

24. Proposing measures to promote the education of creative and collaborative knowledge-builders ¹

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Abstract

In the knowledge economy created by the scientific and technological revolutions, growth correlates with innovation potential and hence creativity is becoming rate-limiting. Companies therefore need the most creative people, those able to take initiatives, and nations want to have a workforce able to create value and jobs, while taking on the challenges of the day. Today, parents realise that their offspring are growing up in a very different world from the one they knew as children; that not only will their children hold jobs that are different from theirs, but will have to change jobs repeatedly. These factors show the need to encourage creativity and develop initiative in children. Comparative analysis of education systems show that a huge diversity exists, interesting attempts are trialled locally but only in some countries does one see national debates on the issue allowing the emergence of new education paradigms that can foster creativity. In terms of policy, this paper proposes experimenting with new educational schemes, developing creative environments and programs, and disseminating the best educational practices within countries and across linguistic barriers by organising a network of well-designed experiments and information exchange that is accessible to all. Ten recommendations addressed to different stakeholders that want to promote creativity can be found below.

¹ This paper contains large extracts of a background paper prepared for the OECD Innovation Strategy. The views expressed herein are those of the author and do not necessarily reflect the official views of the OECD European Union or of the governments of their member countries.

Ten key recommendations to promote creativity in education

1. General recommendations

'You can't do it — it has never been done.' This sentence will stifle any creative effort from the outset. It is too often addressed to students, professors, or leaders who wish to promote change. In a future-oriented society, such a symbol of conservatism should no longer be an argument for deciding on the value of a project.

2. Recommendations for students

As students repeatedly said after disclosing their views on their own futures, 'the biggest barriers were in my head — self-censorship was my worst enemy.' Once students dare to be creative and take initiative, they should work hard and sometimes fight conservatism, pursuing their ideas and finding what Ken Robinson call 'their element.'

3. Recommendations for parents

Build a nurturing environment in which your children can build their creativity and believe in their potential. Help them to find schools and universities where they can blossom and prepare for a future in which so many things will have changed.

4. Recommendations for teachers

Be available for students when they need your feedback on their ideas. Create courses in which they can develop their own projects. Network with colleagues who have similar views about pedagogy, regardless of their discipline.

5. Recommendations for schools and deans

Encourage the creativity in your teachers and students, and provide them the means in terms of time, administrative help, and space to develop creative programs in which students can work on individual and collective projects. If these programs cannot be open to all initially, selection to enter them should be based on students' motivation to take initiative and will to interact with creative students and teachers.

6. Recommendations for universities

Encourage interdisciplinary approaches and the creation of academic programs that can allow students to launch projects and to develop their creativity. Create 'creative spaces' dedicated to the development of student projects open 24/7/365. These spaces should be organised as incubators for ideas and creative talents.

7. Recommendations for foundations

Foundations are the most flexible funding bodies, and often the most creative and reactive. As such, they can be the fastest to fund emerging creative programs and sup-

porting them in the early stages, the same way venture capitalists support emerging start-ups. They could even go one step further and help create incubators that host such creative projects.

8. Recommendations for governments

Be sure your country is among the most attractive for creative talents. Foster a culture of creativity by organising national debate on the subject. Sponsor publications and translations of books and TV programs dedicated to creativity. Create national programs to foster creativity in education. Organise national networks of interdisciplinary creative curricula and ensure their long-term funding.

9. Recommendations for international organisations

Compare national cultures of creativity and programs designed to foster creativity, trying to correlate them with other indicators available in various countries. Promote international debate on the best ways to foster creativity.

10. Recommendations for creative communities of knowledge builders

Develop websites, open source tools, and places dedicated to promote storing, exchange, and creation of ideas among creative and cooperative knowledge-builders by facilitating both online and real-world meetings, ideally in creative places dedicated to such exchange. In order to maximise their impact, such websites should be available to all creative minds and be part of open education resources ².

Introduction

Endogenous growth theory reveals that education, research, and innovation are rate-limiting for economic development. In their book 'Endogenous Growth Theory', Aghion and Howitt (1998) explain why nations should invest in education and research. Furthermore, investing in the development of creativity in education and in the work place can lead to further qualitative improvement, since those who work in creative knowledge are more able to face the challenges of a rapidly changing world. Whereas classical teaching leads to faster *dissemination* of knowledge in the workforce, teaching creativity speeds up the *accumulation* of knowledge, hence of innovation and economic growth.

The 'Matthew effect', a phenomenon according to which 'the rich get richer', also applies in academic settings, where it translates to 'the more you know, the more you can learn.' It is essential that all children be afforded an equal opportunity to become

² Their governance should be close to the one of Wikipedia, yet they would focus on creative knowledge building through cooperative interactions.

knowledge-builders, by acquiring the meta-skills that allow them to update their abilities and create new knowledge throughout their lives. A growing number of nations are trying to improve creativity, initiative, and risk-taking among their citizens. This article will discuss why such improvements are needed more than ever today, and why they can help us to devise policies that will bring about change in our education systems that will foster these qualities in the coming generations.

We live in a world that is changing at an unprecedented pace

The world is facing unprecedented simultaneous challenges today — multifaceted economic/financial, social, climatic, and environmental crises — for all of which we must find creative solutions. What is necessary on this large systemic world-scale is also needed at every level of our society that is undergoing change at such a pace. In fact, the rhythm of these changes appears to be accelerating. Obeying Moore's Law, according to which computing power doubles every year, information has been increasing at around 66 % per year, much faster than the growth of any material goods³. In his book, 'Science since Babylon,' Derek de Solla Price (1961) shows that scientific knowledge grew exponentially between 1700 and 1950, doubling every 15 years. Today, in some fields like computer science, a 15-year doubling-time is considered very slow, since hardware and software become obsolete much sooner.

How can policies help to promote creativity in education?

In a world that is changing at an unprecedented pace, what can education provide that will prepare today's children for the challenges of the 21st century? This paper introduces the forces that lead to rapid environmental change and the impact of a relative lag in educational reform. Adaptability and exploration are key to any species that lives in changing environments, where mechanisms generating innovations are being selected. These biological metaphors helps us to see why the importance of human creativity is growing as our environment change at an increasing pace thanks to the exponential development of science and information and communication technologies. However, education systems are evolving slower than the rest of society and traditional education is not optimally organised to promote creativity and the ability to update one's knowledge.

Hence, only the countries that implement policies to reform their education to promote adaptability and creativity in adults and children are likely to remain at the

³ <http://people.ischool.berkeley.edu/~%7Ehal/>

forefront of human development and technology. Lessons from the social sciences indicate that creativity, initiative, and risk-taking should be encouraged in training today's children to become creative and cooperative knowledge-builders, i.e. able to periodically update and productively use their knowledge in their social and professional lives. Considering that students optimally develop these skills only in fostering environments, as well as the inherent difficulty in assessing creativity in millions of individual children, this article proposes to focus the evaluation of creativity on the quality of the educational environment.

The limits of traditional education

The ever faster rate at which our environment is changing, the way natural systems adapt to rapid changes, and the lessons learned from social science studies of creativity, have been reviewed extensively in the full report prepared for OECD (Taddei 2009).

Here, we will briefly look at how policies could affect the ability of the next generations of children to adapt to such ever-increasing changes. It is clear that different OECD countries have different policies concerning the importance of adaptability and creativity in education. For historical reasons, countries either have a centralised system with a nationwide curriculum or one that allows educational policy to be conceived and implemented at the local level, and even at the individual classroom level if not tailored to the individual child. We will start with a brief historical perspective before describing different attempts that seem relevant for this topic.

Many authors, such as Ken Robinson, Anne Querrien, and Alvin Toffler (1974), argue that public education was designed to increase the skills and abilities of the new generations, while fulfilling the needs of developing industries. In addition to the official curriculum, which included the three 'Rs' (reading, writing, and arithmetic,) children who grew up in the countryside with much freedom, learned to remain silent and respect the authority of the teacher, to be on time, and to start and stop work at the same time as everybody else according to a fixed schedule cadenced by the ringing of a bell. The entire pedagogical system was teacher-centred, and little attention was paid to the specificities, needs, questions, motivation, talents, ability to take initiative, and creativity of the pupils.

The monitorial system as an early alternative

Interestingly, during the same period, both in the French and English-speaking worlds, an alternative strategy developed. This happened partly because the method described above required a number of teachers sufficient to oversee what students

learned, which would have been relatively expensive. The monitorial system, or *école mutuelle*, has been described by Anne Querien to lead to faster learning. According to Wikipedia, it was ...

... based on the abler pupils being used as 'helpers' to the teacher, passing on the information they had learned to other students. The Monitorial System was found very useful by 19th-century educators, as it proved to be a cheap way of making primary education more inclusive, thus making it possible to increase the average class size. The system is not entirely unlike the way professors, assistants and tutors work together in university education.

Introduced in Europe in 1795 by Andrew Bell, who had encountered the concept in India, this system proved efficient, with children learning the program as much as twice as fast. However, in France, the system was replaced in 1832 by a nationally standardised curriculum run by teachers who were trained in an *école normale* ('normal' school, in which they were trained to teach the 'norm' of knowledge). Teachers were subjected to 'inspection' by a national corps, with respect to their conformity to the imposed curriculum. Since that period, and until recently, equivalent models have dominated in most of the world. Although the benefits associated with different educational approaches are periodically rediscovered in various places (e.g. Tolstoi in Russia, and later Montessori in Italy, Freinet in France, Steiner in Germany, and Decroly in Belgium,) they have remained alternative models and not mainstream for decades in industrial societies. Sometimes mutual teaching seems to reappear independently.

Modern alternatives

In French-speaking countries, mutual teaching has recently become popular; some 800 local programs have developed what is called a 'network of reciprocal knowledge exchange', which assumes three principles:

- (a) everybody knows something
- (b) no one knows everything
- (c) from (a) and (b), we can see that everybody benefits by exchanging knowledge.

Interestingly, these pedagogical principles have been applied from primary school through Master's and PhD programs. For instance, one can observe that disfavoured children who failed in classical programs benefit from such an approach. They can gain self-confidence and rely on their ability to profit from knowledge acquisition

and exchange when they discover they have skills that others do not have. At the other end of the education spectrum, talented young scientists can learn to be creative, take risks, and question knowledge much more readily when they interact with their peers. In France, the pioneer *main à la pâte* (hands-on) program championed by physics Nobel Prize-winner Georges Charpak, allowing primary school children to discover science by experimenting, exploring, and debating, has been imitated in various countries.

Similarly, in Germany, interactions among students who learn by teaching (by being teachers themselves) are seen to facilitate foreign-language acquisition. This concurs with the ideas of Seneca, who during antiquity said that ‘by teaching we are learning’. The modern version of mutual teaching is much improved, compared to the 19th-century version, since now the teacher’s role is to supervise interactions among children within a well-structured framework. Students prepare by themselves at home and present their findings while interacting with each other. The initial peer interactions then undergo three more rounds consisting of individual work followed by deeper interaction.

In Italy, a most interesting experience seems to have resulted from a local initiative taken by parents in the city of Reggio Emilia after World War II. Since the inhabitants of that city wanted to promote education that would protect their children from fascism, and building on a tradition that included a role for the community in education, they developed innovative approaches to preschool and primary education. Even though this system has been now copied in many places, they refuse to call it a model, since one of its key aspects is that the creativity of teachers, and the capacity of that creativity to in turn foster creativity in children, be at the centre of their philosophy of not wanting to enforce a stereotyped curriculum. Parents play an active role in Reggio schools. Trust, at all levels, and among all the actors, is an essential component of their philosophy, which also includes an original approach to cooking, food-sharing, the school, and the environment. They consider the environment to be the ‘third teacher’ (after the parents and the human teachers,) which should be designed so as to foster new experiences, exploration, initiative, and creativity. Reggio-type schools have now been established in many countries, and the city of Reggio Emilia has founded a centre to disseminate research and exchange on such pedagogies.

In the Spanish-speaking world, the most notable example of a successful alternative education is the *Escuela Nueva*, which originated in rural Colombia, making that country the first in which rural children have better results than those in cities. This

program has attracted much attention from international organisations, foundations (such as the Clinton Global Initiative,) and local companies. It has spread to 11 countries and currently educates five million children. As *The Economist* described it,

Under Escuela Nueva, the teacher's role changes from lecturing students to guiding their comprehension. Everything that the children learn must be relevant to their family and community. Firms are enthusiastic about the approach of Escuela Nueva to education because, among other things, it promotes core 21st-century skills for contemporary enterprises, such as the ability to take the initiative and to work in groups.

The success of such initiatives show that with limited funding, well-designed programs can increase the quality of education and the ability to take initiatives, while maintaining a creative and open-minded attitude towards learning. However, in the countries mentioned above, systemic change has yet to become the subject of large public debate in a way that could lead to a systemic change.

Knowledge-building

Innovative methods of collaborative knowledge-building have been tested in 19 countries, based on theories developed in Canada by Marlene Scardamalia and Carl Bereiter (2003). According to them, this approach can have broad impact:

Knowledge-building has been shown to yield advantages in literacy, in 21st-century skills, in core-content knowledge, in the ability to learn from text, and in other abilities. However, it is a fact that knowledge-building involves students directly in creative and sustained work with ideas that makes it especially promising as the foundation for education in the knowledge age.

The main principle is that in knowledge-building, work involved in the creation and improvement of ideas can be a source of learning. Adult knowledge-workers produce knowledge, simultaneously learning and updating their skills. Scardamalia and Bereiter (2003, 2006) argue that although achievements may differ, the same process can occur from the first grade to the PhD and after in working life, and that the software platform they developed, *Knowledge Forum*, can be adapted to all age groups. While engaging in these activities, knowledge-builders not only learn the facts they need to move the frontiers of knowledge as they perceive them, but also the meta-skills that are required, such as the ability to cooperate, create, and take initiatives. The practices they describe as 'deep constructivism' increase many skills.

Overt practices, such as identifying problems of understanding, establishing, and refining goals based on progress, gathering information, theorising, designing experiments, answering questions and improving theories, building models, monitor-

ing and evaluating progress, and reporting are all directed by the participants themselves toward knowledge building goals.

Their approaches, followed on a larger scale in Hong-Kong, are summarised as follows (Scardamalia and Bereiter, 2006):

Traditionally, schools are dominated by the teacher-led chalk-and-talk approach. Most of the time, there may not be enough time for students to discuss in class because of the tight teaching schedule and arrangement. In these circumstances, Knowledge Forum can provide space for students to have discussions and to develop their independent and critical thinking. Through the discussion and mutual learning process, students are actually forming a knowledge-building community. And in this community, students have to produce, share, and advance the knowledge of the collective. In this case, the roles of students have changed from that of clients to that of participants and workers in the community. Hence, there is a shift from teacher-directed approach to more student-centred learning. It helps trace out students' own paths of constructing knowledge collaboratively with the teacher's guidance and monitoring.

The collaborative knowledge-building approach is very important to students, not only in the sense that it can help develop better thinking, analytical, enquiry, and problem-solving skills, but it also paves the way for students to develop their lifelong learning abilities and attitudes. This works in line with the recent curriculum reform advocated by the Education Commission report on lifelong learning towards the 21st-century in Hong Kong, which emphasises the importance of learning how to learn.

When creativity and evaluation enters the public debate

Many initiatives have blossomed over the years in English-speaking countries, where the debate on education is fuelled by many different contributions. The edutopia website (supported by Georges Lucas) reviews many of the most promising programs. There are also numerous books dedicated to the study of creativity in education. For instance, teachers can read 'Creativity in the Classroom, Schools of Curious Delight,' by Alane Jordan Starko (1995); 'Creativity in Education and Learning,' by Arthur Cropley (2001); and 'Teaching in the Knowledge Society,' by Handy Hargreaves(2003)⁴. The general public, including parents and students, can read 'The Element,' by Sir Ken Robinson and L. Aronica (2009), and policymakers, managers, and academics will find

⁴ In these books, teachers will learn to teach in ways they were not taught. This is not necessarily obvious and may be one of the reasons education systems lag behind the fast changes of today's society. Teachers must build a capacity for cooperation, updating of their practices, creativity, change, and risk, in order to develop similar behaviours in children.

much useful information in the 'Creative Workforce, How to Launch Young People into High-flying futures,' by Erica McWilliam (2008), which provides a clear description of the need to improve creative education in order to thrive in the digital age. In the meantime, in the US and many other places, a culture of systematic evaluation of children, teachers, schools, and local governments has developed. It is easy to understand the motivation for assessing the results of schools: to encourage the best practices and to better understand what to include in a 21st-century education. These evaluations, which are mostly based on multiple-choice tests, seem to have caused much 'collateral damage,' as described in a book by that title (Nichols and Berliner 2007). Well-designed assessment can allow children to make progress and to develop their abilities, if they regularly receive constructive feedback. However, many scholars have argued that formatted, high-stake assessments, such as those developed by the Bush administration's 'no child left behind' program can only drive everyone involved to do anything they can to 'achieve' in those tests. Perverse effects result, such as cramming, focusing on preparing only for the tests and not on learning, and even cheating at all levels, including by children, teachers, schools, district educational authorities, etc. As stated by a reviewer of this book, these effects are disastrous:

Collateral Damage: How High-Stakes Testing Corrupts America's Schools' powerfully details the destructive effects on education of high-stakes standardised testing. Authors Sharon Nichols and David Berliner construct their case around 'Campbell's Law,' named for researcher Donald Campbell:

... the more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it was intended to monitor. When standardised tests are used for graduation and promotion decisions, or required by state and federal school accountability, both education and the meaning of test scores are corrupted.

In northern Europe, a tradition of inquiry-based education has long been developed. In Denmark, for instance, children are evaluated not on rote learning of facts, but on their ability to express an original viewpoint on a subject that is debated at length in class. The Scandinavian countries happen to be leading in the international ranking, both for their results in education and in innovation. One can see their well-articulated policy, in which experiments in pedagogy are not just the results of individual or school initiatives, but where there is a national policy that promotes such behaviours.

Finland as proof that education systems can be changed

Finland is an interesting case to study, since it went from a country that was internationally rated as average in 1988 to number one in the PISA ranking in 2001. According to Pasi Sahlberg (2007), a leading education specialist who worked for the World Bank and the European Training Foundation, several key factors seem to have been at play:

- During phase 1, an epistemological groundwork was built from 1988 to 1995, the main focus of which was to try to answer the questions: 'What is knowledge?', 'What is learning?' Three complementary books published in Finnish helped teachers to understand first how the classical static conception of knowledge was inappropriate for the emerging knowledge society. The second book was dedicated to summarising research findings on education, teaching, and learning, and the third book built a bridge towards operational implications for teachers.
- Phase 2 began with educational reform that went from a centrally controlled national system prescribing and evaluating a given curriculum to a decentralised one with a national curriculum framework, which enabled building on the epistemological groundwork mentioned above. School curricula were then approved only locally, most often explicitly describing schools as creative places. Schools and teachers were invited to share their experiences in an open school improvement network, which all educators were invited to join, including those working outside schools, such as in scouting organisations and sports clubs. Teachers were required to earn Master's degrees and trained to experiment, basing their experiments on results obtained elsewhere. Former education inspectors, whose previous role was to ensure conformity to the curricula, became advisers, whose job was to help teachers develop creative curricula. Trust seems to have played a key role during this period. The government trusted the municipalities to manage the schools, the municipalities trusted the school boards, which in turn trusted teachers, who trusted the children (repeating is unheard of in Finland, and examinations are reserved for older children).

Probably not surprisingly, such broad reform was not without critics, yet, magically, most of them vanished overnight, when, in 2001, the first OECD PISA ranking was published. This ranking showed that Finland was doing best, not only in student achievement, which was already remarkable, but also in equity. Despite the fact that decisions are made locally, Finland is the country with the least variation in achievement among schools and in economic efficiency (school budgetary expenditure is comparable to that in other OECD countries). Interestingly, the Finns keep trying to

innovate and further improve. Salhberg, for instance, has a dream for education. As he stated in a conference:

My dream is not that one day every school will make adequate yearly progress, as measured by student achievement tests or anything similar. I have a dream that in the future, our schools, their students, and teachers can live in a culture of trust. I have a dream that one day our teachers can work in a spirit of responsibility rather than accountability. I have a dream that soon all our children will learn in truly enriching communities. School improvement has a key role to play in reaching out to this dream. At her murdered husband's funeral, Yoko Ono said: 'If you have a dream, it is just a dream, but if you share it with other people, it will become true.'

Following the Finnish philosopher, Pekka Himanen, Salhberg argues for 'enriching interactions' among students, between teachers and students, and among teachers. For him, schools should therefore enrich communities with creative and competent people developing a creative culture of learning. Enriching interactions should allow everyone to be enriched by the interaction, which presupposes a culture of respect, trust, and freedom.

Where do we go from here?

Main implications for measurement and policy

Assessing the environment

In closing, we will discuss the main implications for measurement and policy. Considering the current state of research, it is not clear whether a test that accurately measures initiative, risk-taking, and creativity in all their dimensions will ever be objectively and convincingly defined. Creativity is not measured easily, and even less so in millions of individuals. ('Thinking out of the box' by checking boxes, seems at least to be a daunting challenge, if not a logical trap.) Given the importance of assessment in promoting changes in educational practice, short of some magical software, one may have to assess other components of creativity and risk-taking. If one cannot easily assess students' creativity, can one assess their creative environments? This seems like an interesting question for future research. Indeed, since creativity requires the ability to think differently, social interactions can easily destroy creativity. Parents, teachers, peers, and more generally, society as a whole, can either promote such differences or destroy creativity in all but the most resilient creative thinkers.

Research in these areas is less developed than the research described above, which is aimed at assessing some aspects of individual creativity. At this early stage, at least two parallel approaches can be proposed: individual polling, and evaluating the general role of discourse in creativity, particularly discourse on education.

Using individual polls, it would be interesting to not only assess people's perceptions of their own creativity, but also the way they see creativity in others, and perhaps the way they think about other's reactions to creativity. The potential differences in the answers to such questions could help us to understand whether the forces that slow the process of creativity are more embedded within individuals or within society. To be more explicit, let us take a simple, concrete example: one could ask a teacher how he/she would react when a student gives an unusual answer or takes initiatives or risks. The teacher's answers could be compared with the answer he/she would give if asked how an average teacher colleague would react to the same situation. It would be interesting to compare such answers at different periods and in different countries. Would there be situations in which, on the average, people would declare that they would react more positively to a creative attitude expressed by a student than by one of their colleagues? If so, it would be interesting to investigate the possible reasons for such paradoxes, in order to determine how to change the collective dynamics and individuals' attitudes, in the aim of promoting creativity.

Evaluating the role of discourse in creativity in different countries could be an interesting measure of the environmental attitude towards creativity. Is it part of daily interaction, part of the school curriculum, part of official discourse? Is it being discussed online, and if so, on what types of websites (blogs, bookstores, official school sites, universities, government)? Can one apply for funding to study creativity or to develop creative programs? Can teachers use forums to discuss how to enhance creativity in their classrooms? Such indicators could then be correlated with other items already available in economics or education, such as innovation indicators, evaluation of students' ability in the PISA, and the percentage of jobs created that belong to what Richard Florida calls the 'creative class.'

If one takes the example of Finnish achievements in terms of education and innovation, and the fact that an important epistemological debate and the publication of influential books that anyone can read all pre-dated these successes, it may well be that such comparisons provide important lessons. Indeed, having a dynamic view of these indicators would be even more convincing, so ideally such data should be available over extended periods. For instance, if official discourse is shown to influence discussions place among teachers, which in turn has an impact in the classroom, one would hope that ministers of education and government leaders

would address the subject publicly. If the availability of books in the national language were shown to be a key determinant in promoting healthy debate on how to promote creativity, initiative, and risk-taking among students, the promotion of good practices could be accelerated by encouraging the publication and translation of foreign books on the subject. If it were shown that countries benefit from research and scientific assessment of creativity related classroom practices, this could lead to collaboration, improved understanding, and adapting the best practices.

Creativity in higher education

At the university level, such international discussions have taken place, and have resulted in specific recommendations concerning creativity in higher education (for instance, see the report of the European Association of Universities (2007) on how to foster creativity in higher education.) This report emphasise the importance of background diversity. Indeed, varied geographic and social origins promote creativity; therefore policies that favour cross-border exchanges and social mobility should be favoured. The report also recommends hiring of 'unconventional teachers' and,

... the establishment of interdisciplinary 'doctoral schools' may be a suitable structure for transcending traditional disciplinary boundaries. Moreover, allowing for electives from a wide variety of disciplines would encourage diversity on the curricular level. Offering students the opportunity to spend some time in placements with external partner organisations related to their degree studies can be another way to create a diversity of learning environments for them.

Some efficient interdisciplinary solutions that promote both the breadth and depth of knowledge have been encountered in higher education. The diversity of disciplines taught, including major and minor subjects, or courses and projects targeted to the interfaces between fields, allow students to discover approaches developed by a range of individuals working in different fields. It can also help them to find the approach that best suits their abilities and wishes, although this would require practical and field activities not yet included in all such programs. Fieldwork or laboratory experience should be a central part of research programs, in order to promote student interest and to confront them with practical situations requiring specific answers. Solutions may be proposed that promote original approaches to old subjects and objects, by encouraging cross-disciplinary studies. For example, the division of undergraduate education into major and minor subjects allows students to benefit from very different teaching approaches and analyses. The possibility to change orientation and enter a graduate program without necessarily having fully completed

the corresponding undergraduate program is another way to promote a diversity of views and analysis among students. By providing such students additional courses so as to build a theoretical base for their future studies, the diversity of approaches will be increased, thus fostering creativity and innovation. In addition, this would promote risk-taking among students, since they would more easily dare to study marginal disciplines, knowing that they could always go back to the mainstream after having explored a singular, individual path among the various disciplines, one that is likely to contribute to their own style and creativity⁵.

They also argue in favour of transcending classical, one-way teaching, passive listening, and hierarchical relationships; they promote creativity by implementing new teaching schemes, including discussion classes, study circles, learning by doing, and debate cafés. For the European Association of Universities, evaluation should be geared more toward the ability to change and promote a creative atmosphere than toward past achievements. Universities should become 'living organisms,' which learn from past successes and mistakes, applying their creativity in order to adapt to a constantly changing environment. No doubt, many of these recommendations could not only improve teaching in universities, but also in high schools and primary schools. Indeed, in 'Creativity in the Classroom, Schools of Curious Delight,' by Alane Jordan Starko (1995), teachers of younger students can find many similar proposals and practical tips and that help them to promote creativity in their classes.

Rethinking education

Thus it seems clear that from an analysis of the literature and various national systems that creating a creative workforce cannot be achieved without making a huge effort to rethink education. We need to construct education systems that empower children, students and adults to take responsibility; that enhance the number of responsible, innovative, free minds that will contribute to seeking solutions to the local and global issues we are facing.

The quality of education can only be improved by developing a culture of questioning and creative thinking. As any researcher knows, asking questions and creating new concepts is key in the progress of science. Too often however, only scientific *conclusions* are taught, to the exclusion of the process of Socratic questioning and creative thinking that are at the roots of knowledge. These processes of inquiry that can be learned by discovering how science works are sufficiently generic to offer any citizen the freedom and the tools needed investigate his/her environment and to de-

⁵ Think of Steve Jobs' study of calligraphy that, according to him, is one of the reasons Apple design is different from that of its competitors.

wise creative solutions for improving it. In today's knowledge society, one should not just memorise facts (which can be found in books or on the web,) but rather express one's own viewpoint, systematically questioning and seeking creative solutions to global problems. While much has been accomplished, there is no unique way to attain this goal of empowering the citizens of tomorrow and enhancing creativity through education. We believe that educators and educational institutions in all OECD countries should make space available for educational experimentation, supporting and funding such experimentation, learning from the results. Conceptual reflection may complement such an approach, but should not be the only bring about change; national and international debate must be promoted that leads us to try, evaluate, and encourage the best practices, implementing a network of educational experimentation that should:

- creatively question existing systems;
- suggest frameworks for experimentation;
- suggest ways to make the knowledge flow across borders and become adopted by national and international institutions, thus go beyond the experimental stage;
- encourage teachers to spend time thinking about how they can promote creativity, risk-taking, and initiative in their classrooms, and to discuss their experiences and results with their colleagues.

Studies of such education systems that could lead to evidence-based reforms are advocated by C. Wieman (2007), another Nobel Prize winner, who argued for a reform of science education:

Science students are leaving their courses seeing science as less interesting and relevant than they did when they started. The typical student is not learning to see the science like an expert, as a set of interconnected experimentally determined concepts that describe the world.

In their paper, 'Redesigning Science Pedagogy: Reversing the Flight from Science,' Erica McWilliam (2008) and her colleagues argue for taking action to reverse current trends that are leading to a reduction in the number of science students in most developed countries. Their review of the literature led them to them conclude:

Young people are more engaged by active tasks than with a passive consumption approach to transfer of core knowledge. It is boredom, not rigour, that disengages them — the difference between static and dynamic sources of knowledge. Creativity is not the antithesis of scientific rigour but the core business of scientific thinking. We now have new understandings of creative pedagogies

that make teaching strategies visible and effective. These strategies can build academic, digital, and social capacity simultaneously, and this is the new core business of the science educator.

Actually, the above statements could apply to education in all domains, and not just science, indicating that while further research must be undertaken, action and policy should not be further delayed. Considering the importance of creativity, risk-taking, and initiative in education, one should not wait for later results, but begin to implement national and international programs. Such programs should favour creativity and maximise the dissemination of knowledge acquired about creativity, by promoting the translation and dissemination of works on the subject, the creation of creativity courses for teachers, students and workers, and the development of web-sites in which teachers can exchange their experiences.

Time and places of creativity

To further promote creative exchanges, a good approach would be to create modern 'salons'; creative places dedicated to free interaction among like-minded creative people who have time to devote to generating new ideas. In such places, the basic philosophy should be as the Japanese proverb says, 'none of us alone is more intelligent than all of us together.' This highlights what has been confirmed by studies such as Dunbar's immersion (Dunbar 1999) in research laboratories: that creative ideas come from repeated interaction among many open-minded and diverse brains that have learned to trust each other and collaborate. Thus, it would be key to educate students to cooperate and exchange ideas in a friendly mode among themselves, and then refine their output. One should therefore teach students to criticise others' ideas without criticising those who advance the ideas, then to help them to improve those ideas by enriching them with their own. Today, the creation of hubs where ideas can flow freely plays a key role in the development of collective intelligence. These creative spaces may be virtual or real places, but they must be developed — not just to socialise — but to interact in a way that promotes creativity and the free flow of ideas. Students should be encouraged to use their online time to maximise creative interaction (new generations of websites that maximise the use of existing tools and to invent new ones are likely to be developed for just that purpose). It is very likely that some of the most promising interactions that emerge online will be followed by real-world meetings in places created to foster creative interaction, or in more traditional spaces 'squatted' by creative people eager to exchange their most recent ideas (coffee shops, cafeterias, in front of vending machines and photocopiers, often create the serendipity needed to increase the likelihood of encounters of creative minds outside formal meetings).

If the past century-style university is affected by the development of online resources and web-based universities, we can be sure that one of its major assets is the campus, since the best organised universities behave like gigantic sites of creativity, where ideas are discussed day and night among motivated students and teachers from all over the world. For an idea of the economic potential of such interactions, one might look at the founders of high-tech companies that started out with nothing and within a decade generated more than USD 20 billion or employed more than 10 000 people. Sixty-four percent of them were created by students from Stanford and Berkeley and 73 % are located on university campuses in California. Two thirds of these students came from other countries and were attracted to the campuses by the creative atmosphere they knew they could find in them.

Being able to create hubs for creative minds should become a priority for any country that wants to stimulate the next generation of groundbreaking innovation. Furthermore, the average age of the founders of these companies was 26. This alone tells us that what educational policy can do prior to such a young age is clearly essential in maximising creativity in the next generation and helping them to invent the future. The example of creative innovators, such as Steve Jobs, the founder of Apple, shows that time is what such creative education needs most in order to blossom, so any curriculum that favours cramming cannot lead to creativity. On the contrary, creative projects should be organised during periods when students can freely devote their time to them.

Educating creative knowledge builders

The impact of these measures could lead to the training of creative knowledge-builders, who would be educated to become '21st-century autodidacts'. It may seem contradictory to train autodidacts, but nearly 25 centuries ago, Socrates already realised that the goal of education is to trigger 'the fire that is inflamed by a spark that then feeds itself'. With Internet access, search engines, and ever better open education resources, the fuel for this fire is now limitless; so the role of teachers in fostering the initial spark and in educating these children to become adults who will update their knowledge themselves is even more important. We must all adapt to societies that are evolving ever faster, since in many fields like science and technology the quantity of new knowledge doubles every few years. Already, each of us must manage an growing stream of information to keep abreast of progress in our areas of interest and skills, to be most effective in our professional or social life. It is essential to learn to master these flows of information and the innovations they enable. As Socrates also said, 'writing cannot grasp knowledge, because, contrary to information, knowledge does not exist outside of humans.' Hence, the role of the educator should be to help students transform that information into knowledge. In

the recent collective book, 'Opening-up Education; The Collective Advancement of Education through Open Technology, Open Content, and Open Knowledge,' edited by Toru Iiyoshi and M. S. Vijay Kumar (2008), the authors conclude by arguing that today, teachers should become 'education sommeliers' who help select from a variety of options, and as facilitators of group work, as well as providers of interactive environments, become agents of effective, responsive, and appropriate learning opportunities.

Concluding remarks

A review of the literature cited in this report reveals that solutions exist that have been validated by research and by experience in pioneering schools, including many that do not always work under favourable conditions. As stated by a teacher cited in the closing lines of 'It's Being Done,' by Karin Chenoveth (2007),

... we know what works in education, the research is prolific; amazingly then, the question today is not about what works but about why we do not implement what we know works in all school for all kids.

Promoting the dissemination of best practices by creating environments and cultural conditions in which they can spread should thus be the priority of education policy. To develop meta-skills, such as creativity, risk-taking, and the ability to take initiatives, policies should free teachers to be creative and take initiatives, allow them to exchange ideas with each other, and to learn the results of successful practices. Although teacher training is essential, it will not suffice to trigger the required changes if national debate is not promoted by all available means. These include commitment by the highest authorities, publication of books (including translations, if need be) television and radio programs, and the creation of websites and conferences aimed at creating public debate on how to educate children so as to allow them to face the challenges of a world that changes too fast for anyone to predict.

From the evidence reviewed in this article, one could conclude that since coming generations will have access to ever more information and tools for dealing with such information, their teachers must also show them how to learn, unlearn, create, organise, prioritise, critically analyse, and decide whether to reject or integrate information. In the future, all children, all students, all citizens should be 21st-century knowledge-builders, able to update their skills on their own. They will also learn to take initiatives — and sometimes risks — combining these new skills to create innovations available to all of society. Education should make them feel confident enough in their creativity to see these changes as opportunities to be seized, not as threats. So that everyone can benefit from ever faster technological progress, chil-

dren and adults via lifelong learning must be taught the ability to learn independently, to collaborate with others, and to maximise their creative abilities. To make this possible, schools and universities must be among the first places of creativity, in which children and adults can develop their potential. In the coming years, we can be sure that countries which mobilise the collective intelligence of their citizens by means of creative education systems will be at the forefront of human development and technology.

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