Background Paper on Innovation and Education

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Prepared by

Hanne Shapiro, Jens Henrik Haahr and Ida Bayer
Danish Technological Institute

and

Patries Boekholt
Technopolis

for

The European Commission, DG Education & Culture

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1. Introduction – Education and the Challenge of Innovation

Europe needs to boost its capacity for innovation – both for economic and for social reasons. But to do so, opportunities and challenges must be identified if education and training is to be measures to that end.

In most interpretations, the Lisbon Strategy was formulated by the European Union as a reaction to increased international division of labour and the competitive challenge from the integration of new regions into the world economy, as well as to the challenges and opportunities of the impact of information and communication technologies on production, growth, and employment and social cohesion and equity.

The challenges and opportunities of globalisation and technological development have led to a strengthened emphasis on innovation as a key driver for sustainable economic development, and on the nature and drivers of innovation. Empirical studies have demonstrated the significance of innovation for growth and development (e.g. OECD 2001, 2004). This is so both at the regional, the national, and the European level.

Consequently, the EU has encouraged both national and regional governments to place stronger emphasis on creating measures and instruments to sustain innovation. This has been followed up by extensive enhancement or the creation of new national as well as regional innovation systems and mechanisms for innovation. Various European Union initiatives have placed new emphasis on innovation as a key objective, including R&D policy initiatives aimed at understanding the nature and role innovation in different contexts.

Many major measures for the modernisation of the EU economy have already been tabled, such as the crucial objective of increasing research and development spending, targeted at 3% of GDP. The European Trend Chart on Innovation has given a clear picture of the innovation performance and of the national innovation systems of the EU Member States, and of their strengths and weaknesses.

Innovation also has a potential role to play in strengthening social development and social cohesion. Innovation in public policies can contribute to lively democracies with engaged, knowledgeable and active citizens. Innovation holds the potential of contributing to the prevention of marginalisation of specific groups. Innovative approaches to social security and to the contents and delivery of public services can contribute to the sustainability of social systems and the development of health care systems. The Young Foundation (http://www.youngfoundation.org.uk) is one of the central knowledge sources in Europe on social innovation.

Methods for measuring the role of human capital in innovation are not well developed (OECD 2001). However, comparative studies indicate that countries with the capacity to innovate are

characterised by an overall high level of education/high share of population with tertiary level education, and there is a widespread consensus that high levels of investment in education and a wide distribution have significant implications for human capital and the growth of economies, and possibly for social capital and social cohesion.[1] Innovation literature also emphasises on the role of learning in innovation processes.[2]

The vital role of education and training and more generally of learning for innovation has repeatedly been emphasised at EU level. Recent European Union policy documents call for education and training policies to provide for "innovation skills" and "innovation-friendly environments" e.g. through modernisation of higher education systems and reforms in general education. For instance, the 2004 Joint Interim Report of the Council (Education) and the Commission – the first report on progress under the "Education & Training 2010" work programme – highlighted that education and training is a determining factor in the potential for excellence, innovation, and competitiveness, and called for urgent reforms of Europe's education and training systems. The 2006 Joint Interim report – the second progress report – concluded that national reforms were going in the right direction, but the pace of reform must be speeded up.

The report especially emphasises a modernisation of higher education systems involving the interlinkage of education, research, and innovation, not least because this has been identified as a key enabler for the success of the broader Lisbon Strategy, but also as a part of the wider move towards an increasingly global and knowledge-based economy.[3]

To further innovation capacity, strengthened collaboration between higher education and industry is also being emphasised[4] and promoted, for instance by the proposal to establish a European Institute for Technology.[5]

Last but not least, innovation has been a key element of a number of EU education and training programmes, for instance the Leonardo Programme and the Socrates Programme. The new integrated action programme in the field of lifelong learning particularly highlights innovation at different levels by specifying the following objectives:

- Contributing to the development of quality lifelong learning and promoting high performance, innovation, and a European dimension, in systems and practices in the field
- Supporting the development of innovative ICT-based content, services, pedagogies, and practice for lifelong learning

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[1] Bassanini, Andrea & Scarpetta, Stefano (2001),"Does Human Capital Matter for Growth in OECD Countries", *Economics Department Working Papers* No. 282, OECD, Paris. Green, A & Preston, J (2001), 'Education and Social Cohesion : Re-centering the Debate'. *Peabody Journal of Education*, 76 (3&4), 247-284.

[2] Lundvall, B. E. (2000), "Europe and the learning economy. On the need for reinventing strategies of firms, social partners and policy makers", Aalborg, Department of Business Studies.

[3] E.g. European Commission (2006c), Communication from the Commission: "Delivering the modernisation agenda for universities: Education, research and innovation", COM (2006), 208 final, 10.5.2006.

[4] E.g. Communication from the Commission to the European Council: "An innovative-friendly, modern Europe" (COM (2006), 589 final) 12.10.2006.

[5] European Commission (2006b), Commission Communication: "Implementing the renewed partnership for growth and jobs. Developing a knowledge flagship: the European Institute of Technology", COM (2006) 77 final, 22.2.2006; European Commission (2006d), Commission Communication: "The European Institute of Technology: further steps towards its creation", COM (2006) 276 final. 8.6.2006.

- Encouraging the best use of results, innovative products, and processes, and exchanging good practice on the fields covered by Lifelong Learning Programme in order to improve the quality of education and training.

Whereas the first objective concerns the overall promotion of innovation in society through education and training, the other two objectives more specifically concern innovation in education through ICT-based learning, and education for innovation through the exchange of knowledge and experiences as a means for improving quality in education and training.

Education systems have evolved over time and have been set up in a particular context for particular purposes. To enhance the contribution of education to innovation, education and training systems must undergo changes to become more innovative themselves, taking various factors into account such as structure, resources, stakeholder involvement in learning environments, culture, teaching methods, and learning methodologies.[6]

As mentioned above, the Council and the Commission have in the wider perspective of the Lisbon Strategy repeatedly called for urgent reforms of Europe's education and training systems, including boosting their capacity for innovation.[7] Some countries have already put in place comprehensive policy actions to boost innovation more systematically in their education and training systems.

Still, with the possible exception of higher education, the debate on education and innovation seems to suffer from an ambiguity of concepts, an imperfect understanding of challenges and possibilities, and a lack of evidence. To that end more analyses, comparative studies, data collection, and knowledge sharing on the interplay between education and innovation seem needed – as a means for supporting further actions in the field at all levels based on evidence.

Against this background, this paper was commissioned to examine the role of education and training in innovation systems and to initiate a discussion among relevant stakeholders on how to improve the contribution of education and training to innovation in the European Union's member states. The key question is how and under which circumstances it is possible to *educate for innovation*, i.e. develop education and training systems and learning practices so as to ensure that the output of education and training facilitates innovation in enterprises and organisations and more widely in civic society.

[6] Case studies particularly from Australia highlight that education and training institutions that are viewed as innovative tend to build on a concurrent approach to innovation in which experimentation play a central role with strong involvement of the relevant user environments as co-creators in the innovation process. Central to the processes are also evaluations, not only to measure and understand impact, but primarily as a continuous feedback mechanism to create learning among all relevant actors. Because innovation processes both at a system and at an institutional level have a *moving character*, this notion of evaluation as a feedback loop and learning mechanism involving multiple levels is central to institutional innovation. Yet when we look at many current pilot initiatives at EU or national levels, such uses of evaluation are still in their infancy, and applied methods primarily build on traditional monitoring mechanisms.

[7] E.g. The 2004 Joint Interim Report "Education and Training 2010: The success of the Lisbon Strategy hinges on urgent reforms" (Council doc. 6905/04 EDUC 43); The 2006 Joint Interim Report on progress under the Education and Training 2010 work programme: "Modernising education and training: A vital contribution to prosperity and social cohesion in Europe" (2006/C 79/01); European Commission (2005d), Commission Communication: "Mobilising the brainpower of Europe: enabling universities to make their full contribution to the Lisbon Strategy, COM(2005) 152 final, 20.4.2005.

The subsequent sections are organised in the following manner: Section 2 contains a general discussion of the role of learning, knowledge, and innovation in knowledge-based societies. This sections provides a description of the most fundamental premises of the paper, namely on the one hand that innovation is important – and increasingly so – for the development of modern societies, and on the other hand that innovation is important both in terms of economic and social development.

Section 3 discusses the concept of innovation and key developments in the understanding of innovation and innovation systems. It describes the different modes of innovation that are important in contemporary society, with a particular view to the relevance of education and training. From this perspective, the question is what the requirements are to education and training systems if innovation systems are to be successful.

Section 4 addresses the contribution of education to innovation at a systemic level. A key question is which challenges education and training systems are confronted with if their contribution to innovation is to be enhanced. Section 5 addresses the contribution of education to innovation at the level of learning practices and educational programmes. A number of issues must be resolved if the contribution of education and training to innovation is to potentially be increased: What is meant by learning or education for innovation? Is there a need for governments and education institutions to consider the significance of "education for innovation" in policies and programmes? Is there a need to establish a firmer base of knowledge on the effects of different skills, competences, and learning practices on individuals' innovative capacities, before firm recommendations can be formulated and actions taken?

The final section of the paper addresses the question of the need for innovation and change in education and training systems themselves. If the contribution of education and training to innovative societies is to be enhanced, is there not a need for education and training systems themselves to develop a culture of innovation and creativity?

2. Learning, Knowledge and Innovation in Contemporary Society

Innovation is crucial in modern societies. This is so both in economic and in social terms. Education and training inevitably plays a very significant role.

This section first gives a brief definition of innovation so as to guide the reader in the following working paper. The paper continues by describing and analysing the most fundamental premises and discussions raised in the paper. One central premise is a shared understanding and awareness that innovation is important – and increasingly so – for the growth of modern societies, not least due to an increasing knowledge intensity in products and services, and that parallel to that knowledge is becoming a commodity driven by development in ICTs and new forms of global competition and collaboration..

Another important premise is that innovation is central to both economic and social development. In analysing the significance and contribution of education and training to innovation, it is therefore fruitful to take broad view of the concept of innovation.

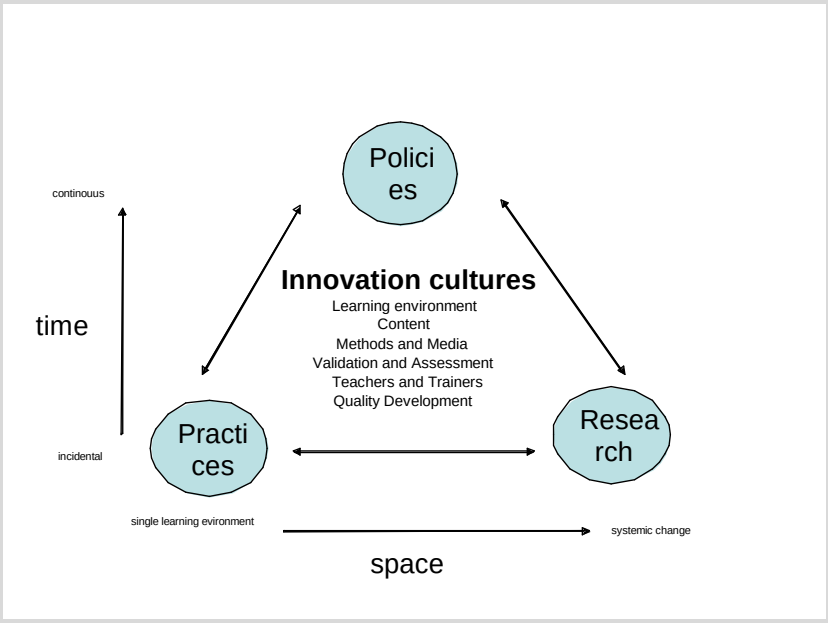
But what are the distinguishing features of innovation?

For the purposes of this paper, the following features are highlighted as characteristics of innovation:

- An innovation is a tangible product, process, or procedure, within an organisation or across organisations
- An innovation must be new to the particular organisational setting within which it is introduced, though not necessarily new to the one introducing it
- An innovation must not be a routine change
- An innovation must produce measurable benefits
- An innovation must be public in its effect

Furthermore, in the Maastricht study analysis of VET systems and their contribution to the Lisbon Agenda, the following seemed to characterise a successful VET innovation culture - likely to be applicable across education sectors.

Figure 1 : Model of some characteristics of successful VET innovation cultures



Sustainable innovation cultures consist of the following elements:[8]

- Innovation is being developed in the triangle between policy (social partners, government), practice (teachers, learners, and the wider public), and research, and needs some alignment of the agendas of those different actors;

[8] The Maastricht study- DG Education 2006

- Innovation is spread across space (cross-institutional transfer) and in a continuous manner over time; mechanisms of innovation transfer have to be considered throughout levels and domains of actors;
- Innovation integrates the different aspects (changing learning environments, content, methods, and media; validation and assessment; teachers and trainers and quality) of teaching and learning in a coherent way.

It should be noted however, that particularly within the field of educational policy, definitions of innovation and subsequently methods to study innovation within education and training are still in their early stages.

The central role of innovation in modern societies

The knowledge society has come to be the framework for how our societies are described, analysed, and benchmarked. A knowledge-intensive community is one wherein a large proportion of its members are involved in the production and reproduction of knowledge[9]. Since as early as the 1970s, an increasing number of diverse jobs in the production, processing, and transfer of knowledge and information have been created – first in the high-technology and information and communications service sectors, and then gradually spreading across the entire economy.

In today's modern societies, economic growth and prosperity is increasingly based on the capacity and ability to produce and use new knowledge or use existing knowledge in novel ways. Knowledge has always been fuel to economic development in one or another sense, but what has changed is the accelerated speed at which knowledge is created, accumulated, and depreciated in terms of economic relevance and value. This is closely connected to an intensified pace of scientific and technological progress.

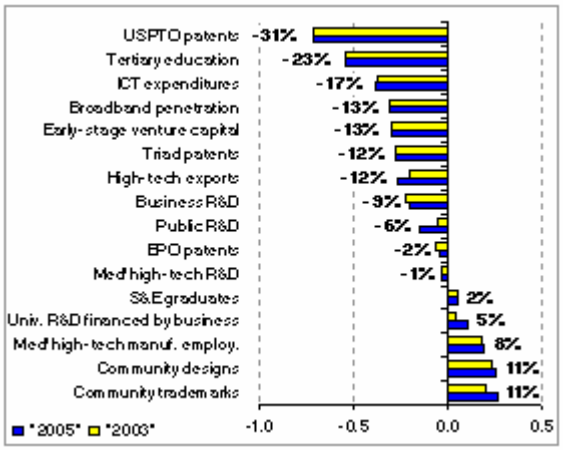
One of the main challenges in modern societies is to achieve high value-added output across industry sectors exposed to global competition. Globalisation and the revolution in information and communication technologies have increased the competitive pressure on manufacturing firms in high-cost locations, and have triggered a shift in the comparative advantage of the leading developed countries in favour of an innovative approach to production, product design, and quality, based on the production and application of new knowledge and ideas and/or through the application of existing technologies to new contexts. Thus the alternative to an advantage based on low wages has shown itself to be knowledge-based, innovative activities.

At the same time, globalisation can itself be understood as a product of innovation – and thus the drivers for economic development and its consequences are mutually reinforcing: The application of constantly improved technologies to the massive means of transport and communication (technological innovation) has produced an unprecedented level of global connectivity (globalisation). Economies are becoming more interdependent, while cultures are becoming more permeable, transparent, and stronger, through an intensified exchange of goods, services, ideas, values, experts, problems, and solutions.[10]

[9] OECD (2004), "Innovation in the Knowledge Economy. Implications for Education and Learning", OECD; Paris, p. 21.
[10] Gurría, Angel, OECD Secretary-General at the Copenhagen Business School, Copenhagen, Denmark, 23 January 2007: http://www.oecd.org/document/37/0,2340,en_2649_34487_37977061_1_1_1_1,00.html.

This development and the shift in comparative advantage have increased the value of knowledge-based economic activity[11] – and the capacity and ability to successful innovation is increasingly becoming the cornerstone in today's western economies. The 'need to innovate' is growing ever stronger, as innovation comes closer to being the sole means to survive and prosper in highly competitive and globalised economies.[12]

Figure 2: Indicators of innovation, EU and US.



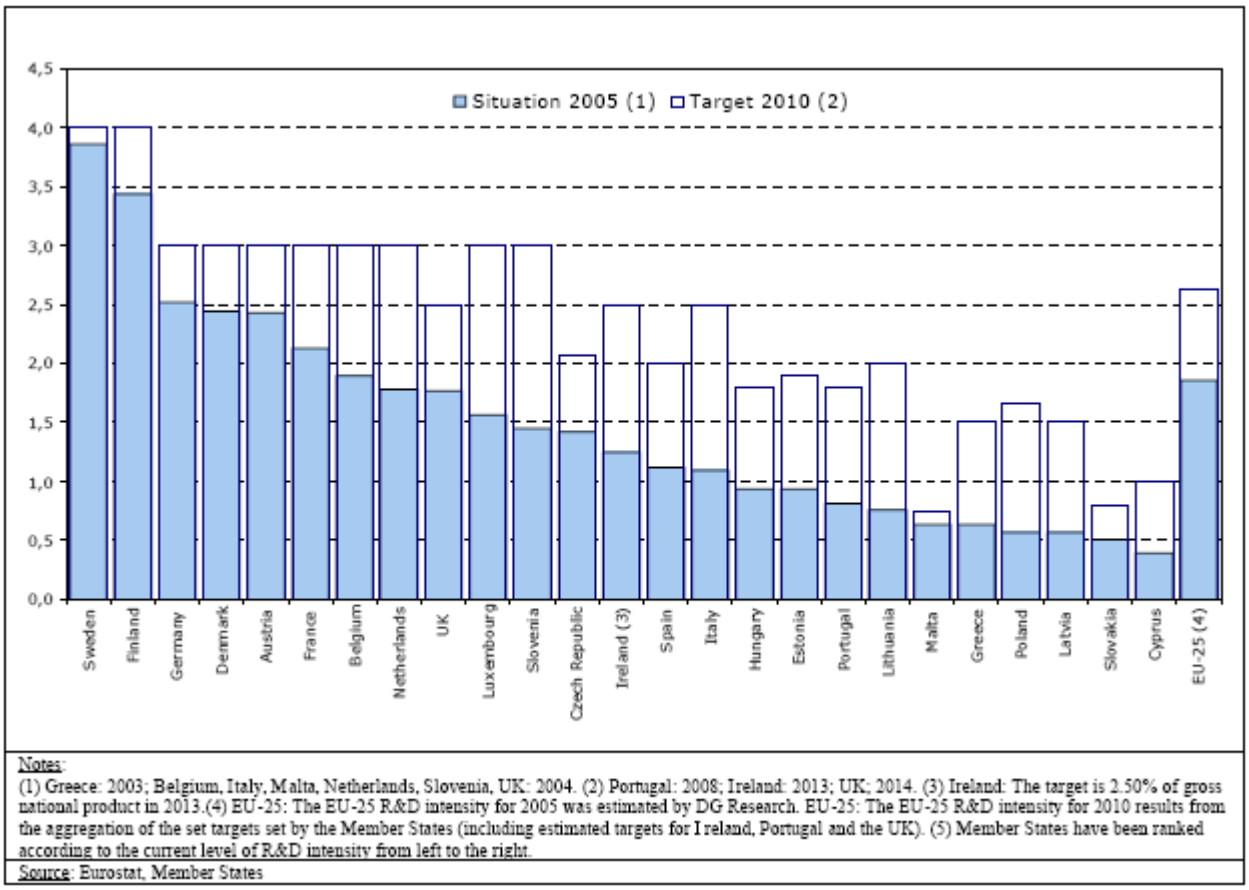
Source: European innovation scoreboard.
http://trendchart.cordis.lu/scoreboards/scoreboard2005/gap_with_US.cfm

Many studies conclude that Europe is lagging behind the US and Japan on a number of indicators on innovation. Figure 1 from the European Innovation Scoreboard shows that on a number of indicators – and particularly education-related indicators - Europe is lagging behind. In 2003 the population with tertiary education was 38% in the US and 37% in Japan, whilst in 2005 it was still only 23% in Europe.

Moreover, with regard to the indicator on R&D investment as an important element in innovation, the EU still significantly trails behind the objectives that have been defined for 2010, as is illustrated in Figure 3.

[11] Audretsch, David B. (1998), "Agglomeration and the Location of Innovative Activity," Oxford Review of Economic Policy, Oxford University Press, vol. 14(2), p 18-29
[12] OECD (2004), "Innovation in the Knowledge Economy. Implications for Education and Learning", OECD; Paris, p. 16.

Figure 3. R&D Intensity (Gross domestic expenditure on R&D (GERD) as % of GDP)



Notes:
(1) Greece: 2003; Belgium, Italy, Malta, Netherlands, Slovenia, UK: 2004. (2) Portugal: 2008; Ireland: 2013; UK; 2014. (3) Ireland: The target is 2.50% of gross national product in 2013.(4) EU-25: The EU-25 R&D intensity for 2005 was estimated by DG Research. EU-25: The EU-25 R&D intensity for 2010 results from the aggregation of the set targets set by the Member States (including estimated targets for Ireland, Portugal and the UK). (5) Member States have been ranked according to the current level of R&D intensity from left to the right.

Source: Eurostat, Member States

The number of researchers in full time equivalent (FTE) per thousand labour force participants amounted to 5.4 in the EU in 2003, compared to 10 and 9 in Japan and the US respectively, and remains essentially unchanged since 1999. At Member State level the picture is quite varied, with sometimes considerably lower figures in 15 Member States, while a handful of Member States show a figure close to or above those for Japan and the US.[13]

More specifically, the link between knowledge and economic productivity and growth rests upon two pillars:

- Through innovation processes leading to the creation of new knowledge and its application in new or better products, services, processes, and modes of organisation, or application of existing knowledge and/or technologies to new contexts¨
- Through education and training leading to a skilled labour force better able to produce and apply new knowledge and information or existing knowledge to new contexts.

These two pillars are related in the sense that education and training plays a central role in the delivery of human capital necessary for building up innovation capacity in society as a whole.

[13] European Commission (2005e). *Key Figures.Towards a European Research Area Science, Technology and Innovation*, Brussels, DG Research; Eurostat (2006). "Science, Technology and Innovation in Europe", 20 November.

The capacity and ability for successful innovation depend on various factors. However, there seems to be a widespread consensus concerning the necessity of the following:

- Education and learning – reform of formal education and training systems so that they are more responsive to the demands of a knowledge society, high levels of skills, and each individual's continual learning throughout life.[14]
- Effective innovation and knowledge production systems and processes, including investment in research and development, promoting enterprise development and collaboration between research institutions and industry.

These factors and their role in innovation will be further elaborated in the following sections of the paper. First, a discussion of the role of innovation to economic and social wealth will be outlined..

Innovation as a means for economic development

It is generally acknowledged that innovation is a key driver for economic growth – that the creation, dissemination, and application of knowledge have become a major engine of economic expansion.[15] Most sectors and industries are currently experiencing what the OECD calls a "Schumpeterian renaissance": innovation is today the crucial source of effective competition, of economic growth, and of the transformation of society.

The overall reason that innovation, knowledge, and technology are such powerful drivers of economic growth is that, unlike capital and labour, they do not suffer from diminishing returns. The creation of knowledge and technological innovation might actually increase the return to further knowledge and innovation, thus creating a powerful growth mechanism.

It has long been recognised that innovation is a major driving force in economic growth and social development. For example, Robert Solow was awarded the Nobel Memorial Prize in Economic Science in 1987 for his work in developing a modern macroeconomic theory of growth. According to the Growth Theory, governments can promote economic development through a variety of means including supporting education and training to develop a more educated work force, stimulating capital investment, stimulating a reallocation of resources from low productivity to higher productivity industries, and promoting technological progress and innovation. The Growth Theory underlines this last factor, technological progress and innovation, as the greatest engine of economic growth.

Since then, a vast amount of research on the effects of innovation on productivity has been car-

[14] The importance of a high level of skills is associated with high levels of investment in education and training. Ashton and Green (1996:11) identified the following five requirements to avoid 'the low skills gap': 1) Government commitment to achieving and investing in a high skills economy and in education, 2) A significant number of employers who demand high skills and support workers to provide skills in the workplace, 3) An adequate regulatory system to control the quality and quantity of work-based training, 4) Significant incentives to gain qualifications and continue learning, 5) Sufficiently developed education system to allow training on and off the job.

[15] E.g. Conceição, P, Heitor, M & Lundvall, B-A, eds. (2003), "Innovation and competence building, and social cohesion for Europe: Towards a learning society", Edward Elgard Publishing Ltd.

ried out. A consensus has emerged that innovation in general has a significant effect on productivity at the firm-, industry-, and country level.[16]

Innovation as a means for social development

Research and empirical studies on social preconditions for enhanced innovation are numerous. For example, Akcomak & Weel (2006)[17] investigated the relationship between social capital, innovation, and economic growth, and found that innovation is a central mechanism that transforms social capital into economic growth. Based on an investigation of 102 European regions from 1990-2002, they concluded that social capital affects growth indirectly by fostering innovation.

Empirical studies on the social effects of innovation are more limited. However, this social perspective in relation to innovation is gaining increased attention, and in the ongoing debate about the Lisbon strategy some scholars have begun to highlight the importance of the collective capacities of societies to ensure social inclusion and cohesion.[18] [19] Notably, the "social innovation" literature pays attention to innovative strategies, policies, concepts, ideas, and organisations, that meet social needs of all kinds from working conditions and education to community development and health and which further extend and strengthen civil society and the social capital of citizens.

Recent EU Commission documents also highlight the importance of innovation to the development of sustainable inclusive societies and more broadly to the successful preservation and development of Europe's social model.[20]

The European consensus is that economic prosperity and social cohesion are and should be mutually reinforcing. For this reason it is important that initiatives to promote economic progress through innovation are also directed towards social ends.

At present, Europe is facing enormous socio-economic and demographic challenges. There are striking regional disparities of income and opportunity – a fact which has become even more pronounced with the most recent enlargements -, the populations of Europe are ageing, there is a high number of low-skilled adults, there are high rates of youth unemployment, etc. At the

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[16] Cameron, G. (1996), "Innovation and Economic Growth", LSE Centre for Economic Performance, Discussion Paper No. 277, p. 10.

[17] Akçomak, İ. Semih & ter Weel, Bas (2006), "Social Capital, Innovation and Growth: Evidence from Europe", UNU-MERIT, Working Paper Series, NO 2006-040.

[18] E.g. Moulaert, F., F. Martinelli, E. Swyngedouw and S. Gonzalez (2005), "Towards Alternative Model(s) of Local Innovation", *Urban Studies*, Vol. 42(11), pp. 1969-1990, October.

[19] An example is the Kataris project where scholars have investigated the creative and socially innovative strategies by which people react to conditions of exclusion, both at the individual and collective level. People in situations of need activate and (re-)produce particular types of knowledge and combine resources in novel ways. The strategies they develop in response to exclusion often exhibit marked differences in the ways in which mainstream society's knowledge and practices are mobilised and deployed, and frequently trigger processes of social innovation that open up fresh venues for policy design and implementation.The KATARSIS project is a Coordination Action under European Commission's Sixth Framework Programme to address Growing Inequality and Social Innovation: Alternative Knowledge and Practice in Overcoming Social Exclusion in Europe. The project is coordinated by Frank Moulaert at Global Urban Research Unit, Newcastle University, United Kingdom

[20] European Commission (2005a), "Working together for growth and jobs. A new start for the Lisbon Strategy". Communication to the Spring European Council. COM (2005) 24, 02.02.2005

same time there is a growing need to improve the level of competences and qualifications on the labour market. These challenges must be addressed in order to improve the long term sustainability of Europe's societies and social systems.

This not only calls for an inclusive strategy towards education, but also a strategy towards innovation based on synergies between mutually reinforcing economic and social policy objectives. Stronger capacities for innovation hold the potential not only of increasing economic competitiveness and prosperity in Europe, but also of contributing to the wider development of our societies.[21]

Innovative solutions and new uses of technology can contribute to lively democracies with engaged, knowledgeable, and active citizens, and to preventing the marginalisation of specific groups. Innovative approaches and creative uses of new technological opportunities can contribute to the quality of contents and delivery of public services, and may add to the sustainability of social security systems and the development of health care systems, as a basis for prosperity and economic development.

Europe has traditionally held a strong position in developing solutions that have improved people's lives all over the world: from life-saving medicines to advanced mobile telecommunications. Innovation is also a key to tackling current and emerging challenges such as climate change, detection and prevention of disease, congestion, and social exclusion.[22]

In this perspective, innovation holds the potential of meeting genuine social needs – specific societal needs unlikely to be addressed by the commercial market.[23]

3. The Concept of Innovation and the Role of Education

Understandings of innovation have developed considerably over time. From an original focus on research-based technological innovations, broader notions have become significant, with the idea of national or regional innovation systems playing a key role to economic prosperity and with non-technological and user-driven innovations increasingly being emphasised. This development accentuates the - potential - role of education and training for innovation.

The main body of literature on innovation focuses on economic innovation and sees innovation as a major driver for economic growth and wealth creation. The Lisbon Agenda focuses on competitiveness and growth and therefore its main emphasis is on this economic interpretation of innovation. However, in this paper a slightly broader view of innovation is included. 'Softer' aspects of innovation, e.g. the role innovation plays in socio-economic development, are also addressed.

[21] Cf. Young Foundation and Said Business School (2007), "Social innovation what it is, why it matters and how it can be accelerated".
[22] European Commission (2006e), Communication from the Commission to the European Council; "An innovation-friendly, modern Europe", COM (2006) 589 final. 12.10.2006.
[23] Kuhlmann S., Edler J. and Behrens, M., eds., (2003), *Changing Governance in European Research and Technology Policy,* Cheltenham: E. Elgar.

From science as a cause of innovation to innovation as a complex process

Up till the 1990s, the debate between economists and innovation policy analysts mainly focused on *technological* innovations. For most of the post-War period, it was assumed that science in some way *caused* innovation. While there was never much empirical evidence for this so-called 'linear model of innovation', it was and is highly influential in policy discussions.

In the current thinking, innovation is a much more complex process,[24] cf. Figure 2, and innovation is seen as taking place in a complex system, where the *coupling* between science, technology, the marketplace, and the other parts of the innovation system, is important. A well-recognised description and *definition of innovation* can be found in the so-called Oslo Manual, published by the OECD and adopted by Eurostat.

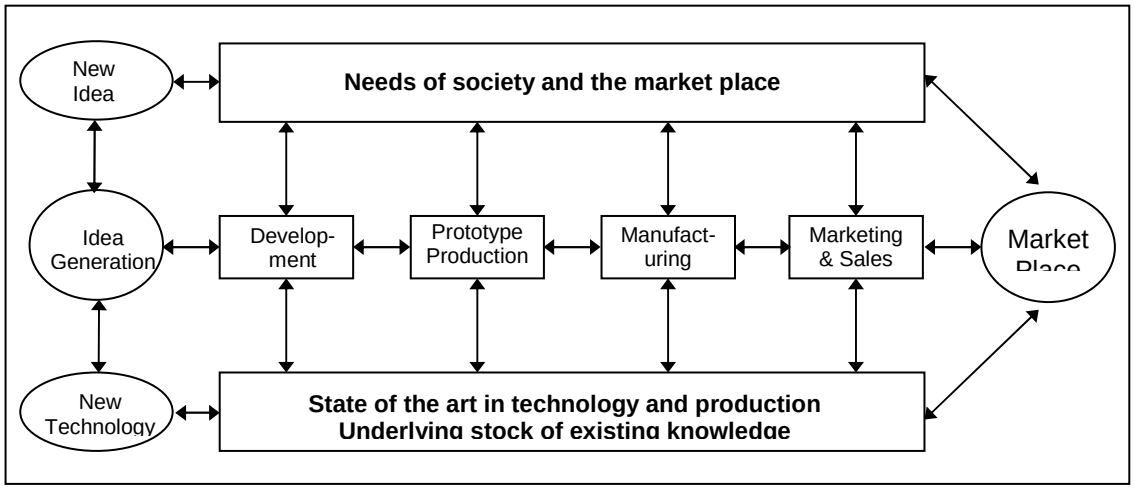
Its characterisation of innovation is: "Technological innovation activities are all of the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes."[25]

Innovation in this sense is mainly an intrinsic activity within the firm. The literature mostly differentiates between radical innovations – radically different from current technology - and incremental innovations or continuous improvement. Each needs a different set of resources and skills to achieve, and generally the efforts and bottlenecks involved in radical innovation are much higher than in incremental innovations.

Complementary to this 'intrinsic' process within firms is the *diffusion* of innovations, e.g. the spread of innovations from the originating firm to other markets, firms, and people. The rate of diffusion helps others than the 'first mover' to pick up the new ideas and develop new innovations on the basis of this first improvement.

[24] Mowery, D.C. and Rosenberg, N., (1978), 'The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies', *Research Policy*, April.
[25] Frascati Manual, OECD (2002).

Figure 4. Modern 'Coupling' Model of Innovation



Source: Mowery, D.C. and Rosenberg, N., 'The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies', Research Policy, April 1978.

New trends in knowledge production and innovation: openness and convergence

The scientific and technological revolution has been driven for a long time by the large firm-based R&D laboratories, by the patent system and its laws, and by the growth of the higher education systems and research within the universities. In the past decades however it became clear that the linear model knowledge production and innovation no longer represents the reality.

A major change in the views on knowledge production in society was discussed and promoted by Michael Gibbons and a group of other authors under the title "The new production of knowledge". Gibbons (1994) pointed to the fact that next to the classical ways of producing knowledge in universities and specialised research institutes, there is an increasingly important so-called 'mode 2 production of knowledge'.[26]

This mode of knowledge production is not dependent on specialised and institutionalised scientific activity, but on application-oriented knowledge, which is distributed throughout society. It is a transient, heterogeneous, cross-disciplinary and multi-actor activity. Empirical evidence can be found in the growth of knowledge intensive business services such as intermediaries, consultants, and engineering firms. Innovation is no longer perceived as a specialised activity in specialised institutions that develop, appropriate, and value knowledge and technology. Instead, the defining principle of the knowledge society is seen in the development of economic, technological, and social innovations, on the basis of knowledge that is widely spread around and shared in society.

These new form of knowledge production lead to new forms of interaction, such as 'co-operative innovation networks', between the science and education system (universities), the economic systems (industry), and the political system (government). Consequently, this leads

[26] Gibbons, M., Camilla Limoges, Helga Nowotny, Schwartzman, S., Scott P. and Trow, M., (1994). *The New Production of Knowledge*, London: Sage.

to changes in market structure, new organisations of infrastructure, new qualifications of employers, new social institutions, and new patterns of consumption.[27] Because of the increasing complexity of new technologies, companies have to work together and with other stakeholders. This cooperation takes the form of sharing ideas, costs, people, and knowledge. New clusters of knowledge evolve and thereby new forms of cooperation. Such new division of roles could have huge consequences in many areas like intellectual property rights, education, and policies. New business models, new education models, and new models for policy making, are slowly evolving to maximize the benefits from these much more interconnected innovation environments.

A second and related trend in knowledge production and innovation is the convergence of different generic technologies such as nanotechnology, biotechnology, information technology, and human cognitive sciences. This convergence is believed to lead to a growth of ´disruptive technologies´ which require deep systems change or systems innovations for their application.[28] Convergence is viewed as having the potential to improve human performance, and it is expected to have a large impact on all economic activities. Business practices are also changing, due to the implementation of intelligence in all sorts of (new) products and services, and knowledge has become a product as such.

Both convergence and the collapse of the linear innovation model lead to a marked increase in the number and diversity of players and stakeholders involved in the process of technology development, and business models are being adapted or re-designed to follow this evolution. Today these factors are often translated into a need for ´open innovation´.[29] The industry is gradually abandoning the traditional intellectual property model, and generic technology development and innovation is carried out more and more in R&D collaboration schemes in which intellectual property (IP) is shared among the participants.[30]

Moreover, in the end rapid technological changes can only succeed if its users positively accept the directions of technological development and the processes that make these happen. Previous experiences with consumer resistance to for instance genetic modification demonstrate this necessity. Policymakers also recognise the need for involving civil society in decision-making processes. It is also necessary to access ´the creative and innovative power of the user´. Inevitably, this increases the range of persons who are likely to work together in developmental processes of experimental learning from physicists, engineers, chemists, physicians, and other scientists, to social scientists, designers, and interested or potential users.[31]

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[27] Van den Besselaar, P. (2000), *De dynamiek van technologische ontwikkeling en innovatie*. http://hcs.science.uva.nl/usr/peter/publications/2000ettaTECH.pdf

[28] Marent, K. & van Helleputte, J. (2003), "De intelligente omgeving: De noodzaak van convergerende technologieën en een nieuw business model". IWT observatorium. Studie 44, Brussels.

[29] The central idea behind "open innovation" is that in a world of widely distributed knowledge, companies cannot afford to rely entirely on their own research, but should instead buy or license processes or inventions (i.e. patents) from other companies. In addition, internal inventions not being used in a firm's business should be taken outside the company (e.g., through licensing, joint ventures, spin-offs). In contrast, closed innovation refers to processes that limit the use of internal knowledge within a company and make little or no use of external knowledge.

[30] ibid.

[31] ibid.

An increasing role of learning, interactions, and linkages, in the understanding of innovation

Gradually, the understanding emerged in innovation literature that firms do not innovate in isolation, but use many *interactions and linkages* with other organisations (suppliers, customers, research organisations, users, and consultancies) to develop new ideas for further innovations.

First, there is an important distinction between innovation and invention to be made. Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out in practice.[32] This distinction is important, as it implies that innovation is a much more complex process involving more actors and thus more sources of learning. Invention is an important but overrated source of innovation and wealth. Most of the knowledge that companies use in innovation comes from outside, so '*absorptive capacity*' – the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends – is key to performance.[33] Wesley Cohen and Daniel Levinthal introduced the idea of 'absorptive capacity' to R&D and innovation literature in a landmark 1990 article.[34]

Absorptive capacity is exploited in various kinds of *learning processes*.[35]

1. *Learning by searching* refers to the generation of new knowledge achieved through formalised search activities such as R&D.
2. *Learning by doing* refers to the accumulation of knowledge gained through carrying out the same kind of activities repetitively.
3. *Learning by using* refers to learning through the utilisation of products;
4. *Learning from advances in science and technology* refers to the absorption of new developments in science and technology.
5. *Learning from inter-industry spillovers* refers to the activities of competitors and other firms in the same industry.
6. *Learning by interacting* refers to 'horizontal' or 'vertical' forms of interaction with other sources of knowledge, such as cooperation with other firms.

The first three kinds of activities are internal to the firm, and the remaining three are external to the firm. Key to all these processes is that learning is a central resource that requires skills from the organisations and people involved. Nonaka has developed the concepts of tacit and explicit knowledge and their meaning for organisational learning. Tacit knowledge is personal, context-specific, and therefore hard to formalise and communicate. Explicit knowledge, on the other hand, is transmittable in formal and systematic language. Following Nonaka's concepts, the process of knowledge conversion and subsequent organisational learning proceeds through four different modes:

1. Socialisation (the conversion of tacit knowledge to tacit knowledge);

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[32] Fagerberg, Jan, D.C Mowery, R. Nelson, (2005), *Oxford Handbook of Innovation*, Oxford University Press, Oxford.

[33] Arnold, E. R. Allinson and A. Muscio (2004), *Absorptive Capacity of Companies: A Review of Literature and Instruments*, Report for Forfás, Dublin.

[34] Wesley M., Cohen and Daniel A Levinthal, (1990), 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, Vol 35 (1), March, pp. 128-152.

[35] Allinson (2006), "Shell Step Innovation Programme, Exploring the absorptive capacities of host SMEs", *Cyprus International Journal of Management* , Volume 11, Number 1, Autumn.

2. Combination (the conversion of explicit knowledge to explicit knowledge);
3. Externalisation (the conversion of tacit to explicit knowledge); and
4. Internalisation (the conversion of explicit to tacit knowledge).

Jensen et al. (2004) develop a distinction originally proposed by B.A. Lundvall between two different but complementary modes of learning and skills development: the STI-mode (Science, Technology, and Innovation) and the DUI-mode (Doing, Using, and Interacting).[36] The STI-mode most obviously depends on explicit know-why, and the R&D-departments in big firms play a key role in STI-processes. Specific R&D-projects will often be triggered by practice (problems with a product, new user needs, and problems with producing), but almost immediately attempts will be made to restate the problem in an explicit and codified form that potential users can understand, since there is a need for interaction and feed-back. This mode depends on the skills of engineers, scientists, and technicians with formal university training, and maintaining the absorptive capacity of the enterprise often requires continuous renewal of their knowledge through lifelong learning.[37]

The DUI-mode of learning and innovation (Doing, Using, and Interacting) most obviously relies on employee know-how which is tacit and often highly localised. This mode involves building structures and organisational practices which enhance and utilise learning by doing, using, and interacting. Knowledge and skills are developed through ongoing problem-solving, and when the process is complex it will involve interaction within and between teams and may result in new shared routines for the organisation. Learning by doing and learning by using are promoted through decision-making autonomy that allows employees to explore new novel possibilities. This is why practices such as self-managing teams and the delegation of authority tend to show a positive relation to learning and innovative performance.

Innovations can be competence-enhancing or competence-destroying.[38] Competence-enhancing innovations build on a firm's existing competences and tend to be especially characteristic of innovation in more traditional or mature technologies (textiles, autos, mechanical engineering). Innovative activity is mostly incremental in nature and typically involves small improvements in existing technologies or new combinations of exiting technologies. Incumbent firms are typically well-placed to carry out such innovations either through investing in in-house skills or through recruiting workers on the labour market with complementary knowledge and skills. This corresponds to the phase of exploiting existing knowledge and competence in Nooteboom's analysis of innovation cycles.[39]

Innovations leading to competence obsolescence, on the other hand, mark significant breaks in the technological architecture or paradigm and typically require new types of skills and knowl-

[36] Jensen et al. (2004), "Absorptive Capacity, Forms of Knowledge and Economic Development". The distinction between STI and DUI-mode learning was originally developed by B.A. Lundvall in a series of workshop reports for our joint EU Accompanying Measures Project, *Labour, Organisation and National Innovation Systems* (Loc Nis). See the project's web page and notably Lundvall, et al. (2004) and Lorenz and Lundvall (2004). http://www.business.aau.dk/loc-nis/

[37] See EU Trend Chart Workshop on Innovation Skills (2004).

[38] Henderson and Clark (1990), "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", *Administrative Science Quarterly*, Vol. 35.

[39] Noteboom B. (2000), *Learning and Innovation in Organizations and Economics*, Oxford: Oxford University Press.

edge. This is characteristic of innovative activity during the early phases of development of a new technological field (e.g. biotechnology). Innovative activity will be characterised by intensive forms of exploration that are favoured by looser, network forms of organisation. Incumbent firms may be at a disadvantage relative to start-up firms, in part because of internal resistance to the organisational and manpower changes required to radically reconfigure their competence base.[40]

The importance of the STI-mode of learning and knowledge management is most obvious in fast moving technology fields such as ICT and bio- and nanotechnology, and it is these sectors which are the focus of most current policy efforts both at the national and the European level.[41] This reflects the combination of respectively path dependency in relation to science and technology policy and the combined pressure emanating from the science community and the big science-based firms. But other "traditional" industries such as food, clothing, and furniture, as well as many service sectors, also draw upon science when it comes to innovating production processes, the use of materials, and the design of new products. Econometric analysis for the Danish case, for example, demonstrates that small and medium-sized firms operating in such sectors tend to be the ones that benefit the most in terms of innovative capability from a stronger connection to science.[42]

DUI-learning is crucial in high-technology sectors. Experience-based learning takes place in daily production and in the implementation and use of advanced technologies. The speed-up of science-based innovation tends to run into bottlenecks whenever the capability to absorb and efficiently use new technologies is limited.

Empirical evidence shows not only that the DUI-mode of learning contributes positively to innovation across sectors, but also that the most promising results are obtained when the two modes are combined. This implies the need for some realignment of policy at the national and European levels.

'Learning by doing': User-driven innovation and the democratisation of innovation

When users become players in the innovation game, there is a need for an innovation model that is based on 'learning by doing'. As long as technological possibilities still grow very rapidly, people must be encouraged to continuously learn new skills and new rules.

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[40] Chesbrough (1999), "Arrested Development: The Experience of European Hard Disk Drive Firms in Comparison with US and Japanese Firms". *Journal of Evolutionary Economics*, 9(3): 287-329. It would be a mistake to identify innovations that are "new for the market" with those that are 'competence destroying' or, conversely, to identify innovations that are "new to the firm but not to the market" with those that are 'competence enhancing'. The development of products or processes that are new to the market may be based on incremental improvements in existing technologies. The diffusion of competence destroying innovations, on the other hand, can pose a major challenge to economies precisely because incumbent firms find it difficult to undertake radical reconfigurations of their competence base.

[41] Jensen, Berg Morten, Johnson, Björn, Lorentz, ned og Lundvall, Bengt-Åke (2004)."Absorptive Capacity, Forms of Knowledge and Economic Development". Innovation Systems and Development: Emerging Opportunities and Challenges, Conference October 16-20, Beijing, China.

[42] Lund Vinding, A. (2006), "Absorptive Capacity and Innovative Performance: A human capital approach". *Economics of Innovation and New Technology* Vol. 15 (4/5) June/July pp. 507-517.

Examples of such models can be already drawn from ICT and biotechnology developments. The development of ICTs shows that the skills of the users have become an important factor in innovation processes. The obvious example here can be found in the discussion about the IT productivity paradox during the last decade, which says that the growing investments in ICTs do not result in increased productivity figures. A major explanation for the "productivity paradox" is that the costs of learning to use the new ICT-based applications are very high, and thus offset any productivity gains.[43]

The idea to involve users early in the innovation process is not new. Technology- and innovation studies increasingly focus on social, economic, and political aspects of and impact on the innovation process. Theoretical concepts like the 'social construction of technology', the 'co-creation of technology', 'selection environment', and other concepts developed in 'innovation studies' and 'consumer studies' provide useful insights for understanding the role of the user. As already mentioned, the interactive process between users and producers can be characterised as a process of mutual articulation; a continuous interactive process which goes back and forth between the designer and the user, aligning the redesign of product characteristics and user requirements.[44] It is a process of 'learning by using' and 'learning by doing'.[45] A user can be consumer, patient, employee, member of a church, and a citizen at the same time; these roles can be conflicting. Also the role of so-called 'non-users' has to be taken into account.[46] The success or failure of innovations depends on the ability to cope with the variety of users who all have different skills, aspirations, and needs, and on the success of the interactive learning process.[47]

Users are not always able to put their needs into words. Sometimes they are even not aware of their needs. A specific group of users are 'lead users'. These users have certain competences, resources, and incentives for innovation. They have needs that foreshadow general market demand and expect to obtain high benefit levels from a solution to their needs. Lead users are sophisticated users who are well aware of their needs for the future. They can give information about the possible product concept and design, and are therefore of great use to producers.[48] Eric von Hippel is one of the pioneers of the theory of user-driven innovation. In his most recent book 'Democratizing Innovation' (2005) he describes in depth how people participate in the development of products they use. Generally, professional users and organisations are identified as lead users, but consumers can also play a role as lead users provided they have the necessary competences and resources.

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[43] Leijten, J. & Vullings, W. (2005), Nanotechnologies and Social choice. Paper presented to Nanotechnology in science, economy and society Marburg, 13-15 January.

[44] Nelson R. R. and S. Winter (1982), *An Evolutionary Theory of Economic Change,* Cambridge: Harvard University Press.

[45] Rosenberg (1976). *Perspectives on Technology*, Cambridge, Massachusetts: Cambridge University Press; Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics*, Cambridge, Massachusetts: Cambridge University Press.

[46] Oudshoorn and Pinch (2003), *How Users Matter: The co-construction of users and technologies*, Cambridge Massachusetts: MIT Press.

[47] Akrich (1995), User representations: Practices, methods and sociology. In A. Rip, T. J. Misa, & J. Schot´(Eds.), *Managing technology in society: The approach of constructive technology assessment* (pp. 167–184). London: Cassel Publishers Ltd.

[48]Von Hippel, E. (1976), "The dominant role of users in the scientific instrument innovation process", Research Policy, Vol. 5 212-239. Von Hippel, E (2005). *Democratizing Innovation.* MIT Press, Cambridge.

In Von Hippels' explanation of the democratisation of innovation, an innovation is a *user innovation* when the developer expects to benefit by using it. An innovation is a *manufacturer innovation* when the developer expects to benefit by selling it. Consumer needs can be a starting point for new product development. Consumer preferences are translated into 'engineering attributes' and can be integrated into the final design.[49] Thus, users can be considered as sources of new innovations and even as designers. They can develop new functions for technologies, solve unforeseen problems, and propose or develop innovative solutions. The positive effect of users' involvement explains why producers of new technologies that work closely with users have a larger innovation success rate.[50]

Besides the important role of users, the involvement of employees in the innovation processes of their firm is crucial for the success of innovations. Recent research shows that many innovation projects within firms fail because of the lack of commitment to the project by the employees. Commitment can be obtained, however, by interactive management and an improved utilisation of the human potential in terms of knowledge and skills. Furthermore, a creative environment is crucial for innovative organisations, as Florida advocates.[51] If the utilisation of employees' knowledge and creativity can be improved, commitment for innovation projects will likely increase as well.

A growing focus on non-technological innovations

Since the early 1990s, a growing body of literature has appeared on non-technological innovations. First of all this referred to innovation stemming from organisational changes, and particularly from *managing innovation*. Tidd, Bessant and Pavitt state that the development of innovation management involves a learning process concerned with building and integrating key behaviours into effective routines, to deal with the challenges of the innovation process.[52] The European Commission has had a central role in supporting best practices in innovation management and has put this forward as a key element, particularly to boost innovation in SMEs.

A recent and influential contribution to the debate on non-technological innovation is centred on the importance of *creativity* for innovation and the value of the creative industries in the economy and society. Richard Florida has emphasised the importance of human capital and talented people for high technology industries and economic growth in regional economies.[53] His research shows that the most successful city-regions are the ones that have a social environment that is open to creativity of all sorts. This, together with other factors such as labour markets characterised by high demand for qualified personnel, cultural diversity and tolerance, low entry barriers, and high levels of urban service, largely determine the economic geography of talent and of creativity. The ability to attract creative people in arts and culture fields and to be open to diverse groups of people of different ethnicity, race, and lifestyles, provides distinct

[49] Kotler, P. (1997*), Marketing Management*, 9th ed., Prentice Hall, New Jersey.
[50] E.g. Leonard-Barton (1988), *Implementation characteristics of organizational innovations*, Communication Research, vol. 15, no. 5 pp. 603-31, October.
[51] Florida (2004), *The rise of the creative class: and how it's transforming work, leisure, community and everyday life*. Perseus Books Group.
[52] See e.g. Tidd J., Bessant J., and Pavitt K. (1997), *Managing innovation, Integrating Technological Market and Organizational Change*, Wiley, Chichester.
[53] Florida (2004), *The rise of the creative class: and how it's transforming work, leisure, community and everyday life*. Perseus Books Group.

advantages to regions in generating innovations, growing and attracting high-technology industries, and spurring economic growth.[54]

In his book 'The Rise of the Creative Class' Richard Florida claims that one third of the American working population belongs to the creative class and works in creative industries. Examples of these industries are Industrial Design, Textile, Multimedia, and Architecture.

According to Florida (1995), regions become the new focal points for knowledge creation and learning in knowledge-intensive societies. As such, they evolve into learning regions. These learning regions function as collectors and repositories of knowledge and ideas, and facilitate the flow of knowledge, ideas, and learning. According to Florida, talent is a key variable in the economic growth of countries, and should be conceptualised as a flow rather than an endowment: certain regional conditions appear to play a role in creating the environment that attracts talent and human capital. These are non-market factors such as amenity and diversity.

Creativity and innovation are interlinked, according to Florida. Without creativity no new products, services, processes, strategies, or organisations will be developed. Since innovation is increasingly important for economic development, creativity becomes increasingly important as well. The importance of creativity as production factor increases. An important role for the education system would thus be to stimulate creativity.

Although it is hard to organise creativity, governments can arrange preconditions in which a creative culture can be deployed. A number of conditions have been mentioned during the Dutch Innovation Lecture in 2005 by the Minister of Economic Affairs Mr. Brinkhorst.

1. Do not exclude anybody, since research is not predictable
2. Arrange for a free exchange of ideas, 'knowledge is power' behaviour kills creativity
3. Stimulate inspiration (as manager)
4. Tolerate failures. Creativity means learning by 'trial and error'

The creative industries can inspire other economic sectors as well. Its existence improves the attractiveness of a region or country, since talent tends to move to places with a creative culture. According to Florida, talent, technology, and tolerance, are the keys for regional economies and the attractiveness for industry to move to a region or country.

Social innovation

Innovation is thus not about technological innovation alone. It involves improving the organisation of work, improving organisations and their business models, and improving the attractiveness of a region or country. The term 'social innovation' is often used to address issues outside the technological development domain.

Social innovation is a term that refers to innovation in strategies, innovative concepts, new ideas and innovation in organisations to meet social needs of all kinds. For example social needs such as working conditions and education, or community development and health. Lit-

[54] Asheim, B.T. (2006). "Learning firms in learning regions: Innovation, Cooperation, and Social Capital", in Taylor, M. and Oinas, P. (eds.), *Understanding the Firm: Spatial and Organizational Dimensions*, Oxford: Oxford University Press pp. 214-234.

erature on social innovation uses the term in various ways, referring to social processes of innovation such as open source methods, to innovation with a social purpose, or to social entrepreneurship.

Social innovation was already discussed in publications of Peter Drucker and Michael Young in the 1960s. Societal trends such as individualisation and globalisation demand new forms of organisation, which is referred to as 'social innovation' as well. In the Netherlands, a Task Force has been set up to assess the possibilities for innovation in labour and an improved utilisation of talent.

A European focus on non-technological as well as technological innovations

Many European policies are biased towards technological innovations. However, the European Commission agreed that all forms of innovation, including non-technological innovation must be taken into account when developing policies. The Council's conclusions are based on an independent expert study[55] and on the previous decisions taken at the Lahti European Council, when the EU's Heads of State and Government agreed to take a strategic approach to innovation with a strong focus on a number of key actions. Priorities are for instance:

- Enhancing closer co-operation between higher education, research, and business
- Developing a policy approach to innovation in services and to non-technological innovation

A 2005 study analysed the determinants and effects of non-technological innovations and compared them with those of technological innovations.[56] A first step was to look at expanded figures on the prevalence of non-technological innovations in certain industry groups, with a special focus on service industries. Conclusions were that the more important technology leadership is to success, the more likely are firms to introduce technological innovations. The harder it is to foresee demand, the more marketing innovations are introduced. For technological innovators it was shown that innovation activities related to technological innovations also induce non-technological innovations. The analysis shows that non-technological innovations do matter for the success of firms.

Innovation systems and the role of the institutional environment

From the late 1980s, innovation literature started to focus on the institutional environment in which innovation takes place. The notion of national *innovation systems* was launched by Christopher Freeman (1987), who described an innovation system as a network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies.

Newer National Innovation Systems[57] theories emphasise the idea that firms and other economic actors have 'bounded rationality,' which makes knowledge, learning, and institutions,

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[55] Aho, Esko, (2006), *Creating an Innovative Europe*, European Commission, Brussels.

[56] Hollanders H., Kenerva, A. Arundel (2005), *2006 Trend Chart Report, Can We Measure and Compare Innovation in Services*, European Commission, DG Enterprise.

[57] See Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, London: Frances Pinter; Lundvall, Bengt-Åke, ed. (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter; Nelson, R.R. (1993), *National Innovation Systems*, New York: Oxford University Press.

the keys to overall economic performance. In this view, economic actors are no longer autonomous robots, but are deeply interwoven into the economic fabric. The performance of the individual firm or institution and the system as a whole are inter-related. Empirical studies on innovation, such as the Community Innovation Survey (CIS), confirm that firms rarely innovate in isolation. They need other economic actors for new ideas and for specialist and complementary knowledge. The unit of analysis is no longer only the individual firm, but also the 'system' of networks within which firms operate. National economic performance is explained as the performance of this total system.

A second key idea, which stems from the central role attributed to learning, is that of historical path dependence. What a company or institution can do today depends upon what it could do yesterday[58] and what it has learnt in the meantime. "Often, the elements of the system of innovation either reinforce each other in promoting processes of learning and innovation or, conversely, combine into blocking such processes. Cumulative causation, virtuous and vicious circles are characteristics of systems and sub-systems of innovation."[59]

As is the case with many new concepts, a precise definition of a 'National Innovation System' is still evolving. Nelson and Rosenberg[60] use a rather narrow definition, namely the "set of institutions whose interaction determines the innovative performance of national firms." Metcalfe says:

> "A system of innovation is that set of distinct institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies".[61]

Based on the NIS literature and the way it discusses innovation processes, the above cited *inclusive* definition is more appropriate. This definition also includes the concepts of knowledge and skills as key drivers for innovation. Figure 3 provides a sketch of a 'National Innovation System': all the actors and activities in the economy which are necessary for economic and social innovations to take place and to lead to development. The education system has a clear role to play in this system, particularly professional education and training and higher education and research.

In the mainstream research and innovation policy debates, the role of education and training focuses particularly on three issues:

- The quality, mobility, and availability of highly skilled people to perform research and engineering.

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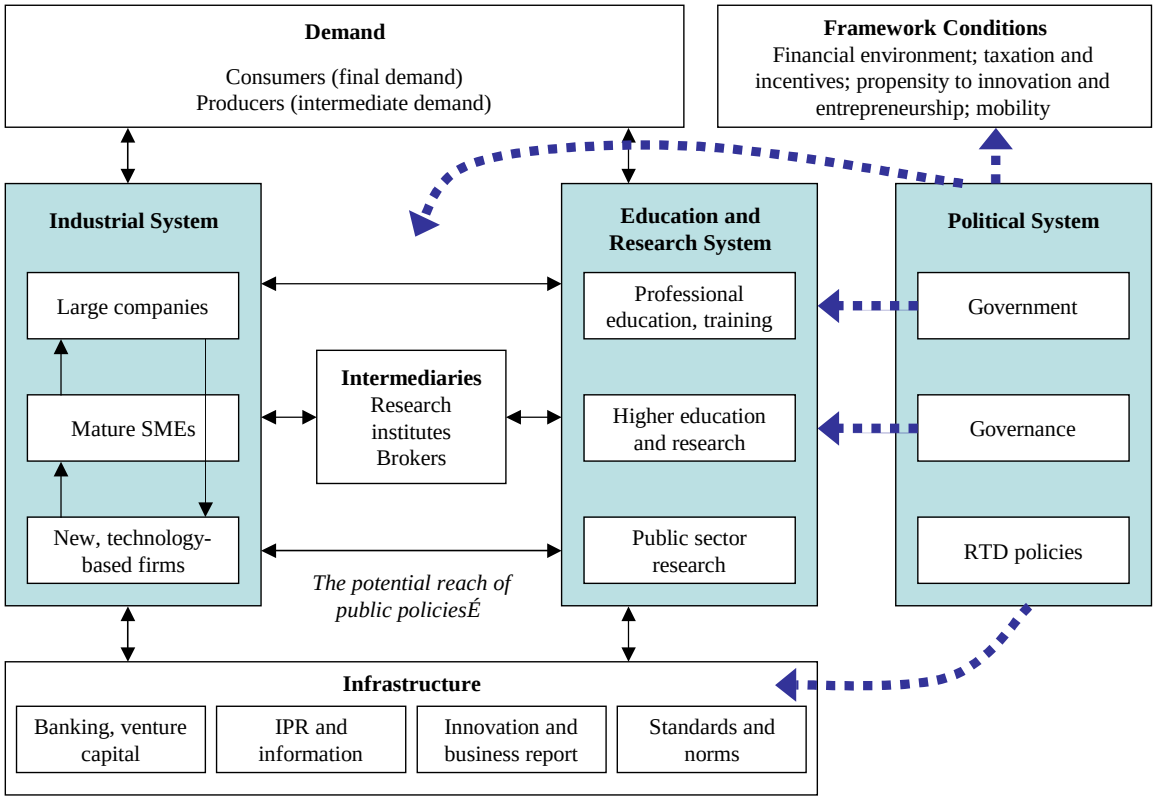
[58] Rosenberg, Nathan (1976), *Perspectives on Technology*, Cambridge University Press.
[59] Lundvall, Bengt Åke, ed. (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.
[60] Nelson R. R. and N. Rosenberg, 'Technical innovations and national systems,' in R R Nelson, ed. (1983), *National Innovation Systems: A Comparative Analysis*, Oxford Univerisity Press.
[61] Metcalfe, J. S (1995), "The Economic Foundations of Technology Policies: Equilibrium and Evolutionary Perspectives", in: Stoneman, P. (ed.), H*andbook of the Economics of Innovation and Technological Change*, Oxford, UK, Cambridge MA, Blackwell, 1995, pp. 409-511.

- The quality, mobility, and availability of specific skills for innovation, including innovation management and ICT skills, communicative skills, and creative skills particularly in relation to design.
- The presence and/or lack of specific entrepreneurial skills and attitudes in Europe and the role of education in stimulating entrepreneurship.

Figure 5. The key elements of a national innovation system



Source: Erik Arnold and Stefan Kuhlman (2001) *RCN in the Norwegian Research and Innovation System*, Background Report No 12 in the Evaluation of the Research Council of Norway, Oslo: Royal Norwegian Ministry for Education, Research and Church Affairs, 2001

The literature on non-technological and social innovation and creativity add a number of other dimensions:

- The need to learning environments that encourage creativity, openness, and 'lateral' thinking.
- The need to stimulate formal and informal learning systems that stimulate creativity and 'lateral' thinking, to underpin the use of new innovations with new skills, and to increase the capacity of citizens, users and consumers to articulate their needs

The main points for debate relevant to the above outline can be summarised as follows:

- *How can education systems stimulate more young people to pursue studies and further careers in science and technology- and is that the main road to a more innovative Europe?*
- *Do training and education systems match those needs in society that underpin technological and non-technological innovation?*
- *To what extent and how can our education system contribute to creating an entrepreneurial climate and attitude amongst its pupils and students?*
- *Are appropriate (life-long) learning practices in place to encourage users of innovations to play an active role in launching innovations and to adapt and apply innovations in their work and private lives?*
- *Are our education systems the appropriate means to stimulate creativity and openness?*
- *Does the current focus on tests and test scores as a means to raise the quality in education systems conflict with demands to our education systems to foster creativity and innovation and more broadly speaking to develop innovation capacity in student populations?*

4. Education Systems for Innovation

The contribution from education and training to innovation depends on supporting frameworks and policies. Potentially fruitful paths towards a stronger contribution include increasing the demand-orientation of education and training systems, increasing the autonomy of institutions and programmes within a framework of relevant economic incentives, upgrading the role of non-university education and training institutions for innovation, and rethinking the role of higher education institutions in innovation systems.

What are the key challenges that confront our education and training systems if they are to contribute more actively to innovation?

The contribution from education and training depends on supportive frameworks and policies

While literature on innovation systems tends to conclude that education and training institutions have an important role to play in contributing to innovation, there are arguments brought forward that such effects are highly context-dependent. As Bainbridge points out, barriers to lifelong learning, and more broadly speaking to an innovation culture, may exist not only within the education and training systems, but also in the associated sub-systems; labour market policies, industry policies, and work organisation practices.[62] Similarly, Gavigan finds that the challenges to education and training systems' capabilities of contributing to an innovation- and learning-intensive economy should be sought more broadly than within education and training systems themselves, otherwise public policies for innovation are likely to fail.[63]

More specifically, while numerous studies have highlighted the intrinsic value of human capital to firm innovation and competitiveness, there is evidence that businesses' demands for knowledge and skills are highly correlated with their overall strategies.[64] Firms that compete on

[62] Bainbridge, S (2003), "Learning for employability". Second report on vocational education and training policy in Europe. Executive summary / Steve Bainbridge, Julie Murray, Tim Harrison, Terry Ward Thessaloniki: Cedefop

[63] Gavigan, J. et al. (2000), "Knowledge and learning – Towards a learning Europe", *The Futures Project, IPTS.*

[64] Sector futures, "Textile sector study" (2004), EMCC. Bainbridge, S (2003), "Learning for employability". Second report on vocational education and training policy in Europe. Executive summary / Steve Bainbridge, Julie

service intensity/quality and continuous adaptation of products and services to particular market segments take many avenues to increase firm flexibility and innovation capacity, whereas firms that compete on cost and efficiency and/or operate in sheltered markets do not set a high premium on knowledge and skills.[65] If more firms are to be geared to innovation, there is therefore a strong point to be made about the interdependency of education and training programmes and business programmes if both are to succeed.

Moreover, while many companies state that the intellectual capital of core employees is a major source of innovation and competitive advantage, a majority of the workforce do not depend on high skills levels to perform their occupational roles,[66] and developments in particularly services industries confirm this. Rather, there is an under-utilisation of skills in many jobs, and low skilled jobs are continuously being created across OECD economies.

In more general terms, it can be argued that knowledge is heterogeneous in nature. Its value is not intrinsic, but is highly dependent on its relationship to the user and the context in which it is applied. This implies that raising the workforce skills levels, in general or as regards particular skills and competences, will not in itself necessarily lead to stronger innovation in economy and society, unless it is accompanied by for instance substantive innovations in work organisation practices and measures which facilitate changes in the priorities and practices of firms.

A study conducted in Norway (Skule & Reichborn, 2002) identifies the factors that distinguish between low-learning and learning-conducive jobs. The authors have made this concept operational in order to assess Norwegian work places. They identify the following favourable conditions for learning through work:

- High degree of exposure to changes;
- High degree of exposure to demands;
- Managerial responsibility (in the job);
- Extensive external professional contact;
- Direct feedback;
- Management support for learning;
- Rewarding of proficiency.

There may be a risk that education and training systems are overburdened with expectations in relation to innovation – development of education and training with a view to stronger innovation is likely to yield positive results only if the surrounding society can and will absorb new skills and competences. Development and innovation at the supply side (i.e. in education and training systems) need to be supported by sufficient capacity on the demand side for new skills and competences – for instance via clear and firm innovation policies, cohesion between regional, labour market, and sectoral policies, and general support of proactive restructuring of

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Murray, Tim Harrison, Terry Ward Thessaloniki: Cedefop; Danish Ministry of Finance (2006), "Livslang uddannelse og opkvalificering for alle på arbejdsmarkedet - rapport fra Trepartsudvalget - Bind 2 Kortlægning og analyser"; Lisbon-Copenhagen-Maastricht Consortium (2004), *Achieving the Lisbon goal: the Contribution of VET*, London.

[65] E.g. New Insight and CARMA (2005b), "Motivation og barrierer for virksomheders brug af VEU; Lisbon-Copenhagen-Maastricht Consortium (2004), *Achieving the Lisbon goal: the Contribution of VET*, London., pp. 48-64.

[66] Ashton et al. (1999), "Work Skills In Britain", Oxford, SKOPE, Oxford and Warwick Universities.

the economy rather than an orientation towards shielding businesses and sectors from competition.

- *What is the role of national and regional policies versus EU policies in supporting and stimulating innovation at the supply side, and – in a balance – the demand side for skills and competences – e.g. in relation to SMEs? And what actions should be taken at each level?*
- *Are relevant policies in place in the EU member states for supporting and encouraging businesses and organisations to absorb new skills and competences?*
- *Is education and training included as a key factor in overall national innovation strategies? If not, would it be relevant to do so?*

Towards increasing demand-orientation in education systems

Faced with new pressures and demands to increase their contribution to innovation in the light of intensified global competition, there are good examples of education systems and institutions that are seeking to become more adaptive and responsive. Several trends and characteristics can be highlighted in this respect, and serve to raise significant questions.

One significant and widespread trend is for education institutions to increase their orientation towards demand, towards the 'actual needs of working life'[67], in the short- to medium-term.

- There is an increasing use of applied development projects in polytechnics and similar institutions with a view to giving support to firms in creating new or improved products, production tools or methods, and services.
- Another measure is a closer linking to workplaces through students' final year projects, based on the notion of cognitive apprenticeship. The objective is to integrate theoretical underpinnings of projects with the concrete practices and reflections about them.[68] At a system level, the Swedish programme Kvalificeret Yrkesutbilding (a tertiary VET programme) is an example of this development.
- Increasing use of industrial placements and internships for students is a third element. The most promising of such developments have included a focus on achieving designated learning outcomes of such placements.

Common education-industry development projects and their close industry collaboration are pivotal to improving the competence of staff in vocational colleges and polytechnics and at the same time increasing the absorptive capacity in firms. Expertise and competence are strengthened by creating opportunities for trainers or teachers to work closely with a company or group of companies with a view to improving firm performance within the companies their capacity to engage with knowledge providers is at the same time developed. There are many examples from the USA of how community colleges function as knowledge brokers in the wider context of regional economic policies (Rosenfeld 2000).

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[67] Danish Technological Institute (2006), *Uddannelsesinstitutioners samspil med erhvervslivet – fra uddannelsesudbyder til udviklingspartnere*; Curtain (2004), *Voctional eduction and training. Innovation and globalisation.* Adelaide. National centre for vocational education research.

[68] Danish Technological Institute (2006), *Uddannelsesinstitutioners samspil med erhvervslivet – fra uddannelsesudbyder til udviklingspartnere.*

Similarly, participation in development projects involving the business sector and education institutions may be central to identifying new and emerging skills requirements among enterprises – dependent, however, on the strategic perspectives and capabilities of the involved enterprises and thus the priority accorded by businesses to being aware of new and emerging skills. In that respect, the University of Flensburg has at an early stage developed such partnerships with industry, analysing forefront practice in order to identify emerging skills sets across economic sectors of activity. There are also examples from the Australian province of Victoria of how regional government has worked closely with industry and education institutions to identify new demands arising from developments in Nanotechnology.[69]

- *Are there weaknesses and gaps in policies to further the development of demand-led education systems, also considering that the competitive strategy of some types of enterprises does not involve a skilled and innovative workforce?*
- *Are there lessons to be learned from technology transfer policies to ensure that growth- and innovation-oriented enterprises define demand in relation to education institutions? Or should education institutions accommodate skill demands from all types of enterprises?*

Reshaping management and financing of education and training to further adaptation and cooperation with businesses

Assumptions are that flexible, demand-oriented, and adaptable education and training systems will enable closer and more direct forms of cooperation with businesses and thus increase the contribution of education and training systems to innovation.

Many reforms have occurred of education systems to spur more demand-oriented behaviour, some with success but also with unintended consequences[70], others with quite disastrous outcomes, such as the UK experiences with learning accounts. Innovation in business and society is likely to be facilitated if education institutions are encouraged also to see themselves as actors in a market for skills and knowledge, and are encouraged to act as strategic cooperation partners for business innovation. However, such a perception of the education system also raises critical socio-economic questions concerning internal capabilities in firms as buyers and users of knowledge, and concerning individuals at the fringe of the labour market or who are not seen as central to the firm's core business. Future research on education and innovation will have to address the implications and unintended consequences of reforms towards more market- and demand-led systems.

Other than redesigning public financing, policy response to drive demand-orientation has been the introduction of principles of "responsible autonomy" in the management of education institutions and systems. The education institutions and programmes are allowed a high degree of autonomy in the definition and implementation of education and training arrangements, but public funding of education and training is linked to the outputs and outcomes of education and training.

[69] http://www.business.vic.gov.au/busvicwr/_assets/main/lib60021/nano_a_paper.pdf,

[70] CINOP (2004, Experimenting with individual Learning Accounts - Geertsma Anna, Westerhuis Anneke, et al.

Responsible autonomy for education systems and programmes is implemented through different policy measures. Some systems, for example the Danish, have systematically used goal and framework management, combined with economic incentives for demand orientation, for instance linking budget allocations to the production of graduates, to quality assessments from students and clients, to the establishment of strategic partnerships with sectors and businesses, to activities which seek to assess the needs and relevance of skills and competences in the local or regional context,[71]or to other indicators of relevant outcomes in the local or regional context.

In the United States community college system, there have been attempts to use such indicators as part of a broader system of accountability across labour market and industry programmes. In Denmark, attempts are also being made to develop indicators that link education and training, regional economic development, cohesion, and innovation.[72]

- *Is there a case for wider reforms in the management and financing of education systems so as to allow them greater autonomy and market orientation and to enable and encourage them to adapt more quickly to developments in demand? What are the lessons to be learned from countries and systems where management by objectives has been introduced?*
- *Both through EU-programmes and through national and regional initiatives, there are a number of experiences with programmes that seek to strengthen public-private partnerships with education and training institutions as central actors. What are the lessons learned from these programmes in terms of contributing to innovation? Should there be a more widespread introduction of incentives for education systems, institutions, and programmes, for establishing strategic partnerships with sectors or key businesses? Are there particular issues to consider in moving from pilot projects to full stage implementation of such incentives?*
- *Can top-down policy measures do more to encourage education institutions to identify and place themselves as key partners for regional competitiveness and innovation, or should such developments be driven by market demands?*

Upgrading the role of non-university education and training institutions for innovation

Higher education has been more centrally placed in the debate about innovation and education than other types of education and training. While there are occasional references to Canadian and US Community Colleges in the literature on technology transfer, literature reviews find that vocational education and training colleges are rarely thought by policy makers to have a role in national innovation systems aside from providing the adequate skills to the workforce. Similarly, primary and secondary education is very rarely mentioned in connection with innovation.

The focus in higher education is understandable in light of the traditional role of R&D-led technological innovation and technology-oriented research in the debates on innovation and innovation systems. However, as argued in the previous section, much innovation and hence economic development is dependent less on original R&D-based discoveries and more on the timely take-up, modification, and marketing of knowledge solutions that already exist, but need to be adapted to local environments.

[71] CARMA & New Insight (2005b), "AMU i nye klæder", report for the Danish Ministry of Education.
[72] Copenhagen Economics and Inside Consulting (2004), "Regionernes konkurrenceevne", Copenhagen.

This has implications for the role of different education sectors and their role in innovation, and for the relevance of different types of policies and programmes. As Gibbons and also Lundvall and Borras argue,[73] non-elite universities and other non-university institutions may thus be better placed as actors in the innovation systems in relation to these types of innovation, because they have more experience in functioning as "brokers" in knowledge communities.

The broker function in knowledge communities may be taken up by education institutions in different ways, resulting in different forms of construction of knowledge across the traditional boundaries between the users and producers of skills and knowledge.

In its simplest form, firms may for example open up for short placement periods of staff from education institutions so that teachers and trainers acquire insights into the latest advances in for instance a particular material composition. The trainer, on the other hand, may help the firm with formalising working processes around this material through highly customised workplace training. In later stages, the education institution may use the knowledge acquired in its own innovation, taking on board the new insights not only in their professional training, but also for example in their apprentice programmes.

A recent study on the role of non-academic institutions in the regional innovation system includes several variations of this model of co-creation of knowledge, each uniquely adapted to the particular contexts.[74] In the evolution of the community college system in the United States as well as the development of the tertiary education system in Europe, similar tends can be observed. It is a characteristic across all settings that the education providers have a broader role than simply being a supplier of education and training.[75]

Another way to encourage the development of regional innovation systems has been to set up new institutions in the form of tertiary level polytechnics. It is characteristic that the mission statement of such polytechnics is to engage actively in the development of enterprises and to produce relevant new knowledge. They not only see themselves as having a role in providing education and training, they also define themselves as innovators and knowledge brokers, and the emphasis is on knowledge in action, not scientific knowledge per se. In Sweden there are multiple examples of how such tertiary institutions have had a central role in the transformation of regional economies. However similar examples can also be found in many other countries.

Polytechnics are expected to focus not only on your small and medium-sized enterprises or emerging industries, but also on traditional small and medium-sized enterprises which have not undertaken research and development on their own and do not have the capacity to do so on their own. Another role defined by governments for the polytechnics is typically the promotion

[73] Gibbons (2004), "Globalisation, innovation and socially robust knowledge", in King R. (ed.), *The University in the global age*. Houndsmills; Palgrave, Macmillan; Lundvall and Borras (2005), "Science, Technology, and Innovation Policy" in: Fagerberg et al. (2005), (ed.). *Oxford Handbook of Innovation*, Oxford University Press, Oxford.
[74] Danish Technological Institute (2006), *Uddannelsesinstitutioners samspil med erhvervslivet – fra uddannelsesudbyder til udviklingspartnere.*
[75] Rosenfeld S. A. (2000), "Community colleges, cluster connections competitiveness and specializations in the US and Europe", New York Columbia University teachers' college. *Economic Development Quarterly*, Vol. 14, No. 1, 51-62.

of regional development and the meeting of regional needs for higher education and a skilled workforce more generally. Examples of this can be found in Finland, Sweden, Germany, Austria, and the Netherlands. Education-based intermediaries also play a prominent role in industrial or regional clusters in the United States and Canada, with a focus on both traditional sectors such as wineries and more recently emerging sectors, such as the creative industries and biotechnology.[76]

- *Given that many firms, particularly SMEs, do not have the financial or human resources to engage with research institutions, should national innovation policies broaden their focus from radical scientific and technological breakthroughs to process-oriented, adaptive, and more incremental forms of innovation? If yes, would this imply a different role for education and training institutions?*
- *Should national innovation policies pay more attention to developing and strengthening the contribution of non-university education and training institutions?*
- *Is there a need for specific initiatives which encourage education and training institutions to take up a broader role as knowledge brokers in innovation systems, and are there lessons to be learned in this respect from previous programmes and initiatives?*

Rethinking the role of higher education institutions in innovation systems

Contemporary innovation processes are complex, involving many actors and sources for learning, and are increasingly conducted in multidisciplinary settings.

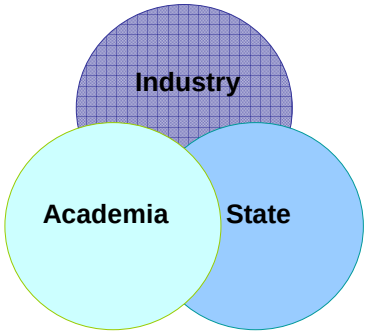
The 'Triple Helix model of innovation'[77] has been developed and formulated as a response to these understandings. The model denotes the university-industry-government relationship as one of relatively equal, yet interdependent, institutional spheres that overlap, collaborate, and cooperate, and as a tool it attempts to capture the multiple reciprocal relationships at different points in the process of knowledge capitalisation.[78] The model has governed regional economic policies in the cross-border Swedish-Danish Øresund Region, with joint public programme funding to that end.

Figure 6: The triple helix institutional relationship between industry, state, and academia

[76] Rosenfeld S. A. (2000), "Community colleges, cluster connections competitiveness and specializations in the US and Europe", New York Columbia University teachers' college. *Economic Development Quarterly*, Vol. 14, No. 1, 51-62.

[77] E.g. Leydesdorff, L & Etzkowitz, H (1998), "The Triple Helix as a model for Innovation Studies" In: *Science & Public Policy*, Vol. 25(3), 1998:195-203; Leydesdorff, L & Etzkowitz, H (2000), "The dynamics of innovation: from National Systems and 'Mode 2' to a Triple Helix of university-industry-government relations" In: *Research Policy*, vol. 29, 2000:109-123; Etzkowitz, H. (2002), "The Triple Helix of University-Industry-Government. Implications for Policy and Evaluation", Working Paper 2002:11, Stockholm: Science Policy Institute; Etzkowitz, H (2003), "Innovation in Innovation: The Triple Helix of University-Industry-Government Relations" Social Science Information, 42: 293-337

[78] As such, the Triple Helix is also a new institutional configuration to promote innovation. Instead of separate institutional spheres or bilateral relations, the relationship between university, industry, and government has expanded into a triadic relationship with converging institutional spheres, for the purpose of stimulating knowledge-based developments. Etzkowirtz (2002) argues that in countries where the interface is well underway, the triple helix is recognised as an empirical phenomenon – in the US it mainly occurs bottom-up through the interactions of individuals and organisations from different institutional spheres, and in Europe it mainly occurs top-down, encouraged by policy measures.



Source: Etzkowitz (2002)

The complexity of innovation processes necessitates that institutional setups be organised so that they that support linkages and interactions between the various relevant actors. At European level, it is generally recognised that European higher education systems have a huge potential for contributing to innovation, and that strengthening collaboration between industry and higher education is a basic requirement for innovation. According to a recent Commission document, one of the greatest current challenges to the realisation of this potential concerns 'traditional thinking': Higher education institutions have to accept that knowledge production is no longer an isolated and monopolised activity, and many European universities still underestimate the potential benefits of sharing knowledge with the business community and society at large. Also, industry has not yet developed sufficient absorption capacity to harness the potential of university-based research.[79]

To increase the contribution of higher education systems to innovation implies that universities share knowledge with society and reinforce the dialogue with all stakeholders. Partnerships between universities and the business community - from large corporations with their own R&D departments to SMEs - can improve the sharing of research results and enhance the impact of university-based education and research on regional innovation.

The following possibilities are particularly relevant for universities if they are to foster innovation through educational activities:[80]

- Increasing education institutions' understanding and awareness of SMEs and their particular business circumstances via more business cases, guest teachers from enterprises, and the introduction of state-of-the-art theory on management and development in SMEs.
- Effective dialog with the business community on future needs for competences and skills of graduates, for instance in the form of advisory boards.

[79] European Commission (2006c), Communication from the Commission to the Council and the European Parliament: "Delivering on the modernisation agenda for universities: Education, Research and Innovation". COM (2006) 208 final, 10.5.2006.
[80] Inside Consulting and Copenhagen Economies (2006), "Universiteter som regionale vækstmotorer". Copenhagen, RegLab, September .

- Development of university units which are to facilitate internships and project work in SMEs in particular.
- Adjustment of educational programmes so as to allow an increasing use of internships and enterprise-based project work
- Prioritisation of tailor-made continuing education offers, for example through specialised units which develop improved and adapted learning methods and design specific solutions to enterprises.

Commitment by university management to business orientation as well as an integrated strategy across research, education, and business collaboration, are preconditions for effective partnerships between university and regional business communities. Results are few where business collaboration is organised as independent activities new to education and research, and where the responsibility for implementing the business strategy is delegated to specific departments, as is still the case in many universities.

There are examples of higher education institutions that have taken initiatives to strengthen public-private collaboration so as to reposition themselves in regional innovation systems, thereby enhancing their contribution to innovation. Examples are particularly seen in higher professional education.

But attempts have also been made within traditional universities through new collaborative arrangements. The Stockholm School of Entrepreneurship (SSES)[81], for instance, is recognised as a leading academic facility in the area of innovation and entrepreneurship. The school unites the region's top academic institutions in medicine, technology, economics, and design, gathering its innovative and entrepreneurial competences under one roof in a joint education programme. Since its beginning in 1998, the partnership has grown ever stronger due to its solid foundation of collective expertise, diversity, international standing, and a commitment to provide cross-disciplinary studies in applied entrepreneurship.

Other prominent examples are Georgia Tech in Atlanta, USA, the research triangle in North Carolina, USA, Tampere University of Technology in Finland, and the University of Salford near Manchester. All these universities have developed unique relations to the business community, and each university is seen as having had a great influence on the relatively high growth levels in their surrounding region.[82]

The previous EU COMETT programme for university-industry partnership for training and technology transfer can in many ways be seen as a forerunner to some of the more recent efforts to facilitate industry-university collaboration.

[81] SSES was founded in July 1998 by the Royal Institute of Technology (KTH), the Stockholm School of Economics (SSE) and Karolinska Institutet (KI) to further develop a teaching syllabus to meet the demands of students and companies. See: http://www.sses.se/.

[82] Inside Consulting and Copenhagen Economies (2006), "Universiteter som regionale vækstmotorer", Copenhagen, RegLab September. According to this study, Georgia Tech is estimated to have the best programme for business collaboration and regional economic development among universities in the US. The University of Salford is known to be very business-oriented. It is branded as 'Enterprise University' and as such has undertaken significant organisation changes in order to enhance the university's contribution to regional competitiveness. Tampere University is also a pioneer when it comes to cooperation between universities and business. Since its foundation in 1965, it has been strong strongly committed to business applied science.

- *Is there a need for further policy initiatives to encourage new forms of cooperation between universities and higher education institutions and key business sectors?*
- *Is there a need to collect more evidence and knowledge of the perceived value added before introducing comprehensive changes?*

5. Education for Innovation

Knowledge and competences for innovation depend on the context and the kind of innovation at stake, and the contribution of education and training to innovation may be increased if education institutions continuously adapt to the specific regional and local innovation practices. It may be fruitful to increase the emphasis on "soft innovation skills" in programmes and practices, and to utilise experiences from entrepreneurship education.

If education and training systems are to increase their contribution to innovation, are there any specific skills and competences that they should address?

Knowledge and competences for innovation depends on context and forms of innovation

Competences associated with innovation and with being innovative are ill-defined and may be highly contextual in nature. One conclusion, based on the study of the role of skills in Korean economic transition, is that technical and specialised skills and competences need to be supplemented with competences for creative and critical thinking. A solid theoretical understanding of the subject area in question is also found to be a prerequisite for effective problem solving - creativity and problem solving takes place against a background of knowledge.[83]

Analyses of innovation behaviours at the enterprise level show that there is a vast array of different styles and approaches, which makes it difficult to generalise about the skills and organisational forms that are most conducive to innovation.[84] Two very different but both highly effective approaches to innovation illustrate this.

- The "radical creativity" approach, mentioned earlier, emphasises that "wherever creativity goes – and by extension, wherever talent goes – innovation and economic growth are sure to follow".[85] At the core of the 'creative class' identified by Florida are scientists, engineers, architects, designers, educators, artists, musicians, and entertainers, "whose function is to create new ideas, new technology, or new content. Also included are the creative professions of business and finance, law, health care, and related fields, in which knowledge

[83] OECD and World Bank (2000), *Korea and the knowledge economy. Making the Transition* A study from 2006 confirms these findings with regard to the role of and requirements to skilled workers in enterprise based innovation (Shapiro 2006a, "The Innovative Skilled Worker", Copenhagen: Danish Ministry of Education

[84] Tether, Bruce, Andrea Mina, Davide Consoli and Dimitri Gagliardi (2005), "A Literature Review on Skills and Innovation. How Does Successful Innovation Impact on the Demand for Skills and How Do Skills Drive Innovation?", A CRIC Report for The Department of Trade and Industry, ESRC Centre for Research on Innovation and Competition, pp. 87 ff.

[85] Florida (2004), *The rise of the creative class: and how it's transforming work, leisure, community and everyday life.* . Perseus Books Group.

workers engage in complex problem solving that involves a great deal of independent judgement".

- The 'technology fusion' or 'convergence' approach is a very different but equally recent view on innovation based on incremental accumulation, and is largely the province of highly co-ordinated innovation processes led by giant (Japanese, Korean, and US) firms.[86] Technological fusion blends incremental technical improvements from several previously separate fields of technology to create products that revolutionise markets".[87] Past examples of areas of technological fusion are optoelectronics and mechatronics. New forms of fusion, or convergence, are now being found in the future of cinema which unites film, computing, and computer games.

These approaches to innovation have different implications for the types and mixes of knowledge and competences that are seen to be conducive to innovation. Technology fusion emphases cross-domain knowledge and intelligence-gathering on a basis of deep and specialised domain knowledge. Here, it is important is to integrate knowledge - technical and scientific knowledge in particular - across disciplines. Examples of such an approach to education and training can be found in post-grad programmes offered by Stanford University to address the human capital needs in new growth sectors. In contrast, the radical creativity approach implies that competences such as creative thinking and capacities for advanced problem solving are essential for innovation, and that a range of different domains of knowledge – both technical and non-technical – can be the basis for creativity and problem solving to foster innovation. Such programmes are for example offered by New York University to address the needs for new types of skills for the creative industries, both for entrepreneurs and employees.

Parallel to this, there is evidence that approaches to innovation vary from sector to sector, with direct implications for the types and mixes of knowledge and competences that are likely to be conducive to innovation. A study by Cathy Stasz (1990) carried out on the notion of service skills across different sectors of economic activity provides valuable insights in the contextual nature of skills. Other studies have found that:

- When asked to identify their main "innovation orientation", manufacturers tend to point to new products and new production processes, while rather few point to organisational changes. Amongst service firms, most point to organisational changes as their main "innovation orientation", and fewer to new products and production processes.
- In terms of their perceived 'strengths at innovation', services with an organisational orientation to innovation placed greater emphasis on the skills of their workforces and their collaboration practices within and beyond the supply chain than manufacturers. Manufacturers placed more emphasis on R&D / technical advances and production efficiency as their strengths at innovation.[88]

These findings underline that services tend to emphasise the 'soft-side' of innovation, in which people and practices are brought to the forefront and where competences such as communica-

[86] Kodama (1992), "Technology Fusion and the New R&D", *Harvard Business Review*. July.

[88] Tether, B. S. (2005), 'Do Services Innovate (Differently)?: Insights from the European Innobarometer Survey', Industry and Innovation, 12.2, pp. 153-184.

tion, teamwork, and problem solving, are more important than 'technology', particularly in the form of technically-advanced hardware. Moreover, innovation in services tends to be more continual than ad-hoc, and continuous learning and adaptation seems to be central. However, as the distinction between industry and service sectors becomes more blurred, so do previous demarcation lines between different skills sets. Reforms to meet these converging demands are seen across many education systems in the curriculum offer, but also more broadly speaking for example in new areas such as music industry and ICT.

Nevertheless different types of knowledge and competences are still central to different types of innovation and for innovation in different contexts. Rather than to increase the supply of certain competences that are seen to stimulate innovation regardless of the context, the challenge for education and training institutions is to adapt to the innovation practices that are predominant in the specific regional or local context and to stimulate innovation by supplying competences and knowledge that are required at the forefront of these practices.

Engaging with stakeholders can provide an outside-in view of practices within the specific environments conducive to innovation, and can thereby help institutions to adapt to the surrounding context. Collaboration with stakeholders can also assist in anticipating coming trends and needs for competences by for example obtaining knowledge of the predominant and upcoming innovation practices and activities in the given setting. Research has shown that (higher) education institutions can become important vehicles and drivers for regional growth and development through systematic stakeholder involvement.[89] Thus, a feedback loop is created between the supply and demand for competences.

- *Is there a need to generate and make available more knowledge to education and training institutions about the innovation practices of the local and regional market they supply?*
- *Could more be done to encourage a rapid adaptation of education and training to the specific regional and local innovation practices?*
- *Should more be done to encourage systematic stakeholder involvement and continuous cooperation and dialogue processes between education institutions and their stakeholders?*

Emphasising "soft innovation skills" and utilising experiences from entrepreneurship education

Even if innovation practices differ from context to context, there is a case to be made for increasing the general emphasis in education and training programmes on "soft innovation skills" such as creative capacities, problem solving, communication, and teamworking. Such competences are increasingly required not only in working life, but also in active and critical citizens and consumers. Furthermore, shifts in employment, with service accounting for an increasing proportion of employment growth, could argue for a stronger focus on development of soft skills through education and training measures.[90]

In increasing the general emphasis on "soft innovation skills" in education and training, decision makers and practitioners in education and training institutions may look to experiences from entrepreneurship education as a source of inspiration. Stimulating entrepreneurship and

[89] Inside Consulting and Copenhagen Economics (2006), "Universiteter som regionale vækstmotorer", Copenhagen, RegLab September.
[90] Danish Technological Institute (2007), "Restructuring in Europe – Anticipation of Negative Labour Market Effects", Study carried out for the European Commission, DG Employment and Social Affairs.

strengthening entrepreneurship education has been a prioritised activity within the framework of the Lisbon Strategy,[91] and entrepreneurship has in this connection been defined broadly as;

> "(…) an individual's ability to turn ideas into action. It includes creativity, innovation and risk taking, as well as the ability to plan and manage projects in order to achieve objectives. This supports everyone in day-to-day life at home and in society, makes employees more aware of the context of their work and better able to seize opportunities, and provides a foundation for entrepreneurs establishing a social or commercial activity".[92]

A number of activities have been launched across the EU in recent years in support of entrepreneurship education.[93] While most of these activities aim specifically at stimulating the willingness of young people to establish their own enterprises, some activities and initiatives include a specific focus on one or more "soft innovation skills". Some of the more interesting examples are Young Foresight (UK), *Sinnalbixen* (Sweden), and Young Enterprise (Denmark)..

- *Should governments and education sector institutions increase their emphasis on the role of "soft innovation skills" (creative capacities, problem solving, communication, team-working) in a broad range of education and training programmes?*
- *Given that the innovation discourse is relatively new to educational policy, is there a need to systematically collect evidence about the experiences with the teaching and training of "soft innovation skills"?*
- *Should an attempt be made to collect relevant evidence from entrepreneurship education programmes and initiatives in this respect?*

Teaching and learning that stimulate and underpin the capacity for innovation

There is broad agreement that the innovation capacity of an individual is based on a number of skills, attributes, and values, but also on the organisational context within which these skills come into play. These include high performance levels in terms of: planning, organising, and communicating - both face to face and through the usage of ICT; working independently as well as in teams - both as leader and as partner, and; generating new ideas using lateral thinking based on a deep knowledge of a subject or field of inquiry (Rychen, S. & Salganik, L. H. 2003). Such abilities and qualities are underpinned by personal attributes reflecting such values as loyalty, commitment to both task and others, well-being, integrity, and enthusiasm.[94]

Research literature on innovation in education underpins that novel pedagogical approaches are central because innovation capability requires learners to be actively involved in processes of

[91]European Commission (2006a), Communication from the Commission, "Implementing the Community Lisbon Programme: Fostering entrepreneurial mindsets through education and learning", COM(2006) 33 final, 13.2.2006
[92]European Commission (2005c), Commission proposal for a "Recommendation of the European Parliament and of the Council on Key Competences for Lifelong Learning", COM (2005)548 final, 2005/0221(COD).
[93]European Commission (2006a), Communication from the Commission, ""Implementing the Community Lisbon Programme: Fostering entrepreneurial mindsets through education and learning", COM (2006) 33 final, 13.2.2006.
[94] Cumming and Owen (2001), *Reforming Schools through Innovative Teaching.* Canberra: Australian College of Education and the Enterprise and Career Education Foundation.

reflection and interpretation.[95] This is supported by empirical findings through action research in actual classrooms and authentic learning contexts.[96] The terminology "active learning" implies learning practices "that involve students in doing things and thinking about the things they are doing"[97].

This poses significant challenges to 'traditional' views of education since it assumes:

- That there can be no clear distinctions between thinking, learning, problem solving, and remembering. All of these are interactively engaged in the construction of understanding (making sense) – i.e. learning.[98]
- *All* learning is situated. This places a strong emphasis on how learning situations are constructed and the quality of *problem spaces* in any activity.
- That knowledge cannot be 'transmitted' from the teacher to the students, e.g. by direct instruction. This calls for novel teaching approaches where the teacher takes on the role as organiser, facilitator, counsellor, and supervisor, of and in learning processes.

With rapid social change, increased demands for higher order reasoning and creative problem solving to deal with increasingly novel and complex situations, and abilities to adapt and modify knowledge for transfer to other contexts and situations, all become preconditions to employability. Thus, direct instruction as the key learning space becomes less valid.[99]

Thus, education for innovation requires learning and teaching approaches and strategies based on the belief that students gain knowledge through exploration and active learning. Hands-on tasks and materials are used extensively, and students are encouraged to think and explain their reasoning as an important component of the learning process. Education is centered on themes and concepts and the connections between them, rather than on isolated pieces of information and facts. Teachers also rely heavily on open-ended questions and promote extensive dialogue among students. Self-assessment, supported by teachers, becomes part of the learning process so that students play a larger role in judging their own progress.

In classroom settings, the effective learning process can be simulated by problem-based learning situations. The student is presented with a specific construction of the world, for example using a textual description, and the dynamics of the world is shown to lead to a contradiction or

[95] This is especially highlighted by social constructivists. The social constructivist view of learning asserts that students construct their own individual knowledge as they involve themselves in processes of interpreting and understanding their learning experience. Learning takes place as a result of this cognitive processing and conceptual restructuring (e.g. Nuthall; 1997). There are a number of interrelated components in constructivist learning. Singer et al. identify four elements: active construction; situated cognition; community of learners; discourse (Singer et al. 2000).

96 For a review of the literature see Smith (2003), "Learning, teaching and Innovation. A review of literature on facilitating innovation in students, schools and teacher education with particular emphasis on mathematics, science and technology", Faculty of Education and Social Work, The University of Sydney.

[97] Bonwell, C, & Eison, J. (1991), "Active learning: Creating excitement in the classroom"; in *ASHE-ERIC Higher Education Report No. 1*, Washington, DC: George Washington University, p. 2

[98] See e.g. Tuomi, I (2004), "The Future of the European Knowledge Society", JRC-IPTS, IPTS Working Paper, 11 August.

[99] Shapiro (2006a), "The innovative skilled worker", Copenhagen: Danish Ministry of Education. Miller, Riel (2007), "Scenario guidelines Learning Spaces 2020", for IPTS- Sevilla

a problem that needs to be solved. Students may also collaborate in solving the problem, for example by taking different roles and presenting different interpretations of the situation.[100]

Effective collaborative learning

The content of any learning task is recognised as a crucial factor in effective learning.[101] It is the nature of the problem in the task that will determine not only the type of potential learning achievement, but even more so the potential for transfer from one context to another. The term 'authentic' is often used to denote that the task is situated in and of relevance to daily life experience. Authenticity is achieved by a task that engages the student in the thinking and communication with others about a particular subject or a theme combined with reflection about the task and the outcomes of the task. Research carried out in the 70s in Germany on adult learning found that the authenticity of learning tasks may be even more essential for lower socio-economic status students, and particularly for their academic achievement in subject-based literacy.[102]

Furthermore, the learning task should engage the learner in the most central concepts of the subject or field, not least to spur motivation. The argument here is that deep engagement with selected concepts and principles, taking time to understand the structure of the subject and be immersed in its discourse, is more central to effective learning than coverage, or 'getting through', the total content of a subject: less content actually fosters higher learning achievement. This has implications for curriculum and syllabus development, and challenges traditional ways of thinking about the content of syllabi, teachers' work, student work load, and assessment.

According to Wenger, learning is not only social, but is also a process of transformation of the role and participation of the learner within a community of practice, gradually moving from being a novice to an expert within a subject or a field of professional practice. Bransford, Brown and Cocking (1999) describe expert learners as:

- noticing features and meaningful patterns
- acquiring a deep understanding of the subject matter in a manner that is organised
- perceiving knowledge as contextual and conditional in its application
- being able to retrieve important aspects of their knowledge with little effort and
- being flexible in their approaches to new situations.[103]

'Expertness' is progressively learned as each learner becomes increasingly proficient in the characteristics described above. Despite current rhetoric about project and collaborative learning, group work does not necessarily result in effective learning, particularly for low achievers (Technological Institute 2005). More important is the manner in which the students work to-

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[100] Tuomi, I (2005), "The Future of Learning in the Knowledge Society: Disruptive Changes for Europe by 2020", Background paper prepared for DG JRC/IPTS and DG EAC, 17 October 2005

[101] E.g. Illeris, Knud, ed., (2004), *Læring i Arbejdslivet.* Roskilde Universitetsforlag; Negt, O. (1975), *Sociologisk fantasi og eksemplarisk indlæring*. Roskilde Universitetscenter. Wenger Etienne (1998), *Communities of practice- Learning, meaning, and identity*, Cambridge University Press..

[102] Negt, Oscar (1975), *Sociologisk fantasi og eksemplarisk indlæring*. Roskilde Universitetscenter.

[103] Bransford, Brown and Cocking (1999), "How people learn: Mind, brain, experience, and school", Washington: National Academy.

gether and the type of thinking and talking that is occurring.

Processing and debriefing, as employed in project-based teams, is a central element in the engagement of learners in learning tasks and in the use of language. This provides opportunities for learners to talk about the task, the manner in which they engaged with the task, and the results or outcomes of their work, and is central to reflective learning. Such a process provides a window for the teacher to grasp the learner's understanding of ideas and concepts embedded in the task and the accuracy of the learner's construction of knowledge. Furthermore, it fosters the verbalising of ideas between the learners and between the learners and the teacher. It is also an opportunity for learners to demonstrate their understanding of the meta-cognitive skills.[104]

In order for the type of collaborative learning and social processes outlined above to be implemented successfully, learners must be prepared to abide by certain rules and principles.[105] These include those that are well recognised in studies underpinning collaborative learning, such as consideration for and co-operation with others, being prepared to listen to one another and provide opportunities for others to talk and participate, being willing to compromise and accept other points of view and ideas, and being willing to work as a team sharing elements of the task and responsibilities.

Findings from newer research on learning suggest that effective learning is based on a deep understanding of and engagement with core concepts and principles of the subject in order to achieve higher order learning and generic skills and capabilities associated with innovation.[106]

- *Is there a need for education institutions and education practitioners to consider changes in predominant existing approaches to teaching and learning?*
- *Are their particular policy measures to be considered within the different educational sectors, given the variety in life trajectories in any given group of learners?*

From imparting knowledge to transferable competences

Novel understandings of teaching and learning illustrate a general shift in curricula thinking to a focus on competences or learning outcomes rather than on input. With the concept of learning outcomes, the notion of competences has evolved to include soft innovation skills such as problem solving, creative capacities, communication, and teamworking. Policy measures at European level reinforce these developments through for example the development of a European Qualifications Framework and the development of common European principles for validation of non-formal and informal learning. At Member State level, there is also substantial activity in

[104] Lave, J. (1991), *Situated Learning: Legitimate Peripheral Participation (Learning in Doing: Social, Cognitive & Computational Perspectives)*, Cambridge University Press**.** Tuomi, Ilkka (2004), "Economic Productivity in the Knowledge Society: A Critical Review of Productivity Theory and the Impacts of ICT", *First Monday*, volume 9, number 7 (July).

[105] Nuthall, G (1997), "Understanding student thinking and learning in the classroom", In B. Briddle, T. Good & I. Goodson (eds), International Handbook of Teachers and Teaching. volume 2. Amsterdam: Kluwer, 681–768 Illeris, K, ed., (2004), *Læring i Arbejdslivet.* Roskilde Universitetsforlag.

[106] Smith (2003), "Learning, teaching and Innovation. A review of literature on facilitating innovation in students, schools and teacher education with particular emphasis on mathematics, science and technology", Faculty of Education and Social Work, The University of Sydney.

the reform of initial education curricula, reflecting a shift from imparting knowledge to developing transferable competences.[107]

This shift has also brought about an ongoing debate on what competences each young person should develop and possess. At European level, the European Parliament and the Council in December 2006 adopted a recommendation on a framework of key competences for lifelong learning, based on a Commission proposal from November 2005. The framework sets out the following eight key competences that young people should have developed to an appropriate level by the end of compulsory education and training:

1. Communication in the mother tongue;
2. Communication in foreign languages;
3. Mathematical competence and basic competences in science and technology;
4. Digital competence;
5. Learning to learn;
6. Interpersonal, intercultural, social, and civic competences;
7. Entrepreneurship;
8. Cultural expression.

Competences are defined as a combination of knowledge, skills, and attitudes, appropriate to the context. Many of the competences overlap and interlock: aspects essential to one domain will support competences in another. Competence in the fundamental basic skills of language, literacy, numeracy, and ICT, is an essential foundation for learning, and learning to learn supports all learning activities. There are a number of themes that are applied throughout the Framework: critical thinking, creativity, initiative-taking, problem solving, risk assessment, decision taking, and managing feelings constructively, all play a role in all eight key competences. These correspond greatly to the earlier mentioned 'soft innovation skills'. Moreover, digital competence includes creative innovation skills, i.e. an understanding of how ICT can support creativity and innovation, and entrepreneurship refers to an individual's ability to turn ideas into action and as such it also includes creativity and innovation.

- *Is there a need to further develop the understanding of consequences for curriculum design if experimental, problem-based learning principles are to be followed and if the focus on transferable competences is to be maintained and strengthened?*

Taking into account the heterogeneous characteristics of learner groups

As previously discussed, the individual's innovation capacity is based on high performance levels in terms of planning, organising, and communicating, and learning approaches that stimulate these are based on students' active involvement in processes of reflection and interpretation. Furthermore, the application of such learning approaches supports the more widely held view that ‘learning to learn’ is one of the most central competences for young people to develop if they are to be equipped for adult life in a modern knowledge society.

This being said, it is it should not be neglected that such a notion of learning puts great demands on students in terms of being effective self-regulators, independent, and self-

[107] European Commission (2005c), “Proposal for a Recommendation of the European Parliament and of the Council on key competences for lifelong learning”, COM (2005) 548 final. 10.11.2005.

disciplined, and that students' abilities to successfully cope with such an environment in that sense may be socially biased.

Studies have shown that if the student does not understand with clarity the procedures that successful engagement in the tasks require, and if teachers' expectations are unclear, the cognitive load[108] on the student increases, with the possibility of loss of attention and focus. This is equally the case when it comes to the ambiguity of tasks. The more ambiguity in the task defined the greater the cognitive load, which may result in a less efficient learning process. In other words, demands on students' cognitive capacity can easily be too high for certain learner groups, and thus there is a risk that some students will fall behind if such factors not be taken explicitly into account.

Efficient learning in this paradigm is dependent on the self-perception and self-efficacy of the learner. This is determined in part by previous learning success and the number of learning activities and contexts in which the learner feels confident in being successful. This seems to impact both motivation and achievement.[109]

Hence, this approach contains the risks of excluding those students who cannot fully live up the implied requirements and prerequisites.

For example, a major study on drop-out rates in upper secondary education found that students with low self-esteem and self-perceived efficacy are less likely to be effective self-regulators and more likely to demonstrate self-handicapping and avoidance strategies.[110] These findings are central to the role of the teacher and to the content of the tasks, but are also central in terms of creating opportunities for low achievers to acquire skills perceived to be essential to innovation.

Policy measures taken to create more open learning outcome-based systems need to face these challenges in order to design efficient and equitable education systems for increasingly diverse student populations who are expected to possess innovation skills as a precondition to employability and active civic participation.

Questions on efficient learning practices and learning for innovation are complex. To guide evidence-based policy making, Europe needs to find ways to begin to analyse and develop indicators on the impact and value of different types of - novel or existing - learning practices, also taking into account the heterogeneous character of learner groups and the multitude of factors that affect learning processes and outcomes.

Does a wider application of novel approaches to learning threaten to increase marginalisation of groups of learners with low self-esteem, low self-perceived efficacy, and a low capacity for self-regulation? If yes, what could and should be done to counter this threat?

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[108] Cognitive load may be defined as the total of the different and conflicting demands placed on a student's attention and involvement in any learning activity.

[109] Walker & Debus (2002), 'Educational Psychology: Advances in learning, cognition and motivation.' *Change: Transformations in Education*. 5 (1), 1–25. Shapiro H. (2006a). "The innovative skilled worker" . Copenhagen: Danish Ministry of Education.

[110] Shapiro et al. (2006b), "God Praksis for fastholdelse I Erhvervsudannelserne". Undervisningsministeriets publikationsserie Copenhagen.

The potential role of information and communication technologies in effective learning

Do information and communication technologies open up new possibilities for effective learning that may lead to stronger innovative capacities among pupils and students, and what is the evidence so far? Information technologies can affect knowledge creation and learning processes in a number of different ways.[111] For a start, the mere capacity to gather and create information was transformed by the widening use of information and communication technologies (ICTs).

Second, ICT reduces the need for physical proximity in many cognitive activities (e.g. distance learning, distance experimentation). Access from a distance not only to writing but also to other modes of expression of knowledge (especially gestures and words) can potentially revolutionise the creation of new learning environments.. It is true that many activities cannot be coordinated by virtual means alone. The emulation and spontaneity generated through physical presence and social groupings remain crucial in many contexts, and physical presence can enable other forms of sensory perception than those mediated through electronic interaction. However, the influence of distance is waning now that the technological capacity is available and improved interface design makes virtual communication more ubiquitous for purposes of knowledge-sharing, remote access and teamwork, and organising and coordinating tasks over wide areas.

Third, ICT enhances possibilities for creative interaction, not only among scholars and scientists, but for example among product designers, suppliers, and end customers, and among students and teachers in real or virtual classroom settings. For instance, the creation of virtual objects that can be modified ad infinitum and are instantly accessible to one and all, can facilitate collective work and learning and dramatically increase the speed of prototyping. Problem-based learning in the classroom can thus be enhanced by computer supported immersive environments where the learner can effectively learn-by-experiencing and look for solutions to problems by collaborating with others and/or by applying different approaches to a problem. Previous framework programmes - telematics for education and the Virtual University - contain numerous innovative examples of the application of ICT for different learning contexts, many of which are so promising that they could be scaled with relatively little investment and most likely result in major innovations in learning environments. New skills such as collaboration strategies can also be learned via computer games. Computer-based simulations are already used extensively in organisational settings, for instance, in design, facilitating "what-if" analyses. As simulation tools become complex and less expensive, they can be used in learning settings ranging from real-life problem solving to primary education.[112]

Fourth, the ways in which information technologies affect knowledge creation can be combined in the development of large-scale decentralised systems for data gathering and calculation and the sharing of findings. Such systems characterise research currently underway in the fields of astronomy and oceanography, and would also seem to offer rich opportunities in the context of learning processes. Finally, ICT provides powerful opportunities for collective actions – i.e. the sharing of "rich" messages among a very large number of people – allowing for the creation and expansion of virtual communities, a possibility which may also offer pedagogic potentials.

[111] OECD (2004), "Innovation in the knowledge economy. Implications for education and training". Paris, pp. 55-56.

[112] European Commission (2005b). "The future of ICT and learning in the knowledge society". Report on Joint DG JRC – DG EAC Workshop held in Seville, 20-21 October 2005.

Unfortunately, there is evidence suggesting that education systems have so far been slow to respond to the opportunities and challenges offered by new technologies. Judging from the English experience, conventional "improvement" strategies have limited potential, especially if the aim is to transform the ways in which students think and to create not just "higher", but "different" outcomes. Most schools are worryingly similar in their structures and methods to those created in the industrial revolution.[113]

New technologies do not alone bring about transformation. A more promising resource for innovators and source of inspiration may be the new modes of operation in the most impressive of today's workplaces. A recent analysis defined a vision of ICT-enabled "learning spaces"(IPTS 2007- forthcoming). The vision of "learning spaces" is an attempt at defining a learning setting which takes into account not only the existing knowledge on effective learning practices but also the existing and future possibilities offered by ICT. "Learning spaces" are characterised by among other things the following:

- Learning spaces are connecting and social spaces: Since learning is a social process, it needs to bring different actors together to share learning experiences. Learning spaces are both physical and virtual spaces.
- Learning spaces are personal digital spaces: Every learner should have a personal, digital learning space where all learning material is accessible; anywhere, anytime, anyway (multiple devices and media). This personal space would allow the learner to navigate the learning process in a non-linear manner.
- Learning spaces are pleasant and emotional spaces: ICTs could make learning content more attractive (media-rich virtual environments) and learning more emotional (by connecting people), and transform the learning process into a pleasant and emotional experience. Many existing learning settings do not invite people to learn.
- Learning spaces are creative/flexible spaces: Learning spaces should be creative spaces, rather than focusing exclusively on reproducing knowledge. Learning spaces would also need to be flexible in combining different learning modes and learning styles, depending on the learning object, the learner, the teacher, and the environment.
- Learning spaces are open spaces with room for reflection: Future learning spaces would need to be open and module-based, enabling people to plug-in again whenever they can. Future learning should enable reflection. It should give people the chance to develop the necessary cognitive and affective capabilities to think and reflect upon their own lives and upon living in the modern world.
- Learning spaces as knowledge management systems: Learning spaces could become informal platforms for organisational knowledge management. This could also involve people more closely in human resource management as it helps to put the right person in the right place at the right time.[114]

- *Should more be done to facilitate the integration of ICT in learning practices and educational programmes so as to strengthen approaches for effective learning and the development of "soft" innovation skills?*

[113] Hargreaves, D. (2004), Policy for Educational Innovation in the Knowledge-driven Economy", working paper for the OECD project *Innovation in the knowledge economy. Implications for education and training*.
[114] See Learning Spaces 2020- In press Technological Institute in collaboration with Dr Riel Miller for Institute for Prosspective studies

- *What types of measures are needed so that policy makers and practitioners can draw more results from the framework programme on ICT applications?*

Even with a wider use of ICT, teachers are still central to effective teaching and learning.

The role of teachers and learning communities among teachers

A number of available case studies on innovative practices - particularly from Australia - emphasise the role of teachers as those providing extra value in learning situations.

As mentioned, novel learning theories emphasise the role of the teacher more as a planner and organiser of learning tasks, processes, and contexts, scaffolding learning to facilitate the learner's gradual self-management of and responsibility for learning, rather than the more traditional role of teacher as both transmitter and controller. This implies teaching practices that are very different to those being currently used by many teachers across educational sectors.

A study by Cumming and Owen[115] on innovative teaching concludes that quality teaching is a highly complex, demanding, and interactive process. Based on case studies, they find that highly innovative educators[116] exhibit personal attributes such as creativity and demonstrate advanced skills in a number of areas with a vast repertoire of teaching strategies including applied learning, enabling students to make 'connections' between key learning areas and engaging any student at a particular stage in his/her intellectual or social development.

More significantly, however, is the extent to which these teachers are able to facilitate innovation and change, especially through the focusing of disparate energies and the development of teamwork for whole-school and other projects. Besides skills and knowledge, these teachers display values described as synonymous with being a true professional. These include a total commitment to those they teach, a willingness to share their knowledge, skills and strategies with others, and an insatiable desire to improve their own practice and 'reinvent' themselves in response to new demands, challenges, and opportunities.

A case study by Mitchell[117] moreover shows that innovation in education and training can occur without teachers being trained as innovators. Motivation for change, leadership supporting change, and the creation of incentives to experiment, seem to be key factors as well, in addition to - most importantly - teachers' thorough knowledge of the discipline(s) they teach.

The implication for policy making is that "creativity programmes" for teachers are insufficient in themselves. The study also confirms the role that learning communities among teachers can play as a tool for innovation in learning practices. Learning communities enable the sharing of ideas, successes, and failures.

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[115] Cunning, J & Owen, C (2001), "Reforming Schools through Innovative Teaching". Canberra: Australian College of Education and the Enterprise and Career Education Foundation

[116] The teachers involved are described as doing extraordinary things in creative ways while managing to sustain their level of innovativeness.

[117] Mitchell, J; Clayton, B; Hedberg, J; Paine, N. (2003), *Emerging Futures – Innovation in Teaching and Learning in VET*. Australian National Training Authority,.

Moreover, attention should also be directed towards key stakeholders from business, community organisations, education systems, and teacher training institutions, as resources that can support innovative teaching and support the establishment of learning communities. Findings from the OECD/CERI project- *Futures of Schooling*, seem to confirm this.

In many educational fields we currently see a tendency towards curriculum crowding as a response to cover new and emerging topics as they evolve. The principles of constructivism indicate that such an approach is likely to fail. How can systems on one hand be responsive to new developments and on the other hand develop sufficient insights in a given discipline and its tools and methods, given the dynamics in knowledge creation? This is one of the topics that needs to be addressed in future educational research.

- *Is there a need for education programmes to include a focus on "soft innovation skills" and learning practices that facilitate innovation as a horizontal priority, rather than thinking of innovation as yet another subject in an already crowded curriculum?*
- *Is there a need for further understanding the implications for requirements to teachers' qualifications of novel effective learning approaches?*

6. A culture of creativity and innovation in education and training

Do predominant organisational cultures and predominant thinking concerning success criteria of education and training systems stand in the way of the systems' ability to foster innovation? If education and training is to lead to stronger capacities for innovation among students and pupils, the systems themselves need to become more innovative and development-oriented. A sustained effort to manage such change is required if it is to be successful.

How can approaches to and practices of learning be developed so as to increase the contribution of education and training systems to innovation?

The need for innovative and development-oriented systems of education and training

The successful application of learning for innovation and the procurement of novel learning outcomes that support the individual's innovation capabilities are dependent on various factors. One of them concerns the systemic level, i.e. education systems and institutions. Learning for innovation in education is situated in a wider context of structures, norms, and policies. New praxis requirements are more likely to be successful if they are in accordance with predominant thinking at the level of education systems and institutions, or if they are reflected in systemically planned pilots that are closely monitored and evaluated so as to generate learning and evidence for wider implementation.. Questions in this connection are

- whether predominant thinking and predominant success criteria for education systems are today sufficiently oriented towards learning and educating for innovation;
- whether predominant thinking and system success criteria are sufficiently supportive of the development of a culture of creativity, and;

- whether national education systems are sufficiently geared to use European education and training programmes in a more structural way as a means for creating large scale pilots which can be the basis for evidence-based system reform.[118]

Transformation of professional and institutional norms in education will not occur spontaneously: it must be engineered by imaginative and courageous policy makers. Just as governments and policy makers can support the preconditions for a creative environment for business and organisations, so can they facilitate developments in education and training systems to this end.

Yet a pure top-down approach is unlikely to work. For education and training systems to develop, governments and education policy makers need to provide the necessary framework conditions and crucial impetus in the form of objectives, motivations, and incentives, and at the same time they need to involve and engage education practitioners actively in development processes and to make use of their knowledge and practical experiences.

The education community in general and schools in particular need to acquire a certain mindset that allows them to be innovators. This requires them to build, identify, and mobilise intellectual capital - knowledge and understanding of what works, drawn from throughout the educational community. The key is to *leverage* such knowledge to ensure that it is applied to change.[119] The introduction of ICT in schools provides a good illustration of how the availability of new methods and tools has only a rather limited effect on teaching and learning unless this is also accompanied by organisational capital in the form of a deeper understanding of the transformational implications of these tools.

By working as communities, schools and education institutions can move beyond individual "tinkering" by teachers and trainers (using trial and error in their methods) and yet not rely on top-down directives.[120]

- This requires both education institutions and teachers to become more accustomed to developing and transferring their ideas and knowledge.
- It also requires a mindset that has been missing from education systems - an ability to take risks and to "fail intelligently". To a great extent, this element of experimental innovation appears to be lacking at present, not just because individuals do not understand how to use educational experimentation in a systemic way as a means to build evidence to feed into policy: Political demands for success create strong pressures not to fail, and increasingly create stigma for doing so.[121]

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[118] See Maastrict study- chapter 2006 for a wider discussion of the use of The leonardo programme for system innovation

[119] Hargreaves, D. (2004), "Policy for Educational Innovation in the Knowledge-driven Economy", working paper for the OECD project Innovation in the knowledge economy. Implications for education and training.

[120] Cf. also European Commission (2007), "Schools for the 21st century", draft Consultation document, February 2007.

[121] Hargreaves, D. (2004), Policy for Educational Innovation in the Knowledge-driven Economy", working paper for the OECD project Innovation in the knowledge economy. Implications for education and training.

Managing change processes in education and training systems

In this light, education and training systems are faced with significant challenges in managing change. Institutional and systemic inertia and protectionism are likely to be obstacles.

However, if there is a pressure to change education and training systems' cultures and values as a precondition to enhancing the systems' abilities to better respond to the needs for innovation capabilities within society at large, then key insights from change management literature could be one of the sources to turn to. Key parameters in successful change management processes include:

1. Establishing a sense of urgency, convincing at least 75% of relevant decision makers and key actors that the status quo is more dangerous than the unknown.
2. Forming a powerful guiding coalition, i.e. assembling a group of key actors with shared commitment and enough power to lead the change effort.
3. Creating and communicating a vision for change. What is the overall objective of the change processes? If education and training practices are to be reformed considerably so as to enhance their ability to foster innovation, what are the precise elements of this objective? If education and training systems are themselves to become more innovative and represent a culture of creativity and innovation, how is this situation precisely defined?
4. Empowering relevant groups to act upon the vision for change. This step includes encouraging risk taking and non-traditional ideas, activities, and actions.
5. Planning for and creating short-term wins. The demonstration of some sort of success within a relatively short period of time is central to maintaining and building up momentum.
6. Consolidating improvements and producing more change. Use increased credibility from early wins to change systems, structures, and policies undermining the vision. Reinvigorate the change process with new projects and change agents.
7. Institutionalising new approaches. This involves articulating connections between new behaviours and systemic or organisational success.[122]

Education and training systems consist of multiple layers and a variety of organisations and institutions. A sustained transformation effort is likely to be needed in diverse contexts and with the involvement of a large number of different actors. Change management experience is one of the sources to turn to. In policy making, futures thinking and scenario methodologies have been widely applied to create out-of-the-box thinking concerning challenges and uncertainties ahead, particularly in technology policy making. The application of futures methods to education policy is a relatively new phenomenon for inducing a culture of innovation and change at all levels. Lessons from such initiatives can give important guidance to policy makers as more experience and evidence is obtained.. One of the more interesting large scale initiatives in this respect is the OECD/CERI work on *Futures of Schooling* and *Futures of Universities*, also involving countries from the EU Community.

[122] Kotter, John P. (1995), "Leading Change. Why Transformation Efforts Fail". *Harvard Business Review*, March-April. Downloadable at www.hbr.org.

- *Is there a need to establish a clear vision for education and training systems' role in innovative societies? Do we have sufficient evidence to formulate such a vision?*
- *Is there a need to introduce new types of methods to create more out-of-the-box thinking concerning purposes and directions of educational reforms, and could foresights and scenario building be a means to that end for European policy making?*
- *Is there a need to initiate strategic initiatives to encourage a wider culture of change in education and training systems in support of innovation, and if so who should be driving such initiatives?*

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