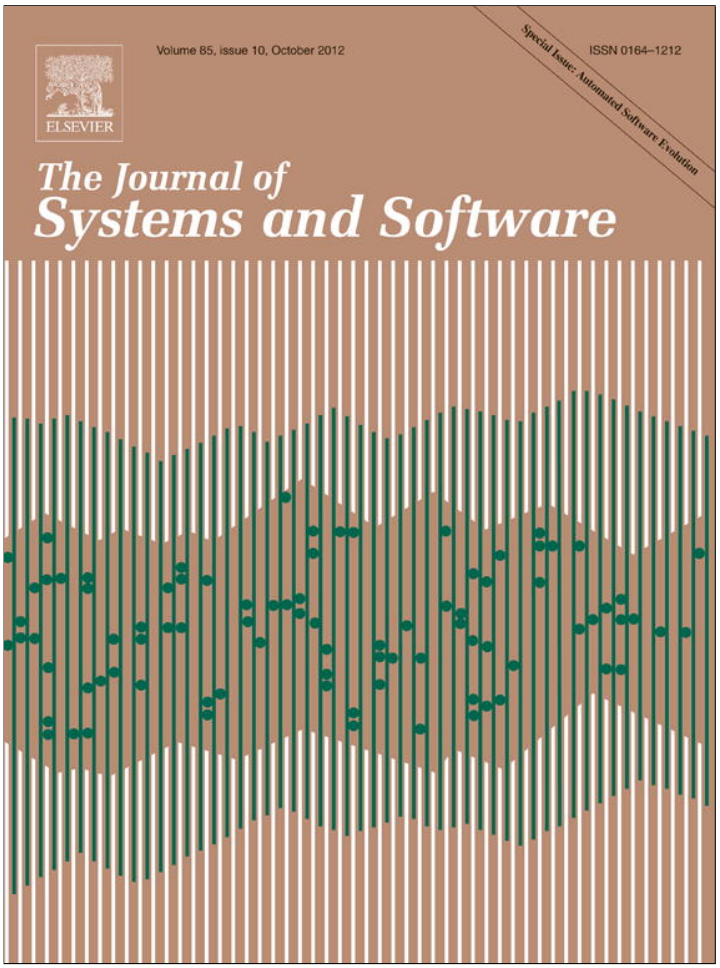

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Controversy Corner

3 + 1 Challenges for the future of universities☆

Alfonso Fuggetta*

CEFRIEL – ICT Institute Politecnico di Milano, Italy

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ABSTRACT

Universities are looking for effective strategies to cope with the global changes that have extended across the world in the past years. Existing approaches to research and education are increasingly perceived as unable or at least insufficient to capture and take into account the complexity and the dynamism of the globalized society. This is particularly true for the ICT sector, which has been radically transformed by technologies such as mobile devices, ubiquitous connectivity, and pervasive ICT. Indeed, as these technologies are inherently disruptive, they are profoundly impacting and transforming the economy and the entire society in general.

This paper aims at discussing the issues and problems that universities are facing to deal with the growth and evolution of the ICT sector. In particular, the paper proposes 3 + 1 challenges they need to address and master. The challenges deal with three fundamental functions of modern universities: research, innovation, and education. Moreover, the paper proposes a fourth challenge related primarily to the attitude and behavior of faculty members and academic boards. The ultimate goal of the paper is to contribute to the development of an effective and useful debate about the strategies to support the evolution and growth of universities, as key players to promote the public good and the overall progress of our society.

1. Introduction

In the past two decades, the Information and Communication Technology sector (ICT) has been shaken up by a number of changes that have profoundly transformed markets, industries, and the society in general. For instance, 10–15 years ago, before the advent of the Internet, telco operators were vertically integrated companies, managing the whole set of functions and services from technology design and development, to infrastructure deployment and service operation. Mobile phones were primarily "phones" used to make analog "voice calls". Most commentators and analysts assumed that PCs and operating systems ceased to be interesting research topics: who would have ever challenged the dominance of the Wintel platform? Even more, most of these technologies were considered "commodities", i.e., standardized goods unable to provide companies/customers with significant competitive advantages (Carr, 2003). Apple was almost irrelevant, Compaq had just acquired Digital, Microsoft was dominating. In general, many commentators were signaling a sort of "end of the history" in the ICT sector.

Nowadays, the world is completely different: the advent of mobile computing, pervasive and wireless internet connectivity, increased memory capacity, and cheaper and more powerful processors have changed the scenario. Giants such as Microsoft, Dell, Intel, and HP (that purchased Compaq about ten years ago) are repositioning themselves. Nokia is trying to find a new strategy, having lost the leadership it had in the 90 s. Apple and Google have reinvented the operating system landscape with Mac OS X, iOS, and Android. ARM is challenging Intel dominance. STM MEMS have made it possible to create revolutionary products such as the Wii and the iPhone. In parallel, new programming paradigms have emerged and a new breed of Internet-based technologies have radically changed the approach we use to develop and deploy software.

These changes in the ICT sector have occurred in the middle of a more general transformation that has been affecting the economy and, more in general, our society. In particular, it is worthwhile mentioning six general issues and trends:

1. *Globalization*. The development model of western countries is being challenged. The globalization is causing a redistribution

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* Tel.: +39 02239541; fax: +39 0223954254.
E-mail addresses: alfonso.fuggetta@polimi.it, alfonso.fuggetta@cefriel.com
URL: http://www.linkedin.com/in/alfonsofuggetta.

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of wealth, labor, people, and resources: *the world has become a unique and integrated ecosystem*, where people, companies, and capitals can move and relocate. From the university viewpoint, this phenomenon has two fundamental effects: first, *students increasingly move across countries and even continents* to find the education opportunities that best fit their interests and attitude; second, *companies tend to move their research and development initiatives* to new and emerging markets, or to countries where the labor force is cheap, young, and with high education levels.

2. *Private R&D budget cuts.* Industries have been reducing their investments and involvement in research and development. Often, this is caused by the questionable assumption that in a globalized world it is easier and cheaper to just "purchase" the innovations and the intellectual property needed to promote the growth of the company, rather than investing to autonomously conceive and develop them. In other cases, industries are consolidating their research activities and/or moving them to emerging markets or with cheaper labor force and higher public incentives for research. A comprehensive and detailed study carried out by the MIT Industrial Performance Center summarize in a few words the impact of these changes on the ICT sector during the past decade (Berger, 2005):

> *The dismantling of these great corporate research-and-development engines was a response, in part, to the new competitive pressure the companies were experiencing. By harnessing R&D ever more tightly to commercializable products and bringing the scientists closer to developers and marketers, the companies hoped to get a bigger bang from their research bucks. They also wanted, simply, to cut their overall budgets. After a surge in R&D spending in the late nineties, this economizing impulse has resumed. Companies that were prime movers in the information technology boom of the late nineties are now cutting back on their R&D expenditures. CISCO, Dell, HP, Lucent, Motorola, Ericsson, and Nortel, for example, all spent a small percentage of sales in R&D in 2004 compared to 2003, and for most of them, the trend has been downward since 2000.*

Certainly, in recent years new companies have emerged, such as Google and Facebook. Apple has become the largest corporation in the world, thanks to the huge success of its innovative product lines. New companies have been created to exploit new trends such as social networks and multimedia. Of course, this new generation of companies do have their R&D centers and programs. But it is not clear at all if they have been able to compensate the shrinking of R&D investments occurred in the previous decade.

3. *Public R&D budget stagnation.* Due to the economic situation and the debt crises, in most western countries public funding for research and innovation has not been increased enough to compensate the decrease in private investments and/or to keep the pace of the investments made in other emerging economies. In general, as illustrated by recent data published by OECD (2011), Europe has failed to achieve the goal of the Lisbon agenda to invest 3% of the GDP in innovation and research (the level being stagnant at about 1.9%), and investments in other OECD countries are stagnant as well. At the same time, China has doubled R&D expenditures, which in 2009 reached 15% of R&D expenditures worldwide (see http://goo.gl/LPjCO on the OECD web site).
4. *Cost and complexity of research and innovation processes.* For many non-ICT companies and public administrations that need ICT to improve their operations and products (especially small and medium ones), the costs and complexity of research and innovation activities are surging, as the challenges to be addressed require comprehensive infrastructures, background knowledge, and diversified expertise. Many companies and public administrations are unable to autonomously develop and/or acquire the human capital and resources they need to support effective research and innovation processes. Open source software and open innovation initiatives are significant attempts to find solutions to this problem. However, the issue is far from being completely and satisfactorily addressed and solved, as illustrated by many studies on this subject (e.g., OECD, 2011).
5. *Aging.* The population of western countries is aging, as life expectancy has increased significantly.[1] This is creating a challenging paradox: the sustainability of our pension systems require the extension of the retirement age, but, at the same time, too often companies consider senior employees unable to upgrade their skills and capabilities to keep the pace of rapidly evolving technologies and markets, or simply too expensive and therefore incompatible with the cost reduction policies they are putting in place.
6. *New education needs.* Most teaching methods and assumptions adopted in the past by universities are no longer valid. For instance, the separation between (under)graduate courses and continuing education is unable to deal with the radical changes occurring in the workers' careers and professional life. Moreover, education and research are increasingly intertwined and synergic: they cannot be considered separately, as they are part of a single, integrated knowledge creation and diffusion loop.

These changes have had profound consequences on universities and research institutions, which are now forced to operate in a world that is radically different from the past and that is challenging consolidated assumptions, conventional funding policies, and traditional academic practices. Are existing universities able to deal with these complex phenomena and changes? How should they adapt to the new world that this evolution is inducing? What kind of society are we envisioning and what will the role of the university be?

2. A crucial distinction: research vs. innovation

In the past decade, universities have increasingly shifted their focus from long-term, visionary researches, to shorter-term, applied initiatives. The main cause for this shift is the pressure to reduce public budgets and find additional private resources and, consequently, to carry out projects that have a direct, immediate, and practical impact on the society, industries, competitiveness, and economic development.

This shift has been carried out without realizing that we have implicitly and harmfully confused two different processes: research and innovation.

- Research is the process through which we advance knowledge, shed light on unknown phenomena, imagine new worlds, invent new technologies, discover new laws or principles.
- Innovation is the process through which we apply our knowledge to increase the quality of life, improve the competitiveness of companies and economic institutions, create new opportunities for citizens and families to promote and enrich their social experiences.

[1] This excerpt is taken from the AOA (Administration On Aging) website (AOA, 2011): "The older population – persons 65 years or older – numbered 39.6 million in 2009 (the latest year for which data is available). They represented 12.9% of the U.S. population, about one in every eight Americans. By 2030, there will be about 72.1 million older persons, more than twice their number in 2000. People 65+ represented 12.4% of the population in the year 2000 but are expected to grow to be 19% of the population by 2030. The information in this section of the AoA website brings together a wide variety of statistical information about this growing population."

Background and purpose of this paper

I spent most of the 90s doing research and working actively in the international research community. I was involved in the organization of several international conferences and also in the editorial board of ACM TOSEM. I carried out several research activities with colleagues in Europe and in the USA.
Conversely, I have spent most of the past decade trying to apply systematically, within companies and public administrations, what I learned during the previous decade. As Scientific Director and CEO of CEFRIEL, I have had the opportunity to meet hundreds of companies around the world. Periodically, I have also discussed the problems debated in the paper with several colleagues in US, European, and Asian universities, and with officers of the EU.
Over the years, I have accumulated experiences, opinions, observations, doubts, beliefs, ideas, pieces of information that I got from my daily experiences, the people I met, the problems I faced. I wanted to organize and structure and integrate these different tiles of the puzzle, because I believe that they can be instrumental to promote the discussion on these topics, and help the research community (and decision makers) envision new approaches to address the challenges we are facing.
Certainly, the paper does not aim at proposing formal solutions or definite answers (I am not so presumptuous or overconfident). I just wanted to organize my personal experiences in a structured way. This is not done quantitatively, but through a number of qualitative observations and evaluations. Undoubtedly, given the complexity of the issues and problems that need to be addressed, it would be easier to redirect request and challenges to the political and industrial world, as they determine, through their funding policies, the nature, operation, and essence of universities. **Nevertheless, universities can and must do their part to lead the change and determine their own evolution**. For this reason, I would like to propose 3 + 1 challenges that I consider critical and foundational, and that should be addressed by universities in the first place.
Disclaimer: My considerations apply primarily to research universities and to problems and issues in the ICT sector, where I have developed most of my experiences. Still, I believe that at least some of the comments apply in general also to other disciplines and domains.

Of course, these two processes are related. In some domains and disciplines it may even be difficult to draw a sharp distinction between them. Nevertheless, there are a number of differences that characterize and distinguish research from innovation, as summarized in Table 1 (Fuggetta, 2011).

Research and innovation are intrinsically different processes and therefore require different methods, skills, and funding mechanisms. Certainly, innovation needs the knowledge, breakthroughs, and ideas developed by research. At the same time, innovation produces experiences, feedback, and challenges that feed the research process. Thus we need to pursue both processes in a coherent and balanced way: none of them can survive without the other.

In this context, the request to "make research" more applicable to concrete situations may be appealing and reasonable in principle, but turns out to be ineffective and even counterproductive in practice.

- In research, the shift toward applied research/development is jeopardizing universities' ability to create novel concepts and breakthroughs. For example, in computer science successful concepts such as object-oriented programming (and languages such as C++ and Java) are based on notions developed in the 60 s (Simula 67). In 1991, Tim Berners Lee created the World Wide Web exploiting concepts such as hypertext and markup languages, both conceived in the 60s. In general, even when research does not provide a direct and immediate impact on society, it is the source and generator of the know-how and the human capital that constitute the cradle for future innovations and market breakthroughs. Limiting the scope, ambition, timespan, and risk of research, in the long run is going to have the counterproductive effect of hampering the ability to innovate and achieve the societal impact invoked by many decision makers and by the public opinion.
- In innovation – the "applied initiatives" – universities tend to use the same approach and method adopted in the research work: researchers identify an interesting topic and look for new ways of dealing with it; this process is carried out using traditional academic resources (colleagues and students), and according to the timeframe and the IP management rules that are mandated by the university bylaws and regulations. Typically, this is *inconsistent with the requirements, needs, and constraints of the companies* that should fund and exploit these activities. Paradoxically, *this approach turns out to be ineffective and even counterproductive for both universities and industries*. Academicians are often unable to publish the results of these applied initiatives in top scientific journals and conferences. At the same time, often these results are difficult to exploit from an industrial viewpoint, as they are too immature, unaligned, or inconsistent with the timeframes, constraints, and deadlines imposed by the market.

Table 1
Differences between research and innovation.

Dimension	Additional description	Research	Innovation
Motivating factors	Factors determining the motivation of people involved in the process	Intellectual challenge Scientific standing and reputation	Market success In general, impact on the society
Approach[a]	Competence and expertise required to carried out the process	Specialization (typically, only the disciplines targeted by the research work, e.g., mathematics and biology)	Cross-functional (all the disciplines needed to bring a solution to the market, e.g., logistics and marketing)
Perspective	Timeframe	Medium-long	Short-medium
Risk		Intrinsic (the research might fail)	Systemic (the company investing in innovation might fail)
Funding		Typically public Visionary	Typically private Venture
Key abilities		Scientific excellence	Ability to deliver Execution
Non-functional requirements		Only those needed to prove the idea	Tailored to users' needs and expectations

[a] This dimension is not to be confused with disciplinarity. Most modern research activities are inherently multidisciplinary. The terms "approach", "specialization", and "cross-functional" refer to the nature of the activities needed to accomplish a research or innovation initiative. In innovation, it is necessary to consider a number of factors that are basically irrelevant in research, e.g., marketing and logistics. The researcher is interested in producing new knowledge (possibly using a multidisciplinary approach), but is not at all interested in the processes and activities needed to bring an innovation to the market.

Certainly, the distinction between research and innovation does not automatically imply that the former has to be carried out in universities while the latter should be the main activity of industries. The distinction aims at characterizing the differences of these two processes, independently of the actor who is enacting them. As discussed above, both universities and industries can – and do – operate in both areas: however, it is essential that they apply different approaches depending on the activity they want to pursue. Universities and industries should not try to address innovation as if it were just a more applied form of research, or research as a longer-term innovation initiative.

A confusing vision about the role and characteristics of research and innovation contributes to complicate the debate about the role of universities in the society, and the strategy that should be used to fund them. Indeed, there are two extreme positions that typically clash with each other.

1. A first position, often sponsored by universities and academicians, claims that universities should be free and autonomous, committed to promote the public good and the future of society, independently of specific short-term economic interests. Therefore, funding should be primarily public and devoted to (long-term) research. Private funding should act as liberal grants to promote and support the activity of universities, young talents, academicians.
2. The opposite vision assumes that universities should serve the society and therefore they should be funded by those who are supposed to directly benefit from the results of their work, i.e., especially industries and private companies. As a consequence, the funding should typically be private and focussed on specific economic and societal interests and needs.

Both positions are legitimate and, most important, they are not incompatible. They are motivated and driven by different starting points, needs, goals. To improve the situation, *universities (and funding agencies and bodies) must clearly identify and distinguish expectations and success factors in order to address each of them properly, aligning means to goals, and finding a proper balance among the different requirements and orientations. In particular, there are two main areas to address*:

- Promote and develop long-term research initiatives that advance knowledge (Challenge 1).
- Serve the society and promote its evolution (Challenge 2).

3. Challenge 1: invent the future

A main motivation for the increasing shift toward applied research is the set of drivers and stimuli that steer the work of the research community: in particular, if the funding and evaluation mechanisms press for a shorter-term, applied approach to research, it is difficult for the research community to escape this fate.

Unfortunately, universities and scholars often have demonstrated to be "more Catholic than the Pope", and have pushed the "short-term, applied attitude" to the extreme.

In the research work, many projects proposed by universities and research centers are becoming too close to typical industrial development. This creates a sort of improper and pointless competition and overlapping, without providing any significant added value. It is necessary to regain the ability to experiment, open new research directions, try risky alternatives, promote the public good, without the concern and the requirements to "get to the market as soon as possible".

As for publications, scientific conferences and journals are accepting papers that tend to cluster around the following categories:

- Papers within the mainstream of consolidated research areas where the scientific community is already working. They are very often refinements/evolutions of previous research activities that have already proved to be somewhat valid and worth using.
- Empirical studies that develop some sort of evidence of the impact of a specific technology or method. This is easier in some areas (e.g., software testing and verification), while it is more difficult in other (e.g., new paradigms for data visualization), and largely inapplicable to more visionary and disruptive papers.

In general, *too often the evaluation criteria and the reviewing procedures appear to be an end rather than a means*, as they are formally executed, but with little attention to the final effect: are we publishing challenging and provoking papers or just those that fit well with the revision process? The ultimate goal of research should be *to imagine the future, push the envelope of what is feasible today, challenge consolidated assumptions, and propose new visions*. Conversely, biased by the existing acceptance criteria, too often authors propose research works that offer only a marginal/incremental evolution with respect to state of art, if any. Too often, conferences are boring meeting where speakers present their works to an audience composed of other authors waiting to present their own papers. Too often, we miss real and effective discussion and elaboration that can inspire new research directions and enable new achievements. Too often, the most lively discussions occur inside informal meetings and events, or outside the conventional scientific conferences and workshops.

Universities, researchers, and scholars can and should promote a number of actions to reverse this trend:

a. Amend university evaluation criteria so that they recognize the generation of new ideas and research directions as valuable and essential, and do not consider just the ability to get contracts and grants, or to publish within the stream of existing conferences and research trends.
b. Activate a joint and coordinated effort to bring these issues and positions to the decision makers in industries and funding agencies. Without public funding, it is impossible to invest in visionary, long-term research initiatives that provide the foundations and the key enablers for industrial competitiveness (Berger, 2005).
c. Promote scientific events where the main goal is not just to refine the state of the art, but rather to *invent the future, explore the unknown, advance knowledge*.

In a period of crisis, the demand for an increase in public funding for research initiatives might appear unrealistic and naive. Indeed, some countries are pursuing this strategy because they perceive it as an investment to exit from the crisis and increase value and opportunities to grow. In addition, there are many resources that are generally and ineffectively spent to support "research and innovation": they would be much more useful if allocated according to a strategy that matches a clear vision and solid evaluation processes. Often the real problem is not just to increase funding, but not to waste money in unfocussed and ineffective initiatives and programs.

Certainly, in making these points universities must be credible. The freedom to invent the future cannot be transformed in a lack of accountability or an uncontrolled consumption of resources. *Universities in the first place should act to guarantee quality and credibility*. First, universities should constantly and transparently assess the scientific relevance of the work being performed. Second, they

should equally support complementary actions oriented toward promoting innovation and societal impact. Third, they should permanently and continuously monitor the alignment and conceptual coherence between short-term and long-term strategies. *These are essential conditions to make the whole process credible and sustainable*.

4. Challenge 2: serve society

Universities have a huge capital of human resources and knowledge that can be fruitfully exploited to have a direct and immediate impact on the society. Indeed, this is the expectation and request of public bodies, private companies, and decision makers: universities should promote the public good by directly supporting the competitiveness of industries, the quality of public administrations, the overall development of the society.

Traditionally, universities have addressed this request by promoting research (Challenge 1) and education (Challenge 3). Over the past decades, universities have created a third "leg" to promote innovation, technology transfer, and a more direct connection with industries and the territory. In particular, universities have created Technology Transfer Offices (TTOs) that are in charge of exploiting the intellectual property created through the research activity. TTOs support academic staff in patenting their inventions, licensing patents, creating spinoffs and startups. The most renowned universities in the world have been extremely successful in pursuing this strategy: they have offered a key contribution to the development of the territory where they are located. Think of Stanford University and the incredible development of Silicon Valley, MIT and the Boston area, the universities of Oxford and Cambridge in the UK.[2]

However, this kind of approach does not fit all the needs and situations. Basically, TTOs, startups, and spinoffs are used to inject new companies or new technologies in the market. This is certainly important and useful, but what about existing companies that do not need those specific technologies offered by the startups? Moreover, often innovation can be pursued without a specific and dedicated research activity: it might reuse existing research and knowledge, or just incremental improvements that do not necessarily require extensive research results, or even no research at all (at least, according to a strict interpretation of the term). How can universities contribute to these disparate and varying innovation efforts?

To address these issues, universities need to offer a different kind of support, a sort of advanced consulting service able to cover five main activities:

- Understand the state of the art in a field of interest, the related trends in technology and science, the visions and directions along which they are evolving and developing.
- Scout for mature-enough technologies that can be used in the design and/or improvement of products and services.
- Support companies and public administrations in carrying out innovative projects to change processes, products, and services through a joint activity. This can be – at least partially – identified with the expression *technology transfer by head and by project:* knowledge is transferred by putting at work in the same team people from the customer/company and from the university consulting service.
- Promote the development and valorization of the human capital of companies, through a combination of advance education programs, mentorship and coaching, and live laboratories and experimental activities.
- Support the strategic development and governance of innovation processes of the company.

In general, an innovation grant is not a donation offered to the university to support its autonomous initiative; the funding company is not just a "donor". University must consider innovation grants as real contracts, established with customers to satisfy their needs, according to their constraints, requirements, and timeframes. It is a huge challenge that requires *changes in the organization, staffing, and processes* of an academic institution, and not just a declaration of intent or an aggressive marketing proposition.

This consideration is even more challenging if we consider the dramatic change in the nature of companies and organizations requiring ICT competences and knowhow. Nowadays, ICT is used by any modern company or institution to innovate its products and services, in all possible scenarios and applications domains (e.g., transportation, homeland security, media, health care, entertainment, logistics, travel, ...). As a consequence, very often ICT researchers have to interact with companies and staff whose cultural background is not rooted in ICT. For instance, the fashion industry have developed complex and extremely sophisticated marketing strategies that, in turn, have changed distribution mechanisms and supply chains. This makes the innovation work even more challenging and different from conventional research activities.

To address these issues and problems, universities need to accept that innovation requires different *methods, approaches, expertise, and capabilities with respect to conventional research activities* (Fuggetta, 2009). Universities should develop specific operational entities, intermediate bodies, that can effectively execute and develop the model depicted above. This entities are qualified by a number of distinctive characteristics:

1. They do have strong links with academic institutions, even if administratively independent and with specific processes, organization, and human resources.
2. They must offer their services on the market as a conventional company. This means to develop a business model, a marketing and commercial strategy, and an investment and financial plan that are coherent with the ultimate goal and mission discussed above.
3. They must carry out projects exploiting *specialized staff, project managers, and professionals*, in addition to traditional academic resources (faculty members and research staff) whose role must be limited to scientific mentorship and technical advising.

Fraunhofer IESE in Kaiserslautern (http://www.iese.fraunhofer.de/en.html), SINTEF in Norway (http://www.sintef.no/home/About-us/), and CEFRIEL in Italy (http://www.cefriel.com) are examples of this kind of entities.

5. Challenge 3: teach how to learn

An essential role of universities is to create the human capital that will foster and lead the evolution of our society. To identify this activity, we normally use the term "teaching". In reality, there are at least two different interpretations of the term "teaching":

i. "Teaching is making sure that students *know* something." In this connotation, teaching means to transmit information and knowledge from a source (the teacher) to a recipient (the student). The goal is to make sure that at the end of the education

[2] Actually, several TTOs appear to have a negative net cash flow, as the revenues are unable to compensate the costs of protecting and promoting the IP generated by the university.

program students are knowledgeable about a specific topic. For instance, in computer science this means to make sure that a student is knowledgeable about programming languages concepts, and their syntax and semantics.

ii. "Teaching is making sure that students *know how to do* something". In this connotation, teaching means to train students so that they become able to accomplish a specific task or activity. For instance, in computer science this means to be able to use a programming environment to create, test, and deploy a specific software system.

Even if a bit simplistic, these two connotations are representative of many positions and opinions on the role and mission of teaching. Unfortunately, they are *unable to capture the complexity of the learning process and of the challenges we are facing*.

Way too often, we consider the teaching process as a transfer of knowledge and notions from a source to a destination that needs to be "filled up", being passive, "empty", and "ignorant" (from the latin word "ignorare", i.e., a person who ignores something). The word "teaching" derives from the word "show" or the latin "dicere" (talk), i.e., someone transferring information to someone else. In Italian, we use the word "formare", which means "to shape", to provide a form to something otherwise shapeless. *All these terms and expressions reinforce the same idea: teaching is transferring "something" to a passive and ignorant audience*. If this transfer does not occur, the person remains ignorant.

Certainly, the learning process does also include some transfer of information and notions. However, if we limit ourselves to these definitions (and the underlying vision), we keep underestimating three main issues that deeply impact on the learning process.

5.1. Inability to retain

In a very interesting paper, Wieman assesses students' ability to absorb and understand the concepts and notions taught in class (Wieman, 2009). His study confirms what other researchers have experienced in similar experiments:

> *Richard Hake compiled the FCI results from 14 different traditional courses and found that in the traditional lecture course, students master no more than 30 percent of the key concepts that they didn't already know at the start of the course. Similar sub-30-percent gains are seen in many other unpublished studies and are largely independent of lecturer quality, class size, and institution. The consistency of those results clearly demonstrates that the problem is in the basic pedagogical approach: The traditional lecture is simply not successful in helping most students achieve mastery of fundamental concepts.*

In general, students retain and master only a small portion of the notions and concepts presented and discussed by the educator and as a consequence the overall efficiency of the traditional teaching process is deeply questioned.

5.2. Extremely dynamic market, technologies, and society

Market, technologies, and society change at an incredible speed. Knowledge growth doubles every two years (source, the US Department of Education and Harvard University). In particular, the IT sector has dramatically changed over the past decades. In general, *what we know about a specific phenomenon or trend at a specific point in time is likely to be outdated after a short period of time*.

5.3. Aging society and its consequences on the labor force

The latest estimation on the average life expectancy indicates that children born in this decade may live over a century. By today standard, it means that they would study until they are 25–30 years old and then work for 45 years and probably even more. In this scenario, the notion of continuing education as we often imagine it (e.g., periodic courses to update their knowledge and skills) appears to be too simplistic and largely insufficient.

5.4. Consequence: teach how to learn

The combined effect of the three phenomena mentioned above suggests that it is necessary to evolve our teaching models to ensure that *persons continuously learn from the environment and from the experiences in which they are involved in*. Certainly, students must also learn specific concepts and notions that increase and improve their background and knowledge base. However, it is vital to make sure that they *acquire the instruments and attitude to permanently act as learning entities, intrinsically able to absorb and expand their knowledge on the basis of the experiences and changes they are exposed to*. For instance, they should be able to critically revise the results of their work, identify their weaknesses and strengths, generalize and contrast them, apply them in different and unexplored contexts, filter and rank information, consolidate knowledge, search for more sources or related concepts and phenomena, and reconsider existing beliefs and assumptions.

We need to center the learning process on the word "education", from the latin "e-ducere", i.e., "bring out". This means to make students able to proactively capture, assess, classify, and organize information, and not just to passively store the notions that someone is transferring to them. This is a huge challenge for the universities of the future. What kind of teaching and pedagogical model should we envision to pursue this vision? How should universities organization change to address these issues? Is it just sufficient to transform existing universities in "internet-based" entities able to offer curricula online? Does this help "learn to learn"?

We need to *deeply and radically rethink the roots of the education model* used in our curricula, and also their organization and timespan. We need to exploit all the advances we have been acquiring in cognitive sciences and learning support technologies, which are increasingly impacting the dynamics of education processes.

The ultimate goal must be to teach students how to learn continuously, anywhere, anytime, during the entire course of their (increasingly longer) life.

Certainly, this notion is not new. Seminal works such as *The Fifth Discipline* by Senge (1990) have explained the crucial role of learning not only at the personal level, but also at the organizational one. Still, often "learning to learn" is assumed to be equivalent to "continuous learning/education", i.e., programs that professional should take to learn "new things". Or also, the emphasis is on "multidisciplinary approaches to learning" or to "learning in a networked and interrelated environment" (Sheppard et al., 2008). Indeed, these are important notions: however, they do not focus enough on the *crucial attitude to autonomous learning as a permanent, proactive, and essential constituent of their professional and social life*. It is therefore crucial to continuously restate and address the challenges and complexity of "learning to learn".

6. Challenge "+1": a cultural change

The improvement and evolution of universities depend on the choices, decisions, and non-decisions of political bodies, industries, economic and financial institutions. Still most of the actions discussed in this paper can be largely carried out by universities, somewhat independently from the decisions of external entities. Will universities be willing and able to pursue them?Universities are facing a cultural challenge: to address the issues discussed in

this paper, first and foremost they need to change or evolve some of the assumptions and beliefs that drive their strategies, policies, and operations.

a. Universities have to structure their strategies and policies around three "legs" or pillars: research, innovation, and education.
b. The three pillars are synergic and equally critical to the development of a (research) university.
   - Research generates the knowledge that is used in education and applied in innovation.
   - Innovation provides exposure to real problems, experiences to animate education, and feedback and challenges for new research activities. It also plays a vital role to demonstrate to the public opinion the value and contribution of a specific discipline. It is through innovation that the results of most research activities are made visible to customers, industries, public bodies, citizens, and also to new generations that are in the process of choosing their career path and course of study.
   - Education organizes and disseminates knowledge, provides feedback to research and innovation, creates the human capital to feed and further support the development of the society and of universities within the society.
c. Innovation is significantly different from research, as these two processes are characterized by different goals, working methods, challenges, and "customers". This means that innovation requires specific approaches that cannot be just an extension or a variation of what we use in research. In turn, this means that universities should adapt their organization and human resource policies to create the right mix of competences and skills to effectively support these different activities.
d. Education has to change, even challenging some of the traditional assumptions and principles that have been adopted for decades in academic curricula and programs. The world has changed, our life is changing: education cannot remain the same.
e. These changes can occur only if academicians and faculty members are convinced and committed to implement them. It is essential to promote a culture of cooperation, real integration of disciplines, attention to the needs and requests of the society, acknowledgment of the differences and peculiar characteristics of research and innovation, and consistently strive for coherent choices and practices.
f. Accordingly, universities should evolve their evaluation criteria to take into account a wider range of potential contributions that faculty members and technical staff can and should offer.

This last point is extremely important and deserves some further elaboration. Traditionally, faculty members are assessed against a number of classical academic activities: publications, research grants, number and quality of graduate and Ph.D. students, patents, students' evaluations. Of course, each university has its own criteria to balance and weight these different factors. These criteria need to evolve and be made coherent with the goals and activities that the university wants to pursue and promote. If innovation is an important pillar with the same dignity as research and education, than it should contribute significantly to the mix of criteria according to which people are evaluated.

In general, the growth and evolution of a complex system – such as a university – cannot be just imposed. It must be driven and accompanied by two essential support actions:

1. a wide, sincere, and deep sharing of vision, goals, and means among all the university stakeholders (faculty members in the first place);
2. evaluation criteria coherent with the objectives that the university wants to achieve.

7. Conclusions

In the introduction, I briefly mentioned a number of issues and trends that characterize our society in general, and the ICT sector more specifically. To cope with these issues and trends, universities need to address 3 + 1 major challenges that are, in different forms and extent, related to them.

7.1. The "+1" challenge

All the six issues and trends cited in the Introduction directly related to the "+1" challenge: universities need to change and evolve to keep into account a world that is changing at a speed never seen in the past. To address this challenge, universities cannot be overly biased or limited by traditions and consolidated practices. Radical changes require a radical rethinking and questioning of the overall organization, focus, and operational model of universities. This a necessary precondition to enable a fruitful and deep innovation of many academic processes and practices.

7.2. "Invent the future"

At the end of her essay on the competitiveness of the American society, Suzanne Berger writes (Berger, 2005):

> *The institutions that nourish research and development, like those that support education and those that sustain the public's commitment to the openness of the economy, are foundations of a productive and innovative society. These foundations need to be able to bear the weight of adjustment to earth-shuttering movement in the international economy. [...] How to adjust and reinforce these public foundations is too large a task for private initiatives alone to undertake. We recognize that our research at the ground level of the firm does not provide the answers. We only know that even the best of the companies that we have seen in the United States will suffer if there is a failure to renew the stock of public resources on which they continue to draw in building their own capabilities.*

Indeed, research is often constrained or slowed down by Issues #2 and #3 (Public and private budget cuts and/or reorientation toward more applied activities). Consequently, the temptation for an academic institutions might be to focus the research work on more "applied" themes and topics, closer to companies' and public administrations' direct interests. Conversely, it is vital that universities keep their role of "inventing the future" by preserving and strengthening their research capabilities. This might require the identification of fewer "true" research lines where each university is more competitive and able to produce disruptive results, or to work within the research community at large to influence funding agencies so that they keep and sustain true research programs and not just to more applied initiatives. This challenge is even more critical for western societies, as emerging economies are strongly investing in public research and development capabilities (OECD, 2011) and are therefore making their countries more attractive also for private R&D investments.

7.3. "Serve society"

The complexity and costs of research and innovation processes, and the need to increase the impact of the research work on the society, demand for a more effective approach to innovation and technology transfer (Issue #4, costs and complexity of research and innovation processes). Universities have knowledge, expertise, capabilities that can certainly be crucial to promote innovation and growth. However, universities cannot pursue this challenge by just making their research work "more applied". This way, they

hamper their ability to "invent the future" and, paradoxically, fail to address the challenge. Serving the society, promoting innovation, apply research results in practice do require methods, skills, and organizations that are different from those typically adopted in academic institutions. TTOs can help and certainly have a role, but they can address only a portion of the challenge: protect knowledge and transfer it to the market through spinoffs and startups. There is a more general need for means and methods that help companies innovate their products and services. These means and methods should be based on a balanced combination of academic and industrial skills, attitudes, and processes. Intermediate institutions such as CEFRIEL do have this constituency. This kind of institutions should be increasingly supported and promoted by universities as their "longa manus" to "serve society". It is not just a blind delegation, but a clever articulation of skills, expertise, and practices. Rather then dilute their research capabilities in pointless innovation or "applied" programs, universities should recognize the specific needs and constraints of innovation processes and articulate their operations, alliances, and strategies accordingly.

7.4. "Teach how to learn"

Population is aging. Technologies are changing rapidly. Companies changes quickly as well. The combined effect of these phenomena (Issues #5 and #6) poses new requirements and challenges to education institutions. Persons need to "learn how to learn", as their professional activity will develop along decades, according to unpredictable and often rapidly variable scenarios.

Over the years universities have developed continuing education programs, executive master courses, and other kinds of continuing education formats. Nevertheless, the issue here is more radical. It is not just a matter of providing persons with training opportunities to "learn one more thing in one more course". We need to promote an innate and deep-rooted ability to continuously learn from their daily work and professional opportunities. This requires more than just inventing new teaching programs: it is necessary to change the education approaches and methodology used in our curricula and classes. It is not important just to assess the student's ability to provide correct answers to specific questions or problems. We need to help them develop the ability to continuously learn through any step of their professional and working experience. It is a profound and extremely complex pedagogical challenge that requires new education skills, methods, and approaches.

7.5. A final remark

Difficult problems and issues such as the ones mentioned in this paper cannot be solved without a wide and deep discussion within the academic community. Aim of this paper is to propose some contributions and, hopefully, provoking arguments to further fuel and feed the elaboration of effective strategies for the future of our universities.

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Alfonso Fuggetta is a Full Professor at Politecnico di Milano and CEO and Scientific Director of CEFRIEL. CEFRIEL is an innovation and technology transfer institution established in 1988 by universities, public administrations, and industries. As a professor and later as CEO of CEFRIEL, Fuggetta has developed significant experiences and insights on research and innovation processes. In the past years, Fuggetta has been a member of several committees of the Italian Government and of the Commission of the European Union. He is also a permanent member of the Research and Innovation Committee of Confindustria, the Italian employers' federation. Fuggetta is also Faculty Associate at the Institute for Software Research at the University of California, Irvine.

Information about the author: In 1992, Fuggetta got a position of Associate Professor (with tenure) at Politecnico di Milano. In 2000, he was promoted to Full Professor. During the nineties, Fuggetta worked on a number of research topics related to software engineering, internet technology, and mobile software and support technology. In that period, he was member of several program committees for international conferences and of editorial boards of scientific journals. In particular, he was Program CoChair of ICSE 97, the International Conference on Software Engineering held in Boston in 1997. He was also member of the editorial board of the ACM Transactions on Software Engineering and Methodology (ACM TOSEM). In 1997 and 1998, Fuggetta was in the top ten list of scholars in the field of software and system engineering, published yearly by the Journal of Systems and Software. In 1997, he was 9th worldwide and second European. In 1998, he was still 9th and first European.

In 2003, Fuggetta was appointed Scientific Director of CEFRIEL. In 2005, he was appointed CEO. CEFRIEL employees more than 140 professionals and collects revenues for about 11 Mll. € (2011). The center is completely funded by the projects it acquires on the market.

As CEO of CEFRIEL, Fuggetta has been in charge of governing the growth strategy of the center and coordinating its activities. In particular, CEFRIEL has developed a number of experiences in applying ICT and design to develop new products and services for private companies and public administrations.