Do we need a revisited policy agenda for research integrity? …an institutional perspective

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Research integrity has emerged as a critical topic in research policy. It has acquired a significant political dimension worldwide, justifying a global conference. The issue has been brought to the forefront by scientists, economists, engineers and historians, among others, and has consistently been addressed by well known science philosophers (e.g., Hannah Arendt, 1983, Susan Haack, 2003). It is a pervasive concern across different research fields and its discussion at a policy level does require a careful preparation with those research communities to facilitate an exchange of ideas. This will enable us all to deepen our understanding of research integrity and to guide policy measures.

Why and where is research integrity needed? Where is it threatened and in which domains? To answer these questions, it is useful to highlight cases in which scientific institutions may choose to overlook facts or results, or to suppress issues from the scientific agenda because of direct external pressures (e.g. from funding entities, governments, or the media), leading in extreme cases to falsification of information. Equally relevant are the contextual pressures that bear on the process of undertaking research, most importantly the structure of incentives (including direct funding, intellectual property laws, political pressure) that may threaten research integrity.

It is critically important to emphasize that beyond the traditional way of looking at research integrity from an individual dimension (e.g., the issues referred by the Nobel Laureate Peter Medawar, 1986, with reference to ethical behaviour of scientists and the integrity of the processes of vetting and validating scientific results), there are systemic and institutional dimensions, including organizational, governance and legal issues, that may be as or more important determinants of behaviour than those related with individual characteristics. In fact, lack of personal integrity is a human failure manifested in myriad professional activities.

In this respect, one critically important and emerging institutional issue refers to the training of students and young scientists in order to provide them with core competencies that help them to become successful researchers and prepare them with the adequate "transferable skills" for the job market outside research and academia (e.g., Ernst, 2003; Roland, 2007).

In addition, recognizing scientific knowledge as a "public good" introduces the need to consider new policy dimensions in science and technology policy. Fostering the development of new knowledge for large public risks calls for a focus on the institutional integrity of science producing organizations. Considering public risks and similar challenges raises questions such as:

- Public risks – when there are critical risks of a public nature (e.g. public health; security) coming from missing out or neglecting information or research;
- Security and defence strategies – integrity issues in security (including terrorism related) aspects and in situations of conflict or war;
- Economic competition – omitting information as a competition tool;
- Proprietary knowledge – ignoring and "depleting" the science commons hindering the fostering of new knowledge

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Given this broader understanding of research integrity beyond the individual perspective, we have selected three main issues. First, looking at research integrity from a science policy perspective, we emphasize the need to strengthen autonomous scientific institutions, as well as the critical role that transnational organizations may play in fostering new and independent science*.* Institutional integrity is, therefore, highlighted, rather than individual ethical behaviour, as also suggested by the Nobel Laureate Richard Ernst (2003). In this context, we emphasize that there is no need to gain recognition for a new discipline, or a new profession (i.e., the so called "research integrity officers"), or even a new consulting business around scientific integrity. Second, we focus on the university and argue for the need to preserve its integrity in terms of its basic functions of research and education. Third, we consider the need to look at the grassroots namely in terms of the requirements to continuously raise public thrust on scientific knowledge, which becomes critically important and includes considering the role that science education plays for the new generations. The paper follows our previous research on the institutional integrity of the university (Conceição and Heitor 1999,2005).

1. Institutional integrity and "open science": strengthening scientific institutions?

Some forty years after John Ziman (1968) launched the discussion on *Public Knowledge* and thirty years after his work on *Reliable Knowledge* (Ziman, 1978) it is still the case that to appreciate the significance of scientific knowledge one must understand the nature of science as a complex whole. In *Real Science*, John Ziman (2000-a) reminds us that "science is social", referring to "the whole network of social and epistemic practices where scientific beliefs actually emerge and are sustained". But he also identified that the trouble is "this network is not regulated by any single prince or principle", so that it requires it to be "clearly presented in the everyday language of the common reader". What does the literature on the evolutionary nature of technological innovation add to the discussion launched by John Ziman (2000-b)?

The progress of scientific and technological knowledge is a cumulative process. Paul David (2001, 2004, 2007) has systematically shown that "open science is properly regarded as uniquely well suited to the goal of maximising the rate of growth of the stock of reliable knowledge". As a result, "open science" institutions provide an alternative to the intellectual property approach. The optimal allocation of resources for the production and distribution of information is governed by the balance between open science and commercially oriented R&D? At what level should governments foster cooperative exploratory research, which is recognized as vital for the sustainability of knowledge-driven economies, to react to the increasing demand from individuals, research units and private firms for incentives for non-cooperative, rivalry knowledge?

Our analysis is based on the way scientific organizations deal with knowledge to foster innovative attitudes, that is, the way organizations promote "learning", where learning is understood as the mechanisms through which knowledge is produced and diffused (see, for details, Conceição and Heitor, 1999, 2001). To understand the importance of this perspective, it is crucial to contrast the standard linear model of innovation with the perspectives that acknowledge the more complex nature of the interaction between science and society.

The contribution of scientific organizations to economic development within the "standard linear model" suggests that ideas and human capital flow linearly to society which, in return, finances scientific organizations, and provides feed-back information. Linear models are both powerful and dangerous. They are powerful because they are simple and parsimonious. Mathematical modelling is easily developed as an input-process-output set of equations, which in economics result in production functions. Their danger, ironically, stems from the power they provide: this kind of modelling necessarily leaves out much of the complexity of the social and economic processes.

In fact, the important strategic role that scientific organizations can play in helping nations to meet public goals has been extensively recognized. These roles have a multifaceted nature, including such diverse aspects as public safety, quality of life, health care, environmental protection and economic development and growth. The specific ways in which scientific organizations have played these roles are dominated by activities associated with the creation and distribution of knowledge (see, for example, Rosenberg, 2002, in the case of universities). The generation and diffusion of knowledge is translated, for example, in improved competencies and skills in the labour force, and in the development and commercialisation of new technologies. However, in face of continuous public funding restrictions and ever more demanding public scrutiny, traditional suppliers of knowledge – such as research institutes, universities, and training organizations – as well as businesses and knowledge based organizations in the public sector (growing users of knowledge), are urgently seeking fundamental insights to help them nurture, harvest and manage the immense potential for their knowledge assets for capability to excel at the leading edge of innovation.

To a certain extent, it can be argued that, at least for the most industrialized societies, a trend is emerging leading to a breakdown of the institutional boundaries that separated companies and scientific organizations. This process of "institutional convergence" can be understood as a result of two forces that come together to impose an ever-closer identification of firms and scientific organizations, and vice-versa.

The first force results from the fact that the creation of added value and wealth is increasingly associated with the production of knowledge, so it is natural that companies look to the way scientific organizations function for inspiration on how to perform creative tasks.

Secondly, the scientific organizations find themselves facing difficulties in obtaining sufficient funds for their basic tasks of knowledge creation, so it is also natural that they look to companies to learn how to derive commercial benefits from their intellectual assets and endeavours. In addition, it should also be noted that there is a clear trend in many scientific and technological areas for companies to increase the outsourcing of research activities, namely in the form of services provided by academic research groups.

As various studies have shown, while this convergence is, to a certain extent, to be welcomed, it can also be dangerous. Rosenberg and Nelson (1996), Dasgupta and David (1994), David (1993), and Pavitt (1987) argued more than a decade ago that this convergence is "acceptable" as long as it does not harm the institutional integrity of scientific organizations. Companies and scientific organizations have evolved in a social context to the point of attaining what these authors call "institutional specialization". Thus, whereas companies are concerned with obtaining private returns for the knowledge that they generate, scientific organizations have traditionally made it public. By means of this specialisation, or "division of labour", the accumulation of knowledge has taken place at a rapid pace, as is shown by the unprecedented levels of economic growth since the end of the Second World War (e.g., Rosenberg and Nelson 1996). For example, these authors show that the universities we know today, despite their long historical inheritance, are relatively new institutions, namely in the way they relate to theirs surrounding social and economic context. And universities have defined themselves almost as non-firms, in the sense that they produce knowledge that is publicly available. To do this effectively, a complex set of incentive structures and organizational features emerged, which are relatively easy to destroy, despite the long time it took for these to evolve.

In other words, an evolutionary metaphor could, with some liberties, be used here. Both firms and scientific organizations have evolved over time as institutions adapted to an environment where different types of knowledge were generated by each institution for mutual benefits. In a simplified way, while firms where able to commercialise and diffuse technologies, scientific organizations specialised in advancing the knowledge frontier at the forefront of the unknown. No insurance mechanism or system of private rewards could possibly lure investors into this most risky of ventures. Scientific organizations assumed this role, with a structure of incentives which never penalizes too much for failure, but that also does not reward exceedingly for successes. This is particularly true in Europe, where employees of scientific organizations and university professors are, to a large extent, civil servants, and their salaries are rigidly structured by the civil servant system in which seniority carries a very heavy weight, and there is not much possibility for competition along the salary dimension (Rosenberg, 2002). The danger is in the "extinction" of one of knowledge creating "institutional species" identified above. If scientific organizations become, at least in the way they deal with knowledge, very much like firms, we will be in fact witnessing the death of an institution (North, 1990).

Following David (2007), the distinguishing feature of fundamental research in science and technology is its open nature (i.e., the "science commons", as also referred to by Nelson, 2004, and Cook-Deegan, 2007, among others). This leads to a continuous tension at the core of the institutions that shape science, requiring a careful and systematic assessment of the integrity of research at the institutional level.

In fact, we can "explain" the need of public intervention for science and technology policies, as resulting from the nonrival character of knowledge. Market mechanisms do not yield the allocation efficiency to be expected from competitive exchange. This opens the need for the establishment of policies that can correct incentive structuresf to motivate agents to produce open science. David (1993) and Dasgupta and David (1994) suggest three ways to yield conditions for the effective production of nonrival knowledge. The first is patronage, consisting of a mechanism by which the government directly subsidizes producers of nonrival knowledge, on the condition that it becomes publicly available at virtually zero cost after it has been produced. The second, procurement, is based on the direct production of the goods by the government, awarding specific contracts to public and private agents whenever necessary. Finally, the third, property, is associated with the privatization of the nonrival knowledge, awarding the producer monopolistic rights that yield returns large enough to cover the fixed costs of production. Both patronage and procurement rely on a direct intervention of the government, by which the nonrival knowledge remains nonexcluded, and, therefore, effectively a public good. Property grants private producers of new knowledge exclusive property rights in the use of their creations.

Making available financial resources (namely public resources) is not enough (see, for example, Conceição, Heitor and Veloso, 2003), because the right incentives for S&T organizations to hook up in learning networks that can generate endogenous growth dynamics, together with integrity in research, are also required. There is not a unique way of accomplishing this. Local conditions, roots and trajectories, matter, which raise the question of science culture discussed below.

The discussion so far leads us to argue that there is a need to strengthen autonomous scientific institutions. Large transnational organizations may be one way of fostering new and independent science, as also discussed by Roland (2007) among others. The experience of transnational scientific organizations – such as those institutions listed, for illustrative purposes, in Table 1 – and their worldwide science networks suggests that the practice of independent and open science calls for effective networks of scientific institutions, together with the development of internal integrity routines and self-imposed codes of conduct at an institutional level.

Table 1. Sample list of transnational research organizations

Organization	Date of foundation, members and key aspects of mission statement	People
CERN, European Organization for Nuclear Research, http://www.cern.ch/, Geneva, Switzerland	1954, includes now 20 Member States. The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available	Employs just under 3000 people, Some 6500 visiting scientists, representing 500 universities and over 80 nationalities. Scientists from 220 Institutes and Universities of non-Members States also use CERN's facilities
ESO, European Organisation for Astronomical Research in the Southern Hemisphere, http://www.eso.org/, Headquarters in Garching bei München.	1962, supported by 13 countries. ESO is the foremost organisation for ground-based astronomy in Europe. It has become the main developer and operator of the largest research infrastructure projects in astronomy but also, in line with the Convention, played a major role in fostering and organising European co-operation in astronomy in general.	

EMBO, European Molecular Biology Organization, http://www.embo.org/about_embo/, Heidelberg, D	1964. EMBO is funded predominantly by the European Molecular Biology Conference (EMBC), an intergovernmental organisation comprising 25 member states.	Approximately 1200 members in Europe and 100 associate members worldwide
ICTP; The Abdus Salam International Centre for Theoretical Physics, http://www.ictp.it/; Italy, about 10 kilometres from the city of Trieste	1964. ICTP operates under a tripartite agreement between the Government of Italy and two UN agencies, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA).	ICTP welcomes about 5,000 scientists each year. About 50% of the 100,000 scientists who have participated in ICTP research activities since the Centre's inception in 1964 are from developing countries.
ILL, Institut Laue-Langevin, http://www.ill.fr/ Grenoble, France	1967 (January 19): The ILL is founded by France and Germany. UK becomes associate on January 1, 1973. Funded today by 12 countries, it operates the most intense neutron source in the world together with a suite of 40 high-performance instruments	449 people including 60 experimentalists in the scientific sector and 19,5 thesis students. 292,5 French, 49,5 German, 48,5 British, 39 Scientific member countries and 19,5 others
ESA Science Program; Euroepan Space Agency, http://www.esa.int/, ESA has its headquarters in Paris and specialist centres in The Netherlands, Germany, Italy and Spain.	1975: ESA is created in its current form, merging ELDO with ESRO. There are 10 founding members. ESA Science Program has been organized within the European Space Agency (ESA). Its mission is to shape the development of Europe’s space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world	some 1900 specialists working for ESA
EMBL, European Molecular Biology Laboratory http://www.embl-heidelberg.de/ Heidelberg, and Outstations in Hinxton, Grenoble, Hamburg, and Monterotondo	1978. A non-profit organisation and a basic research institute funded by public research monies from 19 member states. The cornerstones of EMBL's mission are: to perform basic research in molecular biology, to train scientists, students and visitors at all levels, to offer vital services to scientists in the member states, and to develop new instruments and methods in the life sciences, and technology transfer.	Employs more than 750 staff members. EMBL Enterprise Management Technology Transfer GmbH (EMBLEM) is an affiliate and the commercial arm of the European Molecular Biology Laboratory (EMBL
ICGEB, The International Centre for Genetic Engineering and Biotechnology, http://www.icgeb.trieste.it/ Two locations: Trieste, Italy (Headquarters); New Delhi, India, as well as a network of Affiliated Centres.	1983, through the signing of its Statutes (the international treaty sanctioning its existence, deposited with the Secretary General of the United Nations) by 26 countries during a Plenipotentiary Meeting, held in Madrid. ICGEB conducts innovative research in life sciences for the benefit of developing countries.	More than 300 people from 28 different countries are working in the ICGEB laboratories as research scientists, postdoctoral fellows, PhD students, research technicians and administrative personnel.
ESFR, European Synchrotron Radiation Facility, http://www.esrf.eu/; Grenoble, France	In 1988, twelve European countries joined forces to create the synchrotron in Grenoble. Since then, six more countries have joined the group. Together they create the indispensable synergy needed to carry out advanced scientific research.	About 600 people work at the ESRF. About 6000 researchers come each year at the ESRF to carry out experiments.
INL; International Iberian Nanotechnology Laboratory, Braga, Portugal	2007, involving Portugal and Spain	Planned to employ 200 researchers, 30% of each of the two member states with remaining foreigners

The institutional features of these, and others, transnational institutions are such that research integrity is the glue that emerges to bind the different partners and individuals together. Integrity is self-enforced within the organization, and not based on coercion imposed from the outside or mandated by ethical principles.

In this context it should be noted that the Dutch Memorandum on Scientific Integrity (ALLEA, 2003), which has been supported by the ALLEA Standing Committee on Science & Ethics, is also putting emphasis on the responsibilities of scientific institutions in a way that has inspired actions in other countries. Following Gerard Toulouse[3], this is relevant because:

> “every mature scientist has acquired a strong sense of proper vs improper conduct, which guides his/her personal behaviour. However this is not enough. Scientists have both individual and collective responsibilities and many are best discharged collectively, i.e. via scientific institutions. Indeed, concerning research integrity, that is where most of the effort has to be done presently: raising awareness, carefully analysing root causes, setting the problems in a wider context, in order to keep a sense of proportions, and avoid hasty counterproductive measures”.

To sum up, we argue that institutional integrity requires science policies that are designed and implemented in a way that fosters independent scientific institutions, among which the way in which transnational organizations are organized may provide a useful framework. It is clear that individual responsibilities should not be minimized, but it is the collective nature of institutions that determines in the end research integrity. To be sure, personal misconduct will always happen – in research as in any other professional activity. But as the data recently published by the Office of Research integrity (ORI, 2006) or the survey published by Mulqueen and Rodbard (2000) of federally funded biomedical researchers to ascertain the frequency of use of measures to promote the responsible conduct of research and to minimize the likelihood of scientific misconduct, strengthening the role institutions plays a crucial role in reducing misconduct. In this context, we emphasize that there is no need to gain recognition for a new discipline, or a new profession (i.e., the so called “research integrity officers”), or even a new consulting business around scientific integrity. Policy action should be oriented towards strengthening independent and autonomous scientific institutions.

2. The case of “the university”: preserving its integrity?

This section takes “the university” as the focus of analysis. It is driven from the perspective of higher education policy and considers only the research university.

We must start by noting the need to preserve the institutional integrity of the higher education system. We refer to higher education institutions as knowledge infrastructures where research and teaching activities are guaranteed under diversified actions and policies, especially at a time when knowledge creation is increasingly important and our societies are increasingly dominated by market-based economies. While this may seem like a platitude, the fact is that the social standing of the research in universities is very much path dependent and strongly influenced by the evolution of the local contexts: in many countries, is still undervalued in comparison with education (e.g., Conceição and Heitor, 2005).

The threats to a university’s institutional integrity go beyond the extension of its activities to links with society, which, if excessive, could lead to resources being spread too thinly. Starting with the analysis of the higher education function of teaching, we note that university education combines the transmission of codified knowledge by the teachers with the individual characteristics of the students, in a process in which the interpretation of ideas leads to the accumulation of unique skills. Each student can profit from these skills in the future. The

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[3] Personal Communication, as prepared in the discussion period leading to the “World Conference on Research Integrity”, Lisbon, September 2007. Gerard Toulouse was the Chairman (2001-2006) of ALLEA Standing Committee on Science & Ethics and co-signed the Foreword of the Dutch Memorandum on Scientific Integrity (2003).

university may therefore be tempted to increase the direct price to the students of their education (e.g., Baba, 2003).

Besides the well-known externalities associated with higher education (e.g., Rosenberg, 2002), which justify state support for education in virtually every country in the world with the possible exception of Japan in the past, analysis of the need to provide the skills necessary for the information society in which we live strengthens the arguments in favour of state support for higher education (see Koji, 2004, with specific reference to the Japanese case). The threat of increased privatisation of teaching skills could thus cause serious problems, in that it would lead to a reduction in the resource that really is in short supply in the knowledge-based economies: the skills to use and interpret ideas. This conclusion does not cast doubt on the contributions currently made by students, but rather questions a possible trend that could jeopardise the institutional integrity of the university itself, at least when there is the tendency to decrease public funding.

Moving on to research, it is worth noting that the great majority of the ideas that are generated in universities are of a public nature, this being the essence of the specific contribution that the university makes to the accumulation of ideas. Incentives for the production of these public ideas come from a complex system of reward and prestige within the academic community. Dasgupta and David (1987), following on from the sociological work of Robert K. Merton, describe in detail how this system operates and how it rewards creativity, flexibility and autonomy (see also Stephan, 1996). In many surveys of university teachers, the most satisfying factor, chosen by large fractions of the samples, was autonomy and independence (e.g., UCLA, 1997). Again, the temptation to privatise university research results could threaten fundamental aspects of the way universities work and their essential contribution to the accumulation of ideas.

To summarise, our contention is that the institutional integrity of the university should be preserved, and an important point in terms of public policy is that state funding of universities should not be reduced. However, this measure by itself is not enough. From a more pragmatic viewpoint, the university should respond to the needs of society, which include rapid and unforeseeable changes in the structure of the employment market and the need to furnish its graduates with new skills beyond purely technical ones, in particular learning skills.
A diversified system presents advantages as it relates to research integrity. Analysing the function of university research, actually includes various sub-functions, not always clearly defined, but which should be the subject of distinct public policies and forms of management, as follows:

- R&D, Research and Development, which aims at the accumulation of ideas through convergent learning processes, which are associated with processes of knowledge codification. This is the commonest form of research, particularly in the context of economic development and from the standpoint of the relationship between universities and companies.
- R&T, Research and Teaching, in which research functions as a way of developing teaching materials, as well as of improving the teaching skills of the teaching staff, and which is also associated with convergent processes of knowledge codification.
- R&L, Research and Learning, in which the value of the research is not necessarily in the creation of ideas, but in the development of skills that enhance opportunities for learning. Research thus appears as a divergent function, associated with processes of interpretation.

According to the analysis of Conceição and Heitor (1999) and although the various sub-functions listed above are strongly connected among themselves, R&D and R&T are related with the creation of ideas. In this context, selectivity is required in the choice of individuals with suitable skills for these types of activity. In turn, R&L is associated with a learning process, which seeks to develop learning skills through the experience of doing research.

In these circumstances a diversified system could respond effectively to the different demands made of it in the emerging economy, by being selective in R&D and R&T, and comprehensive in R&L. Indeed, in the context of the knowledge economy, the comprehensive nature of R&T should be extended beyond the university to cover the whole education system, as a way of promoting learning skills. In this situation, it seems essential to place renewed emphasis on education and, to a certain extent, to reinvent its social and economic role. Educational institutions must rethink their relationships with the individuals, families and communities among which they find themselves, presenting themselves as vital providers of opportunities to develop formal learning processes, while at the same time encouraging a way of life that promotes learning through social interaction.

To sum up, rather than presenting a detailed plan of public policy options and forms of management for higher education, we have addressed in the paragraphs above how the concepts developed in the literature can be used to analyse the challenges facing the research integrity of the university in the knowledge-based economy, and what kind of opportunities can be discerned. Among our substantive conclusions are the importance of preserving the institutional integrity of higher education institutions, not only by avoiding excessive dissipation of its resources in activities related to its links with society, but most importantly by maintaining the academic character of its basic functions of teaching and research. In a situation in which education should promote learning skills, we put forward the need to identify and understand the different components of university research, so as to enhance the selectivity of the R&D and R&T sub-functions, while ensuring the widespread availability of R&L. It is argued that a diversified higher education system can free the universities of many of the pressures that they are experiencing today, by helping to ensure the preservation of their institutional integrity.

The analysis shows in the particular case of the university that preservation of its institutional integrity is essential in a situation of sustained flexibility, in which education, besides offering a specific qualification, should ensure the assimilation of learning skills. The signs of the knowledge economy, notably the expansion in university education and the need to manage multiple demands and to ensure participative learning, point towards a diversification of the system, with reference to which it is particularly important to identify and understand the different components of the university's research function.

The question that does appear is how far universities can sustain their own independency and support integrity in research? Phrasing Richard Ernst (2003), "Universities should consider themselves as cultural centers with far-reaching radiance rather than merely serving as training grounds for academic specialists. The integration of knowledge, perception, and comprehension, as well as compassion, is at least as relevant as extreme specialization. Obviously, scientific excellence is indispensable, but insufficient in isolation".

This leads us to better understand how far university networks can effectively contribute to foster basic university goals and preserve research integrity. In fact, many research universities have developed into new and innovative institutions, both national and international in scope, organised as consortia and combining in their open structures teaching, research, business incubators, culture and services. As universities develop new institutional capacities further challenges emerge. In particular, most universities are faced with the need to increase and diversify their sources of funding, as well as with increasing leadership and management functions.

In addition, in recent years a number of Universities in Europe have created clusters and associations driven by student exchange programmes and growing research opportunities, as described in Table 2 for illustrative purposes. These clusters have been particularly focus on corporate matters and we argue that there is a need for a platform of the various clusters and associations of research universities, notably for stimulating the political debate among the various stakeholders at international level and for assisting in the networking of national constituencies fostering integrity in higher education.

Higher education institutions are under pressure to reform as a result of increasing global challenges. The relationship between universities and governments, their main source of funding and their governing authority in most cases, remains an uneasy one and often, does not reflect the realities of an evolving political, social and economic environment. Multiple objectives should not be pursued at the cost of compromising learning and research environments for students, which also require continuous adaptation and improvements (e.g., in the new context of the Bologna process in Europe).

Table 2. Sample networks and clusters of research universities in Europe

LERU (League of European Research Universities) http://www.leru.org/	**IDEA League** http://www.idealeague.org/	**CLUSTER** (Consortium Linking Universities of Science and Technology for Education and Research) http://www.cluster.org/
University of Cambridge	Imperial College London	Imperial College London
Universiteit van Amsterdam	TU Delft	Technische Universiteit Eindhoven
University of Geneva	ETH Zurich	Ecole Polyt. Féd. de Lausanne, EPFL
Albert-Ludwigs-Universität Freiburg	RWTH Aachen University	Technische Universität Darmstadt
University of Edinburgh	ParisTech	Institut National Polytech. de Grenoble
Ruprecht-Karls-Universität Heidelberg (Univ. of Heidelberg)		Universität Karlsruhe (T.H)
University of Helsinki		Helsinki University of Technology
Leiden University		Tech. Univ. of Catalonia, Barcelona
Katholieke Universiteit Leuven		Université catholique de Louvain J22
University College London		Instituto Superior Técnico, Lisbon
Lunds universitet		Kungliga Tek. Högskolan, Stockholm
Università degli Studi di Milano (University of Milan)		Politecnico di Torino
Ludwig-Maximilians-Universität München (LMU Munich)		Georgia Inst. of Technology, Atlanta
University of Oxford		Tsingua University Beijing
Université Pierre et Marie Curie, Paris 6		Ecole Polytechnique de Montréal
Université Paris-Sud 11		Tomsk Polytechnic University
Karolinska Institutet, Stockholm		
Université Louis Pasteur Strasbourg		
Universiteit Utrecht		
Universität Zürich		

3. Valuing science and the scientific knowledge: raising policies to foster science culture?

In the previous sections we have considered the need to foster research integrity from the institutional perspective. We now turn to the grassroots of our initial questions and, keeping a science policy perspective, argue for the need to promote science culture if the integrity of our scientific institutions is to be preserved. Overall, we will remind again John Ziman (2000-a) in that science requires to be "clearly presented in the everyday language of the common reader".

Following the work of Heiderberg (1959, as published in 1977), the idea of technology has been discussed throughout several disciplines and our hypothesis is centred on the need to stimulate the active participation of society in understanding the value and the values of scientific knowledge. This issue was particularly discussed in the context of the European Union by the *High Level Group on Human Resources for Science and Technology* appointed by the European Commission in 2004, EC (2004), either in terms of renewing science education, or creating science culture, and here we reinforce two main arguments, as follows.

First, the need to better explain to the society at large the realizations of the scientific community and to foster the public understanding of science, where schools and other institutional settings (e.g., science museums) have a determinant role in stimulating curiosity and the interest for scientific knowledge. In this regard, the European report on the "Benchmarking the promotion of RTD culture and Public Understanding of Science" (Miller et al., 2002) clearly acknowledges the leading role of national programs such as the "La Main a la

Pate” in France, or the “Ciência Viva” program implemented in Portugal since 1996, but also recognizes the still difficult climate for promoting science culture in Europe. The continued implementation of actions fostering “science for all” is a practice to follow, where the concept of “Knowledge integrated communities” appears particularly suitable to facilitate the joint enrolment of researchers and basic and secondary schools in specific projects driving society at large. It is clear that this requires new knowledge about social behaviours, as well as new methodological developments, and the work edited by Solomon and Gago (1994) still provides important guidelines to help moving towards a knowledge society in a fast moving landscape.

Second, the idea that S&T should be considered as an open system, with different and diversified ways of participation, mainly derived from the fact that scientific activity in increasingly part of people’s live, so that the training of scientists should not be closed to a specific group of people, but rather a broad action and part of today’s education (e.g., Bricheno, Jonhston and Sears, 2000). Under this context, it has become clear that the renewal of education systems has been particularly influenced by constructivism (e.g., Bennett, 2003). Following Piaget’s (1973) view of knowledge construction by using “active methods which require that every new truth to be learned be rediscovered or at least reconstructed by the student”, Seymour Papert (1991) added the idea that the knowledge construction “happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity”. This constructionism viewpoint facilitates the “new milieu of discovery, learning, and sharing” mentioned above, and leading experiences (e.g. Bucciarelli, 1994; Frey et al., 2000) suggest that it allows to:

- Expose students to a multi-disciplinary design experience;
- Prompt participants to think about systems architecture;
- Raise issues of organizational processes in a technical context;
- Built learning communities of students, faculty, and staff.

Following the practices, skills, attitudes and values described by Conceição and Heitor (2005), education must consider that learning a new practice requires moving through discovery, invention, and production not once, but many times, in different contexts and different combinations (see also EC, 2007). The objective is to integrate systems of knowledge and ways of practicing: “without knowledge, practice is limited and without practice, knowledge will never be fully realized” (Reeve and Rotondi, 1997).

Still under this context, the US´s National Academies effort on “How People Learn” (NRC, 2000) provides clear evidence that “designing effective learning environments includes considering the goals for learning and goals for students”. Given the many changes in student populations, tools of technology, and society’s requirements, different curricula have emerged along with needs for new pedagogical approaches that are more child-centred and more culturally sensitive. The requirements for teachers to meet such a diversity of challenges also illustrates why assessment needs to be a tool to help teachers determine if they have achieved their objectives. But supportive learning environments, namely fostering a culture of beliefs in science, need to focus on the characteristics of classroom environments that affect learning. In this aspect, the authors were referring to the social and organizational structures in which students and teachers operate, including the environments created by teachers, but also the learning environments out of school.

4. Conclusions

This paper discusses research integrity from a science policy perspective, emphasizing the need to strengthen autonomous scientific institutions, as well as to deepen a policy research agenda on "research integrity". It draws on recent conceptual approaches to economic growth, in which the accumulation of knowledge is the fundamental driving force behind growth, to examine the contemporary role of scientific organizations, including the university. We suggest that the functions that society commonly attributes to them are beginning to be shared between a wide range of institutions in the context of the knowledge-based economies, so that scientific institutions are faced with demands that require a strengthening of its ability to create and disseminate knowledge: they need to be strengthened in order to become more societally responsive and responsible.

We conclude that while the role of scientific organizations is in need of some rethinking, their institutional integrity must be preserved. The experience of transnational scientific organizations and their worldwide science networks suggests that the practice of independent and open science calls for effective networks of scientific institutions at an international level.

To cope with the variety of demands and with a continuously changing environment, we argue that the higher education system, in particular, needs to be diversified. But the challenge of integrity in research requires effective university networks and a platform of research universities, notably for stimulating the political debate among the various stakeholders and for assisting in the networking of national constituencies fostering integrity in higher education.

Overall, it is clear that there is <u>no</u> need to rush towards the establishment of a new discipline, or a new profession (i.e., the so called "research integrity officers"), or even a new consulting business around scientific integrity or misconduct. To be sure, compliance with and enforcement of basic ethical standards needs to be monitored – because science is always a human endeavour, subjected to the inherent flaws of human nature in this as in all other human activities. Some degree of professional monitoring in science is perhaps indispensable. But this cannot evolve into an atmosphere of suspicion or very heavy-handed policy and professional intervention. What is required, to be sure, is the need to deepen a research-based view of research integrity to deal with its various dimensions. Special emphasis should be given to the presentation and discussion of case studies and specific debates should be organized in terms of empirical evidence provided. But the building-up of a policy research agenda on "research integrity" requires consideration of a systemic and holistic view covering the following two key issues and associated questions:

- Strengthening knowledge institutions:
    - What can we learn from transnational and network organizations in order to set standards for research integrity?
    - How to monitor organizational and governance dimensions, namely size and structure of scientific organizations and their networks, in order to foster integrity in research?
    - Assessing policies for intellectual property protection and the boundaries of open science?
- Promoting research autonomy and independence:
    - How to better assess the conditions for independence of scientific expertise, as well as the institutional factors affecting independence and autonomy?
    - Which tools to easily monitor and assess individual versus collective expertise?

In addition, it has become clear from our discussion that a third issue is increasingly relevant, as follows:

- Fostering science culture, by looking at the grassroots:
    - How to raise the science culture beyond current status?
    - How can we promote and foster science education though project-based learning and other "hands-on" methodologies that consider how people learn?

The analysis on the basis of these questions will certainly convey a dynamic view of research integrity centred on the grounds for credibility of science and leading to responsible research worldwide.

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