The World Market for Telematics Applications to Education: Challenges and Opportunities for Industrialised and Developing Countries

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1. INTRODUCTION

The information society is being built on the basis of two fundamental technological developments. One, is the miniaturisation of integrated circuits which has allowed steep cost reductions and laid the ground for wider industrial applications. The other, is the convergence of computer and telecommunication technologies what has allowed a “shrinking” of world’s distances and opened up opportunities for many applications.

‘Telematics’ is the category that expresses this convergence. It refers to the technological change that resulted in the transformation of telephone systems from voice carriers to voice, data, text and image carriers and in the change of computers from stand-alone “number-crunching” machines into equipment that process, store and display data, text, image and sound and transfer all this information to other computers, asynchronously or on-line. At the heart of this technological change is the digital treatment of information brought about by advanced microelectronics and innovations in software development. Information and Communication Technologies (ICT) is another expression that refers to the complex set of technologies that deal with digital processing and transmission of information. Telematics is a constitutive part of ICT which, however, includes other communication media such as publishing, radio and television broadcasting, also transformed by digitalisation. While innovation in these communication media are pushing for stronger technological convergence, publishing, radio and television are not yet interactive. These media and telematics still constitute distinctive networks.

Telematics applications to education refer basically to novel ways of using computers linked to telephone lines for accessing information stored in a network of other computers situated in different places and for one-to-one, one-to-many and many-to-many interactive communication between learners and tutors at different places, simultaneously or not. Computers have been in use for educational purposes mostly in classroom at universities, research laboratories and schools, particularly after the personal computer revolutionised the market. On the other had, classroom teaching and learning have never made use of the telephone and linked equipment, such as the facsimile machine, as important means of education. The telephone and other communications media were the exclusive educational tools in distance education. The digital revolution changed this distinction and the same as it resulted in the convergence of computers and telecommunication, it is also promoting a convergence in educational applications used in classroom and at a distance.
Telematics applications to education can increase the coverage of education and training and offer high flexibility of delivery in relation to place and time, within a country and across country boundaries, effectively serving learner’s different needs and improving access to sources of knowledge in many orders of magnitude. This flexibility serves also to institutions and individuals that deliver instruction and training, opening up many opportunities for tele-working in education and for business in education services. World trade in electronic-based education goods and services, from stand-alone and networked equipment, educational software, publications and database, multi-media applicatuions, to expert consultancy and the electronic delivery of courses and complete degrees, is expected to grow significantly.

International trade in hardware and in educational software, as well as in educational services delivered on-line or broadcast, is an area of potential international friction, particularly due to the perceived risks of technological and cultural domination by exporters. International trade in this area can develop into an adversarial or collaborative path. It offers many opportunities for both producers and consumers and may, for example, push for much needed innovation at the user end. But it may also involve educational, political and economic risks to user countries that lack the vision, human and material resources required for a responsible and creative use of trade in the benefit of their societies, cultures and economies. Developing countries can benefit from domestically developed ICT applications as well as from this new area of international trade to reduce their immense educational deficits, change their educational practices and upgrade their communication infrastructure. They need however to be able to assess alternative solutions and make informed decisions if they are to harness the new technology for economic and social development and succeed in negotiating favourably with the leading exporters. Most of all, they have to strengthen their position as producers of content, information and knowledge, and have a richer role to play in the international education market than that of importers. For the exporters, it is not only access to potential consumers what is at stake: incremental technological innovation and the exploration of an immense pool of information, knowledge and cultural wealth gives them much wider economic gains.

This paper aims at discussing the prospects for the relationship between industrialised and developing countries in the international education market. Of the triad that dominates the information and communication market, it looks primarily at Europe as the mostly likely challenger of USA and Canada as major players in the international education market. Of the vast potential world importers, this chapter strives to bring the perspective of various groups of
developing countries to the front stage, particularly that of middle-income developing ones.

Section 2 opens the discussion with an elaboration on the prospects of telematics applications to widen coverage of education and facilitate the acquisition of new skills in classroom or in open system environments. Section 3 discusses the infrastructure requirements and the costs involved in upgrading schools for classroom telematics applications. A summary overview of the experience with integration of computers and on-line applications to education in Europe and other developed countries is presented in Section 4 with a view to drawing practical lessons useful to those countries that wish to modernise education. Expansion of the international education market will be affected by developing countries ability to balance the major arguments in favour and against entering the area of new ICT applications to education. These arguments are synthesised in Section 5. Finally, a summary of the discussion and some policy recommendations are presented in Section 6 which concludes the paper.

2. LEARNING NEW SKILLS IN CLASSROOM AND OPEN ENVIRONMENTS

As the pace of technological change in the information society increases, the growing knowledge content in production of goods and services changes job requirements and puts a pressure on skills generating systems, both social and individual. Product life cycles speed up and processes of production change continuously with the consequence that skills learnt in vocational centres, at universities or on the job have to be updated constantly. The usual conception of “once-and-for-all” schooling is being substituted by the acceptance of a continuous process of learning or of skills improvement, not as an individual option but as the best collective way to face the quick obsolescence of modalities of codified learning. New skills are best acquired “by doing” and there are now powerful new tools to help do that and which can be mobilised in favour of continuous learning in enterprises, classrooms and open environments.

2.1 New Skills in the Information Society

The dawn of an information society brought about by pervasive and intense technological change is unveiling the fact that in any sector of production, “traditional” as well as high-tech, manufacturing and service, rapid pace of innovation and strong competition push companies to change their organisation and human resources basis to promote quick and continuous learning.

The learning person, young or adult, scientist or engineer, manager or worker, is at the centre of the learning economy. The learner is expected and needs to acquire general and specific knowledge and keep up with their alteration and more substantive change in order to be able to
participate actively in the economy, society and polity. It is not only that the “knowledge industries” or primary information sector\(^1\) grow and demand higher skilled labour, but also that a host of abilities are now being required of workers, professionals and managers of practically all areas of activity, manufacturing and services. They include long established skills which had not before been mobilised at certain levels of activity and new abilities that are demanded by direct and intense involvement with computers in networked working environments.

Widespread electronic networking in the working environment, requires from managers and employees the difficult abilities of operating with flexibility of organisation and tasks, of acting with wider levels of autonomy and within cross-functional processes (Rajan 1996). At the shop-floor, larger information content in production has pushed for professional profiles in industry that emphasise abstraction, interactivity, speed of response, quality, versatility, and capacity to operate in a virtual team (Lasfargue 1996, Lundvall 1997). Wider dependence on information processing in most working environments require workers with high levels of adaptability because of the speed of change of operating systems, software and network arrangements (Mulgan 1996).

The above discussion of skills requirements is mostly based on the analysis of the intrinsic characteristics of the technologies and their integration in the world of work at firm level. The impact of wider diffusion of information and communication technologies on skills structure and educational levels of the work-force at a more aggregate level are difficult to assess. There are pointers indicating up-skilling but also others suggesting de-skilling (OCDE 1988). At firm level, the shift in the demand for skills is strongly associated with adoption of information technology (IT) and reveals firms’ efforts to become learning organisations.

The diffusion of IT\(^2\) in the developing economies is yet to be assessed and so is its impact on the structure of skills. One snapshot indication of the level of diffusion of IT in developing countries is their 18 percent share of world’s apparent consumption of electronics goods in 1993 (Steinmueller and Bastos 1995: 3). Electronic consumer goods (e.g. television sets, video cassette

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\(^1\) Studies on the economics of knowledge and information have, in the 1960s, introduced the statistical construct of “knowledge industries” comprising education, communication media, information machines, information services and other information activities. The same activities have been called since the late 1970s primary information sectors because they participate directly in the information market. The information activities that take place as part of the manufacturing process for non-information products have been referred to as “secondary” information sectors (Foray and Ludvall 1996).

\(^2\) IT comprises: electronic components, office equipment, electronic data-processing equipment, electronic control and instrumentation, medical and industrial automation equipment, communication and military, telecommunication equipment, and consumer electronics.
recorders, video cameras, tape recorders, compact disc players) account for a significant portion of this market. Fifty-five percent of the total market are, however, composed of data-processing equipment and electronic components. This is a stronger indicator of productive diffusion of IT. Trade in IT involving developing countries is concentrated in the Asian NICs and, more recently, China. The establishment of local production of hardware and software in the NICs and other emerging economies has been explained in some degree by the availability of a skilled work-force and highly trained engineers. However, the majority of employment opportunities in agriculture, manufacturing and services in developing economies, particularly in the domestic-oriented activities, is likely to depend on more traditional skills and expertise. Increased competition in foreign and domestic markets makes it very unlikely that this situation will persist for a long time in the future or that the skill structure in export-oriented manufacturing firms and in those of the services sector will be kept untouched by the wave of technical change. Pressures on the educational system of developing countries will grow and add to their historical difficulties in providing wider coverage of basic, good quality education and higher levels of technical, vocational and post-secondary education.

As Table 1 shows, high adult illiteracy rates and low enrollment in secondary schools in developing countries are additional obstacles to the incorporation of women and larger segments of the total population into learning economies. In all countries, the needs of learning economies in terms of coverage and quality of education and the response of their educational systems appear to be generating a gap that is widening with the pace of the technological change. Many fear that formal education is losing the ability to prepare adequately some of the specialised human resources and of supplying the whole population with the intellectual skills to operate in information-rich economies, societies and polities. Deficiencies of the formal education system in relation to the provision of wide coverage of basic education and generation of creative, independent and reflexive learners, are well acknowledged in developing countries.

<table>
<thead>
<tr>
<th>Groups of countries</th>
<th>Primary¹</th>
<th>Secondary²</th>
<th>Tertiary³</th>
<th>Adult Illiteracy⁴ (1995)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1980</td>
<td>1993</td>
<td>1980</td>
<td>1993</td>
</tr>
<tr>
<td>Low- and middle-income</td>
<td>105</td>
<td>110</td>
<td>45</td>
<td>..</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>90</td>
<td>78</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>East Asia and Pacific</td>
<td>118</td>
<td>120</td>
<td>51</td>
<td>60</td>
</tr>
<tr>
<td>South Asia</td>
<td>91</td>
<td>110</td>
<td>36</td>
<td>..</td>
</tr>
<tr>
<td>Europe and Central Asia</td>
<td>..</td>
<td>97</td>
<td>..</td>
<td>81</td>
</tr>
<tr>
<td>Middle East and N. Africa</td>
<td>98</td>
<td>103</td>
<td>52</td>
<td>65</td>
</tr>
<tr>
<td>Latin American and Caribbean</td>
<td>108</td>
<td>..</td>
<td>40</td>
<td>..</td>
</tr>
<tr>
<td>High Income economies</td>
<td>103</td>
<td>103</td>
<td>..</td>
<td>97</td>
</tr>
<tr>
<td>World</td>
<td>104</td>
<td>109</td>
<td>50</td>
<td>..</td>
</tr>
</tbody>
</table>


¹ Population age 6 to 11. Figures exceeding 100 percent indicate pupils younger or older than the country’s standard primary school age
² Population age 12 to 17. Figures are affected by late entry, repetition and “bunching” in final grades
³ Population age 20 to 24.
⁴ As percentage of population age 15 years and older

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Why is education out of step with society’s needs? One reason is exactly the pace of technological change which does not allow time for an appropriate codification of the relevant knowledge with the consequence that students never learn at school what they are expected to use in their future jobs. Education cannot be identified with training nor ignore shifting demands from the labour market. In more general terms, inadequacies of the current educational systems are seen to emanate from the fact that they were originally designed to meet the needs of agricultural and industrial societies, of standardised manual production, not the diversified, knowledge-intensive production in the information society. Students were conceived as people to be instructed, as the recipients of knowledge to be given them by the teachers. This conception of education passed on to the colonies and became dominant also in the presently developing world. In spite of the contribution of research in education, psychology and the cognitive sciences, educational systems are said to be still dominated by some variation of these old conceptions and there is not much done to develop problem-solving, creative and independent thinking among students. It may be that the ingenuity of education reformers was curtailed by the level of technological development of their societies. Many believe that the advances of information and communication technologies nowadays can help change education into a truly living learning experience (Papert 1993). Whether or not the futuristic “virtual classroom” described by Tiffin and Rajasingham (995) will
be the embodiment of a new conception of education is still a matter of speculation, fear and hope.

Teachers are the key factor in the integration of innovations into education. This is a category of professionals of whom new skills are demanded if the new technology is to be harnessed for education. They are expected to move from a lecturer-centred role into a tutoring one and be able to increase attention to individuals at the same time as dealing with students working in groups. Some think that in order to meet the intellectual challenges stemming from change in the role of teachers, it will be necessary a complete re-engineering of the teaching profession. Pre-service and in-service teachers will have to be offered the means to develop the ability to manage complexity, individuals and groups in time and space, and new resources and tools (Barchechath 1996). Connectivity of schools is reported to help enormously teachers to adapt to these new demands by breaking their isolation and increasing their communication with fellow professionals, making available richer resources for preparation of classes and giving the opportunity for participation in in-service courses (Veen 1996).

In brief, skills now required of managers, professionals and workers, include from abstraction, problem-solving, systems thinking and experimentation - implied in higher levels of education - to adaptability, versatility and the ability to manage complexity and work as a part of a team. In order to acquire these skills and keep updated in the world of work, cultivated curiosity, spirit of inquiry and learning to learn are basic skills to be developed by individuals living in a situation of rapid technological change. Learning was never only about absorbing information, but the flow of information one has to deal with, the dominance of written language and the abstract working environments in the present and foreseeable future fosters more forcefully than ever the development of abilities to communicate, to sift and select, to simulate and model (Mulgán 1996). The quantity of information available on networks requires the development of skills to navigate through information ‘as a precondition to knowing’ (Delors 1996:175).

2.2 Information Technology Applications to Education and Skill Generation

Information and communication technologies have enlarged the amount of tacit knowledge that can now be codified. Multimedia tools can apprehend, store and transmit more vividly particular aspects of reality learners could have never experienced unless they were involved in real “hands-
on” experience or in a master-apprentice relationship. This is exactly what widens up education and training possibilities and may threaten a more complete and integrated knowledge acquisition when this codified knowledge is delivered in piece-meal or “infnuggets” in new modalities of just-in-time training (Gordon 1997). Codification of tacit knowledge cannot ever be complete, the same way as “virtual reality” will always be a simpler, poorer and incomplete model of the real world. Tele-training and “just-in-time” training may represent new opportunities of enriching learning experiences for workers, but they can also entail a modality of de-skilling and reduce workers’ access to consistent and integrated codified knowledge.

Telematics offers a wealth of possibilities of engaging learners in complex and meaningful tasks, of facilitating communication between learners and teachers or more experienced co-learners, of helping individualise education and training, of improving the insertion of learners and their teaching institutions in their surrounding and wider social environments. However, it is important to stress that empirical evidence shows that technology in education only makes relevant contribution to learning when integrated in the overall education activity, linked to programmes of professional development of teachers and within a longer-term commitment of school administration and other relevant authorities to supporting a chosen innovation trajectory (Hawkins 1996; Coley, Cradler and Engel 1997).

Two basic telematics functions, e-mail and information retrieval or file transfer (FTP), and the many applications they support (e.g. bulletin boards, computer conferencing, on-line database) have been in use in post-secondary education, training or for research purposes for many years now in industrialised countries and even in many middle-income developing countries. Since the hypertext mark-up language gave rise to the explosive growth of the WWW, and web browsers were developed, the web became one obligatory source of information to be tapped in by learners and teachers. Hypertextual teaching aids are being used as a modality of “automatic” tutoring that offer attractive possibilities of deeper discussions based on questions that are meaningful to

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3 The development of computer graphic capabilities and compression techniques have widened up the use of image and sound for codifying knowledge much beyond the simulation of virtual reality. Moving of real image, sound and text in CD-ROM have been for some time now an important media for education and training. While a very powerful tool, CD-ROM based information is still mostly used in its stand-alone format. Recent developments of Digital Video Disks (DVD), either in DVD-ROM or DVD-Video versions promise a revolution in the quality of production and reproduction of simultaneous moving image, text and sound information, but will require computers with high-performance graphics and power to display in full the accuracy of motion and quality video. It is possible that DVD-Video players will never reach schools, but DVD-ROM may diffuse more easily through upgrading of CD-ROM and as a component of new computers. Publishers will need some time to switch to this new technological frontier.
learners, complete courses are collaboratively produced with web resources and to be delivered through the web. It is however a matter of further research to unravel the constraints these electronic educational functions may put on novice learners and the psychological and cognitive effects of both information validation and information saturation\textsuperscript{4}.

Beyond the basic, asynchronous functions of e-mail, FTP, and hypertext, there are many more sophisticated and technologically demanding telematics applications that can be used for educational purposes. These include all the synchronous applications for teleconferencing that go from audio- and audiographic to desktop video- and distributed multimedia conferencing. Used in the present mostly as a learning tool for higher level managers and professional staff, these applications require not only special software but also special equipment in addition to the standard personal computer.

3. INFRASTRUCTURE AND COSTS

All telematics functions require reliable telecommunications and, in the case of synchronous applications, a highly developed and potent infrastructure for acceptable quality levels of transmission and reception. When telematics applications involve very diverse communication networks, synchronous applications depend on extra adaptations and may not reach acceptable quality levels. Attempts at mobilising synchronous applications for education across country boundaries in Europe have shown the additional difficulties that stem from differences in the existing telecommunication networks in relation to performance, reliability and functional characteristics (Müller, Lekkou and Weydandt 1996).

Reliable and potent telecommunication infrastructure has been considered as the most fundamental constraint on access to telematics functions by developing countries. The development of radio transmission, compression techniques and of satellite communication technologies have practically removed most of these technological obstacles to access. The question that remains and which is not trivial is economic, not technological.

\textsuperscript{4} As these applications generalise down the educational system, particularly in industrialised countries, families and teachers become concerned with undesired effects on young people of indiscriminate access to a wide array of information as well as long periods of working with computers. E-mail has been reported to be abusively used by novice learners, distracting them from other more demanding tasks; to contribute to isolation from social contact; to expose users emotionally immature to potentially difficult situations through the establishment of deeper intellectual involvement in a clueless environment. Some of these effects seem to fade away, but others may be longer-lasting. Various strategies have been devised to reduce these undesired effects, particularly in a classroom environment. Social and psychological effects on adults and young people of operating in a “virtual” environment are still to be systematically studied.
As Table 2 shows, a telephone line, a personal computer and Internet access, the fundamental components of telematics applications to education, are rare commodities in all but the higher income countries. The wider penetration of television sets in households of middle- and lower-income countries make for a powerful communication infrastructure. Broadcasting of educational programs on television or radio have been used with various degrees of success as a supporting media for distance education in many developing countries.

### TABLE 2: INDICATORS OF ICT PENETRATION - 1995

<table>
<thead>
<tr>
<th></th>
<th>LOW INCOME COUNTRIES</th>
<th>LOWER MIDDLE INCOME COUNTRIES</th>
<th>UPPER MIDDLE INCOME COUNTRIES</th>
<th>HIGH INCOME COUNTRIES</th>
<th>WORLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV RECEIVERS (per 100 inhabitants)</td>
<td>12.9</td>
<td>20.4</td>
<td>26.1</td>
<td>61.2</td>
<td>22.8</td>
</tr>
<tr>
<td>TV HOUSEHOLDS (% of total households)</td>
<td>47</td>
<td>71</td>
<td>87</td>
<td>90</td>
<td>66</td>
</tr>
<tr>
<td>TELEPHONE LINES (per 100 inhabitants)</td>
<td>1.98</td>
<td>9.09</td>
<td>14.51</td>
<td>53.16</td>
<td>12.14</td>
</tr>
<tr>
<td>ESTIMATED PC (per 100 inhabitants)</td>
<td>0.18</td>
<td>1.08</td>
<td>3.29</td>
<td>20.51</td>
<td>4.23</td>
</tr>
<tr>
<td>ESTIMATED USERS OF INTERNET (per 1 million inhabitants)</td>
<td>17.2</td>
<td>811.57</td>
<td>3,757.5</td>
<td>24,679.46</td>
<td>4,833.77</td>
</tr>
</tbody>
</table>


An evolution from this experience is the use of recorded programs on video cassettes for distance and classroom education. If the major aim of technology choice for educational application in developing countries is outreach and economies of scale more than individualised access and interactivity (Hancock 1993), the level of development of their infrastructure would point to a more systematic and innovative use of mass communication. Telematics applications cannot be taken as a solution to mass education in the developing world. They are likely to remain for some decades restricted to higher levels or special education and training and become a distinctive feature of few centres of excellence in secondary and primary education.

World trade figures shown on Table 3 demonstrate that, in a market dominated by high-income countries, middle- and lower-income countries are making an intense effort to overcome deficiencies in their telecommunication infrastructure and to become actors in the world telecommunication market.
High-income countries accounted for 72 percent of world imports and 86 percent of world exports of telecommunication equipment in 1995. Statistics on trade in software and value-added electronic services would probably show an equally concentrated market in spite of strong efforts of developing countries to break in these international markets.

**TABLE 3: TELECOMMUNICATION EQUIPMENT IMPORTS AND EXPORTS (US$ MILLION) - 1990-1995**

<table>
<thead>
<tr>
<th>Groups of Countries (GNP p/capita)</th>
<th>IMPORTS</th>
<th>IMPORTS AVERAGE GROWTH - % (1990-95)</th>
<th>EXPORTS</th>
<th>EXPORTS AVERAGE GROWTH - % (1990-95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income Countries (US$ 725 or less)</td>
<td>1,137.6</td>
<td>4,606.1</td>
<td>32.5</td>
<td>142.9</td>
</tr>
<tr>
<td>Lower Middle Income Countries (US$ 726 to $2,895)</td>
<td>1,714.5</td>
<td>5,336.4</td>
<td>25.2</td>
<td>374.7</td>
</tr>
<tr>
<td>Upper Middle Income Countries (US$ 2,896 to $8,955)</td>
<td>1,992.5</td>
<td>6,727.1</td>
<td>22.9</td>
<td>1,366.0</td>
</tr>
<tr>
<td>High Income Countries (US$ 8,956 and over)</td>
<td>18,834.9</td>
<td>43,626.8</td>
<td>18.3</td>
<td>21,961.1</td>
</tr>
<tr>
<td>WORLD</td>
<td>23,679.6</td>
<td>60,296.4</td>
<td>20.1</td>
<td>23,844.7</td>
</tr>
</tbody>
</table>


While industrialised countries have the infrastructure required for advanced telematics applications to education, the establishment of a modern telecommunication infrastructure in the developing world and the perspectives this will open for international trade (including on-line trade in education and other services) are likely to constitute strong forces for market growth. A modern telecommunication infrastructure brightens also the prospects for growth in developing countries production and exports. Modern telecommunication is already allowing growth of on-line exports of data-processing services from English-speaking developing countries. Distance education and tele-working are both important components of the world information economy.

Advanced telecommunication services demand updated telecommunication infrastructure, which is dependent on large investments. As the telecommunication sector emerges from the exclusive control of the state, it is expected that market forces push for the necessary investments and eventually produce the needed reduction of rates for connectivity and telecommunication services. Re-regulation of telecommunication markets has shown some positive effects in cost reduction, particularly for businesses; the improvement of telecommunication infrastructure, particularly in relation to wireless communication; and telecommunication services, particularly Internet access.
However, privatisation of basic domestic telecommunication services and cost-based pricing may also have a less virtuous effect on affordability which constrain widespread telephone access. Practically every household, school and university in industrialised countries and many of those located in large urban areas of middle-income developing countries have already access to a telephone line, but many more have not and will wait for many years to be connected. In rural areas of most developing countries, telephone connection is an undreamed-off luxury for the majority of households. Telephone lines in rural schools, which usually do not even have a chalkboard, are a far-cry distant educational tool.

In industrialised countries, the costs of connectivity are high and tariffs for basic telecommunication services are still a constraint to wider telematics applications to education. The EU moves to gradually open the telecommunication market, initially for sophisticated data services and private voice networks (1991) followed by basic data lines (1993) and mobile telephony (1996) and the expectation of stronger competition in Europe when the voice telephony market opens in 1998, have pushed companies to adjust their prices already benefiting many customers, particularly businesses and higher income individuals. Annual costs of a "basket" of domestic telecommunication services within Europe range from US$ 320 in the UK to US$ 425 in Spain, US$ 450 in Germany and US$ 500 in Belgium and have not dropped significantly in recent years (Branegan 1997:44). In the USA, where a comparable basket of domestic phone services cost annually US$ 237, the Telecommunications Reform Act of February 1996, defined that schools and libraries will be provided connectivity at special rates. This is an initiative other countries should consider if telematics applications are to make a significant contribution to continuous learning in classrooms and open environments. It may not be difficult for governments in developing countries to emulate this initiative particularly because they still control national telecommunication operators. When and where the necessary infrastructure is present, the costs of hardware and software, of training teachers and of providing technical support to schools become strongest factors that hold back wider telematics applications to education.

The cost of international basic telecommunication services is affected by the interconnection fees charged by domestic carriers to bring the call the last kilometre to the customer's house. Interconnection fees are presently defined in bilateral arrangements between foreign and domestic carriers and, due to their effects on high costs of international basic services, contribute to slow down international trade in telecommunication services. Together with restrictions to market
access, higher tariffs for international basic telecommunication services put some constraining limitations to on-line and cross-border trade in education and training.

The recent international agreement on trade in services is expected to help reducing international telecommunication costs. It defines a compulsory commitment to the most-favoured nation obligation (in contrast to bilateral reciprocity) and transparency by all WTO member countries, but commitment to specific market access and national treatment remains on a voluntary basis. While market opening in Europe is evolving in the expected direction and within the agreed time schedule, some analysts doubt that voluntary commitment to market access will ever allow the emergence of an effectively global telecommunication market (Fredebeul-Krein and Freytag 1997). Restrictions to market access and high tariffs may work as an incentive to international partnerships for local or regional production and on-line delivery of education and training.

4. COMPUTERS AND TELEMATICS FOR EDUCATION: LEARNING FROM THE INTERNATIONAL EXPERIENCE
There is a large international experience with the introduction of computers into schools, particularly in industrialised countries but also in some middle-income developing countries. The compilation of this experience in industrialised countries and evaluation of its pedagogical and cognitive results is at an advanced stage. Similar study of the experience in developing countries is still to be done. Telematics applications to education is a much more recent phenomenon both in the developed and developing worlds. Telematics tools have reached wider education and training applications in industrialised countries with the Internet “boom” in the early 1990s. Evaluation studies of the pedagogical impact of this new educational tool are very few. Expansion of Internet services in the developing world has been similarly explosive during the same period, particularly in middle-income countries and the most affluent urban regions within each country. Telematics applications in developing countries are also expanding very quickly and this pace of growth has not yet allowed a proper evaluation process to be set in place. The social impact of telematics and other ICT applications to education in the developing world is a still unexplored research field.

5 The literature is large, often devoted to drill-and-practice applications and very seldom offering qualitative assessment or international comparisons. Meta analytical studies are now beginning to systematise the copious amount of empirical data. The situation in the USA is very well documented and updated. A recent empirical study of the computer and on-line application in schools in the USA is found in Coley, Cradler and Engel (1997) who also give abundant references. Enlightening international comparisons involving Europe and other industrialised countries can be found in Hebenstreit (1992) and Pelgrun et. al. (1993) which, however, missed the Internet “boom”. Pelgrun et. al (1993) brings in some information from few developing and East European countries.
4.1 The Experience of Industrialised Countries

Since the 1970s, the introduction of computers in schools became an objective of governmental policy in Europe. Policies followed two strategies. One aimed at introducing the teaching of computer science into vocational and upper secondary education in order to develop computer-related skills for participation in the labour market. The other, more comprehensive, had the objective of stimulating the use of computers to improve teaching and learning processes, compensate for the decline in the number and quality of teachers and improve access to education. More recently it has also incorporated the objective of developing communications between schools intra- and internationally. Both strategies required massive and continuous government support until the early 1990s when the policies shifted to supplementary schemes mostly run by municipal or regional authorities.

Resulting from this effort, most of post-secondary teaching institutions, many secondary and a few primary schools in Europe were provided with hardware and developed some expertise in applications of computer-based functions to education. The PC became a standard platform, as a stand-alone piece of equipment, a terminal linked to powerful mainframes or as units of local and wide area networks. Despite of the effort, computers are still a scarce equipment in many schools and those that are available are ageing very quickly (Pelgrum, Janssen Reiner, Plomp 1993). The students to computer ratio is reported to have reached 30:1 for post-secondary and upper secondary education in the UK and France, in the early 1990s, what put them on equal footing with the USA. Figures for lower school levels give a less positive picture. In the Netherlands and Denmark, a significant proportion of secondary schools owned at least one computer in the early 1990s, but it was mainly used for teaching computers as a discipline or for data processing applications in professional training. There were very few computers in primary (6 to 11 year-old students) or lower secondary (12 to 15 year-old) schools. Portugal, Spain and Greece started planning for the introduction of computers in education only in the early 1990s (Hebenstreit 1992:57). The enormous speed in which the installed base of computers in industrialised countries schools grew within a few years can be inferred by the average ratios reached in 1994 in the education system as a whole. In that year, the average students to computers ratio were between 50:1 and 30:1 in Germany, France, the Netherlands, Denmark and Japan. These countries are still far from reaching the more satisfactory ratio of 10:1 of Sweden and the UK.

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6 The National Development Programme in Computer Assisted Learning (NDPCAL) in the U.K. and France’s experiment with minicomputers in fifty-eight secondary schools in the mid-1970s are illustrative. See (Hebenstreit 1992)
which is the same average ratio of the USA. (European Commission 1996a: 20; Coley, Cradler and Engel 1997:3). In Europe, as in general, university students have a better access to computers, but access is still uneven between countries. The ratio of students to computer in post-secondary education in the UK is an average of 10:1, while in Germany it is 50:1 (Meyer and Berger 1996) and in Portugal and Greece may be even less favourable.

An effort to update the installed base of computers of educational institutions of Europe has started recently. Since 1994, governmental authorities of the United Kingdom, France, Finland, Italy, Portugal, Denmark, Sweden and Germany have announced allocation of resources for this upgrading, including connectivity of schools to the Internet. One illustration is the “Schulen und Netz”, a plan of the German government in partnership with private enterprises that aims to connect 10,000 of 52,000 German schools to national and international networks and multimedia services over a three-year period. In some German Länder the goal is to provide universal connection to schools (European Commission 1996b: 21).

In the USA, where practically all schools own computers and video cassette recorders and 85 percent have multimedia computers, these machines have been used mostly as stand-alone equipment. Only recently networking within schools has been implemented and the result of this effort is that one third of all schools is presently connected in local area networks. This is a decisive step towards a more integrated exploration of computers as a learning tool. Sixty-four percent of U.S. schools had Internet access in the Fall of 1996, showing an increase of 15 percentage points in 1994 and 1995. Practically all states have created educational networks for teachers, administrators and students (Coley, Cradler and Engel 1997:17). At present, Europe and the USA seem to be in a similar transition from stand-alone hardware in schools to connectivity; from isolated skills practice to integrating technology into disciplines; from poor preparations of teachers to support for all teachers to learn how to use it effectively in everyday teaching (Hawkins 1996)

It is very large the investment required to update this equipment and reach the satisfactory ratio of 5 pupils per computer\(^7\), not to mention the costs of training teachers and supporting staff. The EU

\(^7\) This was the ideal students per computer ratio used by the OECD for post-secondary education. The now defunct Office of Technology Assessment of the Congress of the United States estimated the required ratio as three students per computer. In 1994, the report of a OECD working group on the future of technology for post-secondary education endorsed the target ratios for 1996 proposed by the United Kingdom Inter-university Committee on Computing. The target ratios were estimated to vary according to the subject area: 1:8 for medicine, humanities
Task Force on Educational Software and Multimedia estimated this investment in Europe to be in the order of ECU 20,000 million, or around 6 percent of the European Union estimated expenditure on education in 1994 (European Commission 1996a: 25). In the USA where schools are already well equipped, the cost of the currently installed technology has been estimated at about US$ 70 per pupil. Expenditure would have to increase to US$ 300 per pupil if the installed base is to be updated to higher technological levels (Coley, Cradler and Engels 1997). Hardware acquisition is the major cost component and depends on how far into the school the technology is deployed, i.e. to a lab, a classroom or each student’s desk. The next costly component is operating personnel, followed by staff development and software. Connection costs (Internet access and telephone bills) in the USA are relatively small, representing from 4 percent to 7 percent of initial and ongoing costs.

Cognitive changes induced by the use of computers and on-line applications are still a matter for discussion. Evaluation of computer-aided-instruction for basic skills and drill-and-practice has concluded for a positive effect on achievement levels and emphasised what changed in the classroom (attitude of the teacher, changes in students behaviour and in the content of what is taught), but there is little comparison between the same course taught with and without a computer. It has been found that computers in education widen the scope of pedagogical strategies; broaden the variety of subjects to be taught; familiarise students with the main applications of computers (graphics, simulation, word processing, data banks, etc.); increase the complexity of subjects and problems that can be handled by students; stimulate autonomy and creativity of the students (Hebenstreit 1992:60-61; Coley, Cradler and Engel 1997: 34-39).

Specific evaluation of electronic networking and of on-line communication applications are very few and many are still ongoing activities. Networking is seen as particularly positive in improving students writing and the overall quality of collaborative work (Coley, Cradler and Engel 1997: 35). Evaluation of on-line access to wider sources of information is less conclusive. On-line access help students become independent and critical thinkers, but it can also decrease confidence in their ability to share work and participate in discussions. It can increase student performance, but younger students who have to shift from “learning to read” to “reading to learn” seem to be less able to benefit from access than older students (CAST 1996).

and education; 1:4 for the social sciences; 1:2.5 for mathematics and computing; and 1:2 in science, engineering and technology (Hebenstreit, Tobin and Winship 1994)
The effectiveness of educational technologies is found to be very sensitive to the quality of implementation of the technology: the best technology used badly is very likely to produce poor educational results. Inadequacy of standardised achievement tests to measure the changes computers and telematics applications are expected to create, the need to consider other factors affecting achievement, and the fact that effects of technological innovation in education may well go beyond student’s learning, are challenges to a more satisfactory assessment of effects of computers and telematics applications to education. Innovative research designs are necessary to gauge the cognitive and pedagogical effects of new technologies.

It is also necessary to evaluate the social implications of telematics applications to education. While they are expected to offer opportunities of expression to learners with special needs, ethnic minorities and women, this can only happen if access to computers does not discriminate against those groups. It seems however that computer use in schools is affected by gender, ethnic and economic factors, reflecting the social environment of school, and seems to aggravate inequity (Reinen and Plomp 1997; Coley, Cradler and Engel 1997).

4.2 The Developing World Experience

Developing countries started introducing computers in schools in the mid-1980s and many have now conditions to offer access to the new technologies to post-secondary and some secondary schools. As usually happen to late comers, they can reap the benefits of leapfrogging instead of having to update ageing equipment.

Quantitative information or assessment of the current level of computer penetration in schools of the developing world is not available. The educated guess is that post-secondary teaching

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8 The introduction of computers in schools of developing countries was mainly done in the mid-1980s, by government initiative (e.g. China, Singapore, Sri Lanka) or stimulated by donations and initiative of individuals (e.g. Zimbabwe, Kenya, Malawi, Tunisia, Pakistan, Philippines) followed by government support, as the case of India (Hawridge, Jaworski et al. 1990). Brazil seems to have led Latin American debate on strategies of introduction of computers in schools with EDUCOM, a five-year governmental project of academic research on the impacts of computers in learning processes launched in the early 1980s (Barros forthcoming). Computers in schools were expected to increase computer awareness, promote computer literacy and develop programming abilities as a discipline and an examination subject. Wider pedagogical applications have not been a concern until very recently and seem to have been pushed into the educational policy agenda by international organisations or donor agencies with the support of local professional elite, including teachers who had themselves had a contact with novel applications during their graduate studies. Already in the late 1980s, however, guidelines of The Commonwealth also suggested pedagogical (to enrich the existing curriculum) and catalytic (to promote change in education) strategies for introducing computers in schools. UNESCO has promoted the discussion of the issue within a broader audience in the developing world through various regional meetings and international congresses about Education and Informatics and has made a systematic attempt at extending the discussion beyond the issue of teaching computer studies.
institutions are, in most middle-income countries, equipped with mainframes and terminals for limited access by learners. Telematics functions, in spite of the obvious limitations of national telecommunication infrastructure, are a very recent addition to educational tools at post-secondary institutions in developing countries and seem to be spreading there also at great speed. Connectivity and telematics applications are percolating down the education system and reaching some secondary schools at impressive speed. There is anecdotal evidence of connectivity for small numbers of universities in lower-income developing countries, in late 1996, as was the case of the University of Zimbabwe and others in Sub-Saharan Africa. In some middle- and upper-middle income countries it is already possible to develop school-to-school co-operating projects between secondary schools in the USA, Canada or Europe and a counterpart school in Latin America, Eastern Europe or Africa. There are projects such as “SchoolNet” in Thailand9, “Smart Schools” in Malaysia, Enlaces (Chile) and “Escola do Futuro” (School of the Future)10 in Brazil exploring the educational possibilities of electronic networking and telematics at great lengths and different levels of technological sophistication.

The costs of equipping schools with computers, software and connectivity seem beyond all consideration for developing countries, even those at middle income level. In addition, a responsible approach to such an initiative would have to consider the costs of training, maintenance and support, which are not trivial. The more modest costs involved in establishing a computer lab has been estimated at US$ 50,000 in Brazil, including Internet connection and excluding costs of training and recurring expenses. Monthly expenditure with telephone charges would represent 20 percent of the fixed costs (Barros forthcoming). In-service teachers training with and about telematics applications is also in developing countries a necessary and costly initiative which may involve the need to upgrade equipment in the institution that is delivering the training and equip those who are receiving education at a distance.

A pilot project with such scope launched in Brazil in 1996 is illustrative. The budget for hardware involved initial costs of around US$ 54,000 per receiving school and US$ 40,000 per delivery institution. The project is fundamentally directed to in-service training of teachers of primary and lower level secondary schools (7 to 14 year-old students) and upper secondary schools (15 to 17 year-old students) in mathematics, physics and biology. Table 4 shows details of the equipment and their estimated local costs.

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9 See http://k12.nectec.or.th
10 See http://www.futuro.usp.br
This pilot project is a two-year initiative involving 4 delivery-centres and 40 receiver-schools with 2,649 teachers and 65,300 pupils, in four non-contiguous regions of the country. Of the total budget of US$ 4.6 million, 63 per cent is destined to hardware purchase. Each participating school is to be equipped with 20 personal computers. As students attend schools in Brazil for only one period of 4 hours daily, the average student per computer ratio in participating schools is 42:1. This is not a very favourable ratio and may mean that many students will hardly have the opportunity of a real "hands on" experience. It nevertheless will allow teachers to test course structures and material and their acquired skills in applying the new technologies in everyday teaching. In fact, the project targets teachers more than their pupils and for this purpose the projected numbers of computers support an ideal average ratio of 3-4 teachers per computer.
**TABLE 4: HARDWARE REQUIREMENT OF PILOT PROJECT OF TELEMATICS APPLICATION TO EDUCATION IN BRAZIL - 1996**

<table>
<thead>
<tr>
<th>No.</th>
<th>TYPE</th>
<th>CHARACTERISTICS</th>
<th>ESTIMATED LOCAL UNIT COST (R$)</th>
<th>TOTAL COST (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) NODE ß (instructor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>“Internet” server</td>
<td>Pentium 150/166 Mhz, 128 MB RAM, colour SVGA 17” monitor, 2 HDD SCSI 4GB, CD-ROM, floppy, LAN interface, no break 5KVA</td>
<td>5,500</td>
<td>5,500</td>
</tr>
<tr>
<td>1</td>
<td>Server with packet radio link</td>
<td>Pentium 100 Mhz, 32MB RAM, colour SVGA 14” monitor, HDD 2GB, CD-ROM, floppy,</td>
<td>4,050</td>
<td>4,050</td>
</tr>
<tr>
<td>1</td>
<td>Radio link</td>
<td>Modem RF 56Kbps, PI2 Card, transmission converter 28mhz to 144 Mhz, reception converter 450mhz to 28mhz, transmitter 2m (144mhz), receptor 70 cm (450mhz), antennas</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>1</td>
<td>Server with phone link</td>
<td>Pentium 100 Mhz, 64MB RAM, colour SVGA 14” monitor, LAN interface, HDD 4GB</td>
<td>4,050</td>
<td>4,050</td>
</tr>
<tr>
<td>8</td>
<td>Modem</td>
<td>28K8 (Hayes compatible)</td>
<td>...</td>
<td>2,000</td>
</tr>
<tr>
<td>10</td>
<td>PC stations</td>
<td>Pentium 100 Mhz, 16MB RAM, colour SVGA 14” monitor, stabiliser, LAN interface, CD-ROM, speakers, microphone, sound blaster, HDD 1.28 GB, floppy</td>
<td>2,500</td>
<td>25,000</td>
</tr>
<tr>
<td>1</td>
<td>Scanner</td>
<td></td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>(II) SCHOOLS (learner)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Server</td>
<td>Pentium 133/150 Mhz, 32 MB RAM, colour SVGA 14” monitor, no break, 2HDD IDE 1.28 GB, CD-ROM, floppy, LAN connections</td>
<td>4,050</td>
<td>4,050</td>
</tr>
<tr>
<td>1</td>
<td>Radio link</td>
<td>Modem RF 56Kbps, PI2 Card, transmission converter 28mhz to 144 Mhz, reception converter 450mhz to 28mhz, transmitter 2m (144mhz), receptor 70 cm (450mhz), antennas</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>20</td>
<td>PC stations</td>
<td>Pentium 100 Mhz, 16MB RAM, colour SVGA 14” monitor, stabiliser, LAN interface, CD-ROM, speakers, microphone, sound blaster, HDD 1.28 GB, floppy</td>
<td>2,500</td>
<td>50,000</td>
</tr>
<tr>
<td>1</td>
<td>Printer</td>
<td></td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

**TOTAL**  
(A + B) 102,650

Exchange rate: 1US$=R$1.0196 (15/08/96)
4.3 Major Lessons from Experience

Countries that have not had previous experience with computers and telematics applications to education should be aware of the lessons that can be drawn from the international experience before engaging in costly initiatives.

The process of introduction of new technology in schools in Europe and other developed regions teaches many lessons on the proper preparation of teachers and decision makers, planning and fully implementing pilot projects, and of making budgetary provisions to allow for hardware upgrading. Training of teachers is the most central focus of all strategy and considered, together with development of courseware, the main determinant of success.

Teachers have to be trained in the methodology of using computers effectively and informed about activities and developments in the field. A good lesson from the European experience is the pilot organisation or ‘centre of competence’, usually a university or teacher-training school, that puts together a pool of experts as computer and telecommunication specialists, teacher students, psychologists, specialists in computers in education, linked to the outside world and able to provide training and support to teachers in their everyday dealings with the new technology.

The European and other industrialised countries experience with quality educational software is also to be closely observed by those regions and countries that want to learn the best way to harness the new technology. Quality educational software remained for many years an unexplored field by commercial companies. Educators had themselves to be able to produce their teaching material. Strong state support was provided for the development of educational software within schools. Nowadays however, the sector is booming and there is wider choice of educational software. Developing countries still have much to do to stimulate the emergence of an industry of educational software adapted to their needs. Some of the more technologically-oriented

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11 Teachers training and the development of courseware were subject to a special, separate and successful programme in Britain of the late 1970s: the “Micro-electronics Education Programme” (MEP), closed down in 1988. Its budget was destined exclusively to training and courseware development. Hardware purchase was accomplished by the special project “Micros in Schools” which targeted first, secondary schools, followed by primary schools.

12 In the UK, in the 1970s, the NDPCAL project supported the development of Computer Assisted Learning (CAL) and Computer Managed Instruction (CMI) for post-secondary and further education. Institutions submitting a project would have to commit own funds in the same amount as those applied for. In The Netherlands, the POCO project of the mid- to late-1980s awarded contracts for the production of specific courseware packages coming out of the pilot and design phases. Two thousand participating schools got a computer laboratory of nine 16-bit MS/DOS computers in a network and two stand-alone computers. The school system had to budget the maintenance costs, the extension and renewal of this starting base and allocate funds for the acquisition of new software.
developing countries have built some expertise in software that can be mobilised for local production of courseware. Such countries have a basis on which build partnerships with experienced educational software producers for a more constructive alternative to trade in quickly adapted foreign material.

One major issue now, for developed and developing countries alike, is to evaluate the quality of what is on offer, stimulate the production of less demanded software for special curriculum needs, provide schools with resources for software acquisition and guide them in their selection of what to purchase. Many of these activities can well be accomplished by educational software clearinghouses that rate software against a set of curriculum standards or, at least, provide a catalogue of previewed software.

An example of curriculum oriented software assessment is what is done by the California Instructional Technology Clearinghouse (CITC)\textsuperscript{13} whose evaluation guidelines include rubrics for evaluating educational resources on the Internet. These guidelines look into content to see its match with standards and curriculum frameworks as well as legal compliance, e.g. if it is not racially or gender biased. They also look into the instructional and program design, assessment strategies and instructional support materials. Software is assessed as “exemplary”, “desirable” or “minimal” in each item of the guidelines and only the courseware judged “exemplary” are recommended for use in schools. Only 8 percent of an average of 200 courseware reviewed by CITC in the period of 1991-1995 was considered “exemplary” and 53 percent was not recommended. Excellence in technical and instructional quality is not enough to guarantee excellence.

Illustration of a less strict, but nevertheless useful aid to teachers in the selection of educational software is done by the "Educational Software Consortium" composed of 19 educational institutions in the USA which publishes\textsuperscript{14} each year an "Educational Software Preview Guide" listing and describing favourably reviewed microcomputer software for instructional use in preschool through grade twelve. The guide is conceived to be solely an aid to educators in locating programs they may want to preview.

\textsuperscript{13} A curriculum evaluation database, as well as CITC evaluation guidelines are available at http://tic.stan-co.k12.ca.us/

\textsuperscript{14} The guide is distributed by ISTE (International Society for Technology in Education), http://www.iste.org/publish/pub.html
5. DO SCHOOLS IN DEVELOPING COUNTRIES NEED COMPUTERS, OR DO THEY NEED TELEMATICS TOOLS?
Governments and professionals of middle-income developing countries answer affirmatively to the first part of the question, but many are still doubtful in relation to the last part of it. The most well-organised and apparently knowledgeable pressure group in favour of wider use of computers in schools in developing countries is the one composed of computer scientists in higher education. Education professionals were not up to recently aware of nor interested in computers, telematics, and their applications to teaching. This has changed in the last decade and nowadays large groups of educators pressure for the extension to their schools of the same facilities they have been used to in their graduate (or undergraduate) courses. Publishers, broadcasters, service providers and telecommunication operators also in developing countries constitute new and stronger pressure groups for integration of new technologies to education. International development agencies play a relevant role now as they did in the past with other technological experiments for education in the developing countries. In these countries as well as in industrialised countries, pedagogical and distributive demands are one line of conflict separating educators, scholars and librarians on one side, and telecommunication operators and publishers on the other. A difficult political challenge to governments is to arbitrate the conflict and promote the establishment of partnerships in the benefit of the many.

At present, to the social and vocational justifications for integrating computers in developing countries’ schools is added a growing awareness that familiarity with computers is necessary to complement literacy and numeracy, because computers are pervading industrial societies and are likely to become important in all countries. A word of caution come from those who draw the attention to the fact that introduction of computers in developing countries’ schools would be useless on conditions of little hands-on experience. Some also argue that the quick pace of technological change implies a high level of uncertainty in the definition of an adequate curriculum for vocational computer-related secondary education and that teaching of a subject that becomes quickly obsolete is a waste of precious teaching time. For many, the introduction of computers in developing countries’ schools is better explained as following an “information technology industry rationale” (Hawkridge, Jaworski et al. 1990) according to which schools (particularly public schools) provide manufacturers with a market with lower levels of uncertainty and high tolerance to costs.
All these considerations have to be debated to inform decision. It is also important to take into account the spectacular change in just few years of the present decade towards informatisation of schools in industrialised countries and the widening gap this advance may result between industrialised countries and the countries still not convinced of the advantages of harnessing information technology for education and training. This is a political decision and some communities may well decide against it. For those who reject this technological innovation now, it will certainly be much harder to bridge the technological gap if participation in the world market and/or their own internal development trends pressure for a reversal of the previous decision, some years ahead.

For the less favoured regions of Europe and many developing countries what is at stake now is not whether they should or not seek integration of new technologies to education, particularly telematics based applications, but how to pursue it, with what scope and at what pace. The risks of pushing forward in the information society are high for many developing countries, but the risks of staying behind are certainly bigger.

Some fear that developing regions are, in relation to these advanced telematics applications, once more having to discover a use for the latest gadget advanced countries want to sell. “I have a bridge, where is the river”, would have said the engineer visiting a developing country in older days (Murphy 1993). Now, the engineer would be replaced by the telecommunications provider or the satellite company and computer manufacturer who, with telematics applications in hand, look for markets in developing countries. Many of these countries still do not have minimum infrastructure requirements and a vocal pressure group in the education sector will certainly help creating domestic support that is necessary for the institutional change and the mobilisation of large resources, frequently of foreign origin, that will finance infrastructure upgrading.

Less favoured regions of Europe and middle-income developing countries certainly have their own priorities in the process of building their learning economies and integration in the global, information-richer society. They may perhaps aim at building, first, their community and regional information roads instead of aiming at information superhighways (Theobald 1996). In fact, these internal information roads may constitute a condition of effective integration in superhighways. If this is so, they will still need telematics applications and the required infrastructure, and as they might have wished to do in the past with iron, they will have to be prepared to decide on when and where to place the electronic bridges. The issue then is to be aware of what the local needs
and lines of desired development are, what options are available, and then make the decision that makes the best use of the human and financial resources.

6. CONCLUDING REMARKS
Continuous learning is an enormous challenge for the learning person, teaching institutions, enterprises and governments. Telematics applications to education and an international market that develops at the basis of wider telematics dissemination can help face this challenge.

Learners need good quality, continuously updated learning materials and flexibility in timing and place of study as much as individual support and guidance. They can have them from domestic or foreign electronically-accessed sources as well as “tele-educators” and co-learners.

Teaching institutions have to provide quality knowledge to a escalating number of students and, usually, within tight budgets. Teachers have to keep doing research and publishing, in spite of the pressure of increasing number of students, not to let drop the quality standards of education. Telematics can help ease pressure on teaching institutions and on teachers, in spite of the high investment in material and human resources for the conception, elaboration and implementation of education activities with the new media.

Enterprises need their staff to use productively the installed equipment, adapt quickly to new tools and working environment, and acquire the expertise needed to improve products and production without compromising working time nor entailing high opportunity costs. While more learning must take place in the context of work, employers are less stimulated to invest in training in a situation of employment instability. This is possibly one of the areas with higher prospects of market growth, opening up large possibilities for just-in-time training for both tele-workers and employees.

While all the above opportunities have been opened in the international market, decision about telematics applications to education and training tend to become increasingly supply-dominated. Developmental objectives as well as the expansion of trade in education goods and services within or across country boundaries will better be served by a stronger presence of demand considerations. Educational needs of users, the available material infrastructure and knowledge capabilities should play a stronger role in policy decisions related to educational technologies. Governments in developing countries have an important “steering” role to play in balancing
supply and demand factors in the commerce of education tools and services by allocating their educational budget wisely and promoting partnerships, particularly in courseware development. Certification of education delivered on-line, accreditation of education service providers and rating of courseware will require innovative institutional arrangements under the leadership of the state.

Governments of countries with different levels of informatisation and integration in wider markets feel obviously also with different intensity the pressures upon their education systems. However, any country that does not want to lose the opportunities of reaping the benefits of high value-added industries and jobs, has to face the challenge of overcoming the skill gap by increasing the levels of literacy, basic knowledge including “informacy” (and “computeracy”) and the more sophisticated and specialised skills of their population, young and older. This challenge can only be met through a concerted action of many social actors and institutions. It calls for the involvement of public authorities at all levels to stimulate and co-ordinate partnerships with and within the private sector, involving libraries, schools and teachers.

The level of development of the communication infrastructure is a constraint to wider diffusion of telematics applications to education and training. Tele-training at bigger private corporations may act as a catalyst for investments in the communication infrastructure and wider diffusion of such applications. The prospects of such applications can serve as a factor for mobilising social support for institutional change, technological research and infrastructure modernisation. The inconclusive pedagogical assessment of their cognitive effects should be an incentive to a selective and integrative approach to the education process in which new technologies are used in conjunction with conventional forms, avoiding commitments of large shares of educational budgets to massive technology modernisation.

Telematics applications are not the solution to mass education, but can help meet educational needs in developing countries, particularly in the pre-service and in-service teacher training, in the strengthening of the research capability at post-secondary and for advanced professional education and training. More sophisticated applications at lower levels of education should be introduced in smaller scale and as pilot projects. Pre-service and in-service teacher training is one field to which telematics applications can make a strategic contribution, particularly in developing countries. Electronic networking can be used for skill-enhancing in specific areas of knowledge.
either by making distance education material accessible on-line, stimulating the exchange of experience and providing guidance and support in the application of new technologies.
REFERENCES


