INTER-AMERICAN DEVELOPMENT BANK

Competitiveness and Science and Math Education:

Comparing Costa Rica, El Salvador and Brazil (Recife) to Sweden

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Executive Summary

The purpose of this report is to document and give deeper substance to the link between math and science achievement and the economic performance of firms in the information and communications technology (ICT) clusters of four countries: Brazil (Recife),Costa Rica, El Salvador, and Sweden. We used Sweden as the comparison country as Sweden's math and science achievements rank among the highest in the world in recent TIMMS and PISA tests.

As outlined in the terms of reference (TORs), are four premises underpin this study: 1) there is a clear link between math and science achievement and the economic performance of firms in a country, 2) this link is forged in the process of technology transfer, 3) the process of technology transfer in developing countries often occurs in exchanges between a transnational corporation (TNC) and its local suppliers, and 4) good math and science skill levels are critical for the technology transfer process to create value, both for the TNC and its local suppliers/partners. To make a case for improving math and science skills below university levels, we would like to add a fifth premise: that technology transfer should be understood in the broadest sense possible – not only transfer of intellectual property (IP) but also transfer of business and technical processes, quality tools, information, and general business practices between firms and education institutions (high schools and universities, and intermediary institutions.) In other words, the technology transfer includes schools and universities.

We selected the ICT sector because our initial research indicated that we would find it in all four countries, and because it represents, for many reasons, multiple aspects of what it means to be a "knowledge economy." Because ICT firms are typically clustered in specific spatial areas (often near a university, as well as TNCs), we decided to focus our case study on specific ICT clusters in each of the four countries. After more investigation, we discovered that beyond call centers there is no real ICT cluster in El Salvador. Instead, we found a budding network of potential future cluster development radiating out from Don Bosco University. In order to look at the extent of technology transfer between TNCs and cluster firms and education institutions, we decided instead to examine the aircraft maintenance cluster (TACA) near San Salvador.

Empirical evidence supports a direct link between the quality of a country's labor force and its math and science achievement rates (Hanushek and Kimko 2000). In this report we present and compare the findings of four research teams in each of the countries. The research teams are recognized leaders in their fields in each country, and have, we believe, the authority to offer their conclusions and recommendations. For that reason we have retained the case writers' "voice" to the largest extent possible.

We believe the findings of the four case studies give real substance to the link between math and science skill levels and the position a firm and cluster can claim on the technology ladder. More than that, we hope our findings reinforce the growing understanding that there is a difference between economic growth and sustained economic development. We hope this study opens the door to a deeper and more extensive documentation of what we found: that in emerging market countries, TNCs tend to compensate for low math, science, and other skills with “solutions in a box.” For a while, this approach can help the firms in the cluster grow, but not sustainably, as there are other, lower cost countries vying for the same TNCs to locate plants in their countries. We hope that this study clearly documents that math, science, and technology skills are essential for cluster firms to ***move up the technology ladder***, thus leading to sustained economic development, and for scaling up production, creating more and better jobs. We believe that this will require a development framework on the part of policymakers that leads to deeper strategic partnerships with TNCs. We hope that our study shows that sustained economic development requires that the actions of policymakers in education **align private sector growth and competitiveness objectives with improvements in math and science in the Latin American countries studied.** While our local, in-country research teams understand the enormous challenges embedded in our recommendations, we believe that the strategies and actions we recommend are doable. In that spirit, we hope that our analysis, lessons learned, and recommendations for action catalyze new, focused investments that support these IDB member countries to dramatically improve math and science achievements.

This report is presented in two volumes and reflects the collaborative work done by the country- research teams Hifab, and its subcontractor, RTI International between December 2005 through August 2006. ***Volume I*** includes an executive summary, a summary section of cross country recommendations, a technical analysis of each country’s case study followed by conclusions and recommendations, and a table comparing each country’s math and science education curriculum goals against the benchmark country, Sweden. Because the purpose of this analysis is to determine the effect of gaps in math and science achievement on the quality of technology transfer, we added an additional column in each of the curriculum goals tables to document whether there is demand by cluster employers for a particular competency. Volume IIA includes the case studies from Sweden, and Costa Rica. Volume IIB includes the case studies of El Salvador and of Recife, Brazil; as well as the research protocols, and outline used to write the case studies. We strongly encourage reading the full case studies, as this will provide the richest context for interpreting the data briefly reviewed in Volume 1 and the competency tables. When reviewing the competency tables, we would like to note that most of the students in the Swedish Gymnasium only complete module A and B. However, students following a program that opens the door to the ITC sector must complete A, B, C, and D of the curriculum goals.

Report Findings

Our study of the ICT clusters of the three Latin American countries and their comparison to Sweden reinforces Hansen’s assertion (2004) that “knowledge - its acquisition, diffusion, and integration, plays a critical role in the process of national development.” Hansen argues that when located in a less developed country (LDC), the higher-tech transnational corporations knowingly and unknowingly function like educational institutions transferring knowledge (e.g., technical expertise, management techniques, job skills, production methods) to national institutions (e.g., domestic industry, universities, public schools, R and D centers) that can move the country up learning and development curves. The study of our cases reinforces his argument that "*the local acquisition of TNC knowledge is not automatic and must be pursued (and applied) tenaciously within the context of a development strategy*."

Unlike the cases of Kista Science City in Sweden, and the ICT Cluster at Recife's Porto Digital, Brazil, our researchers in Costa Rica and El Salvador found no evidence of a sustained development strategy – indeed, that is the premier finding of this study. It may be likely that having an ICT cluster based on the existence of call centers and lower value added assembly creates the illusion of a knowledge economy, when in fact, call centers could be considered the ICT version of earlier "maquila" forerunners. Our findings reinforce Hansen's argument that the quality of technology transfer depends greatly on whether the new technologies are developed in the TNC country or in the developing country. From that point of view, call centers can be considered to be a type of "maquila" work where the technology has been "black boxed" into the call center processes, requiring few math and science skills. Where we did find the link between economic performance, competitiveness, and math and science achievement was when we moved into higher knowledge content (e.g., higher value added) enterprises in each country's ICT cluster – the *local* software and related firms. Lessons learned from other developing countries that have transformed their economies demonstrate that it is possible to use low technology jobs such as staffing call centers in the ICT sector as a way to jump up the rungs of the technology ladder to sustain competitiveness and employ more people at higher wages. This jump sounds simple; however it takes extraordinary agility on the part of policymakers, as well as extraordinary partnerships between industry and education. The rungs of the ladder are made of knowledge. At the heart of this knowledge lie math and science skills.

Description of our process

Hifab International developed a research protocol based on the TOR. The research protocol was reviewed by the IDB. The Case Study outline and questions can be found in Volume IIB. Hifab conducted a search for in-country research teams and retained research teams for all four countries. A short biographical sketch of the case authors can be found at the end of this Volume. Research teams in each country used the case study outline and questions to conduct extensive interviews with employers in their country's ICT cluster, education officials from their Ministries, and regional authorities. The research teams wrote and produced the case studies. The following section, "Lessons Learned," analyzes what we found and makes recommendations for action. The Lessons Learned section is followed by a summary of each case study.

Lessons Learned

Ireland 's example of moving up the technology ladder followed a sequence that is instructive. First they used their workforce to staff the TNC call centers for low skill, relatively low wage jobs. Next, they produced the equipment that runs the call centers.

Next, they designed and produced the software that runs the equipment for the call centers, growing a vibrant software development economy in the process. Each move up the technology ladder created higher paid jobs and required higher-level skills. TNCs were used strategically to facilitate the move up the ladder. The biggest lesson for this study is that the community colleges and high schools were pushed by the Irish Development Authority to teach the skills for tomorrow's jobs before they had become manifest. The Swedish case, as well as our combined experience, lead us to assert that a country's education and training system must be thought of as part of the sector and cluster's supply chain. By technology transfer we mean not only the transfer of intellectual property, but also the transfer of knowledge about practices, processes, and ways of thinking and behaving. This type of transfer of technology, as we suggest, must also include a country's education and training system. In the final analysis, this is the main difference between the Swedish and Latin American cases. In the Swedish case, technology transfer – in the broader context – occurs routinely between education and firms, and firms and education, throughout all levels, from primary education through secondary, post secondary, and on throughout lifelong learning occasions. Swedish companies routinely partner with Swedish educators and vice versa. Underlying that appears to be a spirit of teamwork, and the recognition that "we're all in this boat together."

Using the Swedish case as our benchmark, we will use the four premises of the study to discuss lessons learned, analyze their transferability to the Latin American region, and make recommendations for moving each country's cluster – and its education and training system up the value chain. To the extent possible, we will also discuss what lessons learned from one of the Latin American cases may prove useful or applicable to another case. We want to stress that the things we recommend are relatively *simple* – they are things that have been done successfully elsewhere. The fact that they're simple, however, does not mean that they are *easy*. Implementing our recommendations will require a breakthrough in political will, stakeholder engagement, a commitment to partnership among groups that have not worked together before, a commitment to learning from other countries, as well as sustained investment and hard work. We believe that there is a strong potential for Sweden to act as a partner/mentor to the countries, as they undergo the reform process.

Study Premises

1) To reiterate the five premises underlying this study, there is a clear link between math and science achievement and the economic performance of firms in a country, 2) this link is forged in the process of technology transfer – especially the exchange of knowledge between industry and educators, 3) that the process of technology transfer in developing countries often occurs in exchanges between a Trans-national corporation (TNC) and its local suppliers, 4) that good math and science skill levels are critical for the tech transfer process to create value, both for the TNC and its local suppliers/partners, and 5) technology transfer influences how math and science are taught and learned below university levels

Analysis of our Findings

For the purposes of this analysis it is more useful to examine these premises in reverse order. Starting with #5, technology transfer in the broadest possible sense is occurring at all levels of education and industry between Swedish firms, their supplier base, and the education and training system. However, below university levels, we could find no evidence of this type of broad technology transfer between schools and firms. Regarding premise #4, our study found that, compared to Sweden, a broad base of good math and science skill levels are missing in all three Latin American case countries. Premise #3, that technology transfer occurs in exchanges between TNCs and local suppliers is true for the Swedish cluster at Kista, but not generally for the clusters we examined in the Latin American countries. Indeed, in the Pernambuco case, we found an explicit development strategy that "created a cluster" out of many small enterprises horizontally organized and without a strong central lead.

We found that technology transfer between TNCs and their local suppliers holds true only if the TNC shares its "knowledge" with local suppliers, or better yet, works with local suppliers to create new knowledge and to embed it into product and service offerings. Examples from South Korea, Malaysia, Singapore, and Ireland suggest that there needs to be an explicit economic development strategy that *extracts* knowledge from the TNCs and transfers it to local suppliers, of which the education system is a part.

How have these premises played out in countries that transformed growth into sustained, broad economic development? In the case of South Korea, policymakers insisted that: 1) any foreign owned company wanting to do business in the country form a joint venture with a local, South Korean firm, and 2) the country's education and training system prepares students for future skill needs *before* demand for such skills became manifest. Because of these policy decisions, local South Korean firms learned how to make sophisticated products on their own within a few years, and the education and training system had the necessary lead time to produce the graduates with the skills needed by local employers as they increasingly took the lead over domestic production. (Hansen, unpublished paper 2005).

Ireland's Development Agency (IDA) applied a similar approach, using their English speaking, educated, and low-cost labor as the lure to attract foreign companies to locate call centers in Ireland. Led by Mary Robinson, the President of the Ireland, the IDA insisted that the education and training system immediately start teaching the skills needed to make the equipment that ran the call centers, anticipating that Ireland would at best have a five-year window of opportunity before their call centers migrated to a lower labor cost country. Once Irish firms started producing the equipment to run the call centers, the IDA insisted that community colleges and universities start training people to design and produce software to control the equipment running the call centers. While there were many other strategies the IDA pursued, the lesson here and in South Korea is that policymakers used TNCs as a way to develop their own skills and insisted that the education and training system produce anticipated skill needs, so that their local companies would have the workforce they need to succeed. Both countries set their sights on transforming initial gains at lower-ends of the technology scale into knowledge and skills "owned" by the educational institutions and workforce. This resulted in more sustained movement up the development lader. These countries succeeded because they were committed to the broadest possible transfer of technology between firms and local suppliers, including education. This made it easier for the education and training system to produce the skills for tomorrow's – not just today's jobs. This required a relatively long time horizon of thirty years, broken down into five-year milestones.(Aring, private conversation with IDA Board member 2005).

Examples from Singapore and Malaysia (Aring 1996) show a similar orientation to learning from TNCS how to make the products on their own. Leaders of both countries had a clear vision and simple metrics for how they wanted their societies and economies to develop. A number of years ago, Penang's Prime Minister told Motorola leaders, "I will know we have succeeded in our economic development if our citizens have three things: a passport (knowledge of other countries and resources to travel abroad), 2) a driver's license (evidence of the means to purchase a car and use it), and 3) a credit card (evidence of disposable incomes). (Aring, private conversation with Bill Wiggenhorn, former CEO of Motorola, Penang). To achieve these three things, both countries started by giving away industrial locations and providing low cost labor. However, they insisted on retaining the sole right to train their workforce. By analyzing and understanding the training manuals and the original equipment and their applications, the Malay firms learned how to create the products on their own. Throughout this process of technology transfer, they focused on the skill needs required for producing the TNC products, making sure that local skill development centers trained local production (not management) workers, funded by incentives through Singapore's Skill Development Fund (Aring,1996).

Our study research protocol required country teams to look for evidence of policies or practices that move knowledge from TNCs into the local supply chain, including universities, colleges, and high schools. In the case of Costa Rica and El Salvador, our research teams found no find evidence of policies that would extract knowledge from TNCs and transfer this knowledge into the local supplier companies and local education systems. Instead, our teams found that the TNCs operating in both countries embed knowledge in their products back in their country of origin, largely using the two countries as a source of cheap labor for assembly and related service work. Policymakers in Pernambuco, Brazil, are doing many of the right things as they use intermediaries to link universities with small and medium ICT enterprises, targeting specific windows of market opportunities. However, we found no evidence that Brazilian policymakers consider the education and training system below university levels as part of their supply chain. Insofar as this appears to be the case in the three countries studied, it likely will lead to serious skill shortages as local firms seek to scale up. A closer examination of the examples of South Korea, Ireland, Malaysia, and Singapore, suggests that all five premises will hold true if several enabling factors create a *context for sustained development*, enabling the technology transfer between TNCs and local suppliers, especially the education and training institutions who teach math, science, and technology, as well as other important skills for this cluster. In the next section, we will analyze the four cases from the perspective of these factors:

1) The time horizon stakeholders think is important: short vs. long term

2) vision and leadership: the extent to which policymakers see the education system as a critical part of economic development goals
3) From university levels on down: close cooperation between educators and employers and investment in developing the broadest possible skill base
4) The nature of what's being produced in the cluster. Are TNC and their local supplier firms engaged in knowledge production (requiring technology transfer) or are they using local labor for product assembly within the local country (leading to little or no technology transfer)
5) Whether there are locally based, emerging knowledge industries who want to scale up production

***Enabling Factor # 1: use of longer time horizon*s**

Sweden's policymakers typically look at a time horizon of 15 -20 years, anticipating skill needs by using a number of tools such as their linkages to leading TNCs, OECD scoreboards and data gathered by think tanks, universities, often working collaboratively. Educators, corporations, and policymakers recognize that they have to meet the skill needs of today's jobs while preparing students for tomorrow's jobs. The focus on tomorrow's jobs is the central difference between the Swedish and Latin American cases, and requires a longer time horizon.

Swedish educational policymakers use a longer time horizon to provide stability for the education system. The Upper Secondary Education Act (1994) requires that the educational system, particularly the curriculum, be constantly updated. Sweden has achieved this through the course structure of curricula as outlined in Table 1.
By making sure that almost all 19-year old youth in the country have learned math, science and technology up to a specific level (see Swedish curriculum goals at end of Volume IIA), Sweden can count on having a critical number of people with the required skills and interest to go on to further studies or take up employment. Contemporary debate focuses on how to make the math and science education less theoretical and more practical and related to occupational needs. This is especially important for students with low motivation and /or academic preferences.

In contrast, Latin American employers and policymakers in the three countries studied appear to operate inside a much shorter time horizon. In Costa Rica, the recent global outsourcing report, which indicates that within the next few years the country will move from being number 4 in the world to number 33 because the existing base of skilled workers (and population) is so small, did not seem to be widely discussed or acted upon during the time our investigation – February – June 2006. The time horizon in the Pernambuco case appears to extend to the next five years, while the time horizon in the TACA case (El Salvador) extends only to meet the foreseeable needs of the participating companies. None of these time horizons extends to include tomorrow's jobs – the projection of which would enable a move up the technology (and skill) ladder and create the demand for higher math, science, and other critical skills.

In the case of Costa Rica, existing industry figures show that there will be an insufficient supply of skilled labor to meet projected employment for the next decade. With only 23 percent of students graduating from high school, even the low-end, lower value added industries will not be able to expand. The country produces only 7 percent of cluster relevant university degrees, which constrains the scaling up of local emerging software industries and makes it likely that more value added industries will not consider Costa Rica as a long term location. The Ministry of Education is concerned with increasing the numbers of students staying in the system, as well as with increasing the numbers of students that graduate within the expected number of years (currently only 20 percent graduate in 12 years: K-11). Several efforts are being made to increase interest in math and science and to better train teachers in these fields. However, these needs compete with the need for investing in (e.g.,) rural education in order to diminish the urban-rural gap so prevalent in Latin America. The Ministry of Education and the Ministry of Foreign Trade tend to interface only in those instances when skills shortages (e.g., current leves of English necessary for call center operators) become an emergency. More specialization at the University level is addressed only when TNC's help define University curricula. This is a "catching up" vision of growth for today's jobs, not a sustained development strategy for tomorrow's jobs. Our team found limited evidence that leaders are looking at how to capture possible niche markets of the future and what that would mean in terms of demand and supply of skills.

Enabling Factor #2: the extent to which education is part of economic development goals:

Sweden faces difficult challenges: increased competition from low-income countries is felt more directly in Sweden with the accession of 10 new European Union (EU) member countries in 2004, some of which (Estonia, Latvia, Lithuania and Poland) are neighbors to Sweden. Whereas most of the "old" EU member countries introduced different forms of restriction against free labor movement from the new member states, Sweden together with the United Kingdom (including Ireland) did not introduce any such precaution measures. The differences in salaries are substantial between Swedish skilled workers and skilled workers from the new EU member states. If Sweden wants to preserve its high social standards, including a generalized 5-week vacation system and working weeks that tend to be shorter than 40 hours (37-38 hours is the norm) it needs to constantly be in the forefront as far as quality and technology is concerned. Kista employers and policymakers told us that sustaining their quality of life depends on exports of high cost, high value added products and services to supply the global economy. To compete with other countries successfully, they depend on a critical mass of people to supply the sector (Kista and other ICT clusters) with broad math, science, and technology skills, among others.

Swedish politicians together with employers are highly aware of the fact that math and science skills play a crucial role in preservation of the high standard of living in Sweden. Consequently a number of measures have been and are being introduced to support the generally high level of math and science skills, including:

- Focus on training for math and science teachers. More math and science teachers are being trained (partly also to address the drain of highly skilled math and science teachers from the education sector to industry).
- The opening during the last decade of a number of "IT Gymnasia," upper secondary schools specializing in ICT skills

- A new reform (LGY-07) which will require all teachers to work thematically across the "subject borders". The idea is that students should get a holistic view on life and that an increase in project-based and problem-based work would lead naturally to subjects like math and science
- In the framework of a lifelong learning system there are advanced plans to introduce personal accounts for each person employed in Sweden. The idea is that through tripartite agreements, employers, employees) and the state would contribute to dedicated accounts to support lifelong training opportunities.
- The Government is putting additional money to the universities and higher education institutions specifically to develop science-related education programs, including means addressing the existing gender imbalance of the students at these programs.

In addition to math, science, and technology skills, Swedish employers also depend on a core of basic problem solving, foreign language, music, and interpersonal skills – hallmark skills of knowledge economies. For example, Swedish experts believe that their country's broad base of music skills *combined with the general good knowledge in English* contributes to Sweden's high share of music exports.

Swedish expert of music started with ABBA. After that a number of good musicians have been highly successful in exporting music to Europe, US and Japan. Such musicians include Roxette, Ace of Base, Europe, Cardigans, and the Hives. The biggest share of export income, however, comes from "side products" such as production of music videos, production of world star's new records, etc. A number of world famous music stars such as Madonna and Britney Spears regularly use Swedish producers. It is quite clear that this development would have been impossible without:

- general and equal access to training in how to play instruments
- good English skills
- good general math and science skills, which are crucial to producers and music technicians.

Year	**Export volume(millions of SEK)**	**Percentage change from previous year**
1997	3 368	
1998	3 476	+ 3%
1999	4 321	+ 24%
2000	4 554	+ 5%
2001	4 809	+6%
2002	6 759	+ 40%
2003	6 969	+ 3%

Source: Swedish organization for music export, www.emxs.com

Each of the Latin American countries we studied appears to have goals for economic growth, but the case for transforming growth into sustained development by improving the human skill base for tomorrow's jobs has not yet been made, except in Pernambuco, where Brazil's beginning industry/university partnerships meet the next five years' skill needs. Policymakers in Pernambuco seem to have clear goals for improving the cluster's competitiveness as part of a global strategy for growth. However, as noted previously, we found no policy to improve math and science education below university levels in Pernambuco.

Enabling Factor # 3: from university levels on down, there must be close cooperation between educators and employers and investment to develop the broadest possible skill base: In stark contrast to the Swedish example, employers in the Costa Rican and Brazil case appear to operate in isolation from the education system below university levels. We believe this may be due to at least three reasons:

1) With the exception of Don Bosco in El Salvador (see Box, below) and some of the universities in Costa Rica, and technical schools in Pernambuco, our researchers found that abstract, theoretical learning tends to be more highly valued than applied learning for industrial purposes. This has real consequences for math and science education. According to Jean Piaget, the noted educator, approximately half of any human population is unable to perform formal mathematical operations in the abstract (for a discussion of the cognitive stages of development of mathematical reasoning, go to http://evolution.massey.ac.nz/assign2/MH/webpage.htm). In the Latin American countries we studied, the high value placed on abstract, theoretical learning starts at the university level and ripples throughout the education system, producing graduates who also see the world in this way. In other words, the entire context for education, as promoted by the elite of the systems (universities) is *academic*, as opposed to including "*applied* (industrial)" purposes that are deeply valued in Sweden. This difference in the perceived purpose of education leads to an approach to math and science education in Latin America which is starkly different from that taken in Sweden. In Sweden, math and science are learned in a context of solving problems, many of which come directly from industry. In Sweden, a math or science course is not an end in itself but the means to enable students to have more choices in life – to do something useful with what they've learned. In the Latin American countries we studied, on the other hand, math and science education largely is taught by teachers who are ill prepared and who teach math and science as free standing units with little connection to anything else. Our case researchers found that small percentages of students choose math and science for further study and that, at primary and secondary levels in all three countries, massive numbers of students drop out..

The Don-Bosco – TACA industry education partnership in El Salvador

Over the last 3 years TACA, the regional airline has jointly developed with the Universidad Don Bosco a 5 semester program for aircraft maintenance technicians. Universidad Don Bosco presently graduates about 25 aircraft maintenance technicians every semester and applicants to the program are selected based on a specific evaluation exam that evaluates math and science skills. TACA sponsors about ten students per semester that cannot afford the training and most graduates go to work for TACA after their degree. Today about 750 people work in the aircraft maintenance unit of TACA

(Aeroman) which is certified to do regular maintenance to Airbus units of TACA, as well as various US Airlines under FAA standards. The maintenance unit is expected to double its capacity (and number of jobs) over a 5 year horizon.

Other than the number of higher skill jobs, Aeroman has little impact on other companies or possible suppliers in El Salvador. The specific maintenance tasks are dictated by component suppliers and airplane builder Airbus. Specialized components are replaced according to plan and/or usage and its technical revision is done outside El Salvador at the original manufacturing plants. Other than feedback to suppliers on the experience and performance of the planes and their components, little information and/or technology transfer occurs. Nevertheless, the TACA-Universidad Don Bosco is a good example of academia and the private sector working together to efficiently train higher-level skills in math and science.

2) Policymakers in the Costa Rica and El Salvador appear to focus on attracting companies to invest, rather than leveraging TNC knowledge embedded in their product and service mix to meet their own development goals. A review of the curriculum achievement tables at the end of each case study compares the extent to which employers demand math and science competencies.When compared to Sweden, there appears to be a consistent lack of demand across all three countries studies for the types of math and science skills demanded byemployers and educators.

3) Parallel education systems – although this issue lies outside the scope of our study, our research teams could not help but note the impact of the two parallel systems of education, public and private, in the three Latin American countries we examined. A review of the curriculum achievement tables at the end of each case study indicates the differences in goals and achievement between Sweden and the Latin American countries, and within the Latin American countries, between public and private schools. Because of these two systems, Latin American countries may be undercutting the size of their base and losing the opportunity to produce the critical mass of people with the necessary math, science, technology, and core employability skills.

Enabling Factor #4: what's being produced in the cluster: The 350 Kista companies in the ICT cluster do not assemble or make products. They produce only "knowledge products," such as software or other forms of new technology development or applications. TNC companies in Kista, such as Ericsson, regularly exchange and create new knowledge with local firms. Indeed, the cluster is physically and socially organized to support knowledge exchange and creation, using a "greenhouse" central campus where small companies, the university and high school are co-located and surrounded by the large TNC firms.

Despite the reported success of the Costa Rican ICT cluster, TNCs for the most part use Costa Rican labor to assemble manufactured products whose knowledge content has already been embedded in the country of origin. We believe that is the reason we found little evidence of technology transfer between TNC and local firms in Costa Rica. Of the

26,000 people employed in the cluster, 11,000 work in component assembly jobs. Another 8,000 work in ICT enabled service firms, including call centers, application services, back office services, and enterprise services and telemarketing. The remaining 7,000 workers develop software and support ICT services for the cluster. While TNCs interviewed did not require specific math and science skills from their employees, local software producing firms were concerned about the lack of people who had these skills, especially the relatively small number interested in scaling-up, exporting, and supplying ICT related services to the TNCs. In the case of TACA, TNCs transfer know-how to local suppliers of labor through the partnership with Don Bosco University and a handful of local high schools. We do not understand why this approach to industry education partnerships is not leveraged through transfer to education institutions outside the Don Bosco partnership. As a result, the TACA educator/employer collaboration remains isolated from the rest of the education system. TNCs in the Pernambuco case collaborate with universities and government intermediaries, but there is as yet no perceived need to move this knowledge into the secondary education system, where barely 15 percent meet international standards of achievement. A recent PISA study found that Brazilian students' performance in math and science skill is among the lowest in Latin America, and a recent MERCOSUR study found that Brazil has the lowest percentage of high school educated people in Latin America..

Making the jump between where a given cluster is now on the technology ladder and the skills needed to reach the top via the next rung is the single most important reason for improving the math, science, and technology skill base, as the experience of Ireland, Malaysia, and Singapore illustrate. If a cluster is largely engaged in component assembly, there is no compelling reason for improving education, especially, math, science or technology skills. What is needed is a policy that leverages current production into goods and services that are higher up in the value chain (Hansen, 2005). For example, in Costa Rica, where TNC employers such as INTEL use local workers to assemble components in which math, science, and technology had already been embedded back in the country of origin, TNC employers did not think there was a skills gap for 70-80 percent of the workers. For the remaining 20 percent, employers worked with universities to improve curricula to reflect select specializations needed for the short to medium term horizon. However, the emerging, small local software companies remained concerned about the skills gap. These skills and numbers gaps show up in the Outsourcing Competitiveness Report discussed previously.

Opportunity for scaling up: Swedish employers and policymakers generally recognize that the scaling up of promising innovations is critical for the sustained economic performance of their cluster and for information about the types of skills that will be required for tomorrow's jobs. Sweden has created elaborate tracking mechanisms to monitor performance in the area of commercializing and scaling innovations. The Swedish Innovation Council is leading a number of efforts to promote the diffusion and scaling up of new knowledge within this and other clusters.

We found no evidence of similar attempts to identify promising innovations and commercialize them as soon as possible on the part of the Latin American countries we examined. Scaling up is important if all three countries want to expand employment and continue the move up the technology ladder. For example, scaling up Pernambuco´s current competition strategy will require a massive increase of skilled people. The competition strategy relies on exploiting windows of opportunity found in market niches, as part of a wider, cluster competitiveness strategy. The current supply of skilled labor is insufficient to implement this strategy. Scaling-up was an issue for Costa Rican software companies, while the TACA cluster in El Salvador meets its limited needs through very strong partnerships with Don Bosco university. Beyond these exceptions, our researchers found little policy related discussion about scaling up knowledge intensive production capacities. We believe that several factors account for this. First, as previously discussed, the distinction between economic growth (more jobs) and sustained economic development (making sure the growth transforms into higher skills and know-how) on the part of the workforce, has not yet been made explicit in the political debate that focuses on attracting corporations and jobs. Second, TNCs embed knowledge into products in their home countries and tend to use the Latin American countries as a source of cheaper labor. Third, ICT is a relatively new industry in the Latin American countries, and the demand for highly skilled labor has not yet been created by local firms. Based on our research, we believe that the need to scale up on the part of local firms provides a window of opportunity for initiating a policy dialog that makes education a part of economic development goals, and rapidly growing more math and science skills in the population.

Summary of Findings and Recommendations

Please refer to volume IIA for a complete list of recommendations from all three cases.

1. ***Economic growth does not equal sustained, economic development.*** For sustained development to occur, *education and economic growth strategies must go hand in hand with each other***.** This requires the use of longer time horizons and stronger collaboration between educators, employers, and policymakers. Perhaps the major difference between the case of Sweden and the Latin American countries is the fact that education and economic growth go hand in hand in Sweden. In Sweden, policymakers collaborate with the private sector at different operational levels (from policy to implementation) to create an overall development context in order to maintain competitive performance. To stay ahead in the globally competitive environment, they anticipate tomorrow's skill needs and educate their students accordingly. In the Latin American countries we studied, the difference between sustained development and growth does not appear to be a cause for concern.

   To illustrate this situation, we recommend that a partnership be formed between Sweden and the three Latin American countries to share knowledge on how to integrate growth and education strategies and to leverage them towards sustainable economic development in the ICT cluster. In the context of this partnership, we recommend the formation of a high level Development Authority for the ICT cluster in each country. This should include policymakers, educators, appropriate think/tank and NGO leaders, and local employers in the Latin American countries who will face skill shortages in the coming years. This stakeholder group should begin by reviewing how Ireland, Singapore, Malaysia, and South Korea transformed growth into economic development. In addition to learning from others, the first task of this group would be to create a shared vision and action plan. The plan should be scaled into 5- year economic development goals for the ICT (or other important) cluster, and contain clear (math and science) education and training strategies to achieve these goals. A part of this action plan might include a partnership with Vinnova, Sweden's Innovation Council, which could open a dialog with the Latin American countries' policymakers on how to develop an innovation and commercialization strategy for their ICT cluster firms. Policymakers from Pernambuco could support Costa Rica and El Salvador with their experiences of using intermediaries strategically to build cluster performance.

2. ***Without a development context pushing the move up the technology ladder, local cluster firms have few mechanisms for upgrading knowledge and skill levels.*** In Costa Rica and El Salvador the development context appears to be missing. Costa Rica's reputed success with the ICT sector means little if those firms use low skilled labor, importing "solutions in a box" via TNCs, as is the case of most of the firms in the clusters studied (with the exception of local software producers). Similarly and with the exception of its partnership with Don Bosco, the TACA cluster in San Salvador remains isolated from the rest of the area's economy and education system. The end result could be a cluster, but very little if any knowledge is extracted and leveraged to ripple into the rest of the firms, citizens, or economy. In Brazil the development context does not appear to reach the education system below university levels. Our findings reinforce Hansen's (2005) argument that the difference in economic growth between Mexico and South Korea is that in the case of South Korea, policymakers there made a point of extracting knowledge from TNCs, while Mexico did not. While Ireland started its economic growth with call centers, Irish policymakers recognized that they had to move up the technology ladder within five years before they would lose their relative advantage vis-à-vis other low labor cost countries. Consequently, they learned how to build the equipment that makes call centers, and then transformed those skills into designing the software that runs the call centers.

We recommend that the Development Authority suggested above develop explicit strategies for extracting knowledge from TNCs working in the clusters. These strategies should include benchmarking trips to see how other countries approach this issue, policy decisions about how intellectual property will be treated, partnerships between education and employers, and a possible mentorship from Swedish counterparts.***3. Education must have a larger societal and economic purpose.*** In Sweden, education is not viewed as an end to itself, but rather as the means for something else (the development context). Swedish educators work closely with industry at various operational levels in every sector to make sure that learning happens in a rich context of application (theory *and* practice)**.** In the Latin American countries we examined, math, science, and technology education seem to be largely viewed as a matter of delivering a course, with little thought as to whether it is a) interesting, b) inviting, or c) has any relevance to the student's real life experiences. Our case researchers concluded that math and science education in their respective countries is in crisis situation, with hemorrhaging dropout rates both in primary and secondary schools, poorly prepared teachers without specialized training in math and science, and inequities between private and public schools. A breakthrough is needed as the current paradigm inside which education occurs in the Latin American countries will not yield significantly better results. Producing a breakthrough in math and science achievement also requires a complete overhaul of teacher training, curriculum, school management, and partnerships with cluster firms and universities.

We recommend that a broadly conceived education reform initiative be developed that makes it possible for the three Latin American countries to learn from and alongside Swedish educators, employers, and policymakers on how to create such an overhaul in the context of at least one industry sector. We suggest ICT, as it is central to the development other parts of the economy. This is a drastic recommendation, but we believe it is necessary for each country's survival in the global economy. While each country has its unique challenges, the underlying factors are similar and must be reformed for sustainable economic development as well as broader social purposes. ***4. The role and flexibility of universities is critical in transferring and transmitting technological gains to companies and to the primary and secondary education system.*** In Sweden's Kista Science City, several universities banded together to form an "IT University," co-located with small firm incubators in one building in the middle of the cluster. The university employs a public relations staff who markets the university's services to local firms in Kista. University students in Kista mentor high school students on projects generated by Kista companies. Unlike the Brazilian cluster, and the case of Don Bosco in El Salvador, we found no evidence in Costa Rica of strong industry/university partnerships. Instead, private universities in Costa Rica are growing, attempting to meet the market demand. However, there is a general recognition that these are not as good as the public universities which, for a number of reasons already discussed, tend to be isolated from industry. We recommend that the first step of the broad education reform initiative start with Costa Rica's university-business ICT Center of Excellence for the ICT cluster. The university-business ICT Center of Excellence should focus on how to extract knowledge for tomorrow's jobs and develop curricula and teacher training programs to ripple throughout the system. This ICT Center of Excellence could partner with its Swedish counterparts, such as Kista Science City.
5. In math, science, and technology, as in all subjects, effective teacher training, and ongoing retraining is absolutely critical. Swedish teachers are highly trained, and tend to teach in ways that allow students to manage their own learning as part of a project-based approach to learning. Swedish teachers creatively use policies to stimulate math and science learning. For example, in Sweden's Kista case, high school (gymnasium) students work on projectstaken directly from Kista firms; university students at Kista mentor these high school students. By contrast, in the Latin American cases, teachers tend to be poorly prepared and do not know how to teach math, technology, and science in ways that make these subjects interesting and important for understanding how to use these tools in other settings. As discussed above, we recommend that teacher retraining for problem based learning should be a major part of the reform initiative.

6. Early introduction of technology in education. In Kista, and in all of Sweden, students start working with computers by third or fourth grade. Students in the Latin American countries have few opportunities for using technology in their education. We recommend that a mechanism be found to introduce technology into the classrooms of the public schools in the three Latin American countries.

Recommendations – Generic for all three countries

- ⇒ Create a more powerful context for reforms, grounded in economic development purposes
- ⇒ Improve teacher training with more focus on applied knowledge
- ⇒ Create social partner committees that can influence the curricula
- ⇒ Provide special attention to low performing students to create the critical mass and avoid drop-outs
- ⇒ Improve possibilities for lifelong learning
- ⇒ Improve text books and learning material

Technical review of case studies and comparison tables

The following section presents a technical analysis of the case studies of the ICT clusters in Sweden, Costa Rica, and Brazil. Although we had been assured that an ICT cluster existed in San Salvador, our researchers found only call centers - the most low-skill, rudimentary beginnings of an ICT cluster. Recognizing that call centers did not require much more than English language skills and little math and science skills, our researchers turned to study the TACA aircraft maintenance cluster in El Salvador.

The following technical analysis of each case study follows the requirements stated in the TOR: (pp 2 – 3) and adds a section for conclusions and recommendations.

SWEDEN – Kista Science City ICT Cluster near Stockholm

Sweden ranks in the top of the world in terms of math and science achievement (TIMMS) and serves as the benchmark (comparison) country for this four-country study. "Faced with declining birthrates, increasing competition, the need to assimilate new immigrants, and difficulties with commercializing innovation, Swedish policymakers work together closely to align national education and training policies and practices with national competitiveness and innovation goals"(case author)

Human Capital, technology transfer and competitive gains

1. Where the cluster is in technology ladder

The Kista ICT cluster is internationally recognized as one of the world's leading ICT technology clusters. Only knowledge products, (no physical products) are produced at Kista. Firms provide a range of software related knowledge products in the area of Mobile, Wireless, and Broadband services. The Swedish ICT and electronics industry, with a yearly export volume of close to 140 Billion SEK (19 Billion USD; 2004), is one of the most important industrial sectors in Sweden. In Kista there is a large concentration of high-tech companies, ranging from university spin-offs to world-leading corporations.

Companies such as Ericsson, Nokia, TietoEnator, HP, Microsoft, Sun Microsystems, Intel, and Oracle have offices in Kista.

2. Type and quality of technology transfer in cluster

A number of important research studies, including a major study by Sweden's National Institute for Working Life, (Sandberg 2005) document that technology transfer occurs inside social networks. Networks are defined as formal and informal connections between people in their own and different organizations. Technology transfer is embedded in the process of conversations and related activities within a context of specific individual, firm, and supply chain objectives. The most common activities include consulting, followed by production of software, RandD, and sales, marketing, and distribution. More than half of Kista's ICT companies exchange information with each other, almost half cooperates strategically in areas of product development, production, and marketing. A large number of firms outsource IT activities to other companies, and work as subcontractors to larger firms. The actual networks are not limited to Kista, but expand to include regional and international areas. Technology transfer flows along two dimensions: in spaces of place (hubs, such as a person, or group in a firm), and in spaces of flows (channels, including virtual communities). (Lundmark 2004).

The research institutes in Kista – Acreo and SICS – are important intermediaries facilitating technology transfer between corporations in joint projects as well as between industry and research in the Kista area. In addition to these two research institutes there are a number of formalized firm networks that have been formed by Kista Science City Ltd over the past few years. There are also a number of research centers working as "tech-transfer intermediaries" between research and ICT-corporations. In the matrix below we have tried to summarize some examples of prominent networks and centers that facilitate technology transfer, interactive learning and knowledge diffusion in the ICT-cluster in Kista.

Initiative/center	Name	Activity
Firm networks initiated by Kista Science City Ltd.	Mobile City Initiative	Mobile City Initiative (MCI) is designed to bring together all the stakeholders throughout the entire value chain in the mobile services sector in order to increase the rate of development of these services. MCI functions as a joint platform for representatives of major customer/buyer organizations, systems suppliers, and operators.
	Kista Business Network – KBN	Comprises some thirty small-sized companies with their own in-house developed product.
	Kista Broadband Alliance – KBA	A core group consisting of seven companies has initiated the work. More companies, both in Kista and the rest of Stockholm, receive regular information about KBA. KBA has begun the work with a programme for the area of broadband, investigating the potential for test beds, etc.

	Kista Competence and Environment – KCE	Aimed at personnel/development managers in large-sized ICT companies.
Research centers working as tech-transfer intermediaries between research and ICT-corporations	Electrum Laboratory	Sweden's largest laboratory for the research and manufacture of semiconductor components. The Electrum Laboratory is an open environment providing a meeting place for companies and researchers from different disciplines. The Laboratory is also used by graduate students and also offers laboratory training for undergraduate students.
	Kista Photonic Research Center	The Kista Photonics Research Center is an umbrella organization promoting and giving a structure to the collaboration in the field of Photonics between the private research institute Acreo and the Royal Institute of Technology (KTH), in Kista. It regroups about 120 researchers, PhD students and technicians with activities ranging from basic research and education to commercialization of research results and creation of spin-off companies. The KPRC is one of the major centers for Photonics in Europe.
	The Swedish Center for Internet Technologies	A centre for national and international collaboration in the area of Internet.
	Wireless@KTH	A research center focused on wireless systems and communications. Wireless@KTH engages in interdisciplinary research projects in collaboration between academia and industry.

Recently, Sweden recently developed a coordinated, headed by the government agency VINNOVA. To strengthen the inventiveness of Swedish industry and to facilitate the transference of knowledge and technology between corporate and academic research, VINNOVA runs cooperative programs and projects. In total, VINNOVA administers nine programs for research, development and demonstrations related to information and communications technology and IT usage. In the case of Kista, Vinnkubator is a project supported by VINNOVA and with the purpose of developing the volume and quality of business ideas from universities.

3. Role of universities in tech transfer

The Campus IT University in Kista is a joint venture between several universities. The students gain their degrees from KTH (The Royal Institute of Technology), the University of Stockholm, or from Karolinska Institutet (the Swedish Medical University).

The IT University currently serves almost 4,000 students. The IT University offers a range of different courses, including full-time programs, supplementary training courses and independent courses. There are also two research institutes in Kista operating in the field of ICT: The Swedish Institute of Computer Sciences, SICS, is a non-profit research institute with approximately 90 highly qualified researchers in a wide range of areas. SICS is jointly owned by the Swedish industry and the Swedish government. The goal of SICS is to contribute to the competitive strength of Swedish industry by conducting advanced and focused research in strategic areas of computer science, and actively promoting the use of new ideas and results in industry and society at large. Acreo, with its head-office in Kista, is a research institute in the field of microelectronics and optics. In total Acreo includes about 160 highly qualified scientists, engineers and support personnel. About 33 per cent of the employees of Acreo are women and 25 per cent are of non-Swedish origin.

4. Skill requirements in cluster

Swedish ICT firms at Kista Science City interviewed for this study unanimously stated that math, science and technology skill levels are not an issue in the quality of technology transfer. That is because employers play a leading role in setting curriculum requirements for their industry. When revising curricula for general subjects such as mathematics, a temporary committee is created. This committee includes a number of stakeholders from industry and the world of work. Sweden's curriculum goals in math, science, and technology education are clearly spelled out. These goals are to be achieved by all young people graduating from senior secondary schools at the age of 19. The Swedish curriculum goals were used in each case study as the benchmark for comparison. The Swedish curriculum goals can be found at the end of this section, pp. 28-30, table of Mathematics Education, and list the detailed skills required for all students graduating from secondary education. Students going into ICT further studies must complete all four modules, from A through D.

The structuring of math, science, and technology education

. 1. Situation of math and science education in country and Kista cluster

Kista Science Gymnasium provides an example of how both the *content* and *process* of math, science, and technology education support technology transfer between a high school and cluster firms. Sweden's educators believe that subject knowledge must be understood in the context of core competencies in three levels: *1) how to solve a problem, 2) how to solve the problem so it is not repeated, and 3) how to solve the problem so that it leads to the development of improved products or production processes*. Swedish education policy aims to provide all students with all three levels of these core competencies in math, science, technology, language, and the social sciences. Computers and IT are routinely used by students in school from 3rd – 4th grade on. 95 percent of the education system is financed by the state.

There is a notable degree of interaction between cluster firms and the ICT Gymnasium, (a secondary school), located at Kista. ICT gymnasium students learn entirely in teams, in spaces that were designed to simulate an ICT company. Each semester, ICT students take on projects generated by Kista companies. Students consult with companies and are mentored by students in the IT University. Subject matter is learned inside project activities, graduates meet the requirements for graduation (see Table at end of this section), and students easily find jobs while some start their own IT companies

2. Overall education context

In 1991 a new Government Bill, "Growing with Knowledge," further increased the flexibility and adaptability of the country's education system. The most important aim of these reforms was to prepare all students for higher education, and to become active citizens of an increasingly complex society and work-life. Adult training was reformed to include all lifelong learning, providing free education to any adult. During the past ten years a small number of private upper secondary schools have opened. However, these schools are not allowed to charge for tuition. Instead, such as school, having been approved and certified by the National School Board, is given the same amount of money as the ordinary Upper Secondary School for each student. This amount depends on the program arranged by the school. The reason for allowing such private alternatives is not to create a competitive market in the field of education, but to encourage the trying out of alternative pedagogical and methodological approaches (Montessori, Waldorf, etc) or encourage specialized types of training institution (ICT Gymnasium

3. Policy failures/opportunities

Sweden's policymakers and business leaders confront with serious issues that challenge their future GDP per capita and overall competitiveness. Policymakers work together with each other and business leaders to identify future sources of problems and develop solutions. Some problem areas that are given special attention today are:

How to quickly absorb immigrants into their labor pool. Sweden has, like most western European countries, a relatively large community of immigrant with higher education who experience difficulties in finding work that matches their qualifications. One method to overcome this problem is validation of prior learning, and today Sweden has a number of different initiatives that recognize and validate prior learning. Through validation of a person's knowledge and skills it is possible to assess his/her competence and identify any additional training s/he has to undertake to be able to participate in their profession.

What to do about decreasing innovation rates. In the U.S., the best graduates of leading technical universities want above all to start their own business, seeing this as the quickest source to wealth and opportunity to innovate. This is not the case in Sweden, where young Swedes graduating from the country's best universities, choose to work for the best companies. One reason for this might be that large companies work actively with universities to recruit students still in school. Ericcson in the Kista cluster is a typical example of this. Most universities have special centers that help the students and companies in the matching process. One example of this is Uppsala University's "arbetslivcenter," which one can reach under the following web address: http://uadm.uu.se/jobb/

Conclusions

- Sweden's system works. The country has put in place a number of policies that prepare a continuous pipeline of young people and adults to participate in their knowledge economy. The great majority of young people who enter education leave upper secondary. For some students with low motivation or limited educational abilities there are a number of different measures to help them complete the upper secondary. Also, people can always return to studies and complete their upper secondary education as adults. Between a half and a third of students leaving upper secondary continue on to university education. 68 percent of adults participate in adult education or lifelong learning, sometimes during their working life. This figure does not include in-service learning.
- Approximately 95 percent of education – from preschool through to university and life-long learning - is paid for by the state. New schools and new approaches are allowed to flourish, not to create a competitive market for education but to test out new approaches and ideas.
- Employers and policymakers work closely together to discuss the most appropriate ways to prepare their workforce for knowledge intensive industries requiring high skills and commanding high wages.
- Surprisingly, given the high TIMMS scores, Sweden's education ministry does not require lots of testing. The Swedish educational system is built on key values such as trust and democracy, motivation, and responsibility. In the recent PISA study Swedish students showed high motivation and indicated that they "knew why they were studying" that is to say, *studying for their life*, not for the exam. One reason for this relatively high level of motivation might rest in the fact that the students have the opportunity to choose among different subjects within the educational programs at upper secondary school. In this way it is possible – up to a certain extent – to build your own curriculum, which is a clear motivator. It should also be remembered that like any other country, the Swedish teachers are constantly monitoring the progress of the students through observations and progress tests. Teachers regularly give feedback to their students and their parents. Assessments are not only made during formal tests. Graded certificates are only given after grade eight.

Recommendations

1. Theoretical skills must be accompanied by technical or vocationally applied skills. Swedish educators are concerned that the technical and vocational programs in the upper secondary education have become too theoretical and that the students are not armed with enough technical skills to start their professional careers.
2. Students must have access to a support network of adults if students are given the authority and responsibility to take charge of their own learning. One problem with a more democratic and flexible educational approach is that some students may not be ready to shoulder the responsibility for their own education and that they may not have an adult network around them to provide support.

3. For this reason it is important to have a holistic approach to the educational methodology starting at primary and pre-schools levels, so that students learn to actively seek out competencies as opposed to being passive receivers of knowledge.
4. Although somewhat outside the scope of this study, Sweden must do more to change the underlying culture that promotes innovation and risk taking among its workforce.

Table of mathematics education

Skills required for students in Swedish Upper Secondary School (grades 10-12), Mathematics courses A-D	COUNTRY: SWEDEN			
	Public Schools		Private Schools	
Mathematics A	**In curriculum**	**De facto learnt**	**In curriculum**	**De facto learnt**
Be able to formulate, analyze and solve mathematical problems of importance for everyday life and the chosen study orientation	YES	YES	YES	YES
Have deepened and extended understanding of numbers to cover real numbers in different forms	YES	YES	YES	YES
With and without technical aids, be able to apply with judgment knowledge of different forms of numerical calculations linked to everyday life and the chosen study orientation	YES	YES	YES	YES
Have an advanced knowledge of geometric concepts, and be able to apply these to everyday situations and in different subjects of the chosen study orientation	YES	YES	YES	YES
Be sufficient familiar with basic geometrical propositions and reasoning in order to understand and be able to use concepts and different ways of thinking in order to solve problems	YES	YES	YES	YES
Be able to interpret, critical examine and with discrimination illustrate statistical data, as well as be able to interpret and use common co-ordinates	YES	YES	YES	YES
Be able to interpret and deal with algebraic expressions, formulae and functions required for solving problems in everyday life and in other subjects of the chosen study orientation	YES	YES	YES	YES
Be able to set up and interpret linear equations and simple exponential equations, as well as use appropriate methods and aids to solve problems	YES	YES	YES	YES
Be able to set up illustrate and interpret linear functions and simple exponential functions and models for real events in private finance and in society	YES	YES	YES	YES
Be accustomed when solving problems to use computers and graphic calculators to carry out calculations and use graphs and diagrams for illustrative purposes	YES	YES	YES	YES
Be familiar with how mathematics affects our culture in terms of, for example, architecture, music, design or the arts, as well as how mathematical models can describe processes and forms in nature	YES	YES	YES	YES
Mathematics B				
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientation with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES
Be able to explain, prove and when solving problems, use some important propositions from classical geometry	YES	YES	YES	YES
Be able to calculate probabilities for simple random trials and multi-stage random trials as well as be able to estimate probabilities by studying relative frequencies	YES	YES	YES	YES
Use with judgment different types of statement indicators for statistical materials,	YES	YES	YES	YES

and be able to explain the difference between them, as well as be familiar with and interpret some measures of dispersion.				
Be able to plan, carry out and report a statistical study, and in this context be able to discuss different types of errors, as well as evaluate the results.	YES	YES	YES	YES
Be able to interpret, simplify and reformulate expressions of the second degree, as well as solve quadratic equations and apply this knowledge in solving problems.	YES	YES	YES	YES
Be able to work with linear equations in different forms, as well as solve linear differences and equation systems with graphic and algebraic methods	YES	YES	YES	YES
Be able to explain the properties of a function, as well as be able to set up, interpret and use some non-linear functions as models for real process, and in connection with this be able to work both with and without computers and graphic drawing aids.	YES	YES	YES	YES
Mathematics C				
Be able to formulate, analyze and solve mathematical problems, of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES
Be able to interpret and use logarithms and powers with real exponents, and be able to apply these when solving problems.	YES	YES	YES	YES
Be able to set up, simplify and use polynomial expressions, as well as describe and use the properties of some polynomial functions and power functions.	YES	YES	YES	YES
Be able to set up, simplify and use rational expressions as well as polynomial equations of high powers through factorization.	YES	YES	YES	YES
Be able to use mathematical models of different kinds, including those which build on the sum of a geometric progression	YES	YES	YES	YES
Be familiar with how computers and graphic calculators can be used as aids, when studying mathematical models in different application areas.	YES	YES	YES	YES
Be able to explain, illustrate and use the concept of changing coefficients and derivatives for a function, as well as use these to describe the qualities of a function and its graphs.	YES	YES	YES	YES
Be able to identify the rules of derivation for some basic power functions, sums of functions, as well as simple exponential functions, and in connection with this describe why and how the number e is introduced.	YES	YES	YES	YES
Be able to draw conclusions from a function's derivatives, and estimate the value of the derivative when the function is given by means of a graph.	YES	YES	YES	YES
Be able to use the relationship between a function's graph and its derivatives in different application contexts with and without aids for drawing graphs.	YES	YES	YES	YES
Mathematics D				
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES
Be able to use a circle to define trigonometric concepts, show trigonometric relationships and provide complete solutions for simple trigonometric equations, as well as be able to use these for solving problems.	YES	YES	YES	YES
Be able to draw graphs of trigonometric functions, as well as use these functions	YES	YES	YES	YES

as models for real periodic processes				
Be able to derive and use formulae which are needed to transform simple trigonometric expressions, and solve trigonometric equations.	YES	YES	YES	YES
Be able to calculate the sides and angles of a triangle.	YES	YES	YES	YES
Be able to explain the rules of derivatives and be able to derive these for trigonometric functions, logarithmic functions, compound functions, product and quotients of functions, as well as be able to apply these rules in solving problems	YES	YES	YES	YES
Be able to use derivatives of second order in different application contexts	YES	YES	YES	YES
Be able to explain and use the thinking behind some of the methods for solving numerical equations, as well as when solving problems, be able to use graphical, numerical or software for processing mathematical symbols	YES	YES	YES	YES
Be able to explain the concept of differential equations, and be able to give examples of some simple differential equations, and present problem situations where they can occur.	YES	YES	YES	YES
Be able to determine primitive functions and use these in solving problems.	YES	YES	YES	YES
Be able to explain the meaning of the concept of integrals, and clarify the relationship between integral and derivatives, as well as set up, interpret and use integrals in different types of basic applications.	YES	YES	YES	YES
Be able to present the thinking behind and be able to use some methods of numerical integration, as well as when solving problems, be able to use graphical, numerical or symbol processing software to calculate integrals.	YES	YES	YES	YES
Be able to independently analyze, implement and orally and in writing, a more comprehensive task where knowledge from different areas of mathematics is used.	YES	YES	YES	YES

COSTA RICA

"In 10 years (or earlier) we will be condemned to be only a small niche player because of the dwindling numbers of qualified workers. Our country's reputation is based on past strengths, on which the country has not capitalized correctly, and which has in fact been allowed to deteriorate." (Costa Rican research team)

Human Capital, technology transfer and competitive gains

1. Where the Cluster is in the technology ladder

There is a strong ICT cluster in Costa Rica. However, it is mostly made up of companies at the lowest end of the technology ladder, including component assembly, call centers, business process outsourcing. Transnational cluster companies are multinationals taking advantage of lower labor costs and the advantages associated with Costa Rica's geography. Although Costa Rica has moved up a couple of steps from the apparel assembly, the mass of Costa Rican workers is still at apparel assembly level in terms of skills demanded. Local innovation and investment is still insufficient to generate a real "Costa Rican" cluster to build on local software development which is mostly limited to "enterprise resource planning" or contract- work. University research is limited and under funded. Patenting is almost non-existent.

2. Type and Quality of Technology Transfer in Cluster

Innovation and knowledge transfer do not occur from TNC to local companies except in a very few supply chain situations. On the contrary, small software companies are frequently staffing seedlings for large TNC's that can offer better salaries

3. Role of universities in technology transfer

Local universities graduate good generalists. TNC's require good specialists; hence training is done mostly in-house and on the job. Contact between cluster and local Universities is limited to improving curricula to reflect current corporate needs.

4. Skill Requirements in cluster

The low skills required for 70-80 percent of workers in the four cluster subgroups reflect the fact that the cluster is at the lower end of the technology ladder. Except for knowledge process outsourcing (KPO) and locally owned software companies, *no firms* stated that math and science skills were required for their workplaces. Employers are demanding better skills in English and computer literacy. Higher skills in problem solving are required for KPO and Software development companies. See also Table comparing mathematics education data, pp 35-37.

The structuring of math, science, and technology education

1. The Situation of math and science education in country

Costa Rica's educational system is in a serious crisis. 77 percent of students will not graduate from high school for a combination of reasons: poverty and uninteresting school programs. The crisis is exacerbated by a rigorous admittance exam to public universities, which are the best in the country. This limits the amount of students who have a way of accessing quality higher education. The alarmingly poor results in High School Math and Science tests reflect the lack of students that opt for math/science related careers. Only 3 percent of university degrees granted in 2002 were cluster relevant.

2. Overall education context

Although Costa Rica stands out in the region for its comparatively better education and other public services, the country's education system has deep systemic problems. There are massive dropout problems, both in elementary and in secondary schools. Especially brutal high school desertion rates affect availability of future cluster workers as the system fails to offer interesting options to students relating to current market conditions. There is a lack of conscious direction or policies that promote the cluster's move up the technology ladder by promoting productive interactions between scientific high schools, technical high schools, universities and companies. This leadership and policy gap is holding the country back from a qualitative leap towards a modern knowledge economy.

3. Policy Failures/opportunities

- A very weak Ministry of Science and Technology has been incapable of acting with leadership. Hence all growth and direction is cluster driven. The ITC chamber of commerce called CAMTIC has been forceful and organized in the absence of any real government/academic led action
- Latin American nationals are flocking to Costa Rica for work and local software companies are already contracting work outside the country (Colombia and Chile)
- Costa Rica continues to stand out in the region for its comparatively better education. Proximity to the US and cultural affinity will continue to be key for companies to decide to invest in the country. But on closer inspection, many will choose not to come and those here will choose to expand elsewhere. Some expansion is still possible in the country, but the limit in terms of qualified workers is quickly encroaching!

Conclusions

1. Free Zones (tax free incentives that do not support the public school system) and general country conditions continue to be the main attractor for foreign companies and not the generation of new scientific knowledge that could result from the interaction between Universities, schools and companies. For more value added growth, it is indispensable that every player in the cluster understand its role in the habitat. Additionally, more information and integration by all cluster players:

Academy, Companies and Chambers would help strengthen the cluster as is evidenced in Kista, Sweden. For this, leadership is required.

2. The better use of university resources is hindered by ideological positions common in Latin America that support complete separation between universities and business. This has left the cluster only with a growth straategy based on the dubious advantage of lower labor costs and not a competitive advantage based on the production of knowledge products and services. The recent 2006-2010 CONARE plan (National Dean's Commission) recognizes the pitfalls in this policy and is making an important turn-around. While promising, this is not enough, as many other stakeholders need to embrace the plan.
3. There are deficiencies in the educational system. Several high school desertion rates affect availability of future cluster workers as the system fails to offer interesting options to students relating to current market conditions. There is no evidence of conscious direction to generate economic growth through knowledge. This could be achieved by promoting further interactions between scientific high schools, technical high schools, universities and companies is holding the country back from the real qualitative leap towards a modern knowledge economy.
4. Until now the country has projected an image of succcess that is not necessarily based on a clear competitive strategy but relies instead on comparative advantages of low cost labor and geographical location. Costa Rica's impressive success in attracting companies into the country and the momentum this has created has blurred its vision.
5. In order to continue being competitive in the future Costa Rica needs to become aware of its systemic weaknesses. Policymakers must design a route plan or the country will have lost a unique opportunity to truly position itself in the knowlege economy. It is imperative that a competent authority take the initiative to lead the cluster with vision towards the future. This includes a systemic improvement of the quality and coverage of education in the country.

Recommendations

Develop vision and leadership for a policy framework that builds incentives for those actions that help the country improve on its considerable potential. Market niches of the future should be found in the higher value added spaces of the cluster, in "clusters of knowledge" that the country already has, especially in generating innovation using information and communication technologies. Some of these clusters of knowledge are: production of coffee, tropical agriculture, tropical architecture, biotechnology, ecological tourism, management of protected areas, management of social security systems. For a list of specific action steps, please refer to the Costa Rican complete case study in Volume 2.

At high school level the fundamental task seems to be teaching the scientific method, mathematical logic and problem resolution. Using Sweden as benchmark, CR could improve the following areas:

1. In Costa Rica, there are no individual programs to build on student's interests and abilities, as is the case in Sweden.
2. The Swedish educational system begins by forming a solid basic mathematical base and building upon this base. In Sweden, the program begins with whole numbers, percentages and algebra whereas in Costa Rica the program jumps directly into geometry. There does not seem to be a pedagogical reason for this.
3. The Swedish curriculum includes the use of computers for the math program. This is not the case in Costa Rica The country does have computer classes at schools, but these are not applied to the math learning process
4. Beginning at level C, the Swedish program includes derivatives and integers. This is not included in regular high school programs in Costa Rica. Only scientific high schools and some private high schools include this as part of the normal program. It is important to note however, that Swedes complete the high school program at age 20 whereas in Costa Rica the program is completed at 18.
5. At a the university level we recommend improvement in the teaching of the scientific method and pure mathematics instead of mathematics based on the application of pre-established formulas at the Bachelor in Computer Sciences level. Pure math improves analytical capabilities and problem resolution allowing any professional to assimilate all new technologies rapidly.
6. At a manufacturing level engineers should hone skills in statistics and probability, systemic thinking and deepen their skills in experiment design (selection of variables and testing). Also project development and management skills are necessary.

.

Table comparing mathematics education data

Skills required for students in Swedish Upper Secondary School (grades 10-12), Mathematics courses A-D	COUNTRY: COSTA RICA				
	Public Schools		Private Schools		Cluster
Mathematics A	**In curriculum**	**De facto learnt**	**In curriculum**	**De facto learnt**	**To what extent does the cluster demand these skills?**
Be able to formulate, analyze and solve mathematical problems of importance for everyday life and the chosen study orientation	PARTIALLY *	PARTIALLY *	PARTIALLY *	PARTIALLY *	RARELY
Have deepened and extended understanding of numbers to cover real numbers in different forms	YES	YES	YES	YES	RARELY
With and without technical aids, be able to apply with judgment knowledge of different forms of numerical calculations linked to everyday life and the chosen study orientation	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	RARELY
Have an advanced knowledge of geometric concepts, and be able to apply these to everyday situations and in different subjects of the chosen study orientation	YES	YES	YES	YES	RARELY
Be sufficient familiar with basic geometrical propositions and reasoning in order to understand and be able to use concepts and different ways of thinking in order to solve problems	YES	NO	YES	YES	RARELY
Be able to interpret, critical examine and with discrimination illustrate statistical data, as well as be able to interpret and use common co-ordinates	YES	NO	YES	YES	FREQUENTLY
Be able to interpret and deal with algebraic expressions, formulae and functions required for solving problems in everyday life and in other subjects of the chosen study orientation	YES	NO	YES	YES	NOT AT ALL
Be able to set up and interpret linear equations and simple exponential equations, as well as use appropriate methods and aids to solve problems	YES	NO	YES	YES	NOT AT ALL
Be able to set up illustrate and interpret linear functions and simple exponential functions and models for real events in private finance and in society	NO	NO	YES	NO	NOT AT ALL
Be accustomed when solving problems to use computers and graphic calculators to carry out calculations and use graphs and diagrams for illustrative purposes	NO	NO	NO	NO	RARELY
Be familiar with how mathematics affects our culture in terms of, for example, architecture, music, design or the arts, as well as how mathematical models can describe processes and forms in nature	YES	NO	YES	NO	FREQUENTLY
Mathematics B					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientation with an in-depth knowledge of concepts and methods learned in earlier courses	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	NOT AT ALL
Be able to explain, prove and when solving problems, use some	YES	NO	YES	NO	NOT AT ALL

important propositions from classical geometry					
Be able to calculate probabilities for simple random trials and multi-stage random trials as well as be able to estimate probabilities by studying relative frequencies	YES	PARTIALLY	YES	YES	NOT AT ALL
Use with judgment different types of statement indicators for statistical materials, and be able to explain the difference between them, as well as be familiar with and interpret some measures of dispersion.	NO	NO	NO	NO	NOT AT ALL
Be able to plan, carry out and report a statistical study, and in this context be able to discuss different types of errors, as well as evaluate the results.	NO	NO	NO	NO	NOT AT ALL
Be able to interpret, simplify and reformulate expressions of the second degree, as well as solve quadratic equations and apply this knowledge in solving problems.	YES	YES	YES	YES	NOT AT ALL
Be able to work with linear equations in different forms, as well as solve linear differences and equation systems with graphic and algebraic methods	YES	NO	YES	YES	NOT AT ALL
Be able to explain the properties of a function, as well as be able to set up, interpret and use some non-linear functions as models for real process, and in connection with this be able to work both with and without computers and graphic drawing aids.	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	NOT AT ALL
Mathematics C					
Be able to formulate, analyze and solve mathematical problems, of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES	NOT AT ALL
Be able to interpret and use logarithms and powers with real exponents, and be able to apply these when solving problems.	YES	NO	YES	YES	NOT AT ALL
Be able to set up, simplify and use polynomial expressions, as well as describe and use the properties of some polynomial functions and power functions.	YES	YES	YES	YES	NOT AT ALL
Be able to set up, simplify and use rational expressions as well as polynomial equations of high powers through factorization.	YES	NO	YES	YES	NOT AT ALL
Be able to use mathematical models of different kinds, including those which build on the sum of a geometric progression	NO	NO	NO	NO	NOT AT ALL
Be familiar with how computers and graphic calculators can be used as aids, when studying mathematical models in different application areas.	NO	NO	NO	NO	NOT AT ALL
Be able to explain, illustrate and use the concept of changing coefficients and derivatives for a function, as well as use these to describe the qualities of a function and its graphs.	NO	NO	NO	NO	NOT AT ALL
Be able to identify the rules of derivation for some basic power functions, sums of functions, as well as simple exponential functions, and in connection with this describe why and how the number e is introduced.	NO	NO	NO	NO	NOT AT ALL
Be able to draw conclusions from a function’s derivatives, and	NO	NO	NO	NO	NOT AT ALL

estimate the value of the derivative when the function is given by means of a graph.					
Be able to use the relationship between a function’s graph and its derivatives in different application contexts with and without aids for drawing graphs.	NO	NO	NO	NO	NOT AT ALL
Mathematics D					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	NOT AT ALL
Be able to use a circle to define trigonometric concepts, show trigonometric relationships and provide complete solutions for simple trigonometric equations, as well as be able to use these for solving problems.	YES	YES	YES	YES	NOT AT ALL
Be able to draw graphs of trigonometric functions, as well as use these functions as models for real periodic processes	NO	NO	NO	NO	NOT AT ALL
Be able to derive and use formulae which are needed to transform simple trigonometric expressions, and solve trigonometric equations.	NO	NO	NO	NO	NOT AT ALL
Be able to calculate the sides and angles of a triangle.	YES	YES	YES	YES	NOT AT ALL
Be able to explain the rules of derivatives and be able to derive these for trigonometric functions, logarithmic functions, compound functions, product and quotients of functions, as well as be able to apply these rules in solving problems	NO	NO	NO	NO	NOT AT ALL
Be able to use derivatives of second order in different application contexts	NO	NO	NO	NO	NOT AT ALL
Be able to explain and use the thinking behind some of the methods for solving numerical equations, as well as when solving problems, be able to use graphical, numerical or software for processing mathematical symbols	NO	NO	NO	NO	NOT AT ALL
Be able to explain the concept of differential equations, and be able to give examples of some simple differential equations, and present problem situations where they can occur.	NO	NO	NO	NO	NOT AT ALL
Be able to determine primitive functions and use these in solving problems.	NO	NO	NO	NO	NOT AT ALL
Be able to explain the meaning of the concept of integrals, and clarify the relationship between integral and derivatives, as well as set up, interpret and use integrals in different types of basic applications.	NO	NO	NO	NO	NOT AT ALL
Be able to present the thinking behind and be able to use some methods of numerical integration, as well as when solving problems, be able to use graphical, numerical or symbol processing software to calculate integrals.	NO	NO	NO	NO	NOT AT ALL
Be able to independently analyze, implement and orally and in writing, a more comprehensive task where knowledge from different areas of mathematics is used.	NO	NO	NO	NO	NOT AT ALL

BRAZIL Recife, Pernambuco

"Various public policies in Brazil support ICT cluster development, but these do not seem to extend to education in math and sciences at the primary and secondary levels. Programs include a working credit line for SMEs, with special resources available for software development, as well as programs that promote digital inclusion (Casa Brazil), long-distance education, and The Connected PC, and for upgrading the technology of small firms. New initiatives in internet based ICT include Vortals, (web-portals)." (Case authors)

Human Capital, technology transfer and competitive gains

1. Where the cluster is in the technology ladder

Porto Digital is Information and Communication Technology (ICT) Cluster created in 2000 with a focus on software development. Its purpose is to "produce knowledge locally and export services globally. Though only six years have passed since its creation, Porto Digital is now consolidated, reaching out to dozens of companies from outside Recife, from other states and even from other countries. In 2005 more than 30 new companies came on board or were on their way to do so, attracted by the innovative nature of the project which favors B2B cooperation and integration, institutional promotion and access to new markets. The cluster includes firms developing software, financial and health care management solutions, games, security software, traffic and transportation management software, software usability, and integrated portal, extranet and intranet solutions.

There are approximately 110 ICT firms in Pernambuco, 85 of them in the metropolitan area of Recife. They employ more than 9,000 workers, and their contribution to GNP is US$ 820 million, which represents 3.6 percent of Pernambuco´s GDP. (Brazilian average is 0.8 percent). The ICT industry generates a per capita income of US$ 20,000 in Brazil, and US$ 37,000 in Pernambuco. The average rate of growth in the local ICT industry has increased to 10 percent since the creation of Porto Digital. Major skills developed and demanded by the cluster include web-based solutions, outsourcing, biometry, information security, IT infrastructure, mobility/wi-fi, distance education, and games.

2. Type and quality of technology transfer in cluster

Most technology is transferred through training, graduate courses (both master and PhD), technical visits, scientific conferences, invited talks and extensive use of the library (the cluster has a library with 10,000 domain specific volumes), much of it in the context of using quality improvement tools, which are considered central to the evolution of the cluster. (ISO, CMM, CMMI).

3. Role of universities in tech transfer

The Management Unit (NGPD) of Porto Digital is the result of interactions between the firms in the cluster's productive chain, government and universities. The constitution of the Board is as follows: 37 percent are government representatives, 21 percent come from the productive sector, 11 percent come from universities, 16 percent from non-governmental organizations, and 16 percent from other groups of society.

Created to promote technology transfer between universities, the market and society, the Recife Center for Advanced Studies and Systems (CESAR), in association with the IT Center of the Federal University of Pernambuco (UFPE), develops technology solutions, as well as organizes and structures business units. CESAR was the starting point for dozens of companies, among which InForma Software, Radix and Vanguard. It is responsible for the first professional MSC course in Software Engineering in the private sector in Pernambuco.

The number of private universities has been steadily growing in Brazil. They are a response to a market demand for tertiary education from those who do not possess the academic standards to be accepted to a public university. Although there are exceptions, such as in the Recife ICT cluster, in general, neither public nor private universities collaborate with industry as of how to adjust their curricula to current market needs. Very few educational institutions maintain cooperation agreements with companies. The ones that are in place are typically achieved though the incubation of start up enterprises within university grounds, with contracts with cooperating companies. Because there is no "tradition" at technical jobs in Brazil, i.e., such jobs are considered minor, non prestigious and badly remunerated (which most are, in fact), the very few technical schools are used by students as a part of their academic careers (a step before university) rather than professional training.

4. Skill requirements in cluster

See Table comparing mathematics education data, pp 43-46.

The structuring of math, science, and technology education

1. Situation of math and science education in country and cluster

Cluster employers interviewed indicated that future growth of the cluster is constrained by the lack of qualified graduates with the requisite math and science skills. "In a bad day, I get 10 CV's, in a good day, 50. But less than 15 percent of the CV's make it through the selection process." (Interview with a CEO from a firm with 40 employees). The PISA 2003 evaluation indicates that Brazil's overall performance is among the lowest of all participating countries. PISA classifies math skills in six levels of increasing proficiency. In Brazil, levels 5 and 6 are not significantly achieved, if at all. Barely 15 percent of the students in Brazil's education system (please refer to the case study for a deeper discussion of this topic) scored between 70-100 (considered good to excellent) in mathematics. The most recent census report shows that over 55 million students matriculated in basic education. The report also documents growth in the number of students matriculated in technical schools, (16.48 percent). The table following this review highlights what skills employers demand, as compared to Swedish employers.

In order to better adapt their curricula according to market needs (and to improve technology transfer,) some local universities are demanding more interaction with businesses. In a climate of competition for local education, the ability to increase employability of students is viewed as an asset. Interaction, however, is limited to the university level, and to a much lower extent, to technical schools (much as a part of social and digital inclusion programs). Porto Digital attracts skilled workers from other parts of the northeast of Brazil, as well as from the southeast, Latin America and, more recently, from other parts of the world.

2. Overall education context

Brazil, despite its advantageous economic situation vis a vis other Latin American countries is the one with the lowest percentage of high school educated people, as evidenced by the results of a 2003 Mercosur Assessment. The share of young people in Brazil that have *not* completed primary education is one of the highest among studied countries; about 10% of the 15 to 19 year olds. Also, one in five students in primary school repeats grades. Overall, students repeat two years over the span of primary and secondary school. Education expanded rapidly at secondary and tertiary levels. In absolute terms, student numbers grew by more than 50% at the secondary level and doubled at the tertiary level. The country’s financial resources have barely kept pace with the expanding participation rates.

Despite the fact that the necessary comparison data to evaluate Brazilian educational standards (faculty and student), curriculum, financial cost and infrastructure are in place, there is no indication of a future long term policy in regard to education. Systemic society problems play a major role in today's Brazilian educational panorama. Firstly, the lack of financial support to public schools has produced a need to "push" the students forward in their academic careers. A student repeating a school year is an additional cost that schools can no longer afford. The authors believe this to be a major contributing factor in the decrease (relaxation) of educational standards. A second factor is the gap in pay between teachers in private and public sectors. Public school salaries, as the result of the overall government worker salary policy in the last decade, have become very uninviting.

There is an enormous difference between public and private elementary schools in Brazil. Once of excellent quality, most public schools today provide sub-standard education. With a very few exceptions, the public system today is used only by the population who does not have the means to afford private education in elementary and secondary levels. Interestingly enough, this situation is completely reversed at the university (tertiary) level, where the best schools are public. It is common knowledge Brazil has an "inverted educational pyramid,” meaning that the best resources are put and found at university level. The majority of students that are accepted to those institutions have come from the private school system. This information is corroborated by the WEI report: "*Spending per tertiary student is more than 10 times expenditure per primary or secondary student*".

There are few technical schools, largely because there is no "tradition" at technical jobs in Brazil, i.e., such jobs are considered minor, non prestigious and badly remunerated (which most are, in fact). The very few technical schools that exist are used by students as a part of their academic careers (a step before university) rather than professional training.

3. Policy failures/opportunities

Although State policies emphasize the development of human capital, entrepreneurship and innovation, much more needs to be done to improve the pipeline – the basic education through the secondary level for *all* Brazilian students. While successful public policies support Porto Digital, they don't extend to primary and secondary education. Successful policies include an Investment and Promotion Fund, a Human Capital Fund (vocational training), and a Guarantee Fund backing loans to local software firms. A municipal act allows companies to pay reduced sales tax. Porto Digital builds the capacity of the community's young adults, promoting social inclusion programs for one hundred and forty teens, who take part in the *In'formar* Project. As much as thirty four teens out of fifty already trained by Digital Port are currently working in technology companies. Furthermore, the social department runs a library that is open to the public and has more than 6,000 titles available, including such specifically addressing project management, as a result of a partnership with the Project Management Institute – PMI Recife.

Conclusions

1. There are systemic society-wide problems that play a major role in Brazil's educational landscape:
    a. The lack of financial support to public schools has produced a need to "push" the students forward in their academic careers, contributing to the decrease (relaxation) of educational standards.
    b. A second factor is the gap in pay between teachers in private and public sectors. Public school salaries, as the result of the overall government worker salary policy in the last decade, have become very uninviting.
2. There is a great difference between public and private elementary schools in Brazil, as discussed above.
3. The number of private universities has been steadily growing in Brazil. They are a response to a market demand for tertiary education from those who do not possess the academic standards to be accepted at a public university.

Recommendations

It is fundamental that future policy accomplishes the following:

1. Promote the mathematics and scientific learning in elementary and secondary levels in and outside schools, while promoting high education standards and ethical values.
2. Offer teachers in elementary and secondary levels conditions in which to expand their knowledge, receive training in new (innovative) educational techniques, deepen their

understanding about their subject's content, and provide support to their teaching activities.

3. Identify teachers with industry related experience and offer means by which they can function as multiplying agents of the training and professional development actions.
4. Select, adapt and implement instruction materials that have been successfully used in other projects in Brazil and abroad.
5. Provide adequate classrooms in which to explore the experimental aspects of sciences and mathematics. Those should contemplate, but are not limited to:
    - Specialized classrooms with a VCR/DVD player, models, computer terminals connected to information networks
    - Laboratories (biology, chemistry, computer)
    - Library
    - Exposition area
    - Open air space in which to conduct scientific experimentation
6. Create a network of excellence – linking together schools that can serve as reference in selecting and implementing training and professional development activities.
7. Encourage parents to support the study of sciences and mathematics and make them co-responsible for the improvement of the teaching standards for those disciplines.

Table comparing mathematics education data

Skills required for students in Swedish Upper Secondary School (grades 10-12), Mathematics courses A-D	COUNTRY: BRAZIL				
	Public Schools		Private Schools		Cluster
Mathematics A	In curriculum	De facto learnt	In curriculum	De facto learnt	To what extent does the cluster demand these skills?
Be able to formulate, analyze and solve mathematical problems of importance for everyday life and the chosen study orientation	YES	PARTIALLY	YES	YES	Always
Have deepened and extended understanding of numbers to cover real numbers in different forms	YES	YES	YES	YES	Always
With and without technical aids, be able to apply with judgment knowledge of different forms of numerical calculations linked to everyday life and the chosen study orientation	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	Always
Have an advanced knowledge of geometric concepts, and be able to apply these to everyday situations and in different subjects of the chosen study orientation	YES	YES	YES	YES	Always
Be sufficient familiar with basic geometrical propositions and reasoning in order to understand and be able to use concepts and different ways of thinking in order to solve problems	YES	NO	YES	YES	Always
Be able to interpret, critical examine and with discrimination illustrate statistical data, as well as be able to interpret and use common co-ordinates	YES	NO	YES	YES	Always
Be able to interpret and deal with algebraic expressions, formulae and functions required for solving problems in everyday life and in other subjects of the chosen study orientation	YES	YES	YES	YES	Always
Be able to set up and interpret linear equations and simple exponential equations, as well as use appropriate methods and aids to solve problems	YES	YES	YES	YES	Always
Be able to set up illustrate and interpret linear functions and simple exponential functions and models for real events in private finance and in society	YES	NO	YES	NO	Always
Be accustomed when solving problems to use computers and graphic calculators to carry out calculations and use graphs and diagrams for illustrative purposes	NO	NO	NO	NO	Always
Be familiar with how mathematics affects our culture in terms of, for example, architecture, music, design or the arts, as well as how mathematical models can describe processes and forms in nature	YES	NO	YES	NO	Always
Mathematics B					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientation with an in-depth knowledge of concepts and methods learned in earlier courses	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to explain, prove and when solving problems, use some important	YES	NO	YES	NO	Always

propositions from classical geometry					
Be able to calculate probabilities for simple random trials and multi-stage random trials as well as be able to estimate probabilities by studying relative frequencies	YES	PARTIALLY	YES	YES	Always
Use with judgment different types of statement indicators for statistical materials, and be able to explain the difference between them, as well as be familiar with and interpret some measures of dispersion.	NO	NO	NO	NO	Always
Be able to plan, carry out and report a statistical study, and in this context be able to discuss different types of errors, as well as evaluate the results.	NO	NO	NO	NO	Rarely
Be able to interpret, simplify and reformulate expressions of the second degree, as well as solve quadratic equations and apply this knowledge in solving problems.	YES	YES	YES	YES	Always
Be able to work with linear equations in different forms, as well as solve linear differences and equation systems with graphic and algebraic methods	YES	NO	YES	YES	Always
Be able to explain the properties of a function, as well as be able to set up, interpret and use some non-linear functions as models for real process, and in connection with this be able to work both with and without computers and graphic drawing aids.	YES	PARTIALLY	YES	YES	Always
Mathematics C					
Be able to formulate, analyze and solve mathematical problems, of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES	Always
Be able to interpret and use logarithms and powers with real exponents, and be able to apply these when solving problems.	YES	YES	YES	YES	Always
Be able to set up, simplify and use polynomial expressions, as well as describe and use the properties of some polynomial functions and power functions.	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to set up, simplify and use rational expressions as well as polynomial equations of high powers through factorization.	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to use mathematical models of different kinds, including those which build on the sum of a geometric progression	YES	PARTIALLY	YES	PARTIALLY	Always
Be familiar with how computers and graphic calculators can be used as aids, when studying mathematical models in different application areas.	NO	NO	NO	NO	Always
Be able to explain, illustrate and use the concept of changing coefficients and derivatives for a function, as well as use these to describe the qualities of a function and its graphs.	PARTIALLY	NO	PARTIALLY	NO	Always
Be able to identify the rules of derivation for some basic power functions, sums of functions, as well as simple exponential functions, and in connection with this describe why and how the number e is introduced.	NO	NO	NO	NO	Not at all
Be able to draw conclusions from a function's derivatives, and estimate the value of the derivative when the function is given by means of a graph.	NO	NO	NO	NO	Not at all
Be able to use the relationship between a function's graph and its derivatives in different application contexts with and without aids for drawing graphs.	NO	NO	NO	NO	Not at all

Mathematics D					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to use a circle to define trigonometric concepts, show trigonometric relationships and provide complete solutions for simple trigonometric equations, as well as be able to use these for solving problems.	YES	YES	YES	YES	Always
Be able to draw graphs of trigonometric functions, as well as use these functions as models for real periodic processes	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to derive and use formulae which are needed to transform simple trigonometric expressions, and solve trigonometric equations.	YES	PARTIALLY	YES	PARTIALLY	
Be able to calculate the sides and angles of a triangle.	YES	YES	YES	YES	Always
Be able to explain the rules of derivatives and be able to derive these for trigonometric functions, logarithmic functions, compound functions, product and quotients of functions, as well as be able to apply these rules in solving problems	NO	NO	NO	NO	Not at all
Be able to use derivatives of second order in different application contexts	NO	NO	NO	NO	Not at all
Be able to explain and use the thinking behind some of the methods for solving numerical equations, as well as when solving problems, be able to use graphical, numerical or software for processing mathematical symbols	YES	PARTIALLY	YES	PARTIALLY	Always
Be able to explain the concept of differential equations, and be able to give examples of some simple differential equations, and present problem situations where they can occur.	NO	NO	NO	NO	Not at all
Be able to determine primitive functions and use these in solving problems.	YES	PARTIALLY	YES	YES	Always
Be able to explain the meaning of the concept of integrals, and clarify the relationship between integral and derivatives, as well as set up, interpret and use integrals in different types of basic applications.	NO	NO	NO	NO	Not at all
Be able to present the thinking behind and be able to use some methods of numerical integration, as well as when solving problems, be able to use graphical, numerical or symbol processing software to calculate integrals.	NO	NO	NO	NO	Not at all
Be able to independently analyze, implement and orally and in writing, a more comprehensive task where knowledge from different areas of mathematics is used.	YES	NO	YES	PARTIALLY	Always

El SALVADOR – San Salvador, TACA Aircraft Maintenance mini-cluster

“Despite our hopes of finding an ICT cluster in San Salvador, we found no relevant cluster in terms of high local value added, or evidence of technology transfer from trans-national firms in ICT. Instead, our study pointed us to an interesting “University-Private Sector” joint effort to develop the technical skills required by a large employer (Universidad Don Bosco-TACA/Aeroman). We decided to focus on this example because it bridges the gulf between secondary and higher education, and because it is driven by private sector demand. These two elements or “bridges” are necessary to visualize the relevance that a solid math and science education at the high-school level has for the competitiveness of modern knowledge economies.”(Case authors)

Human Capital, technology transfer and competitive gains

1. Where the cluster is in technology ladder

Over the last three years TACA, the regional airline, has jointly developed with the Universidad Don Bosco a five semester program for aircraft maintenance technicians. Universidad Don Bosco presently graduates about 25 aircraft maintenance technicians every semester and applicants to the program are selected based on a specific evaluation exam that evaluates math and science skills. TACA sponsors about ten students per semester that cannot afford the training and most graduates go to work for TACA after their degree. Today about 750 people work in the aircraft maintenance unit of TACA (Aeroman) which is certified to do regular maintenance to Airbus units of TACA as well as various US Airlines under FAA standards. The maintenance unit is expected to double its capacity (and number of jobs) over a five year horizon.

Other than providing a number of higher skill jobs, Aeroman has little impact or relationships to other companies or possible suppliers in El Salvador, so no broader development of a cluster can be expected. The specific maintenance tasks are dictated by the component suppliers and airplane builder Airbus. Specialized components are replaced according to plan and/or usage and technical revisions are done outside El Salvador at the original manufacturing plants. Other than the feedback to suppliers on the experience and performance of the planes and their components, there is little information and-or technological transfer. Nevertheless, the TACA-Universidad Don Bosco is a good example of how academia and private sector firms work together to efficiently outsource higher skills training, to the advantage of students with a stronger background in math and sciences.

2. Type and quality of technology transfer in cluster

Technology transfer occurs between TACA, the Universidad Don Bosco, and students. This is a good example of how academia and private sector firms work together to efficiently outsource higher skills training, to the advantage of students with a stronger background in math and sciences. Other than providing feedback to suppliers on the experience and performance of the planes and their components, there is little information and-or technological transfer in this mini-cluster. Specific maintenance tasks are dictated by component suppliers and the airplane builder, Airbus. Specialized components are replaced according to plan and/or usage and its technical revision is done outside El Salvador at the original manufacturing plants.

3. Role of universities in tech transfer

As previously discussed, in the case of this mini-cluster, the university serves as the intermediary for a type of technology transfer, (between the firm, faculty, and students), as TACA shares with Don Bosco its demand for skills and the university develops curriculum to supply these skills. Over the last three years TACA has jointly developed with the Universidad Don Bosco a five semester program for aircraft maintenance technicians. Universidad Don Bosco presently graduates about 25 aircraft maintenance technicians every semester and applicants to the program are selected based on a specific evaluation exam that evaluates math and science skills. TACA sponsors about ten students per semester that cannot afford the training and most graduates go to work for TACA after their degree. Today about 750 people work in the aircraft maintenance unit of TACA (Aeroman) which is certified to do regular maintenance to Airbus units of TACA as well as various US Airlines under FAA standards. The maintenance unit is expected to double its capacity (and number of jobs) over a five year horizon.

4. Skill requirements in cluster

Skill requirements are dictated by FAA, and require sufficient math and science skills to certify FAA quality criteria. See also Table comparing mathematics education data, pp 51-53.

The structuring of math, science, and technology education

1.Situation of math and science education in country and cluster

As in the case of Costa Rica, and even after a recent reform effort, the results in math and sciences of the standardized FAES exams in El Salvador have been continuously deteriorating in recent years. Academic achievements as measured by national standardized tests show secondary education in an intermediate-low level. Primary education 2002-2006 results reflect very low achievements records, between two and five, particularly critical in mathematics. At the secondary level averages were 1691 points in 2004 (in a scale of 1900, which equals to basic and intermediate) and 4.67 in a scale of 1 to 10 in 2005. The lowest levels are found in mathematics with 1683 points and in Sciences with 1694 points**.** Approximately 56,000 students take the PAES test, from which a minority come from private schools that usually have a higher achievement in tertiary education.

With a traditionally stronger industrial basis than its Central American neighbors, El Salvador, and particularly the technical High Schools of Don Bosco and others have long offered technical degrees at the high school levels. Before the civil war of the 1980's, 14 different technical degrees where offered to high school students. With the economic collapse of the wartime period, the list of technical degrees shrank to just four and the recent educational reform even reduced the general bachillerato to just a two year program. The technical degrees at high school level remained three years programs, but the number of choices has not grown to past levels. Even with the close integration of the technical schools with the Don Bosco University and its two year programs, the fact is that working in the poorer areas of the country without any governmental subsidies the fact is that its students also face tremendous challenges in mat and sciences.

By concentrating on technical bachilleratos at their High schools, and offering short technical degrees in their University, the Don Bosco system is able to concentrate on “marketable” skills. One of its high schools even started a full four-year technical bachillerato, which could represent a fast track to the “técnico universitario” level. It remains open to what degree programs like this can be used to efficiently improve the education in math and sciences, since it is the labor market which finally will decide the appropriate rewards for these improvements.

The ***Salesianos de Don Bosco*** is the third largest order of the Catholic Church, and operates under a single educational objective: to help young people, particularly in poorer or disadvantage economic conditions to get trained and to find meaningful jobs in the local economy. Since the beginning of the 20^{th} century in El Salvador, the Salesianos order presently operates 5 technical high-schools and its Don Bosco University opened in the 1980's. The Aircraft Maintenance Program project goes back to the collaboration with one of its Engineering Alumni, who today heads the training division of the Aeroman maintenance center. A second, shorter and English based training program is being developed at Universidad Don Bosco for TACA's call center.

Although it is not a specific ICT cluster, the Don Bosco-TACA example can be considered relevant for our purposes in that the program

- fulfills a clear job description by the final employer (the only critical point being that there is to date only one private sector employer in El Salvador that requires the specific skills);
- singles out minimum math and science skills of the high-school applicants as a requirement to be accepted into the program (math results of over 70 percent of the internally defined test);
- most successful applicants to the program come from the five technical Don Bosco high schools in El Salvador, which offer a three year technical high-school degree, vs. the general two year program most public and private high-schools offer;
    - follows industry relevant quality controls defined by third parties, as the technicians hired by TACA have to meet FAA certification standards after some months of in the job training.

2. Overall education context

The present format of high-school Math and Science education in Costa Rica and El Salvador is not part of any broad based policy effort to promote the skills required by the knowledge economy (and its specific sectors like ICT). Recent educational reforms in El

Salvador, by offering a shortened general bachillerato, have reduced the chances for improvements at the high school level and shifted the responsibilities to higher education, which is disconnected from both the public high schools and the labor markets. Moreover, the present system inhibits any positive development for improvements in math and science education since:

- General High School training is based on reaching some ill defined academic standards and does not reflect or pursues the realities of the labor market
- Standardized exams like the Bachillerato in Costa Rica or the FAES in El Salvador, are disconnected from the requirements at the next (University) level, as well as from the labor market
- Teachers are the worst paid professionals (in terms of the years of training required) in the public sector
- Teachers, mostly female, face particular difficulties in maintaining high levels of continuous training efforts because of their parallel duties in society (mothers, wives, head of households)
- Even high school level teachers are trained on a very broad basis, not as specialists, such as chemists, biologists or physicists
- Subject specialist, on the other hand, cannot teach in public schools without at least a three- year training in pedagogy, and combined with the low wages nobody is interested in doing it
- Math and science training is presented as a black box and is not supposed to raise interest but from the brightest students;
- Math and science training is not related to practical matters or job perspectives
- Math and sciences are the core of a Darwinian educational system, that filters the best students at every level, instead of promoting a more democratic result;
- Math and science curriculum exists in a void of objectives in terms of employability;
- High School standards concentrating on reduced choices, number of school days and standardized test “help manage” the growing number of students, but do not help marketability of the students;
- Public Schools consider the challenges in foreign languages as much more important than the ones in Math and science;
- High Schools and Universities seldom jointly consider the transition of the students between both levels and offer support;
- The public sector faces a big short term challenge in terms of job creation, and most educational policies are left for the long term (i.e. are never properly addressed).

3. Policy failures/opportunities

The Don Bosco-TACA case in El Salvador, although it is not an ICT cluster and poor in terms of cluster development, could help with **rapidly** improving math and science education. However, for that to happen, the lessons learned with the TACA Don Bosco case must be shared and leveraged throughout the rest of the country’s schools.

Conclusions

This example offers an interesting set of conditions necessary to improve training of math and sciences; resembling some of the features of the Swedish case:

- a job oriented program, particularly for math and science in terms of curriculum;
- a more flexible environment than the traditional public schools, in terms of developing new teaching methods and degree definitions (without having to go to expensive, private schools);
- better and more specialized teachers, with a clear motivation to work with the less affluent;
- a longer period of high school (3-4 years), so that students will be more mature and prepared to decide on their careers;
- flexibly but directly integrated with higher education venues (Universidad Don Bosco) for more advanced training;
- working cooperatively with the companies that can financially support the training, offer practical internships and finally offer permanent jobs;
- guided by third party quality objectives that promote continuous education instead of just standardized tests at the end of the courses.

This approach to developing better trained human resources could, in a reasonable amount of time, be used for helping El Salvador's call centers move up the technology ladder. It will require significant new investments, and if done in a systemic way, should result in creating new jobs and higher education achievements.

Recommendations

1. Develop a plan for expanding the impact and reach of this mini-cluster. The Don Bosco cluster has a high potential of becoming a real cluster, where a real transfer of knowledge can be done and where there could be cooperation between academia and enterprises. For this purpose the main actors and leaders have to become aware of the potential of this mini-cluster and work on developing a joint plan for growing it further.
2. Replicate this model in other industries/parts of the country. Governmental authorities and the private sector can take the case of the Don Bosco cluster as a real model to follow and duplicate in other areas of the country (particularly in the case of Puerto El Cutuco in La Unión, with Megatec, the Calbo enterprise, for example).
3. CONACYT should be strengthened, giving it more autonomy, support, and budget to develop a model for the country, based on science and technology.
4. Based on the former, effective mechanisms should be designed to comply with the National Policy for Science, Technology and Innovation, including the active participation of universities and productive and entrepreneurial sectors.
5. The Ministry of Education (MINED) should follow up and monitor the results on science and math; it should also implement projects to improve the results of national (achievements, and PAES) and international tests.
6. The different entrepreneurial and industrial chambers should be more concerned with educational, scientific and technological issues, through participation mechanisms with political, curricular, evaluation and design programs.

Table comparing mathematics education data

Skills required for students in Swedish Upper Secondary School (grades 10-12), Mathematics courses A-D	COUNTRY: EL SALVADOR				
	Public Schools		Private Schools		Cluster
Mathematics A	In curriculum	De facto learnt	De facto learnt	In curriculum	To what extent does the cluster demand these skills?
Be able to formulate, analyze and solve mathematical problems of importance for everyday life and the chosen study orientation	NO	NO	NO	YES	Always
Have deepened and extended understanding of numbers to cover real numbers in different forms	YES	NO	YES	YES	Always
With and without technical aids, be able to apply with judgment knowledge of different forms of numerical calculations linked to everyday life and the chosen study orientation	YES	NO	YES	NO	Always
Have an advanced knowledge of geometric concepts, and be able to apply these to everyday situations and in different subjects of the chosen study orientation	YES	NO	YES	NO	Rarely
Be sufficient familiar with basic geometrical propositions and reasoning in order to understand and be able to use concepts and different ways of thinking in order to solve problems	YES	NO	YES	YES	Rarely
Be able to interpret, critical examine and with discrimination illustrate statistical data, as well as be able to interpret and use common co-ordinates	NO	NO	YES	YES (RELATIVE)	Rarely
Be able to interpret and deal with algebraic expressions, formulae and functions required for solving problems in everyday life and in other subjects of the chosen study orientation	YES	NO	YES	YES	Rarely
Be able to set up and interpret linear equations and simple exponential equations, as well as use appropriate methods and aids to solve problems	YES	YES	YES	YES	Rarely
Be able to set up illustrate and interpret linear functions and simple exponential functions and models for real events in private finance and in society	YES	NO	YES	NO (RELATIVE)	Not at all
Be accustomed when solving problems to use computers and graphic calculators to carry out calculations and use graphs and diagrams for illustrative purposes	NO	NO	NO	NO	Rarely
Be familiar with how mathematics affects our culture in terms of, for example, architecture, music, design or the arts, as well as how mathematical models can describe processes and forms in nature	N0	NO	NO	NO	Rarely
Mathematics B					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientation with an in-depth knowledge of concepts and methods learned in earlier courses	NO	NO	NO	NO	Rarely
Be able to explain, prove and when solving problems, use some important propositions from classical geometry	YES	YES	YES	YES	Not at all

Be able to calculate probabilities for simple random trials and multi-stage random trials as well as be able to estimate probabilities by studying relative frequencies	YES	YES (RELATIVE)	YES	YES	Rarely
Use with judgment different types of statement indicators for statistical materials, and be able to explain the difference between them, as well as be familiar with and interpret some measures of dispersion.	YES	YES (RELATIVE)	YES	YES	Rarely
Be able to plan, carry out and report a statistical study, and in this context be able to discuss different types of errors, as well as evaluate the results.	YES	NO	YES	YES	Rarely
Be able to interpret, simplify and reformulate expressions of the second degree, as well as solve quadratic equations and apply this knowledge in solving problems.	YES	NO	YES	YES	Rarely
Be able to work with linear equations in different forms, as well as solve linear differences and equation systems with graphic and algebraic methods	YES	YES (RELATIVE)	YES	YES	Rarely
Be able to explain the properties of a function, as well as be able to set up, interpret and use some non-linear functions as models for real process, and in connection with this be able to work both with and without computers and graphic drawing aids.	YES	NO	YES	NO	Not at all
Mathematics C					
Be able to formulate, analyze and solve mathematical problems, of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES (RELATIVE)	YES	YES	Rarely
Be able to interpret and use logarithms and powers with real exponents, and be able to apply these when solving problems.	YES	NO	YES	YES	Rarely
Be able to set up, simplify and use polynomial expressions, as well as describe and use the properties of some polynomial functions and power functions.	YES	YES	YES	YES	Rarely
Be able to set up, simplify and use rational expressions as well as polynomial equations of high powers through factorization.	YES	YES	YES	YES	Rarely
Be able to use mathematical models of different kinds, including those which build on the sum of a geometric progression	YES	NO	YES	YES (RELATIVE)	Not at all
Be familiar with how computers and graphic calculators can be used as aids, when studying mathematical models in different application areas.	NO	NO	NO	YES	Rarely
Be able to explain, illustrate and use the concept of changing coefficients and derivatives for a function, as well as use these to describe the qualities of a function and its graphs.	YES	NO	YES	YES (RELATIVE)	Rarely
Be able to identify the rules of derivation for some basic power functions, sums of functions, as well as simple exponential functions, and in connection with this describe why and how the number e is introduced.	YES	NO	YES	YES (RELATIVE)	Rarely
Be able to draw conclusions from a function's derivatives, and estimate the value of the derivative when the function is given by means of a graph.	YES	YES (RELATIVE)	YES	YES	Rarely
Be able to use the relationship between a function's graph and its derivatives in different application contexts with and without aids for drawing graphs.	YES	YES (RELATIVE)	YES	YES (RELATIVE)	Rarely
Mathematics D					
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientations with an in-depth	NO	NO	NO	NO	Rarely

knowledge of concepts and methods learned in earlier courses					
Be able to use a circle to define trigonometric concepts, show trigonometric relationships and provide complete solutions for simple trigonometric equations, as well as be able to use these for solving problems.	N0	NO	NO	NO	Not at all
Be able to draw graphs of trigonometric functions, as well as use these functions as models for real periodic processes	N0	NO	NO	NO	Not at all
Be able to derive and use formulae which are needed to transform simple trigonometric expressions, and solve trigonometric equations.	YES	YES	YES	YES	Not at all
Be able to calculate the sides and angles of a triangle.	YES	YES	YES	YES	Rarely
Be able to explain the rules of derivatives and be able to derive these for trigonometric functions, logarithmic functions, compound functions, product and quotients of functions, as well as be able to apply these rules in solving problems	N0	NO	NO	NO	Not at all
Be able to use derivatives of second order in different application contexts	N0	NO	NO	NO	Rarely
Be able to explain and use the thinking behind some of the methods for solving numerical equations, as well as when solving problems, be able to use graphical, numerical or software for processing mathematical symbols	N0	NO	NO	NO	Not at all
Be able to explain the concept of differential equations, and be able to give examples of some simple differential equations, and present problem situations where they can occur.	YES	NO	YES	YES (RELATIVE)	Not at all
Be able to determine primitive functions and use these in solving problems.	N0	NO	NO	NO	Rarely
Be able to explain the meaning of the concept of integrals, and clarify the relationship between integral and derivatives, as well as set up, interpret and use integrals in different types of basic applications.	YES	YES (RELATIVE)	YES	YES	Rarely
Be able to present the thinking behind and be able to use some methods of numerical integration, as well as when solving problems, be able to use graphical, numerical or symbol processing software to calculate integrals.	N0	NO	NO	NO	Not at all
Be able to independently analyze, implement and orally and in writing, a more comprehensive task where knowledge from different areas of mathematics is used.	YES	NO	YES	YES (RELATIVE)	Rarely

Comparative table

COUNTRY: SWEDEN	COUNTRY: BRAZIL					COUNTRY: EL SALVADOR					COUNTRY: COSTA RICA				
Skills required for students in Swedish Upper Secondary School (grades 10-12), Mathematics courses A-D	**Public Schools**		**Private Schools**		**Indsutry**	**Public Schools**		**Private Schools**		**Industry**	**Public Schools**		**Private Schools**		**Industry**
	In curriculum?	*De facto learnt?*	*In curriculum?*	*De facto learnt?*	*Demanded skills*	*In curriculum?*	*De facto learnt?*	*In curriculum?*	*De facto learnt?*	*Demandeds kills*	*In curriculum?*	*De facto learnt?*	*In curriculum?*	*De facto learnt?*	*Demandeds kills*
Mathematics A															
Be able to formulate, analyze and solve mathematical problems of importance for everyday life and the chosen study orientation	YES	PARTIALLY	YES	YES	Always	NO	NO	NO	YES	Always	PARTIALLY *	PARTIALLY *	PARTIALLY *	PARTIALLY *	
Have deepened and extended understanding of numbers to cover real numbers in different forms	YES	YES	YES	YES	Always	YES	NO	YES	YES	Always	YES	YES	YES	YES	
With and without technical aids, be able to apply with judgment knowledge of different forms of numerical calculations linked to everyday life and the chosen study orientation	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	Always	YES	NO	YES	NO	Always	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	
Have an advanced knowledge of geometric concepts, and be able to apply these to everyday situations and in different subjects of the chosen study orientation	YES	YES	YES	YES	Always	YES	NO	YES	NO	Rarely	YES	YES	YES	YES	
Be sufficient familiar with basic geometrical propositions and reasoning in order to understand and be able to use concepts and different ways of thinking in order to solve problems	YES	NO	YES	YES	Always	YES	NO	YES	YES	Rarely	YES	NO	YES	YES	
Be able to interpret, critical examine and with discrimination illustrate statistical data, as well as be able to interpret and use common co-ordinates	YES	NO	YES	YES	Always	NO	NO	YES (*)	YES (RELATIVE)	Rarely	YES	NO	YES	YES	
Be able to interpret and deal with algebraic expressions, formulae and functions required for solving problems in everyday life and in other subjects of the chosen study orientation	YES	YES	YES	YES	Always	YES	NO	YES	YES	Rarely	YES	NO	YES	YES	
Be able to set up and interpret linear equations and simple exponential equations, as well as use appropriate methods and aids to solve problems	YES	YES	YES	YES	Always	YES	YES	YES	YES	Rarely	YES	NO	YES	YES	
Be able to set up illustrate and interpret linear functions and simple exponential functions and models for real events in private finance and in society	YES	NO	YES	NO	Always	YES	NO	YES	NO (RELATIVE)	Not at al	NO	NO	YES	NO	
Be accustomed when solving problems to use computers and graphic calculators to carry out calculations and use graphs and diagrams for illustrative purposes	NO	NO	NO	NO	Always	NO	NO	NO	NO	Rarely	NO	NO	NO	NO	
Be familiar with how mathematics affects our culture in terms of, for example, architecture, music, design or the arts, as well as how mathematical models can describe processes and forms in nature	YES	NO	YES	NO	Always	N0	NO	NO	NO	Rarely	YES	NO	YES	NO	

Mathematics B															
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientation with an in-depth knowledge of concepts and methods learned in earlier courses	YES	PARTIALLY	YES	PARTIALLY	Always	**NO**	**NO**	**NO**	**NO**	Rarely	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	
Be able to explain, prove and when solving problems, use some important propositions from classical geometry	YES	**NO**	YES	**NO**	Always	YES	YES	YES	YES	**Not at al**	YES	**NO**	YES	**NO**	
Be able to calculate probabilities for simple random trials and multi-stage random trials as well as be able to estimate probabilities by studying relative frequencies	YES	PARTIALLY	YES	YES	Always	YES	YES (RELATIVE)	YES	YES	Rarely	YES	PARTIALLY	YES	YES	
Use with judgment different types of statement indicators for statistical materials, and be able to explain the difference between them, as well as be familiar with and interpret some measures of dispersion.	**NO**	**NO**	**NO**	**NO**	Always	YES	YES (RELATIVE)	YES	YES	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to plan, carry out and report a statistical study, and in this context be able to discuss different types of errors, as well as evaluate the results.	**NO**	**NO**	**NO**	**NO**	Sometimes	YES	**NO**	YES	YES (*)	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to interpret, simplify and reformulate expressions of the second degree, as well as solve quadratic equations and apply this knowledge in solving problems.	YES	YES	YES	YES	Always	YES	**NO**	YES	YES	Rarely	YES	YES	YES	YES	
Be able to work with linear equations in different forms, as well as solve linear differences and equation systems with graphic and algebraic methods	YES	**NO**	YES	YES	Always	YES	YES (RELATIVE)	YES	YES	Rarely	YES	**NO**	YES	YES	
Be able to explain the properties of a function, as well as be able to set up, interpret and use some non-linear functions as models for real process, and in connection with this be able to work both with and without computers and graphic drawing aids.	YES	PARTIALLY	YES	YES	Always	YES	**NO**	YES	**NO**	**Not at al**	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	

Mathematics C															
Be able to formulate, analyze and solve mathematical problems, of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	YES	YES	YES	Always	YES	YES (RELATIVE)	YES	YES	Rarely	YES	YES	YES	YES	
Be able to interpret and use logarithms and powers with real exponents, and be able to apply these when solving problems.	YES	YES	YES	YES	Always	YES	**NO**	YES	YES	Rarely	YES	**NO**	YES	YES	
Be able to set up, simplify and use polynomial expressions, as well as describe and use the properties of some polynomial functions and power functions.	YES	PARTIALLY	YES	PARTIALLY	Always	YES	YES	YES	YES	Rarely	YES	YES	YES	YES	
Be able to set up, simplify and use rational expressions as well as polynomial equations of high powers through factorization.	YES	PARTIALLY	YES	PARTIALLY	Always	YES	YES	YES	YES	Rarely	YES	**NO**	YES	YES	
Be able to use mathematical models of different kinds, including those which build on the sum of a geometric progression	YES	PARTIALLY	YES	PARTIALLY	Always	YES	**NO**	YES	YES (RELATIVE)	Not at al	**NO**	**NO**	**NO**	**NO**	
Be familiar with how computers and graphic calculators can be used as aids, when studying mathematical models in different application areas.	**NO**	**NO**	**NO**	**NO**	Always	**NO**	**NO**	**NO**	YES (*)	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to explain, illustrate and use the concept of changing coefficients and derivatives for a function, as well as use these to describe the qualities of a function and its graphs.	PARTIALLY	**NO**	PARTIALLY	**NO**	Always	YES	**NO**	YES	(RELAT	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to identify the rules of derivation for some basic power functions, sums of functions, as well as simple exponential functions, and in connection with this describe why and how the number e is introduced.	**NO**	**NO**	**NO**	**NO**	**Not at all**	YES	**NO**	YES	YES (RELATIVE)	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to draw conclusions from a function's derivatives, and estimate the value of the derivative when the function is given by means of a graph.	**NO**	**NO**	**NO**	**NO**	**Not at all**	YES	YES (RELATIVE)	YES	YES	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to use the relationship between a function's graph and its derivatives in different application contexts with and without aids for drawing graphs.	**NO**	**NO**	**NO**	**NO**	**Not at all**	YES	YES (RELATIVE)	YES	(RELAT	Rarely	**NO**	**NO**	**NO**	**NO**	

Mathematics D															
Be able to formulate, analyze and solve mathematical problems of importance for applications and selected study orientations with an in-depth knowledge of concepts and methods learned in earlier courses	YES	PARTIALLY	YES	PARTIALLY	Always	**NO**	**NO**	**NO**	**NO**	Rarely	PARTIALLY	PARTIALLY	PARTIALLY	PARTIALLY	
Be able to use a circle to define trigonometric concepts, show trigonometric relationships and provide complete solutions for simple trigonometric equations, as well as be able to use these for solving problems.	YES	YES	YES	YES	Always	**N0 (**)**	**NO**	**NO (**)**	**NO**	**Not at al**	YES	YES	YES	YES	
Be able to draw graphs of trigonometric functions, as well as use these functions as models for real periodic processes	YES	PARTIALLY	YES	PARTIALLY	Always	**N0 (**)**	**NO**	**NO (**)**	**NO**	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to derive and use formulae which are needed to transform simple trigonometric expressions, and solve trigonometric equations.	YES	PARTIALLY	YES	PARTIALLY	Sometimes	YES	YES	YES	YES	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to calculate the sides and angles of a triangle.	YES	YES	YES	YES	Always	YES	YES	YES	YES	Rarely	YES	YES	YES	YES	
Be able to explain the rules of derivatives and be able to derive these for trigonometric functions, logarithmic functions, compound functions, product and quotients of functions, as well as be able to apply these rules in solving problems	**NO**	**NO**	**NO**	**NO**	**Not at all**	**N0 (**)**	**NO**	**NO (**)**	**NO**	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to use derivatives of second order in different application contexts	**NO**	**NO**	**NO**	**NO**	**Not at all**	**N0 (**)**	**NO**	**NO (**)**	**NO**	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to explain and use the thinking behind some of the methods for solving numerical equations, as well as when solving problems, be able to use graphical, numerical or software for processing mathematical symbols	YES	PARTIALLY	YES	PARTIALLY	Always	**N0**	**NO**	**NO**	**NO**	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to explain the concept of differential equations, and be able to give examples of some simple differential equations, and present problem situations where they can occur.	**NO**	**NO**	**NO**	**NO**	**Not at all**	YES	**NO**	YES	YES (RELATIVE)	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to determine primitive functions and use these in solving problems.	YES	PARTIALLY	YES	YES	Always	**N0 (**)**	**NO**	**NO (**)**	**NO**	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to explain the meaning of the concept of integrals, and clarify the relationship between integral and derivatives, as well as set up, interpret and use integrals in different types of basic applications.	**NO**	**NO**	**NO**	**NO**	**Not at all**	YES	YES (RELATIVE)	YES	YES	Rarely	**NO**	**NO**	**NO**	**NO**	
Be able to present the thinking behind and be able to use some methods of numerical integration, as well as when solving problems, be able to use graphical, numerical or symbol processing software to calculate integrals.	**NO**	**NO**	**NO**	**NO**	**Not at all**	**N0 (**)**	**NO**	**NO (**)**	**NO**	**Not at al**	**NO**	**NO**	**NO**	**NO**	
Be able to independently analyze, implement and orally and in writing, a more comprehensive task where knowledge from different areas of mathematics is used.	YES	**NO**	YES	PARTIALLY	Always	YES	**NO**	YES	YES (RELATIVE)	Rarely	**NO**	**NO**	**NO**	**NO**	
						(*) curriculum adjustmen									
						(**) university level math									
						Relative: Theoretical or limited									

Short presentation of the researchers

Lars Andersson is a senior consultant of Hifab International, with extensive experience of management of international vocational education and skills development projects. He has, through his national and international work in more than 20 countries, acquired a profound knowledge of labour market analysis, curriculum development and skills and knowledge transfer. At a national level Mr Andersson has been involved in the development of new competence-based training curricula both for youth and adults. On the international arena he has worked for the ILO with the development of their structure for Modular Curricula known as MES (Modular of Employable Skills). His experience furthermore includes dialogue with the social partners as well as in the development of equipment specifications, workshop layouts and learning material development etc. At a national and community level Mr Andersson has developed and managed measures for school-leavers and pupils with social handicaps. In addition Mr Andersson has a thorough experience of quality issues, including quality assurance systems for projects and education processes.

Monika Aring is a senior policy analyst in workforce development for RTI International. She has worked in more than 32 countries, benchmarking and documenting how countries develop successful public policies to grow a skilled workforce. She led studies that assess the capacity of postsecondary institutions to support high growth cluster development in emerging fields such as bio and nano-technology, advanced manufacturing, financial services, tourism, logistics, and arts and design. She has designed and led research teams to conduct studies in international best practices in learning in high-performing organizations such as Motorola, Boeing, Ford, and Siemens. She has worked with municipalities, states and governments on designing and developing programs and policies that lead to better jobs and skills in high growth industry sectors. She has convened and facilitated country-wide forums that bring together stakeholder/leaders to unleash new public and private partnerships in economic and skill development. She is listed in Who's Who of International Women and speaks five languages. Her work has been published internationally and featured in the International Herald Tribune, National Public Radio, Fortune Magazine, New York and Los Angeles Times, and a variety of technical publications.

Carlos Baradello, (native Spanish speaker) project consultant, left his position as Corporate Vice President and General Manager for Motorola Latin America's new businesses to return to academia two years ago in order to advance progress in his area of interest: ICT (Information and Communication Technologies), emerging/disruptive technologies, and new venture formation and entrepreneurship for the economic, social and business development. He takes a special interest in going beyond the traditional established markets (North America, Europe, etc) and looking how emerging technologies could benefit the development of emerging markets and the potential social benefits of the world least privileged. He is a recognized opinion leader in the San Francisco Bay Area on the US Hispanic Market and the economic integration of the Americas. He leads the Hispanic Entrepreneurship center and teaches at the Graduate School of Business and Management of the University of San Francisco. He is currently working with RTI International and Monika Aring on a Bottom of the Pyramid new product development initiative in Mexico.

Dr Karin Breitman is currently a member of the board of the Brazilian Computing Society, Dr. Karin Breitman received her DSc. in Informatics from the Departamento de Informática da PUC-Rio, where she is currently a faculty member and continues to work in her research. She received her MSc in System Engineering from COPPE-UFRJ and was awarded a grant for her DSc at the Technion, Israel in 1995. She was awarded federal grants for her MSc (CNPq), DSc (Capes), a post doc CNPq grant, and currently holds one of the six national ProDoc-Capes grants in Computer Science. She participated in the European Esprit Project Network of excellence 20800-RENOIR and participates in the Software Engineering for Multi Agent Software Systems Project (CNPq). Dr. Breitman has just received a Faculty Award from IBM Corporation to further her research on Autonomic Computing. Her book "*Web Semântica: O Futuro da Internet*" (in Portuguese) was published in 2005. She belongs to ACM (Association for Computing Machinery), IEEE (Institute of Electrical and Electronic Engineers) and the Brazilian Computing Society (SBC), where she currently serves in the Board of Directors as the Special Interest Group and Events Director. In 2005 she was part of the Program Committees for the NASA IEEE Software Engineering Week, Simpósio Brasileiro de Engenharia de Sofware, Workshop em Informática Médica, Workshop de Manutenção de Software Moderna and of the Simpósio Brasileiro de Qualidade de Software. She is the chair of Jornada de Atualização em Informática (JAI 2006), part of the steering comitteee for the IBM – SBC Latin American Autonomic Computing Conference presides the one for the Congresso da Sociedade Brasileira de Computação. Together with prof. Dr. Ricardo Anido (UNICAMP) they are the editors of the "*Atualizações em Informática*" book to come out in July by Editora PUC-Rio. She was recently awarded a personal research grant from the CNPq CT-INFO, to fund outstanding researchers in Software Engineering. Dr. Breitman is currently working on the " *Semantic Web: Concepts, Technologies and Applications* " book (*ISBN 1-84628-581-X*) to be published by Springer Verlag London as an addition to the the *NASA Systems and Software Engineering Book Series,* late 2006.

Michelle Coffey is an independent consultant with extensive experience in institutional assessment of several Investment Promotion Programs worldwide. She has an extensive experience working with donor agencies on program design, implementation and evaluation as well as general promotional strategies and specific subsector strategies for proactive promotion, data base design and personnel training for several countries. Her professional work has given her a profound knowledge of the situation in the field of education, training and workforce development in Costa Rica. She is currently subdirector of a regional multinational pharmaceutical association.

Dr Sulamis Dain got her PhD in Economics at the State University of Camoinas, Sao Paolo, Brazil, in 1980. In addition to this she has undergone post doctoral studies at Berkely University.. She is currently – since 2000 - Full Professor at the Institute of

Public Health , State University of Rio de Janeiro. Her previous professional record includes Full Professor, Economics (Federal University of Rio de Janeiro, Brazil (up to 1993); and Adviser to the Government Leader at the Senate House on Tax and Social Security Reform and Social Policies. Dr Dain currently give lectures both at undergraduate and graduate level (Federal University of Rio, State University of São Paulo and presently Sate University of Rio de Janeiro)), as well as in special courses for high level public managers and Scholars (School of Government, Federal University of Rio, National Development Bank, and many other). She currently carries a Special Grant from the State Government of Rio de Janeiro 2002 onwards, and a Special Grant (top ranking) from the National Research Council related to writing a book on Public Sector Economics (aiming to combine analytical background and practical experience. Dr Dain has been awarded the Inconfidencia Medal, given by Minas Gerais State Government for relevant action concerning University Education Policies. Her research on public policy integrates knowledge of financing aspects of fiscal policies and social policies. Apart from academic oriented research, she has worked as a consultant in projects for ECCLAC, World Bank, OPAS, UNCTAD, European Union and UNESCO, and in Brazil for the Ministry of Planning, Ministry of Social Security, Foreign Affairs, Ministry of Health, Ministry of Labor, Public Sector Institute of São Paulo, Brazilian Institute for Municipal Administration, Ministry of Industry, Science and Technology, Brazilian Congress and private sector.

Carlos Raúl Gutiérrez has a strong academic background in public finance and environmental externalities, i.e. the private production impacts on society and ecosystems. He is also a well-known specialist in strategic issues relating to public-private interface in multicultural situations. At present he is an economist-consultant to the Center for Tropical Studies (CATIE)-CIFOR project on Tropical Forest and Adaptation to Climate Change. Project draws on private sector capital and management capability to deliver public services.
Among his previous assignments can be mentioned design of an Environmental Management System. Monte del Barco (concessionary of the Papagayo Development Pole: review of concession contracts and environmental permits and land facilitating and planning process for Monte del Barco; implementation of emission reducing integrated solid waste management system for five-star hotel and real estate development in Península Papagayo, Costa Rica; Sales Manager to US and Caribbean; maritime logistics with operation of three export terminals, business development (including projects for quarry and maritime terminal operations) in Venezuela and the Caribbean. Bid

Dr Per Lundequist carries a Ph D in economic geography from the Department of Social and Economic Geography, Uppsala University. His research has particularly focused on industrial restructuring, clusters dynamics and public program and performance measurement. Dr. Lundequist is partners and senior consultant at Intersecta AB (www.intersecta.se) and is associated researcher at the"Centre for Research on Innovation and Industrial Dynamics" (www.cind.uu.se), Uppsala University. In the framework of Intersecta Dr Lundequist works with action-oriented strategic research on regional development, industrial clusters, SME competitiveness, and public program evaluation and performance measurement. The assignments are often performed in close co-operation with Uppsala University.

Bertil Oskarsson, is Managing Director of Hifab International, and senior consultant in the field of education, skills development and HRD. For the last 15 years he has been working with competency development issues at policy level and concrete in training institutions and companies in more than 25 countries. In Turkey, Mr. Oskarsson has responsible for the commitment and disbursement of a 36 MUSD Grant Scheme, the objective of which was to provide grants to enterprises, NGOs and other organizations with innovative approaches in skills and competence development. Mr. Oskarsson was evaluator and co-author of a country monograph for Latvia on Employment and Lifelong learning development, and was responsible for monitoring of the Latvian-EU Joint Assessment Paper on how Latvia adjusted its HRD policy to the overall objectives within EU. Other relevant assignments include overall responsibility for a national group for development of strategies for utilising EU ESF Objective 1-3 co-financing for competency development in enterprises in Sweden; participation in national strategy group for the participation in the Leonardo programme, active participation in development of Advanced Vocational Education programme, with a requirement of co-operation vocational training institutions – enterprises – higher education institutions with at least 33% work-based training; participation in drawing up national strategy and national comments to EU memorandum on Lifelong Learning for Sweden. Mr. Oskarsson has long experience of managing international cooperation projects, financed by different donors (including IADB, WB, ADB, EU, Council of Europe, Swedish Sida, and UNDP).

Oscar Picardo Joao, born in Montevideo, Uruguay. In 1998 he graduated Master in Education, at University of Louisville; during the year 2000 obtained postgraduate degree of Distance Education and Digital Net at Universidad de Murcia, Spain, and in Educational Finance at Harvard; and is at present finalising his PhD at Universitat Oberta de Catalunya in “Informational and Knowledge Society”.He is a researcher in the social field, with emphasis on design, application, and evaluation of educational policies in Central America; he is a columnist on major central American newspapers, among these La Prensa Gráfica, and in 1999 was finalist in the Essay Contest on Freedom of Speech, held by the Panamerican Press Society (SIP); is professor *ad honorem* at the State University of El Salvador in diverse educational fields, and guest professor at two Mexican universities. He has worked as an evaluator of the Quality Improvement System of Superior Education, and was nominated in 2004 as “Distinguished Evaluator” by the Minister of Education. During 1999 and 2000 he was the Program Coordinator to the Regional Office for Central America and Panama of the Pan-American Organization for Education, Science, and Culture (OEI); he was the Director of Educational Investigation at Universidad de El Salvador; professor of Masters in Didactics; National Coordinator of Academic and Pedagogical Competences Evaluation (ECAP); Academic Director and Research at Universidad Francisco Gavidia. Actually the Academic Advisor at Colegio García Flamenco, Advisor in Superior Education of the Ministry of Education and Coordinator of Scientific Instruction at Universidad Dr. “José Matías Delgado”.