achieve important milestones in building one of the largest European research infrastructures, where industry and science work hand in hand, its strategic focus for 2030 is now entailing digitisation to a significant extent.

As the university aims to become one of the leading entrepreneurship-oriented universities of technology worldwide, we choose the field of entrepreneur and innovator education as a specific facet to elaborate on, facilitated by the strategic focus on digitisation within the TIME (Technology, Innovation, Marketing, and Entrepreneurship) Research Area. Nevertheless, many chairs at RWTH Aachen University drive similar approaches; hence this case study is just an illustrative example.

STRATEGY, IMPLEMENTATION AND VISION

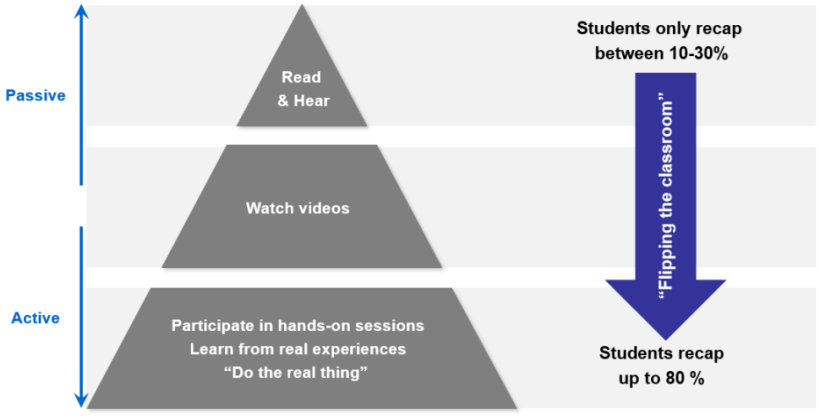


Figure: Flipped classroom method of teaching following Edgar Dale's cone of experience

RWTH Aachen University is dedicated to providing every student with an excellent learning experience and personalised supervision. However, the traditional approach of holding

[5] Case study developed by Bram Wijlands (Managing Director RWTH Innovation GmbH) and Anne Vos (Research Associate, Innovation and Entrepreneurship Group (WIN) - Center for Technology Transfer and Entrepreneurship)

lectures in front of a large audience poses a challenge to a university that has more than 45,000 enrolled students. In order to significantly improve the learning experience, the TIME Research Area started to apply a flipped classroom model. Blended learning, i.e. the combination of online digital media and traditional classroom methods, enables this approach.

The basic course content that is repeated every year is provided as an open online course on an internal RWTH platform, whereas the lecture slots are used for interactive recapping of the content in class. On one hand, students do not attend classic lectures anymore, during which their role is very passive. They may now decide themselves when they watch the lecture videos and thus may replay them as often as necessary. Moreover, they are actively involved in their online learning experience as they engage in weekly recap questions and prepare homework assignments, which account for 40% of the final grade. The fact that today's students are digital natives is an important enabler for shifting much of the basic course content to digital media. On the other hand, moving the basic content online frees much time of the teaching staff to interact with students in a very responsive and interactive manner. Lecture slots are now used for Q&A sessions, case study discussions, group exercises, or guest lectures, which allows the teaching staff to react to the students' demands. Hereby, the students take a very active role, which significantly deepens their understanding. CESAER TFI Case Studying of the taught content (see figure 1). The flipped classroom model allows letting the students decide when and at what pace they undertake the necessary part of passive learning and frees teaching staff capacity to improve interaction with the students in class and to respond to ad-hoc requests more intensively. Consequently, moving from repetition to interaction and exchange improves both the learning experience and the students' supervision significantly. The learnings that were generated through this approach are now used to make entrepreneurship and innovator education available to everybody around the globe.

LEVERAGING THE BASELINE MODEL TO PROVIDE OPEN ACCESS EDUCATION

Every year, more than 50 businesses are founded at RWTH Aachen University. These businesses have their origin mainly in natural science and engineering disciplines. Therefore, the founders have usually not received prior entrepreneurship education as part of their studies. Equipping them with the necessary skills is of utmost importance to us. As such, the TIME Research Area decided to provide entrepreneurial and innovator education in an open access format through the Massive Open Online Course (MOOC) platform edX, which was founded by Harvard University and MIT in 2012. This enables us to make our content publicly available not only to RWTH entrepreneurs, but to anybody who is interested in learning the necessary business skills to innovate continuously and to lead a company successfully. The first MOOC was made publically available in 2016. It received over 12,000 registrations in the first run, a remarkable success for a pilot. The course offering today is still in its infancy, however, currently available MOOCS in the field of entrepreneur and innovator education are:

- Thinking & Acting Like an Entrepreneur;
- Understanding Venture Capitalists;
- Customer-Centric Innovation;
- Innovation & Creativity Management;
- Strategic Management;
- Managing Disruptive Change.

These courses have been launched sequentially since January 2016 and by May 2018, 48,000 users have registered for participation. Hereby, each course is offered about three times per year. To ensure accessibility, every course is offered in English and every MOOC includes English subtitles.

A user that registers for a course has to invest six-eight hours per week over the duration of six weeks to complete it successfully. The learnings from the MOOCs are supported through homework assignments; participants from nearby regions around the world are furthermore teamed up by the course coordinators to stimulate exchange among them. Moreover, participants discuss learning and homework assignments in integrated forums and may participate in an online exam at the end of the course. Therefore, interested individuals get the opportunity to acquire topic-specific knowledge in a reasonable amount of time, free of charge.

RWTH Aachen University is one of only 23 higher education institutions worldwide to offer a MicroMasters programme. In the MicroMasters programme, selected MOOCs are combined into one comprehensive course. It primarily targets business professionals to give them access to a high-quality education programme. Participants will be credited 15 ECTS for having completed the Credential, which will count towards the 90 ECTS required for graduating with the MME-TIME (M.Sc. Management and Engineering in Technology, Innovation, Marketing and Entrepreneurship) degree. The MME-TIME is a Master Degree programme designed for business professionals with a STEM background that combines the latest advancements in digital technology with profound management education.

In sum, RWTH Aachen University follows the vision of providing high-quality education free of charge to people all around the globe. The content for the open access MOOCs is mostly generated simultaneously with RWTH-internal open online courses, which are used in the flipped classroom model. This keeps the invested human resources to a minimum, while the learnings that are obtained through the open access programme also help to further improve the courses offered to regular students. Moreover, the presence of RWTH Aachen University on edX alongside universities such as MIT, Harvard and Oxford supports the university's strategy to spread its scientific excellence internationally. Other CESAER members that offer MOOCs on edX include TU Delft, ETH Zurich, and KU Leuven.

FUNDING

The transition from traditional classroom teaching to blended learning is financed through funding provided by RWTH Aachen University. The necessary resources that are required to offer the content publicly on edX stem from third-party funding and the chairs' own budgets.

TOMSK POLYTECHNIC UNIVERSITY (TPU)[6]

TPU collaborates with many partners within a regional innovation ecosystem. Each category of partner has its own set of purposes and benefits, which can be delivered through close cooperation with the university:

- Big companies are the major purchasers of innovative technologies developed at TPU. They also actively hire our graduates who become 'innovation generators' while working there. Innovative projects elaborated for the big companies are characterised by complex and extensive research.
- Small business can be divided into two types: small innovative enterprises (SIE) of the TPU innovative cluster and other small companies. SIE is an enterprise (with a university share interest or without it) which uses TPU intellectual property for its innovative solutions. Relations with the university are formalised by a licensing agreement and TPU is comprehensively interested in the development of such companies in order to get copyright royalties or sell its SIE stake in future. Other small companies are purchasers of small-scale projects that have greater potential for quick profit.
- Local authorities support innovative university projects using existing tools (such as regional innovative clusters), and appeal to the university for solving urgent problems of the region and the city.
- Federal institutions and ministries provide specific competitive funding for innovative projects performed by students and university employees.

UNIVERSITY INITIATIVES AND ACTIVITIES

The main approaches promoting innovation and entrepreneurial activity in TPU imply the involvement of students. The educational system implemented at TPU considers that 100% of students gain the basic knowledge of entrepreneurial and innovative activity during the second year (the "Entrepreneurship" educational course) and the fourth year (the educational course "Engineering Entrepreneurship") of their studying. For those who wish to further their knowledge between these courses, there are two educational minors with fundamentally different sets of disciplines:

– Technological business (disciplines: TIPS, innovative marketing, project management);
– Intrafirm business (disciplines: lean manufacturing, quality management, logistics).

Another important milestone in the strategy implementation was the establishment of the School of Engineering Entrepreneurship. This structure promotes innovative and entrepreneurial projects in other university schools. The aim of the school is to form an entrepreneurial ecosystem inside and around the TPU, which develops according to the "Open Innovation" model.

[6] Case study developed by Stepan Khachin (Director of the TPU School of Engineering Entrepreneurship) in collaboration with Anton Cherny, Elena Gershelis and Svetlana Rybushkina.

COLLABORATION, SHARING OF RESOURCES AND COMPETENCES

In the existing innovation ecosystem, resource exchange occurs in the context of specific projects, when a group of students develops a topic potentially interesting to the industrial partner, and the latter provides them with material and financial resources. The exchange of competences is expressed by the system of a “single window” of access to all TPU innovative solutions. On the TPU innovations website you can get acquainted with the relevant innovative projects of the university.

UNIVERSITY AS AN INNOVATION ECOSYSTEM INTEGRATOR

Involving all university students in entrepreneurship activities, TPU plays a leading role in popularising innovation and entrepreneurship at regional and national levels.

There are several examples of successful projects in this area:

- Entrepreneurship Cafe - a set of open events - motivating meetings with successful entrepreneurs of the city and the country. Each meeting attracts about 70 enthusiastic future businessmen. During open communication, entrepreneurs share life experience, point out common mistakes, give advice to start-uppers and heads of small companies. The main purpose of these events is to popularise an entrepreneurship (including the development of innovative products) as a professional activity. Cafes have been held for more than six years and are gaining popularity every year. Trainees who attended the café several years ago as a student now act as our guest speakers.
- Competition 10K – an annual competition of TPU entrepreneurial projects, which has been regularly held already for 10 years. More than 100 projects take part in this competition; the final goal is to create a successful business. Sections of innovative projects are of particular interest for regional and national companies - potential innovation purchasers - who are invited to the competition as judges and special guests.

This event successfully attracts innovative and entrepreneurial activities from not only TPU students, but also participants from outside. The contest is not only a selection procedure, but also an extensive preparatory educational programme.

FUNDING STREAMS

Funding is from several sources: programmes of entrepreneurial activity development, targeted donations of TPU industrial partners and from the special endowment fund of the University.

VISION FOR FUTURE

As the number of enterprising youth is steadily growing, we would like to engage a younger generation – starting from high school, so that they come to TPU with basic skills that would become a powerful starting impetus in the trainee's path.

From our point of view, it is also necessary to establish a mutually beneficial exchange of information on technologies owned by other universities and move to the implementation of full-scale joint projects.

DELFT UNIVERSITY OF TECHNOLOGY (TU DELFT)[1]

With nearly 20,000 students, more than 2,900 research staff (FTE) and 8 faculties, TU Delft has been a frontrunner in technology and innovation for over 175 years. TU Delft's commitment with Education, Excellence and Innovation is recognised by various international rankings. TU Delft is one of the top universities in the field of Engineering and Technology in Europe (Top 20, THE ranking), and worldwide (Top 25 QS ranking), and is considered one of the Top 15 most innovative European Universities (Reuters).

TU Delft contributes to global research leadership in fields as diverse as quantum-nano, bio-nano, civil engineering, maritime technology, architecture, transport, water management, aerospace technology and robotics.

Having an evident international vocation (19% international students, 53% scientific staff[2]), we are firmly embedded in the Zuid-Holland region through partnerships with the City of Delft, the province of Zuid-Holland, the Port of Rotterdam, the Metropool-region, Zuidvleugel and the Innovation quarter, as well as with our academic colleagues at The Hague University of Applied Sciences and our LDE partners in Leiden and Rotterdam and the other three Technical universities in The Netherlands through the 4TU Federation.

UNIVERSITY STRATEGY ON INNOVATION AND ENTREPRENEURSHIP

TU Delft regards facilitating and promoting the transfer and application of knowledge through innovation as its social mission. This means the translation of novel knowledge into innovative products, services, processes and new activities. In order to strengthen these activities, TU Delft focuses on the stimulation of entrepreneurial activities through a holistic approach that includes different support programmes tackling the different stages and actors relevant to innovation. TU Delft's strategy to innovation pivots around the following key pillars: entrepreneurial education, identification and protection of new knowledge that can lead to successful innovations, support to techno-starters and efficient collaboration with external stakeholders. The TU Delft Holding, with its sub-holding Delft Enterprises, plays an important facilitating role in this process. Intensive collaboration with the business community is crucially important to supplying society with the developed products and services. TU Delft is committed to improving and expanding the cooperation with the business community at the international, European and national levels. Cooperation with regional knowledge institutions, companies and governmental bodies – through regional innovation clusters, for example – plays a significant role.

STRATEGY IMPLEMENTATION

With over 60 employees, the Valorisation Centre is the main muscle (though certainly not the only) behind the implementation of the innovation strategy at TU Delft, being the main responsible in supporting, stimulating and facilitating scientists and supporting staff in

[1] Case study developed by Servaas Duterloo (Head of unit EU Research Funding & International Programmes, Directorate for Strategic Development) and David Sayago (Valorisation Centre, Section Research Funding)

[2] Including employed PhD candidates.

transforming results of research and technology development to practical, commercially viable, application.

TU Delft support to innovation and entrepreneurship tackles the different stages of innovation through specifically tailored programmes and activities.

EDUCATING INNOVATORS

TU Delft has been recently featured among the top 10 current leaders in engineering education by MIT. Our approach to innovative education has crystallised in areas such as design-led curricula and student-led extra-curricular activities. One successful example of the latter is the D-Dream programme established in 1999. D-Dream (Delft Dream Realisation of Extremely Advanced Machines) is a programme offering undergraduate students the possibility to join a multidisciplinary team for one year in an advanced engineering project. The uniqueness of this programme is that the project is run by the students who take the initiative and are the 'problem owner'. Apart from the experimental and computational facilities provided to the students, D-Dream also offers an *à la carte* training, comprising of advanced engineering modules in which students can explore in-depth the concepts they need to master in order to succeed in their projects. Examples of D-Dreams projects are:

- Nuon Solar Team (World Solar Challenge race winner in 2001, 2003, 2005, 2007, 2013, 2015, and 2017);
- Delft Hyperloop (Best designed hyperloop capsule, Space X - Elon Musk 2017 competition)
- Forze Delft (World fastest hydrogen-powered car between 2015 and 2017);
- I GEM (International Genetically Engineered Machine Grand Prize Winner 2015, 2017).

Since 2013 TU Delft commitment with education has been reinforced by opening our courses to a wider community through through the Massive Open Online Course (MOOC) platform edX. TU Delft is a leading university in this area, TU Delft now offering a range consisting of 88 MOOCs that have been attended so far by a record number of 2 million alumni.

EARLY CAPTURE OF INNOVATION VALUE

Identifying and capturing innovation opportunities at an early stage is key for potential success. At TU Delft we literally dig this information through *in situ* short interviews with potential innovators, not only including research staff but also MSc students. This activity is articulated via Dig-it!, which aims to map the university innovation ecosystem and support the visualisation of as many innovative ideas as possible to facilitate the connection with external stakeholders such as businesses, investors and governmental entities. This programme includes three consecutive steps:

- Xplore: each faculty finds innovative ideas, mapping the university's innovation-ecosystem.
- Xplain: supports the visualisation of innovative ideas by developing infographics, props, animations, scale-models and interactive objects.
- Xpose: the selected innovative ideas are presented at the TU Delft Research Exhibition an annual event that invites external companies.

INCUBATING AND ACCELERATING

Founded by TU Delft in collaboration with TNO and the City of Delft, Yes! Delft is currently supported by around 30 corporate partners, including large companies such as Shell, 3ME or Rabobank. Yes! Delft is a specialised incubator that focused on start-ups that can solve real-life problems in the fields of Blockchain, Artificial Intelligence, CleanTech, MedTech, Aviation, Robotics and Complex Technology.

Yes! Delft offers a variety of programmes combining entrepreneurship education (Discovery Track), supports early stage start-ups to identify their market/product combinations in a pre-acceleration programme (Validation Lab), and enables late stage start-ups to accelerate (Accelerator programme).

Yes! Delft has generated more than 200 companies over the last 12 years, 90% of which are still active or have been acquired by larger companies. A recent example of the later is the acquisition by Philips of TU Delft spin-off NightBalance, a digital health scale-up company that has developed an innovative, easy-to-use device to treat positional obstructive sleep apnea and positional snoring, the NightBalance Sleep Position Trainer (SPT).

INNOVATION ECOSYSTEM INTEGRATOR

In addition to the activities to foster innovation among the TU Delft community, our ambition is also to contribute to the creation of open innovation ecosystems where external parties that want to co-innovate with us can have the possibility to benefit from the generation of innovative ideas and from the unique research facilities available in the campus.

TU Delft's door to the outer world is The Science Park Technopolis. The Science park is an essential part of the Living Campus of TU Delft where education, science, business and government find each other. It is, therefore, the best climate for science-driven innovation and provides an attractive and stimulating location for international high-tech companies and knowledge institutions. Technopolis is home to an increasing number of companies that enter into collaboration with TU Delft and other companies on campus. Examples of companies established at the park are Applikon Biotechnology, VSL, Exact and 3M.

TU Delft is engaged in a wide range of multi-stakeholder public-private partnerships that enable fruitful collaboration between businesses, government and research. Two examples of this approach are:

Robo Valley: Founded in 2015 to close the gap between automation industry needs and supply-side solutions and knowledge, it currently hosts more than 170 robotic researchers that collaborate with other experts, entrepreneurs and decision-makers from the public and private sector. The RoboValley Investment Fund, launched in collaboration with Chrysalix Venture Capital with a target size of 100 million euros, will serve as a tremendous support to identify, invest in and commercialise new robotics technologies. So far, RoboValley is home to 30 robotics start-up companies. Robovalley is one of Europe's Digital Innovation Hubs as recognised by the EC Joint Research Centre.

Biotech Campus Delft: Biotech Campus Delft is an initiative of DSM Delft, Delft University of Technology, the City of Delft and the Province of South Holland, a unique public-private cluster that offers biotech companies a stimulating business environment for research, development, scale-up and production of biobased alternatives to products derived from fossil fuels. The

Biotech Campus Delft host among others the Bioprocess Pilot Facility, a multi-purpose facility where companies, universities and knowledge institutes can test how sustainable production processes respond at larger scale.

Last, but not least, TU Delft is an active member in 4 Knowledge and Innovation Communities (KICs), i.e. Climate, Raw Materials, Health and Digital.

FUNDING STREAMS

The innovation activities in which TU Delft is involved are funded by a variety of funding, ranging from own funds (following a change in the Dutch government innovation policy in 2016, the obligatory contribution from the public resources of universities to valorisation was set up to 2.5%), private funds (both from companies and investment funds), central and local governmental funding (both from the City of Delft and the Province Zuid-Holland, the central government) and EU funds (e.g. European Regional Development Fund - Kansen voor West, European Investment Bank).

VISION ON FUTURE

Our strategy has resulted in significant achievements, such as those listed in the table below.

INNOVATION KEY PERFORMANCE INDICATORS	VALUE
Invention disclosures since 2011	600
Patent published application since 2011	345
Granted patents since 2011	248
Commercialised patents since 2011	140
Transferred patents since 2011	49
Spin-offs since 2008	220
Total amount of funding raised by portfolio companies	100 million euro

The main innovation goals of the current TU Delft Strategic Framework 2018-2024 include to continue to encourage entrepreneurship and stimulate the translation of our research findings into innovative, commercial activities, to increase the number of large-scale, long-term and sustainable programmes for public-private partnerships (PPPs) and to promote and facilitate Open Innovation.

Two examples of newly launched activities are:

1. X! Delft: in collaboration with Roland Berger X!Delft offers corporates the opportunity to innovate in and around the multi-disciplinary and multi-industry ecosystem of Delft University of Technology living labs, institutes, start-ups, researchers and students via tailored, solution-oriented programmes.
2. HollandPTC: an EIB 90 million euros investment to create an independent clinic and research centre in which TU Delft, Leiden University Medical Centre and Erasmus Medical Centre collaborate in providing excellent care and ground-breaking research, with the ambition to be one of the worldwide leading Institutes in the field of proton therapy.

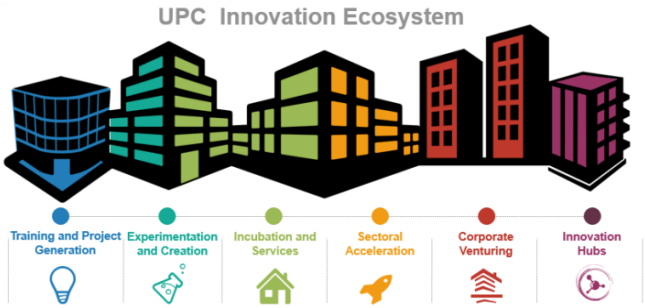
UNIVERSITAT POLITÈCNICA DE CATALUNYA (UPC)[1]

The UPC Innovation Ecosystems are defined as spaces of excellence aimed at the promotion and management of the different innovation processes that are generated at the UPC and its stakeholder community (research, students, alumni, incubated companies and others).

Its mission is to achieve greater use of the synergies that must necessarily arise from integration under the same coordination of interrelated areas that pursue the same goal, generate sources of innovation and increase the capacity to generate innovation at the service of the competitiveness of the productive fabric of the territory.

This new structure has been created to improve coordination and the establishment of global UPC strategies in fields such as entrepreneurship and the promotion of innovative culture, the definition of the incubation strategy, the different itineraries and incubation services, and the definition of the catalogue of services and innovation generation programmes to offer an interim innovation. The clear objective is to position the UPC as the reference technological partner, especially in the generation of innovation-oriented processes.

These UPC Innovation Ecosystems bring together the work of different areas, agents and processes, allowing a greater outpouring of transfer opportunities, increasing the number of innovative projects in the UPC crown. This reinforces the growth and approach to market through the coordination of actions, programmes, interests and needs of the different agents of the ecosystem, and increases the degree of public-private collaboration through the added value that the UPC can bring to the business fabric as an element that facilitates innovation processes.



With the UPC Innovation Ecosystems, it is intended to generate a distinctive seal of quality and a reference that identifies a global process and holistic space of:

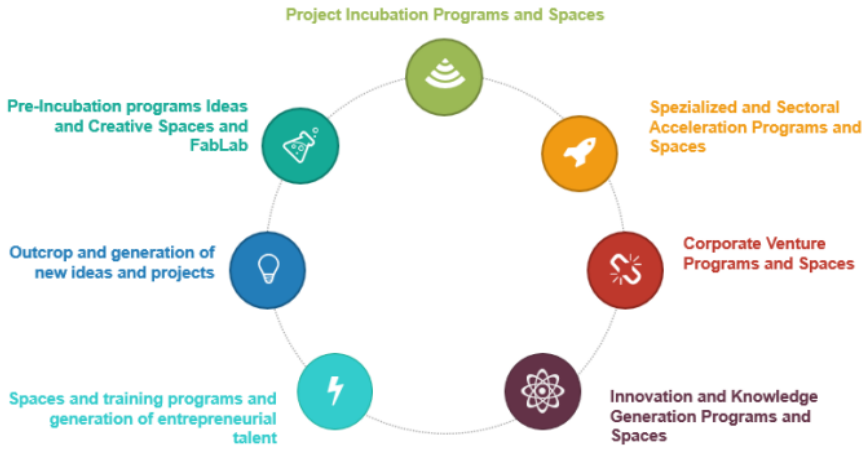
- Training of talent in fields as innovation and entrepreneurship;
- Generation, growth and maturation of innovative projects;
- Preparation and filtering of corporate acceleration projects;
- Building spaces for the creation and generation of open public-private innovation through the Innovation HUBs.

The conceptualisation of the UPC Innovation Ecosystem abides in the concept of inter-connecting, coordinating, directing and leading different actions in order to provide society and the productive fabric, projects, technological proposals and sources of innovation that

[1] Case study developed by Cristina Areste (Innovation Management Services) and Esther Real (Associate Professor)

positively impact on economic development of the impact area of the UPC Innovation Ecosystems.

Thus, in the ecosystem itself, in order to make sense of the holistic concept of a global space for innovation, it is necessary to present different areas of work and/or phases.



At the UPC Innovation Ecosystems, teaching and training spaces will converge around students, researchers, entrepreneurs, in short, the potential talent for the generation of innovative projects. It can be conceptualised in a space specialised for the pre-incubation of technology-based business ideas (Espai Emprèn), based on the follow-up of itineraries specifically conceived and designed by the maturation of the idea to evaluate it positively as a potential business project to constitute and contribute value to society through its technological solutions and services.

Additionally these innovative projects and the own projects incubated in the ecosystem, will be able to be tested, prototyped, and checked for their usability, technological feasibility, etc. This creation space will be integrated with the rest of the services and incubation and growth programmes to serve the UPC Innovation Ecosystem community as an agent of the ecosystem itself, allowing the evolution of the projects and their preparation in the approach to market.

Once the technical feasibility of the project has been evaluated, the projects need incubation services to approach the initial stages of the business project. This will be offered through the development of a catalogue of UPC incubation services, which will include rental services for spaces and facilities, creation of a knowledge sharing community, needs, complementarity of equipment, use of synergies, use of common services through framework agreements that the UPC may have with different service providers (servers, telephony, internet access, specialised software, management and accounting, access services in search of financing, device labs, etc.). Within the catalogue of UPC incubation services, there must be a need to encourage and facilitate the link between projects and UPC capabilities so that the UPC can be recognised as a valuable partner in the generation of innovation. In this way, the relationship with the UPC has to be addressed as the most natural one with a technological partner that the incubated projects can have, due to the proximity that will be achieved with the potential of the UPC Innovation Ecosystems, the potential of its activity of research and innovation, transversally with the areas of knowledge that work at the UPC.

In parallel, and taking advantage of the field of specialisation of each UPC Innovation Ecosystem, the aim is to attract the actors within the ecosystem, the implantation of sectoral accelerators, that allow the attraction of innovative projects of high potential in the field of the ecosystem. So these can follow the different acceleration and growth programmes that these incubators and/or accelerators develop, in addition to attracting more sectoral community, that with the deployment of a good plan of actions, will allow to generate relationships between the different agents present at the UPC Innovation Ecosystem, create community and generate synergies and opportunities among them. In parallel, many of these accelerators give access to specialised mentoring, which the UPC wants to capitalise on leveraging their knowledge of the market in order to bring it closer to the more incipient stages of other projects that begin (pre-incubation/incubation). These actions are designed to help them address them correctly to the market and reduce their time to it, refining their product/service strategies, improving customer discovery, etc.

The last two blocks are those that point to the attraction and involvement in the innovation ecosystem in the private sector, bringing closer the potentials of not only the UPC. The aim is to integrate all the agents and the activity that they can potentially generate, favouring the generation of open innovation that reverts to a competitive improvement of the private companies present in the ecosystem. The ways of linking these can be of different types, depending on the interests and strategies of the companies themselves, but initially the attraction to the ecosystem of tractor companies is considered, of a significant weight in the sector and / or territory. Through the generation of a corporate venture programme, they can have an antenna in the ecosystem and interact, depending on the degree they decide, with some projects that initially could have been the result of a previous scouting made by UPC innovation management staff. These corporate venture spaces will act as a *pseudo* research and / or future generation of innovation with the possibility of being incorporated into the portfolio of the company.

At the same time, the concept of Innovation HUBS will be developed. These areas are proposed as a space of collaborative innovation through the proposal of a series of programmes and services defined, led and coordinated in House UPC, for an internal UPC resource that will execute the coordination of the innovation programmes and programmes agreed between UPC and the related company. These Innovation HUBS bring together the concepts of Open Innovation, Interim Innovation Management, public-private collaboration, focused and targeted technology transfer. At the same time, with this new methodology of collaborative work, the UPC's position is enhanced as a facilitator of the processes of innovation of the productive fabric of the territory, and facilitates the adoption of innovations, arising from the different channels of innovation that the UPC can offer to the productive fabric.

UNIVERSITY OF PORTO (UPORTO)[1]

The University of Porto has 14 faculties, 1 business school and 49 research units which cover the most important areas of knowledge. The Faculty of Engineering is the largest school, with 8,000 students. The other faculties focus on health and life sciences, natural and social sciences, humanities and arts. Overall, the university has 32,000 students from more than 150 countries, which demonstrates the international reputation of this higher education institution. The quality of teaching is closely linked with research. The R&D units along with a significant number of interface institutes make the University of Porto responsible for 25% of scientific production in Portugal. This very significant role is seen by the university as an opportunity but also as an obligation: to actively contribute to the creation of value based on the knowledge produced. In this context, the University of Porto has a strategy of innovation that involves internal players (faculties, R&D centres, interface institutes, tech transfer office, and the science and technology park) along with the main external actors (companies, business associations, local councils and external R&D centres) in order to create a dynamic innovation ecosystem aimed at promoting both economic, social and environmental development.

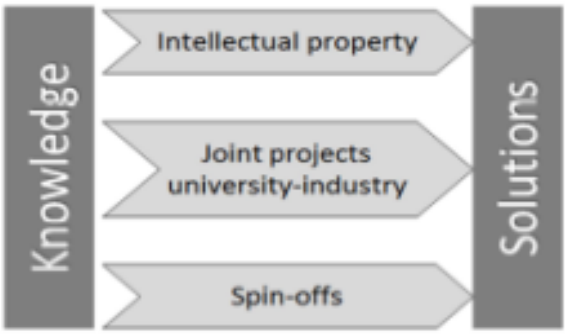
The objective of this case study is to describe and analyse the innovation ecosystem of the University of Porto, deepening our understanding of the role of universities as dynamic promoters of development. Besides this introduction, the paper is structured into five sections. The next section offers a comprehensive overview of the innovation ecosystem developed around the University of Porto. This is followed by sections on the core part of this case study: transfer of technology, creation of new ventures and incubation. The paper ends with a synthesis of the main contributions of this case, and offers a vision for the future of universities as innovation ecosystems leaders and integrators.

INNOVATION ECOSYSTEM

The innovation and entrepreneurship ecosystem of the University of Porto encompasses all stages of social and economic valorisation of knowledge, from its transfer to incubation, including the support of the creation of new ventures whose competitiveness relies on products, processes or business models based on scientific knowledge.

In order to transform the knowledge generated in its R&D structures into effective solutions useful to companies and other organisations, the University of Porto has three major approaches (Figure 1): protection and commercialisation of intellectual property, development of joint projects with industry, and creation of spin-offs emerged within the university's ecosystem.

[1] Case study developed by Carlos Brito (Associate Professor with Aggregation of the Faculty of Economy of UPorto)



This strategy is put into practice through an effective management of the innovation value chain. On the basis of the two traditional missions of the university (Education and Research), the creation of value is based on three major activities: knowledge transfer, the creation of new ventures and incubation. In this way, the University of Porto not only has a strategy, but also sound structures with real impact on the ecosystem. The following sections demonstrate the role of the university as a promoter of change and integrator of actors, resources and competences.

KNOWLEDGE TRANSFER

Knowledge transfer relies primarily on U.Porto Innovation, the technology transfer office (TTO). Its mission is to support the value chain of innovation promoting the best use of knowledge based on the interface between the university and industry. With an extensive experience initiated in 2004, U.Porto Innovation ensures the interconnection between the university's research centres and big and small companies. To do so, this TTO provides technical support in three major areas: protection of intellectual property, the creation of spin-offs, and linking to companies. The results achieved are significant as shown below in the table of Key Performance Indicators (KPIs).

KPIs (31 December 2017)	
Intellectual property	
Patents registered since 2004	+ 460
Active national and international patents	243
Active licensed patents	23
Promotion of entrepreneurship	
U.Porto Spin-offs	58
Patents held by U.Porto Spin-offs	115
Investment raised by U.Porto Spin-offs	+ 64 M €
Link to companies	
A2B – Academia-to-Business programmes	39
Participants involved in A2B programmes	1 168

U.Porto Innovation provides the registration of patents and identifies opportunities for their economic valorisation, examining the best alternatives for placing the technologies generated at the university on the market through licensing or the sale of the patents. As a result of this strategy, the University of Porto is the leader in Portuguese higher education institutions in terms of patents, most of them in co-ownership with other universities or companies.

On the other hand, to stimulate the creation of new ventures, U.Porto Innovation awards the "Spin-off U.Porto" brand to the start-ups that develop products and services produced as a result of research done at the university. The start-ups granted with this brand become members of The Circle, a club of spin-offs whose objective is to promote both internal and external networking, opening technological, marketing and financial opportunities in the most dynamic global value chains. The third mission of U.Porto Innovation is to foster the link

between the university and large and medium-sized companies. In this regard, the programme A2B – Academiato-Business deserves a special attention. It is an innovative approach that facilitates the matching of the university's research centres and the industry aimed at establishing partnerships for the joint development of applied research projects. Samsung, Bosch, GlaxoSmithKline, together with the largest Portuguese economic groups (e.g., Sonae, Amorim and Galp) are some of the University of Porto's clients involved in projects based on the A2B programme.

GENERATION OF NEW VENTURES

In addition to what has been referred to in the previous section, the university carries out several initiatives to promote the emergence of start-ups whose competitiveness is global and based on the integration of knowledge (whether technology-based or not) in their products, processes or business models. The most relevant initiatives in this field are BIP – Business Ignition Programme and the School of Start-Ups, two complementary programmes since the former is technology-driven while the latter is mainly market-driven in nature.

BIP is managed by U.Porto Innovation. Its purpose is to develop competitive business models for technologies created at the university, involving heterogeneous and multidisciplinary teams of researchers, MBA students and corporate executives as mentors. In this 12 week programme, business models are developed and validated by the market, and then presented to investors such as VCs and BAs.

The School of Start-Ups is run by UPTEC, the science and technology park of the University of Porto. It is directed to entrepreneurs who have business projects and are interested in starting their own start-ups. The purpose of the programme is to support the entrepreneurs in view of the challenges they face when developing a new venture. Those taking part in this programme have the opportunity to work at the science and technology park, integrating a network of start-ups and global companies, and being mentored by senior executives of strategic partners who support them in the validation of their business ideas.

INCUBATION

UPTEC – Science and Technology Park of the University of Porto acts not only as an incubator of start-ups but also hosts innovation centres of large companies. Microsoft, Vodafone, Alcatel-Lucent, Vestas and the German institute Fraunhofer are some of the stakeholders with innovation centres at UPTEC.

With facilities that cover an area of more than 30,000 square meters, mostly financed by European funds, the park is structured according to thematic campuses – Technology (UPTEC TECH), Creative (UPTEC PINC), the Sea (UPTEC MAR) and Biotechnology (UPTEC BIO). This gives room for a cluster strategy and the sharing of resources between start-ups, innovation centres and anchor projects, ensuring the specific support they need and, at the same time, keeping them organised in an extensive and cross-cutting network of large and small companies, local councils, business associations and policymakers.

UPTEC is the largest university-based science and technology park in Portugal with a significant impact on the innovation ecosystem (Table 2). More than 500 start-ups were created over the past 10 years. By the end of 2017, there were 194 ongoing projects at the park, involving more than 2,400 people in a range of areas such as nanotechnology, energy, health,

biotechnology, information technologies, digital media, architecture, relationship marketing and content production. The annual impact on GDP is quite significant, reaching almost 190 million euros, and the generation of taxes is about 40 million euros per year.

KPIs (31 December 2017)	
Entrepreneurial projects	
Total	194
Start-ups	119
Innovation centres	41
Anchor projects	21
Graduated companies	64
Human resources	
Jobs	+ 2,400
Economic impact	
On GDP	188 M €
Generated tax revenue	40 M €

CONCLUSION

The University of Porto is strongly committed to the creation of value (economic, social and environmental) based on the knowledge produced in its R&D centres. To do so, it acts as a leader and integrator of resources and competences owned/controlled by internal players and external actors. The results achieved are significant in terms of contribution for the creation of a dynamic ecosystem with high impact on the development of the region where it is located.

The contribution of this case study can be summarised in the following vision for the future of universities as innovation ecosystems leaders and integrators. *Companies need solutions*. Universities produce scientific knowledge but companies need effective solutions to improve products, processes and business models. In this regard, a key success factor of any university is the ability to transform (which is more than transfer) knowledge into valuable solutions. An important skill for those who work in the promotion of innovation is the ability to stimulate the "dialogue" between researcher centres and companies, two types of organisations with very distinct cultures, objectives and governance structures.

Long-term relationships. Universities must work with large and small companies, policymakers, local authorities at diverse levels. However these links cannot assume a transactional and short term character. Rather, they must assume a long term nature since this is the only way for building trust and routines between the university and its main stakeholders.

Networking, networking, networking. The success of any university ecosystem depends on the integration of different but complimentary actors, resources and competences. In this context, universities face an important challenge since they produce the "raw material" for the global and sustainable competitiveness of most businesses: knowledge. But its valorisation is only achieved as a result of a joint work of actors that operate at the regional, national and European level.

UNIVERSITY OF STRATHCLYDE (STRATHCLYDE)[16]

INTRODUCTION OF THE UNIVERSITY AND ITS REGION

The University of Strathclyde is based in the city centre of Glasgow, Scotland's largest and most industrial city. The University's strategy and institutional culture stems from its foundation in 1796 as a "place of useful learning", created at the beginning of the industrial revolution to support the development of working people alongside more conventional University students of the time. It later became the "Royal College for Science and Technology" before becoming the University of Strathclyde in 1964.

Today the University's strategic vision is to be "A leading international technological university, inspired by its founding mission that makes a positive difference to the lives of its students, to society and to the world". This vision is underpinned by three strategic objectives: *Outstanding student experience, Internationally-leading research,* and *World-leading innovation and impact.* The latter objective is seen to be vital in supporting the international competitiveness of the local economy by attracting new companies, and supporting existing companies in the region in the development and adoption of international leading technologies.

Strathclyde has invested heavily in new research staff and research infrastructure over the last 10 years and was ranked in the top 20 research intensive universities in the UK by Times Higher Education (THE) on the basis of the 2014 Research Excellence Framework (REF). It is the third largest in Scotland behind the comprehensive universities of Glasgow and Edinburgh.

	2007	2017
Budget	226M Euro	328M Euro
# staff (FTE)	3024	3325
# of research staff (FTE)	372	528
# students	21,735	23,633
# publications	1577 (SciVal)	2227 (SciVal)
% top 10% publications	12.9%	17.6%

UNIVERSITY OF STRATHCLYDE: KEY FACTS AND FIGURES

Glasgow has a strong identity, both as a city and as a city region, but also as the western part of the "central belt" of Scotland – the urban area linking and surrounding Glasgow and Edinburgh. Scotland is a devolved nation within the UK, and the Scottish Government provides core funding for teaching, research, and knowledge exchange, while competitive research funding is awarded by UK Research & Innovation (UKRI), at UK level.

Strathclyde has a strong role in the city region economy, particularly through its collaborative industry centres, and through its strong involvement in the City economic strategy which is led by Glasgow Economic Leadership (GEL), co-chaired by the Principal of Strathclyde and the Leader of the City Council. It includes leaders of the key economic sectors in the city today: Digital, Engineering and Manufacturing, Financial and Business Services, Life Sciences, Higher and Further Education,

[16] Case study developed by Tim Bedford (Associate Principal and Research & Knowledge Exchange, & Professor of Risk & Decision Analysis) and Yvonne Kinnaird (Knowledge Exchange Policy and Outreach Manager)

Tourism, and the Creative Industries. Strathclyde students and researchers engage particularly strongly in the first five sectors.

IMPACT ON THE REGIONAL INNOVATION ECOSYSTEM

The University has always had a strong commitment to industrial collaboration, but the strategy of scaling up local industrial collaboration centres dates from around 2008 with the establishment of the Advanced Forming Research Centre (AFRC) by the University, and with Rolls-Royce, Boeing, Mettis Aerospace and Timet as founding industrial members, and the construction of its physical base next to the Rolls Royce factory near Glasgow Airport. It is now a hub of the UK High Value Manufacturing Catapult, has more than 130 staff, and has added Aubert & Duval and Bifrangi to the Tier One members and more than 20 companies as Tier 2 members. The Centre has unique expertise and facilities in the UK in forming and forging, and its collaborative research programme generates shared IP for the members. It provides R&D and a host of advisory services to other companies in and out of the region, including a new lightweighting centre collaborating with local aerospace companies.

The AFRC development demonstrates the University playing a leading role in bringing together companies to cluster around innovation projects, and in persuading government of the case for strategic investment, that is, acting as an *innovation ecosystem integrator*. The next stage of development will further accelerate investment into the city region. As a result of work led by Strathclyde, the Scottish Government has announced the creation of the National Manufacturing Institute for Scotland (NMIS) and an Advanced Manufacturing Innovation District incorporating AFRC. Strathclyde is the anchor institution in this development, playing a vital coordinating role in a project which has so far attracted public sector upfront investment of more than £100M. With a strategic role in leading digital transformation in Scottish manufacturing and in translating research into commercial impact, NMIS is a strategic collaboration between the Scottish Government and the University to make a step change in the competitiveness of Scottish industry through adoption of cutting edge research and innovation, and through a step change to skills provision. In collaboration with the local authorities in the region, an Advanced Manufacturing Innovation District (AMID) has been established neighbouring NMIS, and the first companies are now committing to create facilities there.

NMIS creates immediate impact in the city region, but has both a Scottish national function, and through the adjacent UK HVM Catapult, a UK wide function, enabling it to benefit from support and partnerships, and to contribute to smart specialisation objectives, at each regional level.

A large scale example of international collaboration taking place in the Advanced Manufacturing District, and benefitting from UK and Scottish governments innovation support, is the new Medicines Manufacturing Innovation Centre (MMIC) which will carry out industrial scale pilot production of drugs using continuous manufacturing techniques developed in the University's Continuous Manufacturing and Crystallisation Centre (CMAC). Applying a similar membership model to the AFRC (described above) CMAC brings major pharmaceutical companies (such as AstraZeneca, GSK, Novartis, Bayer, Lilly, Takeda, Roche and Pfizer) together in a consortium to support disruptive innovation. The MMIC has been awarded £42M capital funding from the Scottish and UK Governments and from major industry partners under the UK Government Industrial Strategy. It gives the CMAC research, with collaboration from national and international partners including Graz and Nanyang Technological University, an industrial base in the local region, as well as demonstrating how international research

partnerships can be harnessed for local economic impact. The MMIC aims to attract over £80M of R&D investment by 2028, and create 80 high value jobs directly by 2023.

Glasgow City Innovation District is another example of the University of Strathclyde's 'integrator' role. Scotland's first Innovation District, GCID, has recently been established in the area around the Strathclyde campus. GCID will expand from the University's Technology and Innovation Centre (TIC) which opened in 2015. Together with the Inovo building, which provides flexible, reconfigurable space for companies, the TIC is a hub for multidisciplinary research and innovation, as well as being a major conference and meeting venue for academia, industry and other government agencies. It has created space for more than 600 researchers and generates nearly £20M additional research income to the University per year, as well as providing a base for more than 30 innovation-led organisations. These include the first UK Fraunhofer Centre (in Applied Photonics) and Fraunhofer UK; the headquarters of the Offshore Renewable Energy Catapult; the Scottish Centre of Excellence in Satellite Applications (part of the UK Satellite Applications Catapult); three of the eight Scottish Innovation Centres – the Centre of Excellence for Sensor and Imaging Systems technologies, the Digital Health and Wellbeing Institute, and the Industrial Biotechnology Innovation Centre. Furthermore Entrepreneurial Scotland (the main organisation for Entrepreneurs) is based there, as is Technology Scotland, the sectoral organisation for businesses in Enabling Technology. The TIC also hosts Weir's Advanced Research Centre, the Low Carbon Power and Energy collaborative Programme of SSE and Scottish Power, and the Advanced Nuclear Research Centre. The CMAC programme discussed above has grown rapidly as part of TIC. Established in 2011, the CMAC has a £150m funding portfolio and currently comprises more than 130 staff and researchers, including academics, post docs, and more than 45 PhD students, as well as an experienced support team.

Glasgow City Innovation District is now being developed as a collaborative partnership with the City Council, Scottish Enterprise, Entrepreneurial Scotland and the Chamber of Commerce to develop the downtown area around TIC and the Council's nearby Tontine Accelerator. The core technological innovation element of this will be the new TIC Zone, in which the university is expanding research clusters with industrial partners and RTOs in QuantumTech, HealthTech, Industrial Informatics, FinTech, SpaceTech and 5G/Next Generation Comms, together with an expanded hub to support technology-entrepreneurship

DEVELOPMENT OF INNOVATION TALENT

In the University Strategic Plan the development of world leading innovation and impact, and more broadly of Knowledge Exchange, is a strategic priority. Developing talented people who can shape innovation both inside and outside the University is seen as a fundamental enabler.

Strathclyde uses its partnerships to develop new programmes, particularly at masters and PhD level. This has led to a number of specialist courses designed to meet demand from technology change, such as the UK's first FinTech MSc, and MSc programmes in Data Science and BioTechology developed in conjunction with Scottish Innovation Centres and designed to meet new industry demands.

At doctoral level the University has a competitive fund to establish new Strathclyde Centres for Doctoral Training. All Centres for Doctoral Training require industry co-investment to ensure linkages and pathways to impact. There are 18 centres in total with new centres in 2018 including Digital Health Implementation and Analytics; and Lightweighting and Design using Advanced Materials. EPSRC funded Centres for Doctoral Training also require industry leverage, and these

have been particularly significant in producing highly talented people to go into new industries such as offshore renewable energy and continuous pharmaceutical manufacturing .

Our GlaxoSmithKline (GSK) PhD Partnership, where we have research engagements on a range of drug discovery programmes, while developing GSK researchers, has been recognised internationally. The partnership with GSK is both an MPhil / PhD programme, and a Doctoral Training Centre. Since 2009, the collaboration has involved more than 140 students.

Within the University we have our own MSc in Knowledge Exchange (KE), modules of which can be followed as part of our flexible Researcher Development Programme. Early career researchers – both staff and PhD students - can become recognised 'Impact Champions' providing them a key role in leading innovation projects through our Impact Accelerator Account. However, with the priority on world leading innovation and impact in our strategic plan, a more structured approach has been adopted to ensure that staff incentives support our priorities. The University has therefore changed its HR approach: knowledge exchange, alongside research and teaching, is appraised as part of the annual review of all academic staff. In addition the University has created a whole new career path for KE staff, alongside the conventional academic, teaching and research career paths, which goes from early career KE Associate up to Professor of Practice. This allows the University to both promote those performing excellently in KE, and to recruit staff with industrial experience at any level. With now around 150 staff in the KE career path, these staff play a key link function between the University and its multiple industrial partners, and hence are incentivised to carry out the function of innovation system integrators

RESEARCH QUALITY AND CROSS DISCIPLINARY COLLABORATION

The University is one of the leading science and engineering universities of the UK, as shown by its place as a framework partner of the Engineering and Physical Sciences Research Council (amongst the top 13 of UK universities, and one of only 2 in Scotland), and was ranked in the top twenty for research intensity by Times Higher Education (THE) on the basis of the 2014 Research Excellence Framework (REF) data. THE also ranked Strathclyde Physics research at number 1 in the UK in the REF on the basis of its Grade Point Average. Strathclyde attracts more funding than any other University in Scotland from Innovate UK.

The University strategic research themes focus on the sectors of Energy, Advanced Manufacturing and Materials, Health and Wellbeing, and, Ocean, Air and Space, with an underpinning theme of Measurement Science and Enabling Technologies, and overarching business and societal themes of Innovation and Entrepreneurship, and Society and Policy. The University's strategies for research and innovation are closely linked with a strong emphasis on collaborative partnerships (which may be regional, national, or international). These are sometimes with other universities on research (focussed on more fundamental research) and with industrial partners (and typically also with other University partners) on "mixed TRL" levels. The University's largest strategic industrial centres are AFRC, CMAC, (both discussed above) and the smart grids centre Power Networks Demonstration Centre (with industrial members including Scottish Power Energy Networks, Scottish and Southern Energy Power Distribution, UK Power Networks, Vodafone, CISCO, and others), again demonstrating our collaborative partnerships and integrator role to research and innovation in another discipline The University recent track record and new strategic plan, beginning in 2010, has helped to realise an overall increase in research income from £36M to £65M; growth in the number of PhD students from 1005 to 1485; and research income from industry from £6.2M to £11.9M. This

growth in research income and human capital provides a basis on which to grow the themes/clusters in our areas of expertise listed above.

ENTERPRISE AND ENTREPRENEURSHIP

University expertise and activity in enterprise and entrepreneurship sits across our academic department, the Hunter Centre for Entrepreneurship, part of Strathclyde Business School, and our TTO, Research & Knowledge Exchange Services (RKES). These coordinate activity within the University Enterprise Forum, an open body that includes all across the University who see enterprise and entrepreneurship as key to their roles.

The Hunter Centre for Entrepreneurship is now one of the largest University-based centres of entrepreneurship research in the UK providing Entrepreneurship training through its undergraduate and postgraduate teaching. This includes Masters programmes on 'Entrepreneurship, Innovation and Technology', and 'Entrepreneurial Management and Leadership' and a University wide course "Entrepreneurship, Innovation and Commercialisation" which attracted 115 students from across the University in 2017/18: a growth of 42% on the previous year.

Additionally, as part of its socially progressive outreach programme, the Hunter Centre runs Enterprise Clinics, delivered by cross-disciplinary teams of Business School students who conduct research and consultancy projects for local businesses facing specific challenges.

The Hunter Centre delivers an acceleration programme for small businesses, called the Growth Advantage Programme (GAP), for companies outside the University, and have developed iGAP (the innovation growth advantage programme) for small technology-led companies. This is currently delivered in Tontine House, the City Council run Accelerator and Incubator based in the Glasgow City Innovation District, as part of our collaborative programme of activities within Glasgow City Innovation District. The quality and quantity of our work for small businesses has been recognized by the Chartered Association of Business Schools Gold award.

The commercialisation process for University IP is led by our TTO, Research & Knowledge Exchange Services (RKES). The commercialisation strategy focusses on selection of high growth potential spinouts through a gated development process and follows a commercial investment strategy in which the University can make follow-on investments in conjunction with other investors and thus minimize dilution in successful companies. On average the University gains £5.9M per annum in commercialisation income (based on a 3yr average and including Licensing and Venturing data reported to the SFC).

Since the development of the commercial investment strategy in 2012, 5 spin-out companies have been established, and there have been 16 investments from the fund made in both spin-out companies and new companies formed.

The Hunter Centre for Entrepreneurship collaborates closely with RKES in the Strathclyde Entrepreneurial Network (SEN) which provides entrepreneurial support for staff, students and alumni in the pre-start, start-up, and acceleration phases of company formation and can provide early stage investments through the Strathclyde Entrepreneurs Fund. Since 2005, SEN has helped to support the formation of over 150 companies through its Enterprise Hub. The hub is now developing specialist foci with the launch of Scotland's first Fintech accelerator recently announced.

In recognition of the University's approach to entrepreneurship, Strathclyde was named UK Entrepreneurial University of the Year in 2013/14 at the Times Higher Education (THE) awards.

VISION AND STRATEGY FOR THE NEAR FUTURE

The University of Strathclyde is a catalyst for change in its region, as shown by the leadership of its Principal in the Glasgow Economic Leadership group, its development of the Technology and Innovation Centre (TIC) and surrounding Glasgow City Innovation District, and its role as the anchor institution leading the new National Manufacturing Institute for Scotland and the Advanced Manufacturing Innovation District. It has consistently acted both as an orchestrator of the regional innovation system and to ensure its UK wide and international connectivity, for example through its attraction of UK Catapult organisations to Glasgow, and the establishment of the UK's first Fraunhofer Centre.

The development and expansion of the innovation districts is a key goal of our strategy for creating impact in our region, supporting technology-led company creation and acceleration, investment in R&D, inward investment, and international expansion. The inwardly focussed University strategy in attracting new staff and creating new infrastructure is strongly predicated on ensuring excellence in basic research and translation across underpinning research. This aligns well with both Scottish Government policy goals and UK industrial strategy priorities in increasing productivity, business investment in R&D, and inclusive growth.

ANNEX VI: MEMBERS OF TASK FORCE INNOVATION

Mr	Morten	Dahlgaard	Aalborg University	Denmark
Mr	Pavel	Krečmer	Brno University of Technology	Czech Rep.
Mr	Jan	Vlachý	Czech Technical University in Prague	Czech Rep.
Mr	Johan	Bil	Ghent University	Belgium
Mr	Horst	Bischof	Graz University of Technology	Austria
Mr	Luis	Caldas de Oliveira	*Instituto Superior Técnico*	Portugal
Mr	Jens	Fahrenberg	Karlsruhe Institute of Technology	Germany
Mr	Mindaugas	Bulota	Kaunas University of Technology	Lithuania
Mr	Yolande	Berbers	KU Leuven	Belgium
Ms	Charlotta	Johnsson	Lund University	Sweden
Ms	Sølvi	Silset	Norwegian University of Science and Technology	Norway
Ms	Silvia	Bianco	*Politecnico di Milano*	Italy
Mr	Roberto	Tiezzi	*Politecnico di Milano*	Italy
Ms	Mara	Baccolla	*Politecnico di Torino*	Italy
Mr	Emilio	Paolucci	*Politecnico di Torino*	Italy
Ms	Laila	Elina	Riga Technical University	Latvia
Ms	Anne	Vos	RWTH Aachen University	Germany
Mr	Bram	Wijlands	RWTH Aachen University	Germany
Mr	Ricardo	Migueis	CESAER Secretaria	Belgium
Mr	Peter	Buxmann	*Technische Universität Darmstadt*	Germany
Ms	Liliyan	Kiryanova	Tomsk Polytechnic University	Russia
Ms	Olga	Mazurina	Tomsk Polytechnic University	Russia
Mr	Johannes	Fröhlich	TU Wien	Austria
Ms	Tanja	Sovic-Gasser	TU Wien	Austria
Ms	Esther	Real Saladrigas	*Universitat Politècnica de Catalunya*	Spain
Mr	Vincent	Hargaden	University College Dublin	Ireland
Mr	Chris	Baker	University of Sheffield	UK
Mr	Tim	Bedford	University of Strathclyde	UK
Ms	Yvonne	Kinnaird	University of Strathclyde	UK
Ms	Agnieska	Skala	Warsaw University of Technology	Poland