

OECD Education Working Papers No. 84

# Business-Driven Innovation: Is it Making a Difference in Education? An Analysis of Educational Patents

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https://dx.doi.org/10.1787/5k91dl7pc835-en

OECD

**Unclassified** **EDU/WKP(2012)21**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **03-Oct-2012**

**English - Or. English**

**DIRECTORATE FOR EDUCATION**

EDU/WKP(2012)21
**Unclassified**

# BUSINESS-DRIVEN INNOVATION: IS IT MAKING A DIFFERENCE IN EDUCATION? AN ANALYSIS OF EDUCATIONAL PATENTS

**Dominique Foray and Julio Raffo**

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*This paper analyses business-driven innovation in education by looking at education-related patents. It first draws a picture of the challenges for innovation in the formal education sector, which suffers from a poor knowledge ecology: science is hardly linked to core teaching and administrative practices. It then turns to a common indicator of innovation: patents. In the case of education, patents typically cover educational tools. An analysis of education-related patents over the past 20 years shows a clear rise in the production of highly innovative educational technologies by businesses, typically building on advances in information and communication technology. While this increase in educational innovations may present new opportunities for the formal education sector, the emerging tool industry currently targets the non-formal education rather than the formal education system. We shortly discuss why business entrepreneurs may be less interested in the market of formal education.*

*This paper was written as part of CERI's Innovation Strategy for Education and Training.*

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**JT03327742**

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## SUMMARY

This paper analyses business-driven innovation in education by looking at education-related patents. It first draws a picture of the challenges for innovation in the formal education sector, which suffers from a poor knowledge ecology: science is hardly linked to core teaching and administrative practices. It then turns to a common indicator of innovation: patents. In the case of education, patents typically cover educational tools. An analysis of education-related patents over the past 20 years shows a clear rise in the production of highly innovative educational technologies by businesses, typically building on advances in information and communication technology. While this increase in educational innovations may present new opportunities for the formal education sector, the emerging tool industry currently targets the non-formal education rather than the formal education system. We shortly discuss why business entrepreneurs may be less interested in the market of formal education.



## RÉSUMÉ

Cet article porte sur l'innovation entrepreneuriale dans le secteur de l'éducation, à partir d'une analyse des dépôts de brevets dans le secteur éducatif. Premièrement, il propose un tableau des défis de l'innovation dans le secteur de l'éducation formelle, dont l'écologie du savoir est faible : la science y est peu liée avec le cœur des pratiques pédagogiques et administratives. L'étude porte ensuite sur un indicateur courant de l'innovation : les brevets. Dans le cas de l'éducation, les brevets couvrent généralement des « outils » éducatifs. L'analyse des brevets éducatifs durant les vingt dernières années montre une claire croissance de la production de technologies éducatives hautement innovantes par des entreprises privées, qui s'appuient souvent sur les progrès des technologies d'information et de communication. Bien que cette croissance des innovations éducatives puisse donner de nouvelles opportunités au secteur formel de l'éducation, l'industrie émergente d'outils éducatifs cible actuellement les secteurs informels d'éducation. Nous discutons brièvement les raisons pour lesquelles les entrepreneurs privés semblent moins intéressés par le secteur de l'éducation formelle.



## ACKNOWLEDGMENTS

The authors thank Stéphan Vincent-Lancrin for his invaluable editorial guidance and suggestions. The paper was developed as part of the "Innovation Strategy for Education and Training" project by the Centre for Educational Research and Innovation (CERI).

# BUSINESS-DRIVEN INNOVATION: IS IT MAKING A DIFFERENCE IN EDUCATION?

## AN ANALYSIS OF EDUCATIONAL PATENTS

by

Dominique Foray* and Julio Raffo**

This paper analyses business-driven innovation in education by looking at education-related patents. The paper first argues that the formal primary and secondary education sector poses serious challenges to innovation. It then shows a dramatic increase in certain types of innovations: those covered by patents. After an analysis of the emerging tool industry that drives this increase, it concludes that most of these innovations concern higher education and the non-formal education sectors – and that their promises for the primary and secondary education sectors remain to be exploited.

## 1. A first look at innovation in education

Educational innovation is the act of creating and then diffusing new educational tools, as well as new instructional practices, organisations and technologies. Innovation is not research. It is (often) based on research and the advance of knowledge and consists in changing processes and practices in order to improve the quality and productivity of the service which is delivered. Getting an education sector in which valuable innovations are constantly generated and efficiently used and managed is a major challenge to "re-invent" public education and find solutions to the so-called "Baumol's disease".

Many years ago, William Baumol introduced an interesting distinction between progressive and non-progressive sectors. Non-progressive sectors involve the sectors in which productivity growth is limited, very sporadic and far smaller in magnitude than what is happening in the progressive part of the economy (Baumol and Bowen, 1965; Baumol, 1967). Such productivity gap between two kinds of sector gives rise to Baumol's (or the cost's) disease. Education has always been considered by experts as a paradigmatic example of a non-productive sector (Roza, 2008; Hill and Roza, 2010).

In education, changes are typically proposed from outside the schools and then disseminated by "reformers" into them. The source of these changes is not innovation but reform! A reform (or "outside-in") logic creates little chance for a successful adoption, implementation and institutionalisation of new practices. And policy makers will be frustrated by the failure of many reforms to endure and to displace poor practices. Instead, innovation involves a decentralised way to use new knowledge and information (both from research and current practices) in order to identify problems and generate solutions. Because people are motivated to disseminate knowledge and solutions that they have themselves created, there are natural, but under-used, channels for easy dissemination (Foray and Hargreaves, 2003). Repositories of

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open educational resources that are generated and shared by teachers and other educators are one of these formal channels (OECD, 2007a).

Last but not least, it is useful to stress that one of the major challenges associated with the study of educational innovation is the lack of data. Studies of technological innovations traditionally focus on research and development (R&D) spending and patenting. These measures are unlikely to be satisfactory in this context (although we will analyse patent data to a certain extent below).

### *1.1 A difficult science and a poor link to practices*

The educational sector is often characterised by experts as a sector suffering from an innovation deficit and a structural inability to advance instructional technologies and practical knowledge and know-how about pedagogy at the same rate as what is occurring in some other sectors.[1] *« Consider the efforts to develop more effective educational practices in schools: even if we do know more about educational practices than we did previously, knowledge creation in this domain has been slow and there have been severe difficulties in diffusing "new and superior" knowledge »* (Nelson, 2003).

The main problem is the difficulty to develop a science which can illuminate practices and provide guidance to their systematic improvement (Foray, 2001, 2006). Formal research and development (R&D) has largely remained of secondary importance both for the training of people and for the generation of useful innovation. What Nelson and Murnane wrote more than 20 years ago on education is still by and large true: educational R&D is very weak in producing practical solutions: *« [In the education sector,] R&D should not be viewed as creating 'programs that work'; it only provides tidy new technologies to schools and teachers. It is thus a mistake to think of educational R&D in the same way as industrial R&D »* (Murnane and Nelson, 1984). Educational R&D generates too rarely knowledge of immediate value for solving problems and developing applications. There will of course continue to be contributions from social science theory to education. However, the goal of this kind of research is not to provide and develop a repertoire of reliable practices and tools to solve immediate problems that teachers meet daily in their professional life: *« For novice teachers, practical problems in classrooms are not usually perceived to be solvable by drawing upon the psychology of education or child development that have been studied in universities »* (Foray and Hargreaves, 2003).

This problem of a very weak link between science and the improvement of practices is crucial since it influences negatively both the supply of and the demand for research. This weak supply and an insufficient demand create a fundamental inertia in the system.

There are three factors explaining the poor role of science as illuminating practices in education:

On the supply side, educational sciences are just very hard to do. Berliner (2007) wrote about educational research as the hardest science: "*we do our science under conditions that physical scientists would find intolerable"*. Compared to designing a bridge, the science to help change schools and classrooms is harder to do because context cannot be controlled and the difficulties to generalise across contexts reduce the value of any research finding to illuminate a body of practices.[2] There is indeed an educational science but nothing like an applied science or engineering discipline to develop a body of knowledge and techniques that could illuminate educational practices.[3]

On the demand side, most practitioners who are (or should be) involved in the improvement of practices do not believe that the educational problems they are facing in the course of their professional life can be solved by inquiry, by evidence and by science (Elmore, 2002). They do not believe for example that it is necessary to have a developmental theory of how students learn the content and how the pedagogy relates to the development of knowledge and content. Weak incentives for teachers to use research are

rooted in deep cultural norms; teachers tend to believe that teaching is an individual trait: the foundation of the performance involves natural quality, inspiration, talent and not a set of competences acquired over the course of a career (Elmore, 2002). Because of this cultural norm, it is very difficult to make a case for knowledge management, building data bases about evidence on "what works" and encouraging teachers to behave as engineers by searching for solutions to problems in case books. « *Teachers are primarily artisans, working alone in a personally designed environment where they develop most of their skills by trial-and-error tinkering. In short, they learn to tinker, searching pragmatically for acceptable solutions to problems their 'clients' present* » (Foray and Hargreaves, 2003; see also OECD, 2004, 2007b).

Finally, there is a general deficiency of incentives to codify technical knowledge and know-how and the resources allocated to codification are weak. Numerous practices remain tacit; not explicated and not articulated, invisible and difficult to transfer. "*There is no more in education than a weak equivalent in the field of pedagogical knowledge to the systematic recording and widespread use of cases found in surgery or law and the physical models in engineering and architectural practice. Such records coupled with comments and critiques of experts allow new generations to pick up where earlier ones left off*" (Foray and Hargreaves, 2003). Some important mechanisms to support the cumulative nature of knowledge and its progressivity and to materialise the potential for spillovers are simply missing. *« The beginner in teaching must start afresh, uninformed about prior solutions and alternative approaches to recurring practical problems. What student teachers learn about teaching is intuitive and imitative rather than explicit and analytical » (ibid.)*. When excessive stocks of knowledge are left in tacit forms, this makes them more costly to locate, to appraise and to transfer. One result may be excessive insularity and waste of resources resulting in the underuse of existing stock of knowledge. This may therefore create private and social inefficiencies.

### *1.2 Translating increasing pressures about performance into innovation*

To put it in Nelson's words, the key of success in advancing technical knowledge has been the designing of practice around what is known scientifically. For various reasons, this key is not operating well in education.

As a result, policy makers, industries and the society as a whole are asking schools to make improvements in the presence of an extremely weak technical core. As Elmore puts it in a provocative way: "*Consider what would happen if you were on an airplane and the pilot came on the intercom as you were starting your descent and said, "I've always wanted to try this without the flaps". Or if your surgeon said to you in your pre-surgical conference, "you know, I'd really like to do this way, I originally learned how to do it in 1978". Would you be a willing participant in this? People get sued for doing that in the "real" professions, where the absence of a strong technical core of knowledge and discourse about what effective practice is carries a high price"* (Elmore, 2002).

The problem is not so much about the lack of incentives for schools and managers to improve educational practices and technologies; these incentives are there, probably less powerful than in other sectors, but pressure for performance of schools, which are channelled through higher standards and accountability, is increasing and creates thereby such incentives. The problem rather lies in the way practitioners, teachers and administrators try to respond to these incentives and pressure. The problem lies in the failure to translate such pressures into innovation, improved practices and the development of instructional know-how and technologies. Practitioners do not try to improve practices by relying on a strong technical core of knowledge that should be available in case books and data bases. Instead, they respond to the increased accountability by changing structures; but changing structure does not change practices. As Elmore (2002) argues forcefully, people and schools put an enormous amount of energy in changing structures and usually leave instructional practice (innovation) untouched.

## 2. Patents in educational and instructional technologies

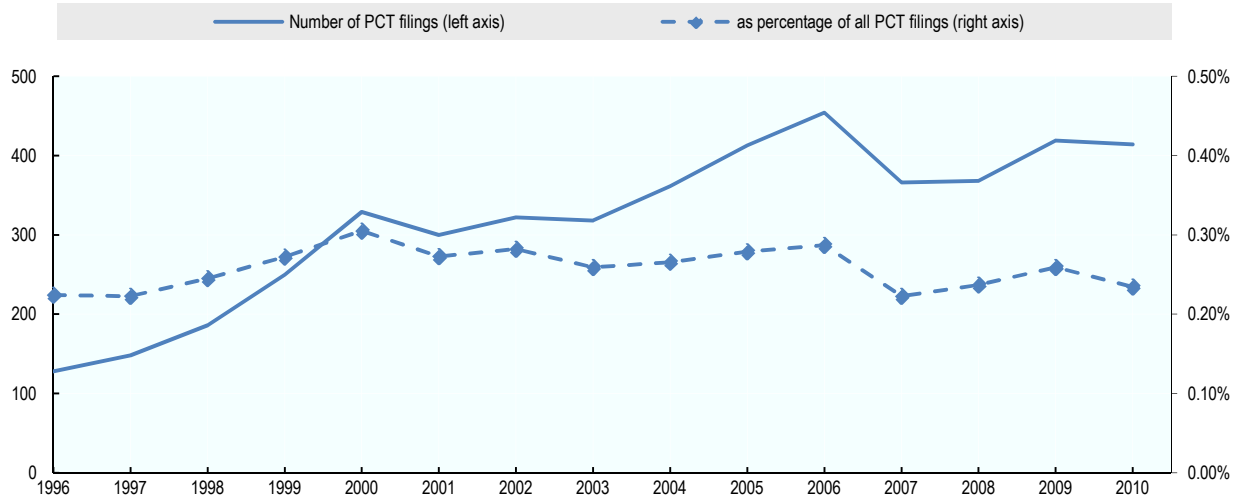
### *2.1 A small (innovation) explosion?*

A quick look at patent data provides us with a slightly more optimistic view of innovation in the education sector.[4]

Following Foray and Raffo (2009), we consider educational and teaching-related technologies as any patent filed under the G09B IPC subclass. This subclass is defined as "*educational or demonstration appliances; appliances for teaching, or communicating with, the blind, deaf or mute; models; planetaria; globes; maps; diagrams*". This subclass covers simulators regarded as teaching or training devices, which is the case if they give perceptible sensations having a likeness to the sensations a student would experience in reality in response to actions taken by him; models of buildings, installations, or the like. But it does not includes simulators which merely demonstrate or illustrate the function of an apparatus or of a system by means involving computing, and therefore cannot be regarded as teaching or training devices; components of simulators, if identical with real devices or machines (see Box 1 for examples of recent patents filings).

While their number remains relatively low, patent applications have increased dramatically from the mid-nineties in the domain of educational and teaching technologies (Figure 1). This 3-fold increase in patents filed corresponds to a flat trend for these technologies as a share of the total production of technologies, which shows that this traditional sector is growing at the same pace in technological terms as the average. A drop in patent filings is noticeable in 2007, and education-related patent filings have grown again from 2008 but at a slower pace.

**Figure 1. Evolution of world's education-related patents by priority year (1996-2010)**




Note: The figure shows the evolution of the number of patents filed in G09B IPC subclass under the Patent Cooperation Treaty (PCT) by priority year, and the evolution of the share of these patents in all PCT filings.

*Source*: Based on WIPO Statistics Database.

**Box 1. Examples of education-related patents**

Education-related patents are typically filed for products or devices that will be used in a training or education context, for training processes related to a specific set of skills (music, medical, foreign language, reading, etc.), or for a general method that can be used in multiple educational settings. While many patents typically build on advances in information and communication technology (ICT) and propose some sort of simulators of real life practice, patents filed also concern objects or devices or tools that are not primarily ICT-based: card games to learn languages; mock-ups of chests, infant torsos, jaws, blood vessels or organs designed to practice specific medical techniques; teaching devices for some specific mathematical question, for example a device about Pythagoras' theorem demonstrating it arithmetically, geometrically and algebraically; or just a ruler to facilitate the learning of reading.

A list of examples of titles of education-related patents filed in 2010 is provided below for illustration purposes.

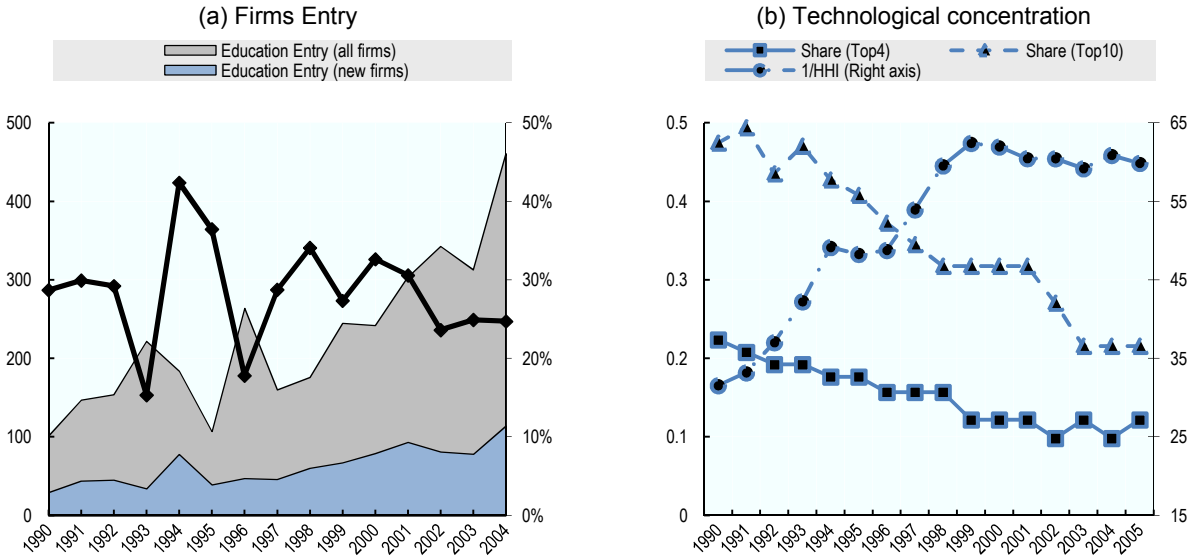
- Apparatus and method for the lifelong study of words in a foreign language
- Second language pronunciation and spelling
- Foreign language learning device
- Pronunciation evaluating device and method
- Chinese character study book
- Method for learning vocabulary and the principles of English sentences through a card game
- Brass instrument practice device
- Music tablature player
- Portable practice tool for heart massaging in cardiopulmonary resuscitation
- Real-time x-ray vision for healthcare simulation
- Hemorrhage control simulator
- Tracheal intubation training model and method for producing tracheal intubation training model
- Device for simulating cardio-pulmonary resuscitation techniques
- Learning assembly and infant torso simulator for learning the act of respiratory kinesitherapy
- Method for training specialists in the field of ultrasound and/or x-ray diagnostics
- Periodontal training
- Teaching aid for preschool education
- Head model for brain-imaging device and technique for producing same
- Blood vessel model for medical training and method for manufacturing same
- Movable learning gaming machine using movable toy
- Weakness finding system and method
- Methods and systems for assessing psychological characteristics
- Method and system for quantifying technical skill (in surgical task)
- Pythagorean teaching device
- Young children's aid to quick counting
- Educational ruler for facilitating reading
- Communication and skills training using interactive virtual humans
- Multi-user headset teaching apparatus
- Adaptive teaching and learning utilising smart digital learning objects

Source: WIPO

This growth is not only explained by large companies' strategic behaviours trying to apply their existing technologies to the education sector, as we can observe also the formation of a population of small firms which are specialised in the development of technological solutions to educational problems and issues. This is apparent by the entrance of new firms (Figure 2.a), but also in the declining (technological) concentration evidenced by different indicators. Figure 2.b shows that the concentration – expressed by

both technological shares held by the top 4 and by the top 10 firms – has been steeply declining over the past two decades. The inverse Herfindahl-Hirschman Index (HHI), an indicator of the oligopolistic nature of industries, furnishes a similar picture, showing that the technological concentration has been reduced from around thirty to sixty "ideal" firms. However, all three indicators suggest that this evidenced de-concentration might be slowing down or, if we consider the Herfindahl-Hirschman Index, even regressing. In any case, these preliminary results suggest the emergence and consolidation of an industry specialised in the production of educational and instructional tools and knowledge with strong roots in new information technologies. A large part of this industry is made of small and specialised firms.

**Figure 2. Firms filing education-related patents (Entry and Technological concentration)**




Note: (a) Firm figures have been retrieved from their Triadic patent families. (b) Figures are built from the firms' Triadic patent families portfolios.

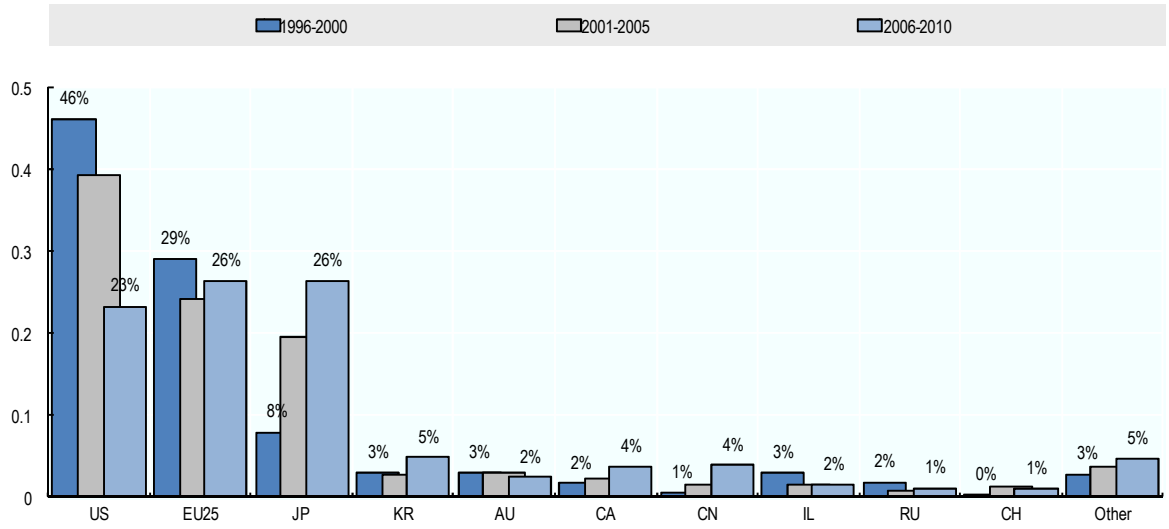
*Source*: PATSTAT (September 2008).

The top 100 firms filing these patent applications are major multimedia and/or electronics firms (*e.g.* Matsushita). They manage their R&D by harnessing economies of scope, *i.e.* developing educational applications based on their generic technology, as part of a diverse project range. While the major non-specialist firms (with fewer than 5% of their patents in that category) are largely predominant for these patent applications, there is evidence that an innovation-intensive industry specialising in education is emerging: there has been a rise in the share of applications filed by specialist firms, owing more particularly to the those filed by Chinese and Japanese firms. The list of the top 100 *specialist* firms (those with 50% of patents in the above category) includes smaller firms: developing and marketing educational solutions is their business model. These specialist firms are mainly Japanese, Chinese and American.

As far as geography is concerned, the world share of the United States in education-related PCT filings has decreased significantly in the past 15 years, from 46 to 23%, and is now overtaken by both the European Union and Japan, that had the top education-related number of applications in the world between 2006 and 2010. The decrease of the United States is in line with the idea of the emergence of a specialised industry, and a decline in the filing of education-related patents by non-specialised companies. The world's share of education-related patents filed by Japan has trebled, and Canada, China, and Korea have also known a significant growth from a much lower starting point (Figure 3). Figure 4 shows this trend by country using a 5-year moving average to smooth the growth. In the European Union, the growth has been fuelled by an increase in education-related patent filings in Germany, France and the United Kingdom. A

small number of countries have increased both number and shares of filings: Finland, France, Norway, and Spain (while the United Kingdom and the Netherlands have lost some shares). A similar sustained upward trend can also be observed in Korea, China and Canada.

**Figure 3. World share of education-related filings by first applicant country**




Note: The figure shows the distribution of all patent filings in G09B IPC subclass under the Patent Cooperation Treaty (PCT) across countries.

*Source*: Based on WIPO Statistics Database

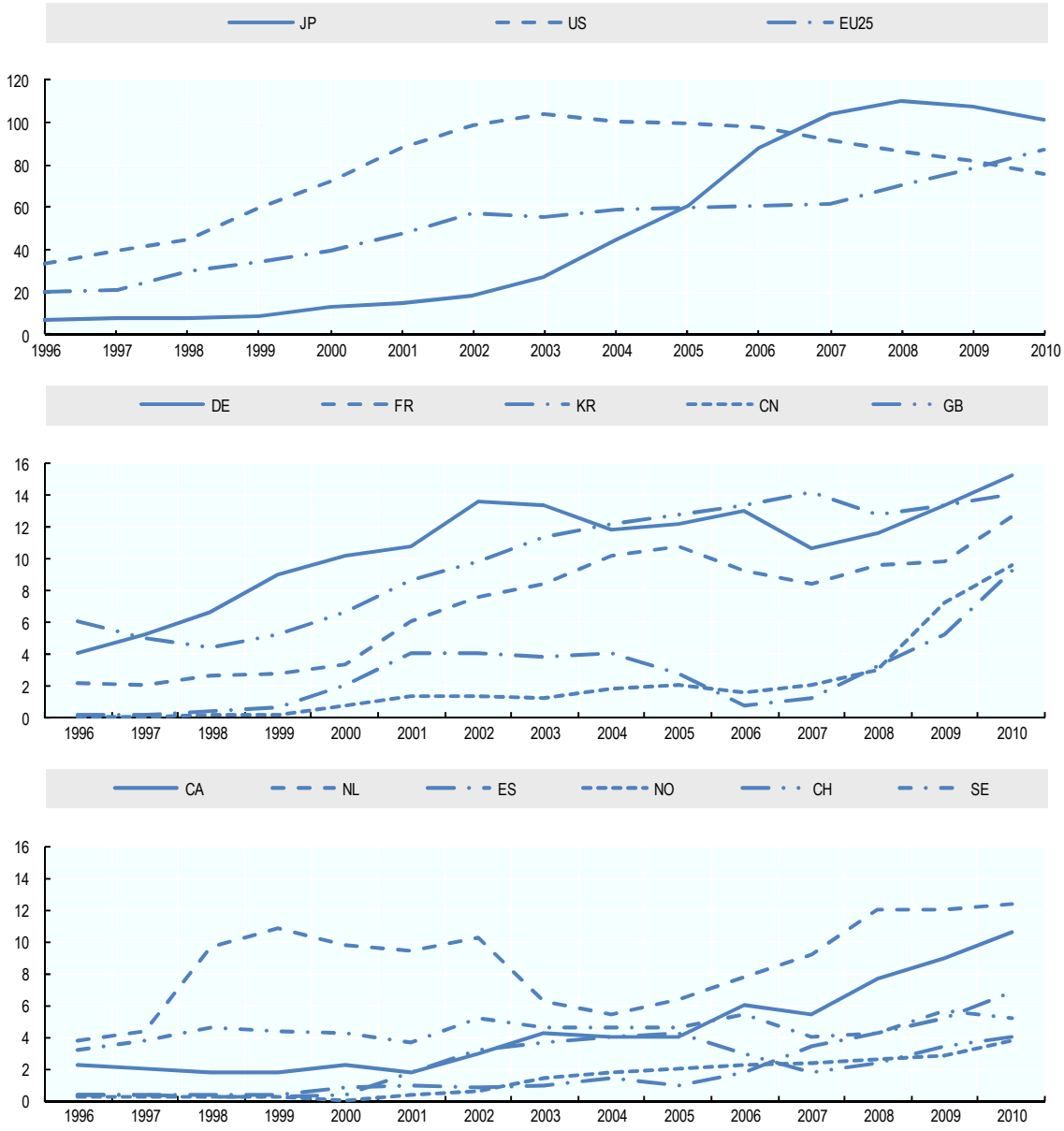
### *2.2 The development of instructional technologies in the wake of a great general purpose technology*

Information and communication technology (ICT) is clearly a source of innovation in education systems: ICT offers potentially a wide range of new tools and instruments to profoundly change the technological, organisational and institutional foundations of the sector considered. In this case, the development of ICT provides opportunities to enlarge the repertoire of instructional technologies. The so-called process of co-invention of applications is not a minor matter since it is the process by which the technology diffuses across a wide range of sectors and specific applications are generated.

In fact, the characteristics of a general purpose technology (GPT) such as ICT lie in *horizontal propagation* throughout the economy and *complementarity* between invention and application development. Expressed in the economist's jargon, a general purpose technology extends the frontier of invention possibilities for the whole economy, while application development changes the production function of one particular sector. The basic inventions generate new opportunities for developing applications in particular sectors. Reciprocally, application co-invention increases the size of the general technology market and improves the economic return on invention activities related to it. There are therefore dynamic feedback loops in accordance with which inventions give rise to the co-invention of applications, which in their turn increase the return on subsequent inventions. When things evolve favourably, a long term dynamic develops, consisting of large scale investments in R&D whose social and private marginal rates of return attain high levels.

**Figure 4. Education-related patent filings by priority year and inventor's country**

Moving average (5 years)




Note: The figure shows the evolution of the number of patents filed in G09B IPC subclass under the Patent Cooperation Treaty (PCT) by priority year and inventor's country.

*Source*: Based on WIPO Statistics Database

The renaissance of innovation exemplified by the rise in education-related patents seems to be strongly associated with the dynamics of ICT. The application of ICT in education should not be considered as a single innovation; it could result in an array of technologies that can be applied in a variety of ways. ICT can be viewed, also, as an enabler of change: schools engage in a series of activities which could not have been done without it. It is however premature to claim that the education sector has already

reached the position of a central user sector having the potential to significantly boost the dynamics of ICT – or that ICT has significantly changed the technical core and ways of operating of the sector.

## 3. Discussion

### *3.1 An emerging educational tool industry*

A quite intensive innovation activity regarding the development of new instructional tools and technologies is observable. The locus of this activity is not really inside the traditional frontiers of the sector. We observe the formation of a tool industry: a population of specialised firms that invent, design and commercialise educational tools. Such a process, as in any historical case of a tool industry emergence, involves a process of relocation of knowledge – at least in part away from the point of delivery of the educational service. There is some shift in knowledge "holding" which involves the emergence of a new site of knowledge accumulation: the tool producer. Historically, one important reason for the emergence of a tool industry (beyond the classical reason of market size increase) is the rise of a systematic approach to the problem of increasing productivity of industrial or service outputs. The process of relocation of the specialised knowledge about tools outside the institution which delivers the final service (the school in our case) allows to produce generic and multi-purpose machines and tools which replace the specialised tools developed formerly within each specific organisation delivering the service.

Historically, the formation, emergence and development of tool industries have often generated efficiency gains and economic growth through greater specialisation, intra-segment competition between the tool producers and an effective coordination between the tool companies and the downstream organisations.

Given our observation and discussion of the innovation deficit in "the core" of the education system (the classroom), it is good news that a population of entrepreneurs enter and grow on the market for new educational tools. Companies competing to invent and commercialise tools are expected to play a great role in enhancing innovation and productivity in the downstream sector.

However there is a need to qualify this trend. One important concern is related to the ability of the public sector to exploit the opportunities offered by the emerging tool industry. Another concern is related to the increasing activity of patenting. While the legal monopoly granted by patents is needed for small specialised firms to enter and thrive in the market, it is likely to adversely affect efficiency in the short run (static efficiency) through the pricing of ideas and knowledge which were used to be freely accessible in the former period.

### *3.2 Patent problems with the new structure*

The development of a market for instructional tools can imply that potential users must now pay to access methods and knowledge that used to be obtained for free but are now explicitly priced in the form of licensing agreements. In educational communities, some of the new patents are likely to generate great anxiety as practitioners realise that they are infringing patents and violating the law just by applying methods and practices that they used to apply freely since the beginning of their professional life. Researchers in biomedical sciences are quite good in simply "ignoring" (in the sense of failing to obey) the patents on research tools. And the firms which have been granted these patents either anticipate bad appropriability of their knowledge by granting licenses on a large scale or simply tolerate infractions, especially by academic researchers. This set of norms and practices on both sides result in minimising in a quite effective way the social inefficiencies which are potentially generated by excessive patenting in biomedical research (the so-called anti-commons problem: see Heller, 1998). It is not clear whether

schools managers and teachers are in the position to have similar behaviours and what the strategic responses of the small specialised firms holding the patents would be.

For example, in 2006 Blackboard Inc. was granted a patent by the US Patents and Trademark Office "for technology used for Internet-based education support system and method" covering 44 different features that make up a learning management system. Frank Lowney, Director of the IT management system at the Georgia College and State University Library wrote: "*Much of what Blackboard claims to have invented really came from and was freely given by the education community. Now the community is being punished through a gross lessening of competition in this market*" (Networkworld, 2008). For an Associate Professor of Medical Education, the real question is: "*What are they going to do next, try to patent word processing and charge you royalties if you are using it in a classroom? If obvious uses of technology to facilitate teaching based on standard software applications are allowed to be patented just because they are used to support education we are in real trouble*" (Inside Higher Ed, 2006). The problem with Blackboard patents and, we suspect, hundreds of patents for educational technologies clearly involves the now usual conflict between open source communities, which are proliferating in the educational world, and for-profit businesses attempting to enforce their claims on some (software) patents. But a new problem arises here which is about patenting in an area where traditionally the norms of public good and free access were strongly dominant.

Another problem with the vertically disintegrated structure of the emerging industry lies in the ability of the small specialised companies to capture the benefits of their innovation. Transaction and bargaining costs on these markets for methods of pedagogy are likely to be very high; and patents as a means to capture the value of the innovation might be not so effective (depending partly about how the first problem is going to be solved). The problems of the firms considered here are rather similar as what has been described by Cockburn (2003) with regard to the tools companies in the biotechnology sector.

### *3.3 A tool industry for what market?*

Innovation needs entrepreneurship or at least needs a complex distribution of firm's size and age including a strong population of entrepreneurs at one extreme of the continuum. Baumol has written extensively and convincingly on the role and crucial position of the entrepreneur or young innovative firms as a mechanism for fuelling innovation and as an organisational form which is needed to complement large companies' modes of operation. But the educational sector seems to have severe barriers to entry so that entrepreneurial activities in the sector sound as not very attractive: the reward structure in this sector is not in favour of competitive entry of new firms and radical innovators willing to take risk and be creative in the prospect for huge private return on R&D and other innovation activities. Berger and Stevenson (2008) have well identified some of those barriers:

- the lack of investment in innovation of the education sector;
- the existence, in many countries, of a so-called "big edu" – an oligopoly of a few very large suppliers of educational resources which solve the problem of a highly atomised demand by building an enormous sales forces; entrepreneurs cannot afford to play this game;
- slow sales cycles, as buyers involve too many people "in charge" at different levels (State agencies, districts or local authorities, schools);
- the constraint of pilot programs to test an innovative tool that makes it impossible for start ups to sell at a scale that is economically viable;

- the lack of a business culture for managing innovation in school systems: rather than buying new tools and systems, administrators usually choose to solve problems by using more intensively in-house people because this costs "nothing" (people are already paid for). Few school administrators have a formal training in business decision making or in calculating returns on investment;

- the treatment of teacher time as a sunk cost: people generally see no benefit to saving this time;

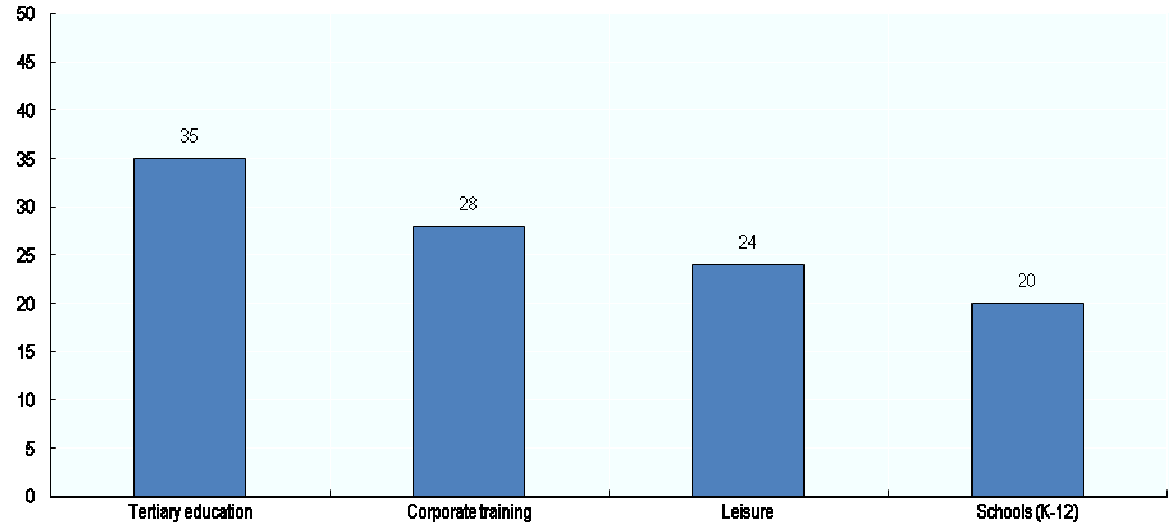
- the frequent recommendation by public authorities that administrators should not meet with entrepreneurs and vendors to avoid any unfair advantages, creating a "vendor wall" that prevents them to be informed about new solutions;

- the limited size of potential returns, and the long time required to get a meaningful one, which in turn makes it difficult for venture capitalists to be interested and for the most innovative start ups to get funding from them. Angel investors can be a substitute to a certain extent;

- the possible interference of foundations and charities that give away for free the very things that entrepreneurs are trying to turn into a business. This unintended consequence of a strategy of building a commons is a well-known phenomenon in developing countries, seen as killing entrepreneurial spirit.

Beyond all the problems identified above, the public sector of education is also a special market in the sense that "the consumers" do not necessarily want to buy every year a better product that a restless innovative activity needs to offer and commercialise.

**Figure 5. Number of top 50 companies with a specialised education patent portfolio in specific markets (2010)**




So we are facing a quite disturbing puzzle: we observe some intensive innovation activities but the market seems rather difficult; so what are these entrepreneurs really doing? The puzzle's solution is straightforward: these companies are targeting other markets than the formal primary and secondary education sector: corporate training, education during leisure time and tertiary education are perhaps smaller markets but they seem far more "entrepreneur-friendly". An in-depth analysis of the top 50 specialised companies in patenting educational tools allowed us to identify in which education markets they operate. Figure 5 shows the results of our web search: 35 out of the top 50 specialised firms operate in

the tertiary education market, while only 20 operate in the schooling sector. Fewer companies commercialise their inventions in the formal primary and secondary education system than in the other market segments.

## 4. Conclusion

A good news for education – a sector which displays notorious difficulties to generate and exploit innovations to improve practices – is that an educational tool industry has emerged; that is to say a population of small firms specialised in inventing and commercialising (mainly ICT-based) instruction technologies. New sites of knowledge generation and accumulation have emerged: the tool producers.

However the main commercial target of these companies is not the huge public school system. This market does probably not satisfy most conditions for attracting and sustaining a strong entrepreneurial activity in the tool business. Could the public school system better exploit the opportunities offered by the development of a tool industry? Is there enough innovation friendliness in the public sector in terms of management practices, governance and culture, as well as funding and resource allocation logics? These are some of the issues that education decision makers should now start examining.

Other "smaller" markets seem to be attractive enough for entrepreneurs and this connection explains to a certain extent why we have observed the patent explosion and some increase in the number of firms specialised in the tool business.

An important question for further research is whether the invention of tools for corporate education (or training) and other "smaller" markets" has *spillover* effects in the sense of building user capabilities (in a very broad sense) in the large formal primary and secondary education sector so that this sector can progress in learning how to exploit the opportunities offered by the growing educational tool industry.

## NOTES

[1] Technical knowledge involves in this case the broad set of both embodied and disembodied knowledge that enable the development of pedagogical practices and instructional technologies.

[2] See Foray, Murnane and Nelson (2007) about the comparison between educational research and research in the biomedical area. Cooke and Foray (2007) describe the United States policy experience in developing an education science through the development of experimental research capacity.

[3] See Shavelson (2011) who addresses the issue of rigourous and relevant research in education in a very insightful way.

[4] For this analysis, new methodologies are applied to available patents. First, to avoid the typical problems of double counting and home biases, we reduce our universe of analysis to only triadic patent families (that is, patents files in the European, Japanese and US patent offices). Second, we automatically retrieve and consolidate the main applicants by following a similar approach to Raffo and Lhuillery (2009). Last, we screen manually the resulting dataset to increase the quality of the process.

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