Computing in Cochabamba Bolivia : a qualitative survey to promote a view of computing of computing personnel, policymakers and managers in Cochabamba/Bolivia

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COMPUTING IN COCHABAMBA BOLIVIA:

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PREFACE

This thesis is about computing in the district Cochabamba, Bolivia. This research has been done on request of the computing department at the Universidad Mayor de San Simon (UMSS) in Cochabamba, Bolivia. The department was founded 15 years ago. At the moment there are three fulltime and fourteen part-time teachers working in the department. The entire capacity is used to educate the 1200 Licenciatura students (bachelors). A support for Master students, Phd students and research is beyond the existing capacity. Due to a less adequate organisation and the fact that computing students could get jobs before graduating, there have only been six students who obtained their Licenciatura-title.

At the moment there is a co-operation between UMSS and the University of Utrecht, the Netherlands, called MEMI, proyecto para Mejorar Enseñanza en Matemáticas y Informática. MEMI is financed by the NUFFIC. One of the goals is to improve the education in the computing department. This research can be used to support this goal.

This report is written as thesis for a Masters study "Technology and Society" at the University of Eindhoven, the Netherlands.
The study is focusing on the coherence between technology and social sciences. "Technology and Development Sciences" is a specific course in this M.Sc. program. This course aims at training engineers for a professional career related to the international development problems. Engineers of this kind could contribute to the improvement of the technological capability, as well as to the establishment of a well-balanced process of technology transfering industry, non-profit organisations and governmental institutes. In the course technical and social-economic subjects are taught in a ratio of one to one. Some of the social-economic subjects included are: transfer of technology, technology assessment, research methodologies for developing countries, statistics, international law and macro-economy.

I want to thank my supervisors, Jack Gerrissen for his enlighting ideas and Paul Lapperre, who also worked very hard to finish this thesis in time.

ENGLISH ABSTRACT

This thesis is about computing in the district Cochabamba, Bolivia. The three actors in the field of computing are the government, enterprises and educational institutions. The enterprises can be consumers or producers of IT products (Information Technology). Investigated are the computing related government policy, IT consumption of enterprises, the situation of IT-production and the education in computing. These items are related to the status and policies in other developing countries. The educational situation in Cochabamba is compared with one of a developed country, the Netherlands. The various ideas which exist about computing education are presented. Using this information the role of education in Cochabamba is looked into.

Finally ideas are presented about a strategy, which Bolivia can use to enhance the development of IT.

The relevance of this thesis is to contribute to the development of view w.r.t. computing science of the people working in this area, managers and policy makers in the district Cochabamba, but also more general, in Bolivia.

Conclusions

There are no computing organisations (of software houses, educational computing institutions, hardware dealers, educational computing institutes, etc.) which try to develop a view of computing which the government can use in making policy.

Government

Government policy is lacking.

Enterprises

The computing situation in Cochabamba is the same as in many other developing countries: low level use, no hardware production, small tailor made software production and much piracy.

Educational institutions

There is a lack of computing personnel in education as well as in enterprises. The main reasons for this are:

* There is no defined educational hierarchy with its supervised levels.
* The teachers are mediocre. This is caused by mediocre education.
* Memorising is important in Bolivian education at all levels. Due to this, people have no view of computing and do not learn to use new knowledge.

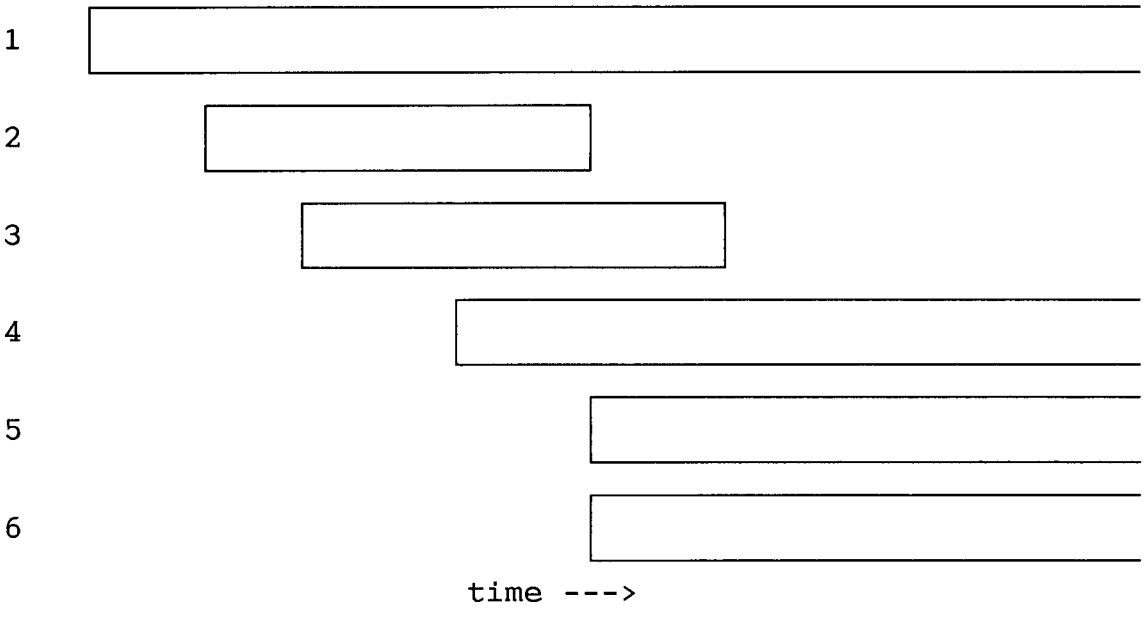
The goal in the presented strategy, is to stimulate the use and the production of software. Changing the Bolivian education from "memorising" to " basic understanding" is suggested but outside the scope of this strategy. View of computing is needed and one has to stimulate this development of view within the strategy. The proposed strategy consists out 6 tracks:

track 1. Initiating computing organisations.
track 2. Organising the computing education.
track 3. Updating and upgrading the current computing experts and train new ones.
track 4. Establish partnerships between educational institutions and enterprises.
track 5. Establish a Master program.
track 6. Initiating research in computing.

Computing organisations can give advise on the implementation of the tracks and help in the implementation. Track 2 and 3 can be started after the creation of at least a few organisations. One can organise education but without computing experts to fulfill new demand from education it does not mean much. On the other hand it is good for the educational institutions to know the future rules for them, so that they can anticipate in training personnel. For the establishment of partnerships in track

4, companies will have to have some faith already in educational institutions. That is why track 2 and 3 precede track 4. On the other hand educational institutes have to start as soon as possible with these partnerships to earn money and further improve their situation.

The planning in time for the defined six activities is given in the next diagram:



SPANISH ABSTRACT

Esta tesis es sobre informática en el distrito de Cochabamba, Bolivia. Las tres unidades básicas en el área informática son: el gobierno, las empresas y las instituciones de enseñanza. Estas empresas pueden ser consumidoras ó productoras de productos IT (productos de Tecnología de Información). Lo investigado son s cosas: primero la gestión del gobierno en el área de informática, secundo la consumición de empresas y tercero la situación de producción de IT.

Esta información esta comparada con el status y gestión de otros países en dessarollo. La situación de enseñanza en Cochabamba está comparada con la de un país desarrollado (Los Paises Bajos). Las ideas que hay en el área de educación de informática están presentadas. Usando esta información, hemos evaluado la educación en Cochabamba. Finalmente esta presentada una estrategia que podemos usar para estimular la informática en Bolivia.

Este tesis es relevante para contribuir al desarrollo de la visión en la informática de : primero la gente que trabaja en este área, segundo politicos y tercero personal de gestión en el distrito Cochabamba, y en general en Bolivia.

Conclusiones

No hay organizaciones de informática. (de casas de software, de instituciones de enseñanza, vendedores de hardware, etc) Ellas podrían desarrollar una visión de informática que el gobierno podría usar para hacer gestión.

Gobierno

No hay gestión de gobierno en el área de informática.

Empresas

La sitituación en informática está más ó menos lo mismo que en otros países en desarrollo: el uso es de un nivel bajo, no hay producción de hardware, los programas de sofwtare son pequeños y hay muchos "piratos" de software.

Institutos de enseñanza

No hay suficientes empleados en el área de informática, en educación, pero tampoco en impresas. La razones principales para esta situación son:

* No hay una jerarquía determinada por niveles con supervisión.
* Los docentes no están bien preparados porque hay una educación insuficiente.
* En la educación de Bolivia, en todos los niveles, la memoria es muy importante. Resultado es que la gente no tiene visión, y no aprende a usar logica.

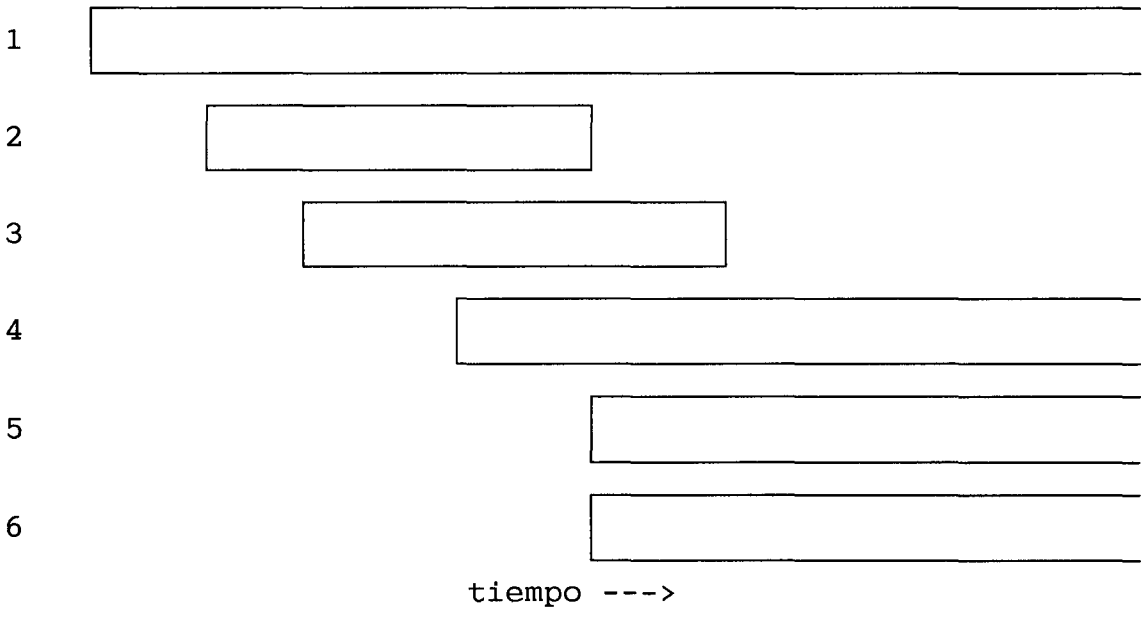
El objetivo de hacer una estrategia, es estimular el uso y la producción de software.
Cambios en la educación, desde "rememorar" hasta "una noción basica" es recomendado, pero no está incluido en nuestra estrategia.
Para alcanzar el objetivo, visión es necessario y tenemos que estimularla en la educación. La estrategia tiene 6 vías:

vía 1. Iniciar organizaciones de informática.
vía 2. Organizar la enseñanza de la informática.
vía 3. Formación adicional para los docentes y otro personal de informática, y capacitar nuevo personal.
vía 4. Establecer cooperación entre instituciones de enseñanza y empresas.
vía 5. Establecer una educación de Maestría.
vía 6. Iniciar investigación de la informática.

Organizaciones de informática puede aconsejar en la implementación de las vías y ayudar en su

desarrollo. Vía 2 y 3 pueden empezar después la creación de algunas organizaciones de informática. Se puede organizar la educación pero sin buenos profesores esta organisación no significa nada. Al otro lado, las instituciones educativas ya saben las reglas del futuro y pueden anticiparse: preparar personal.
Para establecer cooperaciones en vía 4, las empresas ya tienen que tener alguna confianza en las instituciones educativas. Por eso vía 2 y 3 preceden a la vía 4. Al otro lado las instituciones educativas tienen que empezar lo mas pronto posible con estas cooperaciones para ganar dinero y mejorar la situación.

El espacio de tiempo de estas 6 vías está dibujado en el siguiente diagrama:



CONTENTS

1 INTRODUCTION

1.1 CONCEPTS

The most important concepts are stated in this paragraph.
A complete list can be found in appendix 8.

Computing, information technology (IT) is the design, implementation and maintenance of a computer-supported information system. Included is production automatisation and administrative automatisation.
By administrative automatisation is meant office-automatisation, management information systems, networking and more specific applications, for example in education, transport and product-design.

One can use computers in all types of enterprises and organisations: financing, insurance, real estate and business services, health care, education, libraries, research, public services, cultural services, transport, communication, construction industrial production, mining, etc.

The *IT producers* include hardware producers (producers of computer components and related equipment like e.g. printers and modems), software houses, hardware shops and computer service agencies. Computing education will not be included.

Computing personnel, computing experts are the people working on all levels in computing. This can be in the IT producers, enterprises which use computers, research, education, policy making etc. Someone who enters data in the computer has nothing to do with the design, implementation or maintenance of a computer supported information system and therefore is not a computing expert. In Bolivia, however, one does include this type of personnel in the definition. Therefore at some points they will be included, but it will be mentioned explicitly.

High level computing personnel in Bolivia stands for personnel, often with a university degree, working on a higher level than a programmer of simple office automatisation. Included are system analysts, computing division manager, policy makers etc. A problem with the use of this concept is that most computing experts do all types of work within companies and there is not a real job distinction in Bolivia like in The Netherlands.

People having a *view* w.r.t. computing are people who have developed opinions about computing related issues like e.g., the possibilities of computing for a company, the possibilities of computing for a specific country, what computing education should look like and how a government can stimulate computing. People having a view w.r.t. computing do not have to be computing experts.

Information management, information policy is a policy directed at obtaining, storing and distributing information in a certain area. The storing and distribution can be done with the help of computers.

1.2 PROBLEM DEFINITION

There were indications that there was a discrepancy between the supply and demand of computing personnel. Information from the field revealed that the people graduated from the university (Licenciados and Ingenieros) spend most of their time doing low level jobs.

The original research-proposal therefore was to investigate this discrepancy between the supply side (educational institutions) and the demand side (enterprises) with respect to computing personnel.
What organisational variables were to influence this demand? For example variables like firm size, de-

gree of centralisation, available resources (both human and financial), structure of the information system function, competency of system development personnel and user sophistication [1].
The relevance of the research was that it could be used in the educational planning.

Soon after the start of the investigation however, it was discovered that this discrepancy is not only caused by a lack of lower level computing personnel but also by the fact that there is no demand for high level products.

Like a vicious circle, the high level personnel is occupied by low level jobs and does not have time to stimulate a demand for more advanced products.

Another more important reason is the lack of knowledge and view of computing personnel and policy makers.

Therefore high level computing personnel is not pushed to put efforts in developing high level applications: in order to break the vicious circle they will need to find time to think and to read about possibilities for new applications in their fields of work.

During the interviews in the orientation phase of the research it was noticed that most of the computing experts had no idea what failed in the educational system and what it could look like. They had never come in contact with different ideas about computing science education and had no opinions on how Bolivia could come to development in computing. A clear computing policy is therefore lacking in Bolivia, one does not see the importance. Further, most of them did not know what more is possible with computers, because information about more advanced applications is lacking. They were often not conscious that they were behind in the area of computing.

The managers within companies have little knowledge in the area of computing, so there is no demand for more advanced computing products from that angle and the computing expert often decides what they can do with computers. Since the majority of the computing experts only have little knowledge, these are low level applications of computers. So there is not an actual demand for computing science personnel at a certain level, because there is no demand for products The personnel determines the work in this area. It is not said that all managers should have an education in computing, but they should know something and should get informed by their computing staff (see also chapter 6, Opinions about Computing Education). The same is true for all-round policy makers.

About the only type of automatisation known in Cochabamba is simple tailor made office automatisation and a very premature sort of management information systems.

Because of the fact that estimating the demand (where there *is* no demand at all) was not really interesting, it was decided to abandon the first research proposal. Instead of the old problem that high level computing experts are doing low level jobs, the new more basic, underlying problem became the lack of view.

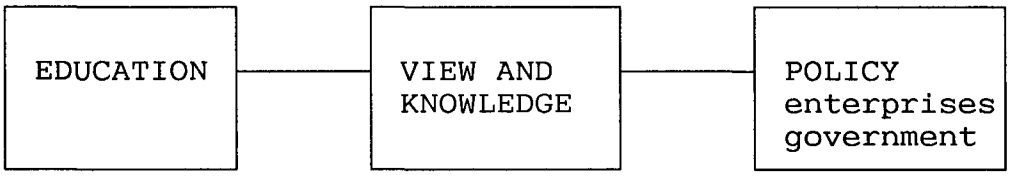


figure 1 the main-cause and -result of view

In figure 1 one can see the general picture that education is the main determinant of view and knowledge. The policy of enterprises and government is determined by this view and knowledge. More specific, the educational system in Bolivia does not seem to contribute to the development of view of computing. This lack of view leads to the absence of policy or to wrong policy. The consequence is that

companies have no policy on computing personnel and investigating possibilities of new applications is not promoted. Therefore there is no demand for more advanced products which is the main reason why high level personnel is doing low level jobs.

1.3 AIM OF THE RESEARCH

Because lack of view of computing is one of the big problems in computing in Bolivia, it was decided to make the aim of the research: making a contribution to the development of view. View of managers, policy makers and people working in the area of computing in Cochabamba. In this way it is possible to contribute to policy making in computing and to the stimulation of the demand for advanced computing products. We want to stimulate computing by improving view.

Changing the aim implied the necessity of switching to a more qualitative research.

1.4 RESEARCH QUESTIONS

Since the aim is to make a contribution to the development of a view, the question is:
"What contribution can be made to improve the view with respect to computing in Bolivia?"

Therefore the sub-questions investigated are:

1) What is the computing situation in other countries w.r.t. government policy, education and situation in enterprises? The situation in developing countries in general, in countries in the same region as Bolivia and in developed countries?

2) What is the computing situation in Cochabamba w.r.t. government policy, education and situation in enterprises?

3) How does the situation in Cochabamba compare with the situation in other countries w.r.t. government policy, education and situation in enterprises?

4) What is the general role of education w.r.t. computing?

5) What is the role of education w.r.t. computing in Cochabamba?

6) What strategy can be used to enhance the view w.r.t. computing in Cochabamba, Bolivia?

1.5 STRUCTURE OF THE RESEARCH

After some exposure to the field situation, on basis of discussions with a variety of people and direct observations, I came to the conclusion that a basic lack of view with respect to IT is at the bottom of the IT problems of Bolivia in general and Cochabamba in particular.

The three major influences in IT are the government, educational institutions and enterprises. These enterprises can be IT consumers or IT producers. These are the actors, which are used to describe and analyse the computing situation.

In order to identify IT problems, or in other words to analyse the computing situation, the situation in a number of selected countries was compared with the situation in an "ideal typical" IT environment: The Netherlands, with a particular focus on one of the actors: education.

From this comparison it became clear that the major IT problemes of developing countries, compared with the "ideal typical" focus on:
* Lack of government policy
* Low level use, no hardware production, small tailor made software production and much piracy.

* Lack of computing personnel

The situation in Bolivia in general and Cochabamba in particular, in major aspects, appeared to be similar with the situation in other developing countries. Major exceptions are India, Brazil and Chile.

Although quite a number concrete steps could be envisaged to ameliorate the situation, these steps will almost be impossible to take without a wide spread view with respect to IT.

Taking in regard all this, basic lack of view with respect to IT/computing is defined as follows: people having a view w.r.t. computing are people who have developed opinions about computing related issues like e.g., the possibilities of computing for a company, the possibilities of computing for a specific country, what computing education should look like and how a government can stimulate computing. People having a view w.r.t. computing do not have to be computing experts.

Through a number of interviews with representatives of the various actors, information was gathered w.r.t., among others, view of IT. The total numbers of interviews:

government:	3
educational institutions:	6
IT consumers:	12
IT producers:	7

For reasons of expediency an open type of interview was choosen.

The interviewed persons confirmed lack of view. This lack of view is indicated by
* lack of opinion about government computing policy
* lack of opinion about computing education
* lack of computing knowledge and thoughts about the possibilities of computers.
* lack of interest in this research

There is no theoretical framework for "lack of vision". Making this would be the work of psychologists and sociologists.

Next suggestions were made with respects to strategies which can ameliorate the lack of view and stimulate computing.

1.6 METHODOLOGY FOLLOWED

Information on the first research question, the situation in other countries, was collected by a literature study. The Netherlands was chosen as an example of a developed country.

For the second research question, what is the computing situation in Cochabamba, information was collected by open interviews and a literature study. The people interviewed were persons in key-positions who could contribute to the information already gathered. Among the people interviewed were people working in educational computing institutions (*institutos* and universities), government policy makers, computing personnel working in state-owned and private companies (small and large), experts working in hard- and software houses. In practice it appeared to be impossible to make a random selection within the three actor groups. As usual in developing countries, for interviews are almost entirely dependent on being referred from one contact to the other. It is my strong feeling that within the interviewed groups there has been no, or little, bias.

Also literature was collected about educational programs, obtained during visits to the educational institutions, and policy plans.

To compare the situation in Cochabamba with the situation in other countries, the role of the various actors was compared and analysed on basis of literature and interview information.

Information about the role of education w.r.t. computing, in the fourth research question, was collected by a literature study.

For the fifth research question on the role of education with respect to computing in Cochabamba we related the issues in the role of education w.r.t. computing, see the previous question, to the local situation.

The strategy for Bolivia is based upon information gathered for the previous questions and conclusions already made.

2 COMPUTING SITUATION IN SELECTED COUNTRIES

2.1 SITUATION IN DEVELOPING COUNTRIES

2.1.1 General

In this paragraph the situation in developing countries is described per actor, the actors being the government, educational institutions and enterprises. These enterprises can be consumers of IT products or part of the IT producers. There are also non-typical developing countries like India adn Brasil.

About the only kind of automatisation which is known in developing countries is simple office automatisation. Large-scale database management systems, fourth generation languages, distributed data processing systems, production automatisation and system development productivity tools are unavailable to most organisations.

So in most developing countries the computer is basically used for data processing applications like payroll, invoicing, stores, accounting, etc. [2]. The main reasons for this low level use are the shortage of skilled and experienced computing personnel, and the fact that the user environment has not been demanding. There is no demand because most functional managers are not knowledgeable about the potentials of computers [2]. The managers are not informed properly by the computing experts.

Governments in these countries usually have no explicit policy in the computing field. It already starts with the fact that a lot of countries do not see information management as an instrument to come to development. Paragraph 2.1.2 is about government policy. In 2.1.2.1 information policy is discussed and 2.1.2.2 is about policy in computing.

2.1.2 Government

2.1.2.1 Information policy

In many third world countries there is a general lack of attention and support to the establishment and maintenance of adequate national information systems and services, with or without help of computers. These countries, having other concerns, do not give information the priority it deserves. The availability and use of information has a potentially tremendous value when applied towards a particular need or task, specially with respect to meeting development objectives. Information could play a vital role in assisting the advancement of economic growth in developing countries [3].

There is a need to convince developing countries that investment in management of information is an integral part of the development process. The effective use of relevant information and the development of ideas and attitudes, over a long term, shape the development of a society. Furthermore, information that is essential for decision-making and problem-solving can be used, to increase economic productivity, to develop more efficient and cohesive domestic economies and to establish important human and economic connections with the rest of the world [3]. With the use of IT one can obtain more information and quicker. In economies, where new ideas are created at high speed, the time to bring these to the market is minimal, the time needed to take decisions is less than in slow ones, and they generate wealth and power faster than slow ones do. The quicker and the more information one can obtain, the more right decisions can be taken [4].
One of the first problems in making policy in this area is to determine what information is needed most [4].

2.1.2.2 Computing policy

Often people from non-technological societies are only interested in how they can use this wonderful product. They do not look at processes which yielded the solution and at the basis upon which such a technology was developed. When they have not transferred the way to find solutions to new problems, each time they have a new problem, they need to find a problem solver. In the absence of looking at the processes, no real transfer of technology takes place [5].

What choices do developing countries have? Either the developing countries adapt and use the knowledge to enhance their drive for social-economic development, or they fall back even further [5].

As long as the technology is foreign and elitist, it will be perceived as another dimension of dependency and another mechanism for manipulation and widening the gap between rich and poor. Once the technology is understood by some and used by many, it becomes domesticated, familiar, non-threatening, and therefore capable of being harnessed to meet one's own needs. Innovative applications may be pursued w.r.t. local problems in neglected areas such as agriculture, education, energy and health care (affecting the large majority of the rural and poor citizens) rather than relying solely on the urban, industrial uses that are already well known from the experience of the developed world. One has to find out if current design criteria adequately meet the needs of the developing country application [5].

Baeza-Yates, and others, think that the government should be active in this area because IT is not as any other product [6]. Because:

* It needs "brain ware"
* It can be easily reproduced and needs special legal protection
* It is easy to smuggle software from one country to another without paying tax
* It requires special maintenance and continuous updates

As already said, computing technology is not at the moment the most important problem facing any particular country [5].
It is said that many countries, because they think computing technology is not important, are not likely to be involved in the development or creation of the hardware and/or software of information systems [7]. Efforts of these nations must therefore be directed towards investigating methods and ways for the best utilization and possible adaption of the existing information systems/technologies. This in order to use the available information technology in the best way.

But there is also a group who thinks it is very important to adopt the technology as a tool for solving the countries major problems. First because information in general is very important. In this respect, computing and information technology ought to be treated like any other instrument of policy to achieve national goals [5]. Secondly, because the computer can be used for specific (innovative) applications to local problems.

The use of computers within a developing country might suggest dependence on software and peripherals manufactured in developing nations, but conversely it would decrease the reliance on the industrialised countries for information and data-processing services [5].

Studies indicate that information systems in developing countries at the moment usually thrive when assisted with external aid. Once the aid ceases, the information systems tend to function at a lower level of productivity or become inactive [3].

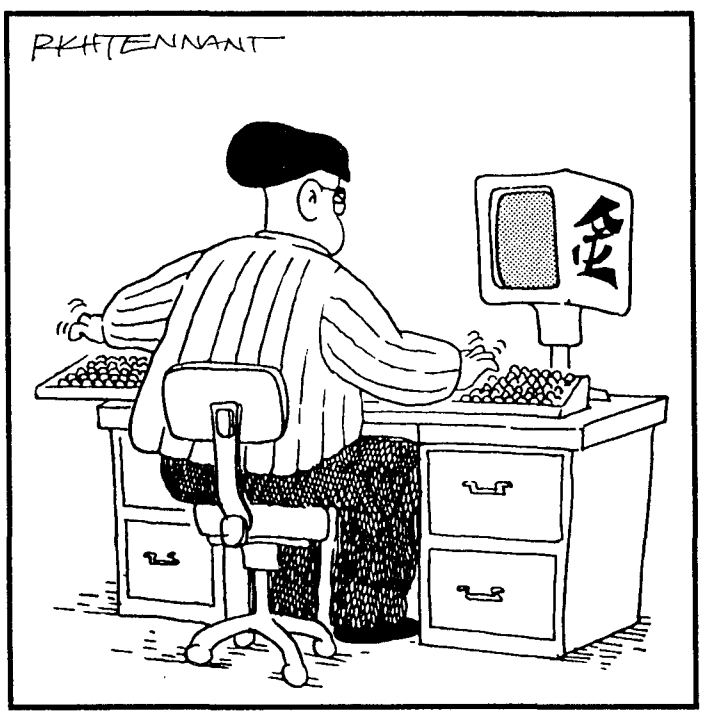
Developing countries need to commit a critical mass of human and capital resources to the development of the computing in the near future, in order to exploit the benefits of the technology [5].

A guiding framework from the government within the public and private sector institutions in the computing field will stimulate development and fruitful interaction without unnecessary duplication, wastage or scarce resources, and policy conflicts.

What policy can the government adopt to stimulate the development in the area of computing?

To formulate effective strategies for development in computing, a country requires a good understanding of its special macro/external environment [1]. A preliminary assessment of the present state of computing development in given country has to be made before one can decide on a feasible and desirable future scenario or evolutionary path for computerization [5]. Munasinghe presented a method to estimate the demand for computing products (as a function of the price of computing products, national income or level of economic activity, etc.)[5]. Based on this information one could decide on a scenario.
Simply borrowing or transplanting from developed countries development experiences and technology without a precise understanding of environmental differences is insufficient.
Lu and Farrell give 6 relevant macro environmental differences between developing and developed countries: [1]

A) Economic and social conditions
   An example of how economic conditions can influence the use of computing is that in most less developed countries the wages are a lot lower. In contrast, the computing equipment and supplies are often much higher in price, among others due to import tariffs. It is therefore, much more difficult to justify costs of automatisation based on improving operational efficiency by displacing labour costs [8]. A social condition is that many companies are small and family-owned, and therefore more informal and people-orientated. Much secrecy is associated with their business operations, policies and operating procedures lack formal structure, therefore the growth in the use of computing will be slow.
B) National infrastructure
   Paragraph 2.1.3.2 "IT consumers", will deal with infrastructure (among these are telecommunication networks, electronic power supply).
C) Educational conditions
   See paragraph 2.1.4, "Education" and chapter 5, "Role of education in computing.



D) Political and legal conditions
See this paragraph with its references.
E) Cultural conditions
Cultural aspects can be, the language (and its characters) and the greater tolerance to errors. These aspects have their influence via the other issues.
F) Management aspects
They are discussed in section 2.1.3.2 "IT consumers".

One of the most important things to come to a policy is to start a discussion about what a country should do in the field of computing. A discussion on which a government policy can be based. One of the ways to do this is by initiating committees in the area of computing science. While it is true that few countries have Central Computer Utilisation Committees, the focus of such committees is usually narrow and their powers are too feeble, to be effective in the area of policy formulation [9].

These computing committees can be related to the universities and international computing science organisations (like ACM and IEEE) A computing organisation can for example:

* State what different types of computing jobs, specialists at a particular level, should be able to do [10].

* Establish codes for behaviour for computing specialists [10].

* Make lists of the possible jobs for computing specialists [10].

* Maintain the standards of computing education among the private and public organisations [5]. A reduced number of standardised degrees and titles offer employers a clear guideline of the type of graduates they hire. It is also advantageous to high school students who can easily know in advance the effort required to graduate and the professional market they intend to enter.

* Provide a regular forum for exchanging ideas (conferences, workshops)[5]. Also interchange of information regarding available hardware and software resources should be promoted [5].

* Help to ensure the integrity and the security of data in computers and to prevent abuse of privacy [5].

* Function as a jury in computing related conflicts, for example problems between software house and customer.

* Give advise in computer software and hardware.

Government support of computing education will stimulate the use of IT products and the IT industry. The government can promote the use of IT products, which will also stimulate the IT industry. Some countries are more directed to setting up their own industry, like India, and others to stimulating a good use of the technology.

In paragraph 2.1.4, on education, some suggestions are given to how the government can support computing education. 2.1.3.1 is about how to support the IT producers and in 2.1.3.2 how to stimulate the IT demand.
Government imposed regulations that would restrict or delay purchasing of computers and related items should be minimised [5].

Collaborating in these areas with other countries can have many advantages. At the international conference of the Third World Academy of Sciences (TWAS) in Trieste, July 1985, the discussions led to the conclusion that developing countries should move quickly to formulate and apply computing development policies. A proposal was approved to pursue the setting up of a new International Centre for Computers and Informatics (ICCI),which could play a crucial role in the development process. This

because developing countries have a lot in common and ICCI could mediate fruitful exchanges of ideas and information among these nations. Secondly, there are several initiatives and projects that individual developing countries may not be able to undertake on their own which could be done collectively through ICCI. The centre could also have a role as an intermediate between south and north. Although there are a number of other international and regional organisations, they do not appear to cater adequately to all the needs of the developing countries.
ICCI might provide the framework and the driving force for Third World computer development and application efforts in the following priority areas:

* Policy analysis, formulation and implementation. Comparative studies among countries, country level studies and detailed studies of applications in specific sectors.

* Education and training

* Software development: in areas interesting for developing countries.

* Hardware and micro-electronics development.

* Dissemination of information, produce its own publications and reports, organize and participate in meetings. One major objective would be to facilitate and encourage the work of the relatively isolated researchers in developing countries.

Also in paragraph 2.1.4 the advantages of foreign co-operation in the educational field will be discussed.

bird's-eye view of situation and possible remedies
Most governments in developing countries have no information policy.
This is one of the reasons why there is no computing policy neither. The first action to be taken is to start a discussion (using computing committees) on which results a policy can be build, taking into account the present situation. This policy could stimulate development in different areas: IT use, software development, hardware industry, etc.

2.1.3 Enterprises

2.1.3.1 IT producers

The perspectives for a hardware industry are not very positive, because it needs a high initial investment and a very high level of computing personnel. But the software industry has its possibilities. At the moment most of the software houses make small tailor made software for the local market.

Local industries have an advantage on the local market: they know the language, the local procedures, and traditions. The local market however, is often small in developing countries, but IT export industries can use specific local knowledge in their programs. For example, Chile's expertise in the timber industry is exploited by Excelsys Engineering's logmeter [11]. A large use of software in one's own country will be a stimulant for export. A large domestic demand will stimulate local IT industry and therefore university growth, development of products, etc.

Most developing countries export raw materials with little added value, but in order to stimulate GNP growth, they will have to develop industries with high added value products. In that sense, the development of an IT industry could appear as a good opportunity, since software products are essentially "pure added value" [6]. Other advantages of this industry are: it is non-polluting, it requires less initial investment than other industries and it provides a relatively high income to entrepreneurs and employees [6].

Today's software market is concentrated in North America, Europe and parts of Asia. Developing countries have not yet played a major role in the software market, although India must be named here

as a country which does have an impressive software industry. But there are reasons to believe developing countries could do so:

* There is a movement towards market economies. Many Latin American countries are moving away from protectionists policies toward free trade, giving local companies the opportunity to enter the world market.

* The capital needed to enter the global software market has decreased.

* Communication networks help to shrink the world [11].

* Advanced developing tools are being developed for all the phases of the developing process. This makes the development of software easier.

Developing countries have the advantage that their personnel-costs and overhead costs are relatively low. The nature of software development also favours small companies with relatively low capital requirements [5]. The majority of the companies in developing countries is small.

On the other hand, there are drawbacks for building a software industry; absence of entrepreneurs as well as manpower with the necessary computing skills, inadequate capital markets, inadequate government incentives to stimulate small software firms, small local software markets, poor marketing skills, the absence of semi-automated programming, language barriers and lack of competition from other more advanced developing countries. Also the widespread and unauthorised copying of software has undercut the markets and profits of those who make the original development costs (see the next paragraph on piracy). The flow of new products from risk-taking entrepreneurs will depend on the returns that they expect for their efforts [5].

There are three types of software (export) industry [11]:

* Programming services: software subcontracting from abroad
* Conversion and localization. At the moment this is often only done superficially for Latin America.

* Product development

In the case of programming services, communication infrastructure is particulary important.
Governments that want to stimulate software production may take the following actions:

* Passing tighter copyright laws

* Supporting the creation of new IT enterprises

* Creating export channels for computing products

* Demanding systems themselves

* Improving infrastructure, like subsidising telecommunication

* Establishing research in university programs to stimulate the production of world-class software.

* Reducing trade barriers which will make it possible for software companies and universities to import modern hardware and software tools at competitive prices.

* Planning and coordinating industry efforts. This can be done in a co-operation between software industry, government and universities.

* Initiating a policy of protection (introducing high import duties) for a few years. This will make foreign

software less marketable on the local market and allow local industry to compete better with foreign, more advanced products and thus build capacity. Import substitution, export promotion, self-reliance versus cheaper more advanced technology from abroad and avoiding technology lags are key issues [5].
It is uncertain how a government could protect an industry (computing in this case) at such an immature stage of development, when the direction of the technology is not yet firmly set. Protectionism might choke off the inflow of new ideas which seems to be critical to the current development of the technology and industry might become out of date. One way of doing this is to only have protection for a certain period of time in which the local industry can grow, using the local market, and try to become international competitive. Therefore a policy of protection can best be done by countries which have a sufficient large home-market in order to set up a local industry which in the beginning only supplies to local market.

Brazil forbids foreign software, functional equivalent to local software, to enter the market (see paragraph 2.2). Also India has high import tariffs on IT products. The US wants the GATT to establish international trade policies that would prevent such restrictions. Developing countries think that GATT negotiations must include provisions that allow economies of developing nations to mature and that promote infant industries [12][5].

2.1.3.2 IT consumers

As stated before, computers are used on a low level in most developing countries. While the newest hardware and a lot of modern software is available, the utilisation is inefficient in the sense that only small systems are developed and existing systems are not used to their full extent.

Does this mean that organisations in developing countries are experiencing the same difficulties encountered in the earlier years of computing in developed countries, such as ineffective use of computer resources and poor, undisciplined, and incomplete system development [1]?
There are at least two big differences. First the costs of computing power have decreased drastically since then and therefore also the risks of investing and the costs of making mistakes. Storage space and speed are not major drawbacks any more. Secondly there are tools/methods to develop software and better programming languages with the result that labour, which used to be done by high level people, can now be done by less educated people. Because of this the computing experts have more time to give attention to users and the organisation and are less machine orientated.

Reasons for the low level use overlap with reasons for the inefficient utilisation of computers, among them: [13]

* Choice of the wrong machines
* Unpreparedness of organisations to receive the machines
* Improper allocation of the computers in organisations
* Inadequate software and maintenance support
* Lack of manuals due to piracy
* Communication gap between users and technicians
* Misunderstanding about the social-economic impact
* Inadequate service infrastructure [5]

Three key items of service infrastructure for IT consumers are electric power, telecommunications and support services.

Poor power supply will limit the reliability of computers, but also increase costs, either due to the adverse effects of uneven supply or the burden of having to purchase additional electrical equipment to protect against voltage fluctuations and blackouts.

The quality of telephone services will determine the ability for computer users to benefit from high-speed, reliable data transmissions facilities. They can benefit from the stand-alone mode but the major benefits will not be realised until networking and communications are widely available. Even the poorest countries have access to high-quality international telecommunication services but the weakest links in the telecommunication are often the local telephone networks.

After hardware is purchased, the range of support services, usually taken for granted in developed countries is invariably lacking in developing countries. Unavailability of spare parts, trained maintenance technicians, and standard system operating and application software.

Finally, several related issues arise with regard to the working environment that could adversely affect the performance of the information technology devices, including control of temperature, dust, vibration, insect pests etc.

But the main reasons for the low level and inefficient use are the shortage of skilled computing personnel and the lack of knowledge of managers.

There are differences between Western companies and companies in developing countries. These differences may influence the "goodness to fit" of the information system in its organisation. The "goodness to fit" is influenced by two issues, the characteristics of the company and the knowledge of/ and experience with the technology.

A) Characteristics of the company:

A first characteristic is the rationality, or maturity, of the organisation and of the environment in which the organisation operates. Only rational processes can be automatised. It was no accident that the first computer based applications were payroll and accounting-type tasks. In developing nations, rationality lacks in many of the companies' jobs [14]. Related to this lack of rationality is the lack of an organisation-wide information system plan [1].

Such lack of rationality/informal practices also have other consequences. In general, a company will not like an outsider or an employee to know about these practices. For this reason there are a lot of enterprises who prefer to develop software within the company. This does not promote the exchange of computing related information.

A second characteristic is management in developing countries. Management is often autocratic instead of consultative. This makes it hard to advise on computing issues, although the manager does not have the knowledge to do without advise [1]. In developing countries decision support systems are not often used, [1] though it would be a very good tool for an autocratic manager who makes decisions on an ad-hoc bases. Because of the management style, the degree of decentralisation is low [1]. The very nature of the computing technology may serve to undermine tight central control [15]. Computers support decentralization because they can make information better accessible to all. And access to information is power.

A result of making decisions on a ad-hoc bases is a lack of formal planning, specifically for system development, formal cost benefit analysis and system evaluation. Also manpower policies are often not stated, which has influences on the following issue, "knowledge of/ and experience with the technology"[1].

B) Knowledge of/ and experience with the technology

Users have to know what is possible with computers to create a demand. They have to know the

good and the bad points of the computer use. Developing nations do not have a history of acceptance, or even exposure to computers. What should be done, is the establishment of a cultural and organisation infrastructure, exposure of the citizenry to information systems and creating a demand within the society for information systems [14]. One could do this via a periodical magazine.

Also the role of the computing experts in informing users and advising managers is very important. But due to the fact that many system development personnel have their training strictly in computing science, they are often more interested in system development technology and not what the system is to accomplish [1].Suggested is that as an organisation becomes a more experienced computer user, it shifts the focus from computing management to data resource management.

2.1.3.3 Piracy [16]

Especially in developing countries there is a lot of software piracy. There are even developing countries in which the hardware dealers offer illegal copies of software within the deal (a.o. Paraguay and Bolivia). For these low income countries the price of software is very high. Since they have no own software industry to protect, actions against piracy do not have a high priority.

One can say that piracy has done much to spread software literacy in developing countries and access to intellectual property is necessary for rapid and sustainable economic development.
Is it therefore strange that developing countries think that intellectual property protection will leave them at a permanent disadvantage, especially since the retail costs for software are enormous for them.

In general, especially in developing countries, there is the widespread idea that there is nothing wrong with making copies of software without paying for it.

But there are other ways then piracy to spread computing literacy. Ways with less bad side-effects. Permitting piracy is not in the long-term interest of countries that wish to develop their own economies and innovative potential. If violators are forced to purchase software legally, they might create their own products since that might be cheaper [16]. Some people say that first a local software industry, who which benefit from software protection must exist, before legal action is taken [8].

Piracy also causes inefficient use of software. Because there are often no manuals, not all the possibilities of the software are being exploited. This is especially true for more sophisticated software. In developed countries the software dealer sells specialised computing science books and manuals. This type of business is missing in developing countries.

Another problem of piracy is that people will not make a selective choice of the software they are going to use. When they have to buy it, they will be more selective. Giving advise in buying software could be a job for a computing-society.
Actions, against piracy, that can be taken are:

* Allowing violation of intellectual property:
  There is a difference between piracy and violating intellectual property. Piracy is making copies of software without developing effort at all. Violating intellectual property also includes developing similar software. Allowing the last type of violation in the first developing phase has less bad side effects because it will stimulate the own software industry and allow software producers to get experienced. Piracy should be forbidden because it causes under-utilisation of software and withdraws the local software industry.

* Enforce change of current pricing strategy:
  Software companies have the legal right to the economic gains that follow from their ideas and inventions, although the intellectual property law was never intended to guarantee profits or financial gain for producers of such works. The current pricing strategies do not seem to take into account the low incomes of developing countries and legal action will never have its effects if software is not

sold to developing countries at reasonable prices.

* Legal protection:
  Legal protection is needed but this will not be sufficient to prevent software piracy. The legal framework for protecting software is difficult to enforce and interpret. Forcing countries to change their practices by sanctions will not work without a continuing dialogue to change attitudes as well. One should educate users and professionals on legal and ethical aspects of computing.

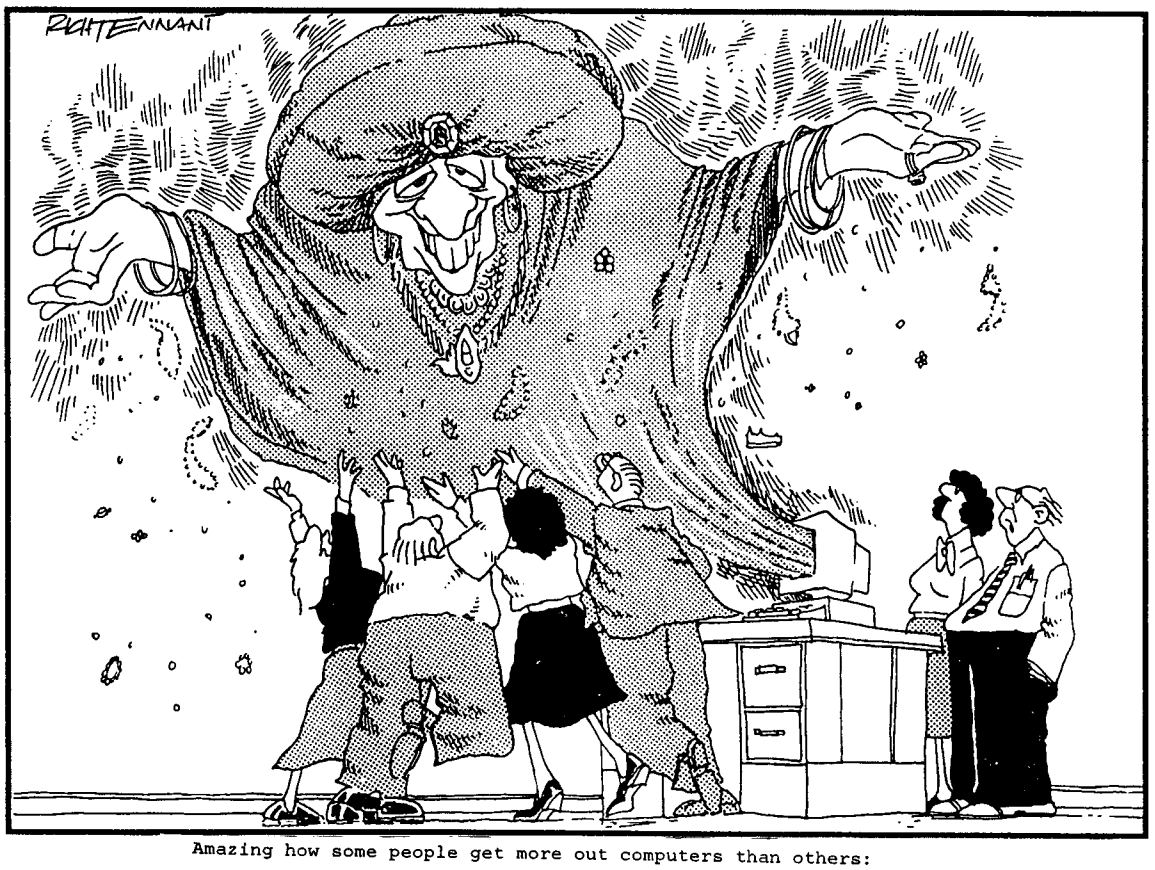
Furthermore, one can encourage their local software production so that they will have their own intellectual property to protect. The computing situation in Chile and Uruguay is starting to improve: their own software industry is trying to grow and also other responsible companies with international activities are trying to improve their image by obtaining their software legally [16].

bird's eye view of situation and possible remedies
Most developing countries only use low level IT products. Chances for a hardware industry are slim. Most software is illegally copied, which makes it hard for the software houses to survive, but there are possibilities for software production. Actions to be taken are the improvement of the computing education and the provision of a better infrastructure (telecommunication, intellectual property rights, software pricing strategy, etc.).

2.1.4 Educational institutions

Who has to be trained in computing? One can make a distinction between computing specialists and users. Computing education is to train computing experts while computing literacy courses are for users.

Zmud and Cotterman [14] state that as pure technical skills can be bought, computing technicians must be educated after the users. The lowest priority is an academic computing science program, because a major problem is the under-utilization of systems, caused by a lack of end-user understanding of computing. Developing an computing educational system without the capability to exploit it is inefficient and ineffective.



Amazing how some people get more out computers than others:

On the other hand, computing experts are needed to educate the users and to guide the users in making choices concerning hardware and software. Users have found it difficult to communicate with the computing professionals who have been very inward looking, exhibiting a closeness to the machines rather than the people using them [2]. In the process of choosing applications and developing computer systems, a dialogue is necessary between users and computing experts. The communication gap is also still a problem in developed countries. Training information analysts who function as a bridge in the communication between the user and the computing expert could be the solution.

computing experts

In quite a few developing countries, private business orientated training institutions, have mushroomed solely with the purpose of spinning money. Pleasant experiences in computing education in developing countries are only a few. Perhaps it is due to the fact that there is no good model to copy, even from developed countries where it is known that due to rapid changes in computing, standards in computing education have not yet been firmly established [13]. High level education is missing.

The first crops of system designers are drawn from other functional areas. Training to them is provided mainly by vendors, the knowledge gained is machine specific and not generalised. Most of the vendors found it easier to train clients in data processing applications rather than educate them in designing decision orientated systems [2]. The availability of skilled manpower is a serious problem and has various dimensions. In most of the less advanced countries there are shortages at all levels, while in the newly industrializing nations the low level staff, like programmers are often in excess while those with graduate degrees in computing science are in short supply [5].

One of the issues concerning manpower is that, on one hand the educational system has to deliver people who can solve the practical problems in the enterprises but on the other hand there should also be people that can stay in contact with the computing science on an international level.

Why do development countries need high executives? Computing staff with graduate degrees could cover three items in the first phase of development: [17]

* to create and set into motion the schooling for medium executives.
* to supervise these medium executives in working situations.
* to keep in touch with technological developments (fundamental research) and transfer the knowledge which is applicable in the country.

The educational institutions must ensure that the instructors are compensated financially so that they are not lured away by the industry or equipment suppliers.

users

Concerning the users there are two extreme thoughts. There are people who think users should be educated in computer use and the other group who think it is a task for computing scientists to develop methods and tools for user friendly system development. In the last case "computing literacy" will not be that important. This idea is becoming more common in developed countries (see chapter 5: "role of education in computing").

Some of the methods which are already being used are: user-centred system design, rapid prototyping and participant design. The goal of these methods is to get the demands of the users clear. There are many anthropologist doing research in this area because not only the type of organisation influences the properties of the software but also the cultural context. This has the consequence that these Western tools are not always appropriate to use in a non-Western country.

The major problems in education in Africa and probably also in lots of other development countries are: [9]

* Inadequate educational facilities.

* Deficient background (almost no exposure to computer environments and terminology before entering an university or an instituto).

* Lack of high level manpower

* High costs of computer systems

* Inappropriate curriculum in computing education

* Need for strategies and policies. Lack of national awareness about the significance of computing as a necessary tool for social and economic development.

How can a country improve its educational program?
Without any help at all, it will be hard for developing countries to do this. Two options for help are: [18]
A) With the help of industrialised countries
B) In a co-operation between developing countries.

A) Industrialised countries can

* Provide teachers;

* Give financial aid to create institutions and purchase materials;

* Design training programs;

* Help developing countries to develop their own options and views. Development in computing is not a process of imitation. For example, educational computer software implies educational methods and ideas. Before using this software one should ask if one does support the underlying ideas and methods. A country has its own culture which might imply that they have to make their own educational computer software that support their ideas, or not use these type of programs at all. This could be an area of research in the different developing countries: "how can one adjust software to specific users, what are the characteristics of the culture in this country, which influence their needs and impressions";

* Trainees may be accepted in schools in the industrialised countries. The last may hinder the development of local training structures and it may generate brain-drain.

B) A co-operation between developing countries in developing regional training institutions may be preferred, because it diminishes the change that qualified people move to more developed countries. Other advantages of regional training institutions are that you can teach about difficulties and problems of the developing countries, you create a dialogue between developing countries, you create the opportunity for computing specialists to know each other and once back in their own country this may lead to fruitful exchanges.

Before one starts to "improve" computing education, an analysis of what kind of people are needed is to be made. Educational needs are different in the different stages of development, implying that the facets of computing education and training should progress gradually as the development grows from one state to another.
So sending people to developed countries to obtain degrees in computing science, is out of the context considering the real needs of developing countries [13].

Computing training and education must be in line with their requirements and should grow with their needs. And most of the developing countries, primarely, do not require computing scientists, but require application orientated professionals. In their profession they should be able to start as programmer/analysts and be capable of being promoted as system analysts, senior programmers, etc., with working experience over a reasonable period of time.
In a report of the United Nations, it is mentioned that one should concentrate on the small companies because they are in the majority in the Developing Countries [19]. This would mean that education should concentrate on the development of low level office systems, work in service organisations, etc. The majority of the computing specialists probably should get an education anticipating the enterprises'needs of the country now, and in the near future (see chapter 5, "The role of education in computing").

One of the problems, especially when the education given is of higher level than needed in the country, is the "brain drain": the migration of people with high educations. They also often stay in more advanced countries after completing their study there. Educating computing experts without the capability to employ them to the fullest is not only inefficient and ineffective but those specialists will most likely migrate to nations better able to utilize their talents.
As the standards of living for professionals increase in developing countries, hardware costs fall and local research facilities and communication networks improve, there will be less incentives for students to remain in North America or Europe after completing their education [20]. Adequate salaries, good working conditions, challenging tasks, and other incentives are more likely to reduce or even reverse the brain drain rather then attempting to enforce service or prevent travel abroad [5].

bird's-eye view of situation and possible remedies
There is a poor education in developing countries due to the lack of facilities and good personnel. In most countries there are personnel shortages at all levels. Governments have to make an analysis of who has to be trained: what kind of users, what kind of computing experts. After this they have to make an educational hierarchy and decide on how one wants to achieve this (in co-operation with neighbouring countries or with Western help).

2.2 SITUATION IN OTHER SOUTH AMERICAN COUNTRIES

The countries in this area had policies of import-substitution from the 1930's, 1940's to the 1970's, 1980's. Then it became clear that they had an enormous deficit due to the decrease in export prices of primary goods, an increase in import costs and the small export of industrial goods. In the 1970's, 1980's most countries changed to a free market policy. Until 1984 there was a lowering of the living standards and after that there was a 3 year period of a modest recovery. Since then the growth has been trivial, just able to keep up with the population increase. The main exporters of industrial goods in the region are Brazil, Argentina, Columbia and Chile.

In most South American countries computing courses are given at the public and Catholic universities and at small private schools. About all these countries have a connection to a international computer network. Not all these connections are directly, but they use a modem to connect to a network node else where.

Tables have been made with brief information related to IT of 7 South American countries.
Literature used: Chile [6][20], Paraguay [4], Uruguay [8][4], Brazil [21][8], Ecuador [22], Colombia [15], Argentina [4].
An empty cell in the table means that no information was available.

Government

	Chile	Paraguay	Uruguay	Brazil	Ecuador	Colombia	Argentina
import tariff	open market policies	hardware 16%	hardware 10%	mainframes 50%, printer and software 100%, mini's and PCs. market reserve of 10%			mainframes, minicomputers 10%, printers and software 24%
general IT policy	stimulating computing: education, software industry and the IT consumption	no official IT policies	software development is promoted hardware has received little attention	protection IT producers, especially hardware protection ended in 1993		stimulating education, especially of users	open, used to be protected
infrastructure	telecommunications good supporting IT events creating export channels	state owned telecommunications poor but favourably with many other developing countries	telecommunication infrastructure is pretty good. digital lines available				
piracy policy	passing tighter copyright laws	there are old, vague laws, they do not include software in specific	no legal action but campaign to discourage uses of intellectual property	acceptable intellectual property protection			

Table 1

Enterprises

	Chile	Paraguay	Uruguay	Brazil	Ecuador	Colombia	Argentina
hardware sector		imported hardware of which most is reexported, smuggled to a.o Brazil and argentine, who used to have high import tariffs qty PCs increasing		"Law of Similars" no imports of goods similar to local ones Import PCs restricted there is hardware production		IDCS, regional government organisations rent equipment to companies	
software sector	exporting software started with tailor made products, then standard products, now, large tailor made projects and vertical markets are explored cause of grow is innovation		one of the "priority" areas is banking, banking software developed and exported to peru, Chile, spain and sweden.	IT industry protected by restricting the import "Law of Similars" no import of goods similar to those produced domestically.			
piracy	piracy is very common	notorious for pirating software Hardware dealers include illegal copies of software with the sale of their PCs	selling hardware and software separately instead of including illegal copies of software in the sale of hardware				
public consumption	large consumer of IT products		largest consumer				
IT use	local market play an active role in demanding systems			protection led to expensive IT products			

Table 2

Education

	Chile	Paraguay	Uruguay	Brazil	Ecuador	Colombia	Argentina
research	government is financing research traditional universities are being consulted in industry technology transfer projects.			local companies invest money in R&D		no research due to the high student/faculty ratio	
colegios					no computing due to a lack of equipment.		
computing personnel	good educational, structured scheme of degrees. there is Phd program continuing education offered staff send abroad for education	Catholic university is only good school, help of Italy research done on problems with applications to the local economy, this university also has a network node.		priority to higher education lower and middle-level technical neglected scientific community under equipped also under paid braindrain is intensifying. lack of personnel	shortage of teachers due to low salaries most teachers part-time spanish readers lacking, english-speaking teachers spend much time translating most are trained at a bachelors level by public and private universities	resources dedicated to low level computing education, most state universities lack the resources low level education fulfils the demand. graduate level lacks	
users		almost no computer use at home			users are informed of the power of IT systems to stimulate IT demand certification of software to help the user decide	the government priority is educating users	

Table 3

Organisations and recommendations

	Chile	Paraguay	Uruguay	Brazil	Ecuador	Colombia	Argentina
organisations	Chilean software industry is organised (ACS) more professional organisations,among SCCC the academic society, which is connected with ACM CIDS committee to promote software industry ,participation of ACS, universities and SCCC Chile is active in CLEI, the latin american computing organization IT events organised					computing diffusion centres '83 co-operate with the National Service for Learning, state universities and other government offices no other computing communities	
recommendations by local organisations	government has to perform certain tasks relationship universities and producers is needed, to keep people aware of the state of art update computing curricula, include ethics, document writing, marketing etc. certify level and quality in education					Research should be done to educational hierarchy graduate level needed to stimulate computing sector computing communities should be started, the source of exchanging ideas	

Table 4

One can divide the South American countries: those having a computing policy and those not having policy. Chile, Brazil and Uruguay do have a clear policy.

Chile en Uruguay are software oriented while Brazil's emphasis is hardware. In Chile and Uruguay the government is the IT consumer and their telecommunication facilities are relatively good. Both are already exporting software. IT industry in Brazil is promoted by import restriction while Chile uses an open market policy; Brazil is the only state with high import tariffs for hardware. Research in Chile and Brazil is already supported by local companies.

Educational hierarchy is lacking in most countries. Chile has one, but the levels yet have to be certified. Graduate level is missing in most countries. Piracy and lack of computing personnel are common problems.

2.3 COMPUTING EDUCATION IN THE NETHERLANDS

2.3.1 General

In The Netherlands, the diversity in educational types in the area of computing science is great. Courses and formal trainings are given at different levels and in different areas. Education is under state control. There are public and private educational institutions.

Almost all trainings in other areas than computing, include courses in computing. They are also included at primary and secondary schools.

Due to rapid changes in computing technologies, standards in computing education have not yet been firmly established [13]. Also in The Netherlands, the contents of the different studies still change a lot, due to these rapid changes and due to changes in opinions about how one should organize the education.

The formal computing science education is given at 4 levels: Masters and PhD, MBO, HBO,. The level of HBO is more or less the level of Licenciado in Bolivia (about the bachelors level in the States) and the level of MBO might be compared with the level of *Tecnico Superior* in Bolivia.

The duration of the Masters, HBO and MBO education are all more or less 4 years full-time but the levels, on which the courses are given, are different. All three can be started after secondary school.

In certain sub areas of computing there are possibilities to do a HBO after MBO in less years. The same is the case when one does a Masters after HBO. The studies at the level of HBO and MBO are more business oriented and the studies at the universities, Masters and PhD, more scientific.

Education is conducted in different areas. The three main areas are system development (software orientated), system engineering (more system orientated) and information science.

The task of providing trained system analysts (part of the information analysis) to the industry is being increasingly performed by the business schools. About all studies at the various levels include a practical working period or research period. Every university or school has its areas of specialisation.

2.3.2 Phd and Masters

The PhD and Masters studies are conducted at the universities. At all the universities where there is a Masters program for computing science, there is also research and the possibility to do a PhD.

A PhD degree can be obtained in all the areas of computing science but there are different specialisations per university. A PhD takes about 4 more years after a Masters.

Master studies with the same name can be implemented differently at the various universities: computing at one university can be more theoretical then at the other university. The amount of supporting courses in the universities at a Master level, like Dutch, English, economy, etc. are minimal. In general, a specialisation period, often in the form of a practical working period is part of the last year. The different studies in the area of computing science in The Netherlands are:

* Computing/Drs.
  This study aims at the computer and its programms. Organisation aspects are excluded. The difference with Computing/Ir is small. The Drs-study is more software orientated while the Ir-study is more machine orientated. Courses in the areas of mathematics (more and more applied to computing) and computing are included (programming, datastructures, computer architecture etc.).

* Computing/Ir, technical computing (computing engineering).
  This study aims especially at the technical aspects of specifying, designing, construction of systems and programs. The courses included are within the areas of mathematics and computing. Different specialisations can be information techniques (device orientated), theoretical computing science, system programming, technical appliances, etc.

* Business-mathematics and computing science/Drs.
  This study aims at the area of information systems to solve specific problems in the area of micro-economy and econometrics. The study includes courses in mathematics, computing science and micro-economy/econometrics. This training is given in only one university.

* Business Orientated computing science.

This area aims at the application of computing in companies. It is more information-analysis orientated.

Furthermore, there are Master trainings which as far as contents are concerned are a specialisation or a mix of the ones above. Examples are information systems (a mix between business-mathematics and computing science and "business orientated computing"), artificial intelligence (a specialisation of Computing/Drs) Also in the electro-technical studies there are courses in computer hardware and specialised data-processing (process control, image-processing, etc.).

2.3.3 HBO

There are three different types of education on this level, HEAO, HTS and AMBI.

* The computing study of the higher administrative training (HEAO) is business-computing science: the students will not become technical experts but more information/organisation experts. The information analyst will, together with the user determine the information needs which can solve existing problems. Courses included are business administration courses, automatisation courses (system analysis and design, system simulation, information systems, database-organisation, programming, computing organisation) and supporting courses (mathematics, english, communication techniques, economy, dutch and law).

* As part of the higher technical schools (HTS):

  i. Computing
  Like computing/Ir only at a lower level. Classes concerning the systems side are included like robotics, technical infrastructures, operating systems, etc. The possible areas of specialisation depend on the school. To give an indication of the different areas in which classes are given listed are the contents of one of the schools: 15% information systems, 35% computing (software orientated), 15% computer systems (system orientated), 15% mathematics, 10% business administration, 10% supporting courses.

  ii. Computer integrated manufacturing,
  This study is directed to production automatisation. Itcontains courses in mechanics, production organisation, product design, computer networks, databases, hardware, software engineering, quality control of the production, etc.

  iii. Technical computing science
  This study is a specialisation in the study for electronic engineering. It is more hardware orientated than the study computing. It aims at jobs in the automatisation (also software) process, the IT industry and the technical computing.

* AMBI
  AMBI is a training with its exams made by the nonprofit organisation Exin, the Dutch educational institute for computing science. It consists of different courses which can be done separately. It is not a full-time training and the student determines his/her own speed. This training is not given in a specific school but there are private institutes who give classes to prepare students for the exam. The courses are in the area of computing and only when necessary to explain things, they give courses in mathematics or business administration. Among the different courses are information science, databases (design and programming), design of programs, compilers, computer architecture, operating systems, communications, office automatisation, system development (tools and methodologies), quality control and security aspects, object orientated programming and system programs. As part of different courses they learn programming languages. For the different professions, listed by the dutch society of computing, a suggested list of courses is made.

There are also a few trainings, which are not really part of the computing science education but constain many elements of it, for example: "computing in a laboratory" and "computing in geography".

2.3.4 MBO

There are three types of education on this level: MEAO, MTS and PDI.

* The study of the medium administrative education (MEAO) is Business-computing science.
  The students will not become technical experts but more information/organisation experts. Courses included are information systems, system analysis and design, business administration courses, programming, database-organisation, and supporting courses (mathematics, sociology/psychology, english, communication techniques, economy, dutch and law).

* In the medium technical schools (MTS) trainings are given in:

  i. Technical computing science
  This is a specialisation for the study in electronic engineering and qua area like HBO-technical computing science.

  ii. Computing
  The area of this study is about the same as HBO-computing, but on a lower level.

* PDI
  PDI is a training in which exams are made by a nonprofit organisation Exin, the Dutch educational institute for computing science. It is a training for users who want to know more about computing or for starting computing specialists which can do a specialisation within this training. PDI is not a fulltime training and consists out of different courses which can also be taken separately. The student can determine his/her own speed. Private institutes give classes to prepare students for the exam. The different courses are in the field of : programming principles, maintenance of programs and data, programming languages, organisation and technique in ciphering centres, automatisation and technique (e.g.digital systems, production automatisation) de-central computer use, software packages and MS-dos. The students can choose out of 5 specialisations, which will determine the courses they will have to take.

Further, there are trainings on a MBO level, in which to students work 4 days a week in the same area and go to school 1 day a week. There are trainings in industrial automatisation and basic administrative functions in computing.

2.3.5 Other

There are also a few organisations who give workshops and specific courses. The Netherlands Organisation for Education in Informatics (NOVI) organises up to date business orientated advanced courses and will also give specific courses on demand. Last year, courses were given in the areas of information planning, information quality control, testing systems, project management, C++, writing for users, network management, SDM-2 (system development methodology), relational databases, expert systems, windows, object orientated software, etc. There is also an organisation for post-academic education who also organise courses in computing science in co-operation with universities and other organisations. Courses are also given by hardware and software houses.

3 COMPUTING SITUATION IN COCHABAMBA

3.1 GENERAL INFORMATION BOLIVIA [23],[24],[25],[26]

Bolivia is a landlocked South American republic, founded in 1825 after it became independent of Spain. It has some of the richest natural resources in the region. Disagreement with neighbouring countries, on the access to natural resources, resulted in wars that provoked the loss of more than half of the original territory in the last 150 years.

form of government	republic
territory	1m sqkm
population	7.5m
official language	spanish
main geographic regions	tropical, mountain area
GNP per capita	US$600 ('89)
government policy	free market
% population in agriculture	42.3% ('88)
% population in industry	12.8% ('90)

The descendants of the Andean cultures constitute the majority of the population.

In 1952 miners and farmers staged the so-called national revolution. Mines were nationalised, there was an agricultural reform and political rights were granted to all inhabitants. After the revolution in 1952 an import substitution policy was initiated.

In 1984 Bolivia changed policy towards liberalisation with support of the IMF. Before that time, like in other Latin American countries there was a high inflation. With help of the IMF they succeeded in controlling the inflation and the last years there was a rate of about 15%. Since '87 there has been a small growth again of the GNP, just sufficient to keep up with the population growth.
Today Bolivia is the poorest countries of the continent, with one of the lowest incomes per capita and one of the highest rates of mortality and illiteracy. Political instability was one of the reasons of marginal development. Since ten year the country is more or less stable. Nowadays only a small part of the companies are state owned.

The majority of the population lives in rural areas. Mining continues to be the principle source of export, followed on a much lower scale by gas and some agricultural products like coffee, sugar, soya, wood etc. 42.3% of the labour force works in agriculture which contributes 21.6% of the gross domestic product (1988).

Industry is scarcely developed and concentrated in the major cities, orientated mainly on the national market. 10.6% of the gross domestic product is made in the industry (1988). Prospects for industrialization are limited by the small size of the domestic market, the few possibilities of export markets, the poor infrastructure, shortage of technically trained personnel, the low level of investment, shortages of capital goods and the uncertain supply of raw materials. The majority of the manufacturing companies (90%) are small (1 to 4 employees).

The crisis of mining causes a general economical crisis and the nation becomes more and more dependent on credits, donations and narco traffic.

3.2 GENERAL INFORMATION COCHABAMBA

Cochabamba is a district in the centre of Bolivia. There are only two cities in the district, Cochabamba and Quillacollo. The city Cochabamba has about half a million inhabitants. Its altitude is two thousand meters and it has a very nice climate. They say that Cochabamba has an everlasting spring.

The main part of Cochabamba is mountain area. But it also has a tropical zone, the Chapare were all kind of fruit is grown. Agriculture is very important for the district's economy.

Also 90% of the Bolivian coca production is from Cochabamba. 95% of the world production is located in just three countries: Bolivia, Colombia and Peru. In Bolivia coca for export is grown in the Chapare. Part of the profit stays in the district. The Bolivian government estimated that the gross value of the coca production in '86 was about 55% of the formal GNP and about 4 to 5 times the value of the formal export.

3.3 GOVERNMENT

3.3.1 General

The information used in this section came from literature [27][28] and interviews. Particularly interesting for this section were the interviews with policy makers of Cenaco. A list of interviewed persons is given in appendix 7.

Bolivia's leaders have not really seen computing as an instrument ideally suited to promote economic and social development. They are under-rating the significance of computing as a modern agent or carrier of development and progress.

The last vice president, Luis Ossio, thought that "Ciencia y Technologia" were very important and the government should spend money in technology transfer, and included a better information system within his priorities [28]. No notable actions have resulted from his ideas.

Most persons interviewed, said that the government is not doing anything to stimulate the use of computers. There are no governmental actions in the area of computing. One might understand that they have more important things to take care of, but companies want the government to at least improve education in this area.

The government does not stimulate the use of computers in companies, it does not stimulate research, education, nor does she do anything about the illegal copying of software. There is no policy to stimulate IT industry.
Sometimes there are rules, but they are not implemented. Examples are the intellectual property law and the rules for the "institutos" in Bolivia.

There is also a government institute for computing, CENACO (see the next paragraph) but they are not very active at the moment. One is preparing a law in the area of computing (paragraph 3.3.4) which, among others, states new strategies and a new function for CENACO. Also basic elements are set up to arrange normalisation, educational hierarchy, hardware production, etc.

Bolivia has a national committee of new technologies, having a project which monitors the international technology development. One of their areas is computing. The project exists since 1991 and gets financial and technical support from the European Community and the Universidad Andina Simon Bolivar. The main goal is to spread computing related knowledge. They plan to organise seminars. There has been a reunion in '92 with people from countries in the region, to exchange ideas about the different situations. One of the problems of this organisation is that it is not very open. It was very difficult to get information about it. In the UMSS they had not heard from the organisation the last two years. So they wo not be doing a good job spreading knowledge.

3.3.2 CENACO

CENACO (Centro Nacional de Computación) was founded 20 years ago. All the big cities have their CENACO (Oruro, Cochabamba, St Cruz, Sucre, Tarija). The headquarters are in La Paz. The objectives of CENACO were to do the processing of data for the state companies. Software had to be made for this and people were needed for the programming. Therefore CENACO founded its own educational "instituto" about 15 years ago. But now there are less state companies, due to the recent liberalization policy, and most of these companies have their own computers, programs and personnel. CENACO's objectives changed, they are still doing some data processing for companies (state and private) and they lease hardware to enterprises. There is not a lot happening in CENACO at the moment and in Cochabamba they employ only 2-3 people, not including the personnel in their instituto. CEIN is the "instituto" of CENACO. Now, most people educated in CEIN are working for private enterprises.

CENACO La Paz arranged a conference last year with speakers from countries in the region. CENACO is, among others, preparing a law in computing.

3.3.3 State companies

All state companies have their own computing policy and computing departments. There is no overall government policy. Most state companies are big. State companies which were visited are Ende, Yacimientos, Cordeco, Lloyd, Elfec and Administracion Regional de Impuestos. A lot of information about state companies also was provided in interviews with managers of CENACO, software houses and hardware dealers. More information about the people interviewed can be found in appendix 7.

State companies become more and more market-orientated due to the change in government policy towards a free-market economy. But still, in most of the state-companies there is a lot of bureaucracy and favouritism involved. For example in hiring someone, with the result that wrong people occupy jobs in computing. ENDE, the state-national-electricity company is run more like a private business and here things are organised better. Also in Elfec, a state company, there is a lot of favouritism involved and for that reason they hire a software agent to develop new systems. The agent is more likely to finish in time and the costs are fixed. The impression exists that in state companies, the percentage of people in computing science jobs with a computing education, is smaller, than in private companies. On the other side, information gets more attention in state companies than in private companies.

3.3.4 Computing law

A law is being prepared in the area of computing. This will cost a lot of time in Bolivia, according to those interviewed, and it is not likely that the proposal will become a law in the next three year. The law is being prepared by a few organisations: CENACO, "Normas y Technologia del Ministerio de Industria y Comercio" and the "Camara de Disputados Comision de Informatica".

The goal of the law is to set up the framework for the development of a strategy in the area of computing and to establish norms and mechanisms contributing to national politics in this area. It includes:

* Making a hierarchy in computing education
* Making norms and standards.
* Promoting research and scientific education in the area
* Promoting initiatives for hardware production
* Regulating the processes of
  - importation
  - commercialisation (?)
  - system development
  - hardware and software use in state enterprises
* Making anti-piracy laws

Institutional mechanisms and financial resources to promote and administer politics and strategies in this area are being established in the law [27].

These institutions would be SENADI (Secretaria Nacional de Administracion y Desarrollo de la Informatica). The CENACO departments in the different districts would become a part of SENADI [27].

While it is true that a few countries have Central Computer Utilization Committees, the focus of such committees is usually narrow and their powers are so feeble that they are ineffective in the areas of policy formulation [9]:

* A high executive of CENACO La Paz did not want to spend more than five minutes on the interview (see appendix 7). After a telephone conversation with the director of CENACO Cochabamba who supported the investigation, he agreed to 15 minutes. The fact that he does not see the importance of this kind of research for his country is remarkable for someone in his position. He also was convinced that Bolivia was not behind in the computing area.

* In 1992 there were regional meetings with representatives of the organisations preparing the law and computing specialists. There were for example people from the "Universidad Mayor de San Simon". They said that, although they had studied hard on the proposal and were able to give good comments, the representatives were not interested in their opinions.

Given the poor information available to most potential computer users in developing countries, the lack of standards and guidelines could easily lead to chaotic results. On the other hand, excessive controls and inappropriate standardization by uninformed government's bureaucrats may stifle initiative and give rise to higher costs due to the lack of competition among suppliers. Regulations might also be dangerous because it will slow down the adaptation of new systems do not not agree with the norm but perhaps are better. Would it be possible to adopt flexible standards that facilitate software transferability, while still permitting technological innovation, by, for example, evaluating them periodically? These issues have to be examined [5].

Normalisation is important for the uniformity of methods, software and hardware. Nowadays two different hardware systems can be connected with the appropriate software most of the time, but the hardware solution is more efficient. One can also think about, for example, safety standards and usability standards defining user friendly software.

In developing countries one can already include issues in the law which are not yet applicable in the country, but will become so later (and already are in other countries). An example for this are the level requirements for a master education. Government regulations that restrict or delay purchasing of computers should be minimised,[5] but in some Bolivian state companies one has to go through a lot of bureaucracy, which delays the purchases tremendously.

3.4 EDUCATIONAL INSTITUTIONS

3.4.1 General

The information used in this section came out of literature [29][30] and interviews. Particularly interesting for this section were the visits to the educational institutions. A list of these institutions is given in appendix 6.

The general educational situation in Bolivia consists of three types of schools. There is "colegio": primary school from the age of 6 to 12, and secondary school from the age of 12 to 18. After secondary school one can go to the university or do courses in an "instituto". Trainings in computing are given in both types of schools. More information about computing in the colegios will be given in paragraph 3.5.4.

The titles you can get in the institutos are "*Tecnico Medio*" and "Tecnico Superior". One can give this title for any computing training since there is no control of the official rules for the institutos. Therefore, these titles have little value and the name of the instituto where you took the course, is more important. The titles of the universities are Tecnico Superior, "Licenciado" and "Ingeniero".

In general, the universities have trainings of 3-5 years, more or less fulltime. The computing-institutos, with few exceptions, give courses in software packages and languages, which take 1-2 hours a day, for a certain period (1 month to a few years). Most students of institutos have fulltime jobs.

The students in Bolivian education are used to memorising things. That is also what they learned in "colegio". Even in the last semesters of the university training there are questions in the exams which do not require a deep basic understanding of the material. The consequence is that they are not able to apply the things they learn. Because of this memorising, it is hard to define the level but we will try by saying that the level of the Licenciatura and Ingeniero is a bit higher then the (U.S.) bachelors level and the level of Tecnico Superior is about bachelors level. The level of the courses in the institutos is low. The only objective of the institutos is to make profit.

There is a great difference in private and public colegios concerning the quality of the education. But on both schools students learn to memorise. There is no noticeable difference in quality between public and private universities.

To enter the university, for a program of Licenciatura, Ingeniero, or Tecnico Superior there are two options: you can take an examen or you can do a preparing course of one semester.
The institutos are open to everyone. CENACO/CEIN, a computing institute, is an exception to this rule and wants students to have finished their colegio.

In Bolivia there is no computing education on a Masters level.

Lately there is a lot happening in the field of computing education: new trainings have started at an university level, institutos disappear and start. The number of institutos is growing quickly.

Almost no courses are given to re-inform and update the people working in computing, on a higher level than the institutos do. UMSS (Universidad Mayor de San Simon) and Universidad Del Valle organise more advanced seminars but very irregularly. The hard- and software houses also give courses on an irregular bases. The "Federacion de Empresarios Privados" has a sub-organisation called IDEA, which organises courses to managers in all kinds of areas, but not in computing. They say that managers do not have interest in these courses and the lack of competition does not force them.

It is already said that students do not learn to apply the theory in practical situations. This might be one of the reasons why the education does not get a lot of appreciation in business. In the U.S. the universities are partly financed by companies.
Other problems in the education are:

* Bolivia is isolated from the rest of the world: there is not a lot of information, a shortage of literature, especially up to date literature (in Spanish) and modern software. The main reason for this lack is the high price of these goods.

* The level of the teachers is not adequate, they are not up to date, do not have enough basic knowledge and lack qualities to teach, and it is said that sometimes they teach things that are not true. Even worse is that the educational system is not open for criticism and discussions. Often teachers do not give copies of the book they use to students. This, in order to keep their status as "expert".

* The salary of teachers is low and it is difficult to obtain good personnel.

* There is a lack of practical work in education, especially in the universities, due to a lack of equipment and a lack of practical experience of the teachers.

* There are often courses, like the courses in mathematics, which do not contribute to a better understanding. More applied mathematics, in which one learns problem solving in stead of using methods, would be better.

* The students also do not speak English very well. Therefore, there are problems with English study books. Because students are used to memorising it is extra difficult when the material is in another language, they will have to translate everything word by word, in stead of trying to understand the clue.

* There is no uniform idea in the educational institutions of what kind of people are needed in business. For example UPB (Universidad Privada Bolivia) has the idea that institute people are doing the work of *Ing./Lic.* and they are not doing it well. They want to educate enough computing experts for these jobs. They also could have concluded that institutos should improve their program.

* It is never is investigated what kind of jobs the different possibilities of training should lead to and also what kind of courses a study should include.

* There are almost no links between education and business. Some practical projects are done in enterprises but there are no courses given to companies and there is no research. The different universities in the area have no co-operation.
  But things are changing. For example UPB is subsidised by companies to educate better prepared students and the computing department in San Simon also tries to improve the contacts with companies.

In paragraph 3.4.2 the situation in the Universities will be described, paragraph 3.4.3 is about the computing institutos. The section on education will be finished by discussing the computing situation in the colegios.

3.4.2 Universities

General
Four years ago there was only one university that gave classes in computing, nowadays there are four. There is only one university, the public university UMSS, where students have already finished their computing study. The other universities with a training in computing are UCB (Universidad Catholica Bolivia), Universidad Del Valle and UPB (Universidad Privada de Bolivia). The program Tecnico Superior is only given by the Univalle and takes 3 years. The program for Lic. and Ing. takes 5 years. UPB is an exception and here the program takes 4.5 years. The difference between the study for Lic. and Ing. is that the first one is more scientifically and software oriented while the last one is more system oriented.

Personnel
There is no research at the universities, only education. Not many people have an appropriate computing background, therefore it is hard to get adequate teachers. But UPB and UCB say they do not have problems obtaining teachers because they have money. UMSS and Universidad Del Valle say they have problems obtaining teachers. There is a large difference between the salaries of the teachers in the different universities. Therefore it is even harder for the state university to get personnel. The ratio students/teachers is so large that there is even no time to do research.

The salaries are about (according to Oscar Pino, head of the computing department of the Universidad Catolica):

	UPB	UCB/DelValle	UMSS	Companies
docent:	$ 1000	$ 700	$ 300	$ 1000 - $ 1500
dean:	$ 1200		$ 2000	

Teachers in UMSS are automatically saving for a pension and health insurance is included. For this, people are willing to give a class in the evening or early in the morning. In the private universities the classes are more during the day because they employ more fulltime teachers. There are also classes in the universities given by *egresados*. These are students in a Ing./Lic. program, who have finished all there courses and can start their thesis. UPB says that all the teachers are Masters, but the teachers often have a training in an area other than computing science.

Teachers get contracts for one semester at a time. At the state university one can get contracts for life. But due to organisational problems this is not the case yet in the computing department.

One of the problems is that the teachers do not have a lot of practical knowledge. Often the programs look pretty good, but without good teachers to implement them, the education will be poor anyway.

Some characteristics will now be stated per university.

UMSS
The program in the public university, UMSS (Lic.), is directed towards scientific computing. The study in the computing department takes 5 years and already exists 13 years. There are 1200 students in the department. It is the training with the largest number of students, because it is the cheapest university. At the moment there are 3 fulltime and 14 part-time people working in the program. Only six students have graduated, due to a less adequate organisation of the computing department and due to the fact that most of the students left the university before obtaining there diploma. They left because there were enough well-paid jobs for them and they already can use the title "egresado" if they have finished all the courses.

Because of problems obtaining personnel, the university tries to persuade students to stay after finishing their studies. The program "Licenciatura en Informatica" was developed years ago, and the contents of the courses have not changed a lot with the result that they are the state of art of the past. At the moment a new curriculum has just been approved and they are going to introduce it gradually. Just changing the name of a course is considered insufficient. The contents of the courses is also slowly being modernised (by updating the teachers).

There are plans to initiate research projects in co-operation with local companies, to make money and to provide experience to the students.

UMSS is the only university in Cochabamba that has a connection to an international network. The only other university in Bolivia that has a network connection is Universidad San Andres in La Paz.

Occassionally the department gives courses for outsiders on a high level but not on a regular basis. The department has a co-operation project with the University of Utrecht in The Netherlands.

The contents of the program are presented in appendix 1.

UPB

The program in UPB (Ing.) has two areas of specialisation:

A) business administration
B) hardware/tele computing

The program in UPB for "Ingeniero de Sistemas" is 4.5 years. The first semester of this program has just started and there are 7 students.

The program is presented in appendix 2.

UCB

The program in UCB (Ing.) is directed to

A) business administration
B) scientific computing

It leads to the title "Ingeniero de Sistemas". The program exists for 1.5 years now and the number of students are 160 in the first semester, 50 in the second semester and 60 in the third.

They say not to have many problems with the quality and quantity of the teachers but more with the quantity of the computers (not with the quality)

The courses per semester are given in appendix 3.

Del Valle

Universidad del Valle has four programs

A) "Sistemas informaticos" (Ing., System orientated)
B) "Informatica de gestion (Lic., Software orientated)
C) "Sistemas computacionales y electronicas" (Ing., Hardware orientated)
D) "Tecnico Superior", a program of 3 years.

This university was established 4 years ago.
Ingeniero de sistemas informaticos has 170 students, Licenciatura en informatica de gestion 60 students, Ingeniero de sistemas computacionales y electronicos 50 students. 30 students are doing the 3 year training.

The faculty has problems getting personnel and like UMSS they try to persuade students to stay after finishing their study. These teachers will not have business experience. The university also has a shortage of good computers and there is no capacity for big projects. A lot of money is spent on

salaries in order to get good teachers.

Now and then, the faculty gives a public tutorial in a specific area for students and people who are interested: courses have been given in Unix, networks, artificial intelligence and parallel systems. There is co-operation with the university of Mons, Belgium.

In appendix 4, the curriculum is given.

3.4.3 Institutos

20 institutos were visited of a list of 30 institutos (appendix 6). The other 10 institutos were not possible to locate, they are not likely to exist anymore or have moved to unknown places.

The institutos give trainings for Tecnico Medio (*operador* and *programador*) and Tecnico Superior. They also give seperate courses.

General
The majority of the institutos were not giving courses in computing four years ago. 40% of the institutos already existed in '89, from which the majority have their primary function in the education for secretarial personnel.

In 1989 there were other institutos, less, but it is not possible to get a clear insight in these former institutos due to a bad registration. It is said that the amount of institutos grew as mushrooms the last few years.

Some old institutos disappeared. It was told was that the short life time had two reasons. First, people prefer to study in a new instituto. Secondly, after five years, there are not many students and the computers are old and have to be replaced which is a big investment and the managers often prefer to quit or return to their main area: secretary courses. Half of the institutos are primary institutos for secretarial personnel. These secretary students also have to learn to work with software packages, so the instituto has computers anyway. From 15% of the institutos it is unknown if they have courses for secretarial personal.

Teachers
It is difficult to get an insight in the level of the teachers in the institutos. About 50% of the institutos say they are employing technical superiores and 65% say they are employing Ing. and Lic. These figures cannot be true. Most of the teachers work part-time in the institutos, early in the morning or in the evening and have a job in an enterprise. The impression is that a lot of egresados and other university students are working in the institutos. There are Tecnico Medios who give classes and also the best students of the instituto help with the teaching. All the teachers get contracts per course and can get "fired" at any time.

Level and courses given
The level and the contents of the courses for Tecnico Medio (programador and operador) differ in all the institutos. Except for CEIN, all the institutos are private and their only goal is to make money. This is one of the reasons why quality is often lacking.

The institutos are registered at Supervision Departemental de Institutos Comerciales. There are obligations considering the institutos which give courses for Tecnico Medio, but only the registration and tax is important for this supervising department. Rules concerning the duration of the course and the amount of hours per day are not being checked and rules about the contents do not exist.
All institutos are accepted. Officially the program for Tecnico Superior should take 3-4 years of study, 40 hours a week. The study for Tecnico Medio should take 2 years, 40 hours a week.

The trainings should officially take a lot longer then they do.

There are also institutos (6 out of 20) which only give separate courses in software packages and languages. It is not possible to estimate the number of students who finish these courses per year due to the bad administration and a great fluctuation in the number. These separate courses take about 30-40 hours (1-2 months,1-1.5 hours per day). The rest of the institutos have trainings for operador and programadores, but the classes can be taken separately. Univalle makes a difference between the different software packages : a language costs about 100 hours, and a dBASE package 60 hours. Also in CENACO the courses in software packages cost about 60 hours. The programs for Tecnico Medio are a mix of these courses.

The courses most named by the institutos are:

type	package	% institutos
word-processors	wp	100%
	wordstar	30%
	ms word	15%
systemsoftware	dos	95%
	unix	15%
spreadsheets	q-pro	85%
	lotus	75%
databases	dBASE 3	75%
	fox pro	50%
	clipper	30%
	informix	20%
	dBASE 4	20%
languages	pascal	50%
	basic	45%
	C	30%
	assembler	15%
draw packages		45%

Courses only named by one or two institutos are cobol, fortran, autocad, norton, windows and prolog.

In general, courses are given on a low level and software packages are only superficially explored. Most institutos say they give courses in all the software packages, you only have to ask for it. So it is possible that a course is named which they have never given.

Operador

The program for operador contains courses in software packages. In the 9 institutos, giving this training, it is a mix of an operating system and software packages in the field of spreadsheets, word-processors, databases and sometimes a draw package. The duration varies much: from 3 months to 8 months, from 60 hours to 240 hours. The average is 6 months, 140 hours in total. It is not possible to make an estimation of the number of students finishing the program each year because the number fluctuates

a lot per year for all the institutos and the administration in most of the institutos is chaotic.

Programador
The program for programador, given by 8 institutos, also contains courses in languages besides the software packages and one or two courses in "introduction in computing" and "flow-diagrams". The software packages are treated more thoroughly. There are 2 institutos, CENACO and Gemicom whose education is considerably larger than others. The duration of the other 6 is about 12 months but due to differences in hours per day the amount of hours varies from 144 to 360 hours with an average of 280.

CEIN, an instituto to provide personnel, was started by CENACO 15 years ago. Nowadays, the provision of software for state companies, formerly done by CENACO, is decentralised. CENACO, now, is not more than CEIN, a director and his secretary. CEIN is the most well known instituto and is also considered the best among the majority of the companies which were visited. It has, besides courses in software packages and a program for operador, a more extended program for programador. It consists of 22 classes, each of 8 weeks, 1.5 hours per day (total of 1320 hours, about 8 months fulltime). About 50 students per year finish this program, but there are a lot more students because they get a certificate at different levels within this training. The courses within this program are listed in appendix 5.

The program for programador in Gemicon takes one year, about 3 hours a day (a total of 1140 hours). At the moment there are about 90 students in the program and it is the first year it is given. The program is still a bit vague. It is described in more detail in appendix 5. Most of the teachers are teachers who first worked in CEIN.

Tecnico Superior
There are two institutos who have a program for Tecnico Superior, the institutos Del Valle and Latino America.

Del Valle (no connection with the university Del Valle) has a program for analista de sistemas (Tecnico Superior), but this program is only 2 years, 1 hour per day (total of 480 hours) in contrast to the common idea that a training for Tecnico Superior takes 3 years, more or less fulltime. Nevertheless, it is one of the four more extended programs given by the institutos. The instituto started 1 year ago and at this time there are no students who have started the second year yet. The first year is equal to the program for programador and has 70 students at the moment (included the people who only do one year). The program presented in appendix 5.

Instituto Latino Americano has a program for analista the sistemas (Tecnico Superior), which takes 3 years, 3 hours per day and in total about 2160 hours. Because there are only a few students per year, this program has not much importance. Every year the program seems to start with about 15 students but only a few finish their study. The rest continues the study in UMSS which is less expensive and leads to the title of Lic. The courses in the program are listed in appendix 5.

3.4.4 Colegios

The colegios in Bolivia are for students from about 6 to 18 years old. They all ought to be the same level.

Sanabria a.o.[29] have been visiting 30 colegios in the district Cochabamba to see, what they did in the area of computing, what was the education of the teacher and what kind of equipment did they have.
The information in this paragraph is based on this rapport.

57% of the visited colegios did give some classes in computing. Only in 61% of these schools the students are obliged to do the courses.
From the 23 colegios giving computing classes, 5 gave only courses to the students the last 4 classes

(ciclo medio), 11 give courses the last 7 years (ciclo medio and intermedio) the other 5 give courses to all students.

The courses in software packages which they give are Lotus 123 (14 colegios), DOS (14), Word Perfect (12), draw packages (6) and dBASE III+ (4). The languages they give are Basic (14) and LOGO (10) In the training, some theoretical background is missing which could support the practical part. Although they are instructed with respect to software packages, 13 of the 40 colegios do not use the computer as a tool in other classes. But when they do this, it is often in the field of mathematics (6), physics (3) or literature (3).

Of the 252 computers used in schools, 46% are XT's. 33% are AT's and 9% are ATARI's [29].

3.5 ENTERPRISES

3.5.1 IT consumers

The information for this paragraph came out of the interviews. Particularly interesting for this section were the interviews with people from software houses, hardware dealers and IT consumers.

The list of interviewed people is given in appendix 7.

General
The computer applications in business are for low level jobs like accounting payroll, stock control, sales administration, routine reports, production administration, etc. In general, companies have PCs, bigger companies have mainframes. They use spreadsheets and word processing programs. In big companies a switch from a mainframe to a network was noticed.

Some more advanced/non-common IT products used in Cochabamba are named in paragraph 7.1, "Possibilities for Computing in Bolivia".

Except-import tax, there are no restrictions in use of hardware and software, one can buy the most modern types. The import-tax is 31% on both. The reason for this is to make money and not to protect their own IT-industry.

Computers are already used for a long time in big companies but on a small scale and at a low level. The last years small and medium companies are starting to buy PCs.

The main obstacle at the moment, to introduce more advanced systems, is not financial, but a lack of awareness.

Personnel and education
Computing personnel as well as managers are behind in this area. Therefore there is no demand for more advanced systems. If there would be demand there would probably be no knowledge to fulfil this demand.

One can get the most modern hardware but with the personnel, the knowledge and experience to exploit these systems to their full extent is missing. The situation in La Paz and St Cruz is said to be better then in Cochabamba. Over there they use somewhat more advanced systems and the users and computing specialists have more knowledge.

There is a lack of attention for information in general in enterprises. The computing specialist often also has to do the information planning in a firm before he can start his work.

According to the head of the business administration department of UMSS this situation is slowly changing. More often people with a business administration background are asked for management

jobs; there is an increase in this demand since Bolivia changed its policies to an open market policy. One of the problems is that the only courses in computing science given in Business Administration, at least in UMSS, are simple software packages; however they are starting discussions about the contents.

Often companies just buy computers because their neighbour has one or because they want to be modern. They will try to find uses for them later. Then they might find out that they need software to be able to do something with it and they hire someone to see what they can do with it. In La Paz, the situation seems to be better because the computing literacy is higher. In the state companies the man who decides what will be bought, often gets a personal bonus from the hardware dealers. So the hardware bought is not always the best choice.

The computing expert often decides what they do with computers. And since a majority of the computing experts only have little knowledge, this consists out of low level applications of computers. So there is not an actual demand for computing personnel of a certain level because companies do not know what they want.

Five years ago there were managers who thought a computer could do everything, but nowadays they are better informed and have a global idea what they want to do with them before they buy them. Also the areas of application are broader now, it is not just accounting. But 90% is still in the administrative area.

Courses for managers should be given by IDEA, a sub-organisation of the Empresarios Privados Cochabamba, which gives courses to managers. At the moment they do not give courses in this area because there would not be sufficient interest. Others say that there is enough interest but that the courses are to expensive and at a wrong time of the day.

The computing specialists in a company often do all the jobs: she/he has to find applications, do an analysis, an do the programming, in practice they just do the last thing according to a lot of people. Because of this, there is nearly no job differentiation and the programs are small. Licenciados also do low level jobs when they should be the ones to stimulate a more advanced use of computers! Also operadores do the work of requirement analysis.

Besides financial reasons, a company often prefers a computing specialist from the institutos because he has more programming experience. For them there is no difference between what a programmer and what a Lic can do. People studied in the institutos are also more wanted because they are cheap. This has the result that in a lot of companies Lic./Ing. earn the same as Tecnico Medios.

In bigger companies there are more people working in the area of computing. In most companies they work in a group, and they all more or less do the same work. In some companies they have a hierarchy and Lic. do the system analysis, programmers do the programming, operadores take care that everything works and help the users, and operadores enter data.

Most companies use the institutos and their superficial courses to update there computing personnel. Also hardware dealers give some courses on request as an extra service. In a lot of companies there is a demand for more advanced courses, like courses in Unix, programming in dBASE and Informix, database theory and networks.

The end users are starting to get more informed. Computing literacy is slowly improving. More and more universities and colegios are giving computing courses to their students. These courses consist of learning software packages.

Only in Lloyd they said that there were some problems with the users, who had a negative attitude towards computers, but that was years ago. In almost all the firms the users get instructions. In general there are not a lot of problems with the end users. They might be replaced if they do not adapt.

The salaries for programmers are between $300-$1400 and for licenciados the same, although they are likely to get more soon because of better performance. In a lot of companies there is not really a difference in salaries between Lic., Ing. or Tecnico Medio, but the achievement is important.

For some, Lic. and programmers can do the same, others say the opposite. Camacho (CENACO Cochabamba), for example, says that the Lic. and Ing. do all the work in companies and for the Tecnico Medios it is hard to find a job. Others say that Lic. are not needed because their training is too theoretical; companies want people with more practical experience. Companies have most faith in graduates from CENACO.

Problems with computing personnel mentioned in the interviews are:

* They speak nearly no English. Most manuals, programming languages and some of the software packages are in English.

* In a lot of companies they think that a computing-employee should also know a lot about business administration, and should be able to make a requirement analysis all by himselve. One of the problems is that personnel in business administration and other areas, lack basic computing knowledge which makes it hard to work with an computing expert and provide him with the necessary information. In other words, there is a communication gap between the users and the computing specialists

* The systems are often not really integrated within the organisation because the programmer had no eye for the organisation, did no information analysis and just started programming. This is one of the dangers of isolated computing specialists.

* There is not enough practical work in the Lic. study.

* There is not enough competition between the computing specialists. At the moment the majority is not even finishing their studies because they already find jobs. A solution could be to have degrees on more levels.

* The people who did a programming course in the institutos do not have a problem-solving ability.

* Computing experts are lacking knowledge on hardware, but the majority of the companies say that the hardware shop takes care of this. And hardware shops do not seem to have problems in this area, they train their own personnel. There might not be a lot of problems with maintenance of hardware in the administrative area, but in the area of networks, robotics, system software there is a lack of knowledge. This is not that obvious yet because there is no demand for these other applications in computing.

* All-round people in the area of computing are lacking. These are needed because companies often only want to hire only one computing expert.

* The university students in computing science get too many courses which are not useful in the companies here, like all the mathematics and the courses in Artificial Intelligence. These are courses for Masters not for undergraduates. Only in some companies they thought they should know more of networks and communication.

* The personnel is not up to date. Now and then software and hardware houses give courses, but not on a regular basis. Also the low level courses are not up to date. For example, in the institutos, Basic is still popular. In this field it is even more important to give up-to-date courses because things are changing quickly.

* Ethics are missing and companies are very afraid that company information will be spread, or that programmers will not finish their job or copy programs exclusively made for them.

Software related issues
A lot of the software is developed within companies. A software house is too expensive and for security reasons it is better to have someone within the company. Security is important because there are informal practices in a lot of companies, also programs can be copied and sold to a competitor. According to the software houses, however, there are no problems with companies out of security reasons.

The majority of the programs is not being documented. Some say that this is because the programmers have not learned how to do this, but the majority say that they do not want to spend money on this. Software houses do not do it out of security aspects, they just write a user manual. If the computing specialist of the company leaves the firm, there are often big problems because no one knows how the software works and there is no documentation.

The standard software is very expensive and there is a lot of software piracy. Only the public companies are said to be able to pay for the legal version of this software. Hardware shops include illegal software within their hardware sales, like in Paraguay.

Companies use the systems for a very long time when they finally have it. They are not doing a lot of software maintenance, but perhaps that is not necessary in non-changing companies. There is no formal evaluation of the system. One of the reasons is that there are no real problems for which they introduce computers. Evaluation is difficult to do if there were no reasons/goals to introduce the system at the first place. In a few companies they are changing to new systems, for which they have to reprogram all applications again, but these companies do not even bother to do a new system analysis, or to evaluate the old systems.

Hardware related issues
There is no production automatisation with analog controls (although Coca Cola is doing a study in this area). It is said that this cannot be cost effective with the low wages. There are almost no systems which have all the different programs integrated.

Shortage of hardware maintenance personnel is not a big problem in Bolivia, but the bottleneck is the use and construction of software. Hardware related problems are:

* In Cochabamba there is a lot of dust. The computers have to be cleaned more often, probably have a shorter life. But the economic age is still smaller than the technical age.

* Also the power supply is very irregular and companies have to buy extra equipment to regulate the line power. In the instituto Bits, for example, two of the computers stopped functioning after 18:00 pm, because the power is to weak during these rush hours. Because of the irregular power supply people buy a power regulator with their computer. This leads to extra costs.

* The telecommunication structure is not optimal, especially the local infrastructure. In cases where they want this type of infrastructure they use radio-links, or they buy expensive Entel lines, the national telephone company.

* The after-sale service from the hardware houses is expensive. Often you pay a fixed amount per month. Whenever there are problems the service is fairly good. Some big companies do their own hardware maintenance.

3.5.2 IT producers

The information for this paragraph came out of the interviews. Particularly interesting for this section were the interviews with people from software houses and hardware dealers.

The list of interviewed people is given in appendix 7.

General
In Cochabamba there are some software houses and hardware dealers but no hardware industry, nor is there in the rest of Bolivia. There seems to be a company in La Paz building computers from hardware components. There is no specific registration of the IT producers in Bolivia.

Computers are used in companies but not much in private homes. In lots of copy shops in Cochabamba there is a PC and you can let your handwritten report be typed in the computer.

Software
The software houses are small, employing 1 to 4 people. Standard software is not being developed nor traded, just tailor made software. Most of the standard software packages used in companies are illegal copies.

Disadvantages for companies letting a software house do the work are:

* Company secrets may leak out

* Programs specifically made for them can also be sold to competitors

* If companies want to change small things afterwards, they have to hire the expensive software house to do it.

There is no organisation which guarantees the quality of software and which guarantees the integrity of the software houses.

When a software house is asked to make something, the equipment is often already bought by the company.

For a software house it might be better not to document the programs because of piracy. At least it will be harder to adapt the stolen software. The same with the manuals, although users-manuals are made most of the time. As already mentioned, lots of enterprises also do not want to spend money on documentation other then user manuals. There is missing ethics in Bolivia, employees of a software house steal programs and start their own companies on basis of these programs.

Because of the illegal copying of software there are often no up to date versions and no documentation, which promotes the back-ward situation even more. Camacho says that it is not difficult to obtain the last software version illegally.

Hardware
The hardware dealers have a position with a lot of influence. Because it is difficult to obtain information about hardware, they are more or less the ones who can decide which computers the companies are going to use. Most big companies have Wang mini's (Vs 65) at the moment and their programs are in Cobol. At the moment they are switching to Unix.
The main reason is that there is no good database management system for the Wang. They already use the Wangs since about 12 years.

Also the prices of computers are a lot higher than in the United States. Part of this is because of the import tax of 31%, but part because of the monopoly position of the hardware dealers here. Buying equipment directly in the States has the disadvantage that there is no backup service.

4 COMPARISON COMPUTING SITUATION COCHABAMBA AND SELECTED COUNTRIES

4.1 BOLIVIA AS A DEVELOPING COUNTRY

Bolivia is a typical developing country. In this paragraph the characteristics, typical for developing countries, will be discussed per actor, as it was done in chapter 3 and 4; government, enterprises and educational institutions. Some general characteristics are:

General
* There are no forums, computing societies, for exchanging ideas.
* Most software used is pirated, copyright laws are not enforced.
* There is an absence of manpower with adequate computing skills.

Government
* The government does not see information management as an integral part of the developing process.
* The government does not have an explicit policy in the computing area to stimulate the use, to structure education nor to stimulate software or hardware industry.
* A guiding framework from the government which will end, unnecessary duplication of work, wastage of scarce resources and policy conflicts is still not introduced.
* A preliminary assessment of the present state in computing, with an assessment of the macro environmental influences, has never been made.
* Hardware prices in Bolivia are higher than in most Western countries due to import tariffs of 31%.

Enterprises

IT consumers:
* The only type of automatisation known in Bolivia is simple office automatisation.
* Manuals are often lacking. This is one of the reasons why there is under-utilisation of modern (pirated) standard software.
* Managers do not have sufficient knowledge of computing.
* Often the wrong hardware is bought.
* There is a communication gap between users and computing experts.
* More advanced applications (in areas as agriculture and tax registration) thrive on external aid.
* Many companies are small and family owned. Secrecy is associated with their informal practices. This influences computing.
* A lot of processes in companies are not structured, which makes it hard to automatise them.
* The computing expert in a IT consuming company is not functioning as a consultant for the manager.
* There is an inadequate electric power supply.
* The local infrastructure of telecommunication is poor.
* There is a lot of undisciplined system development.

IT producers:
* There is no hardware industry.
* Software companies develop only small tailor made software. Bolivia has a small local software market.
* It is hard to get a loan to start an IT company, the capital market is inadequate.
* There is a lot of undisciplined system development.

Educational institutions
* Educational facilities are inadequate.
* The curricula in education are inappropriate.
* Private training institutions have mushroomed solely with the purpose of spinning money.
* Bolivia has no high level education in computing.

bird's-eye view of situation
Bolivia is a "typical" developing country with respect to information technology. Government policy is lacking, the IT use is low level and the computing education is of a low level and often bad. The only IT production is small tailor made software.

4.2 BOLIVIA AS A SOUTH AMERICAN COUNTRY

As most South American countries, Bolivia does not have a clear policy in computing. The situation compares with the situation in Paraguay: producing small tailor made products, no government policy, no hardware production, hardware dealers include illegal software, lack of educational hierarchy and no research.

Like in Colombia the number of students per teacher are enormous in the public universities, therefore research is not possible.
As in most Latin American countries computing courses are given at the public and Catholic universities and at small private schools [8].

4.3 COMPARISON EDUCATION COCHABAMBA AND THE NETHERLANDS

A global comparison is made between the educational situation in Cochabamba and The Netherlands, but the reader should keep in mind that the demand from business in Cochabamba is very different than that in The Netherlands. In chapter 6, the role of education in Cochabamba, the education will be related to the situation in companies, using the comparison in this chapter.

In drawing up a curriculum there are two points to take into consideration:
A) The academic content of the curriculum.
B) The requirements of the country: what jobs are the students supposed to perform after their study [9].

The differences between Bolivian and dutch curriculum will be listed per item:

General
* A clear Bolivian policy for educational hierarchy is missing. Herefore possibilities to stream from lower to higher levels are undefined. The levels of the trainings should at least be supervised.
* The level of the education in Cochabamba is a lot lower and there are no programs for Master or Phd. Therefore there are no computing specialists who can keep up with the international level.
* The computing education in Cochabamba is less diverse, there is no specialisation.
* In The Netherlands there is no isolation from the rest of the world, they have more up-to-date material, they have on line contact via networks and there is enough money to visit other universities, conferences and workshops and buy books.
* There are no clear thoughts in Cochabamba on what the education should look like. There is no view of computing.

Staff
* The educational background of the teachers in The Netherlands is always of a higher level than the courses they give. In Bolivia this is not the case. In Holland teachers more often have a background in computing.
* In Bolivia there is a shortage of teachers and a lot of them are mediocre teachers. Besides this, they are not open for criticism and therefore are not likely to improve their teaching.
* A lot of people in the Bolivian universities have old-fashioned ideas about including modern

developing tools in the educational programs.
* There is a lack of practical work in the Bolivian universities: this is due to a lack of equipment and a lack of practical experience of the teachers. Teachers often only want to give theory.

Contents
* The mathematics in Bolivia are not applied to computing. Another issue is that often the way the mathematics is given does not lead to a better problem solving because the students have to memorise formulas.
* The Bolivian programmers do not learn how to document a program.
* Courses about modern development in computing science, like fourth generation tools, modern programming languages, distributed systems, multi-media and parallel algorithms are not included at any level in Bolivian education.
* Courses, missing in the institutos in Cochabamba, are e.a. security aspects, ergonomical aspects, effects of automatisation, production automatisation, networks and technical aspects (technical design), documentation of software, methods and tools for system development.

Students
* The Bolivian students do not speak English and have problems reading it. In the area of computing most modern books are in English.
* The Bolivian students have never been trained in problem solving. The "colegios" are concentrated on memorising rather than creative thinking. This memorising is the main cause of the lack of view!

Types and levels in the education hierarchy
* Already named items are, the missing educational hierarchy in Bolivia, the lower level in Bolivia and Dutch education is more diverse.
* Workshops for managers are missing in Bolivia.
* Additional education for computing personnel, to stay up-to-date lacks in Bolivia.
* In Bolivia there are no specific trainings for information analysts
* There is no research in Bolivia because money and manpower lacks. The workload for present teachers is already high and they often do not have an adequate level of knowledge.
* In Bolivia the level of the education is not guaranteed. In Holland there is an organisation which arranges the exams for low level training in computing and private institutes give courses to prepare students for these exams.
* As said, educational hierarchy is missing in Bolivia and at the moment there is kind of a gap between training at universities (Lic./Ing.) and the low level training in the institutos.

bird's eye view of situation
The Bolivian education has no good hierarchical structure. Levels and types of specialisations are not well defined and trainings with the same name may differ a lot. Most trainings are not up to date. High level education is missing (PhD and masters). There is kind of a gap between training at universities (Lic./Ing.) and the low level training in the institutos.

5 ROLE OF EDUCATION IN COMPUTING

5.1 WHO HAS TO BE TRAINED?

Who has to be trained? The satisfactory answer could be :"everybody", from computing specialists like system analysts and designers, (system)programmers and specialists in industrial data processing to users, but especially in developing countries, there is not the money and personnel to implement this.

One can also make a distinction between computing educating and informing, and say that users should only be informed. This informing would lead to "computing literacy".

The users non-participation can lead to obstructing of the data processing development, unadapted, ill-accepted and less efficient data processing. Users can be managers on all levels, operating staff, teachers in primary and secondary schools, etc. [18]. There are also ideas that training of users is not very important.

There are various arguments in favour and against informing:

A) Ideas pro computing literacy

Users should have a basic computing knowledge. Without a widespread appreciation and basic understanding of computing capabilities and limitations, people are unlikely to make use of the technology as well as they should [5].

Education of users will end the under-utilization of information systems [14]. Under-utilisation means that a technically sound information system is not used by those for whom it was intended or is used ineffectively. Users have a lack of understanding of computing although they often have to play an active role in the demand, design and conversion efforts.

Zmud and Cotterman suggest a national strategy to develop an infrastructure for computing by regularly exposing a population to computing. To educate the users, priority should be given to introducing computing materials into established academic programs, especially those in business and public administration [14].

B) Ideas con computing literacy

In developed countries there is a growing support for the idea that computing scientists should develop user-friendly systems and methods and tools to support the communication between users and computing scientists in de development of systems.

Two big issues, in the design of the computing science education, are "whether courses in other areas should be included in the computing science programs" and "whether one should be guided by the personnel demands in the area of computing science"

One of the biggest dilemmas concerning education and manpower is that the educational system has to deliver people who can solve the practical problems in the enterprises but on the other hand there should also be people who can stay into contact with the computing science on an international level. In developing countries these two tasks are in conflict, because the international level is a lot higher than the level used in companies. This question will be included in section 5.3.

There are three ways in which computers can be used in primary and secondary schools: [35]

A) As a tool in classes or outside school. One can use spreadsheets and word-processors in physics, mathematics, biology, etc.

B) As an educating tool. There are educational software packages to learn mathematic, music, etc.

C) In classes about computing science. How does a computer work, what are the underlying concepts, what are the influences of using computers, how did things develop in this area over the years, what are the possibilities in using computers, etc. Computing science would be a basis course like are physics, mathematics and biology. In a special issue of the ACM about computing education a curriculum for such a course is given [35].

5.2 THEORY APPLICATION AREAS INCLUDED?

Should computing science be mixed with other areas? Which courses should be included in the curricula besides pure computing? For example, mathematics, economy, business administration, English and aspects of the profession such as ethics, legal aspects, applied research, etc. can be included. And, the other way around, should courses in system analysis be included in the business-programs?

There are ideas that integration of computing in other areas like business administration, economics, geography etc., should not be implemented because there is too much changing in the area of computing science, and one does not want to change this education every semester [31].

The company managers in developing countries do often not have knowledge in this area. They have no idea what they can do with a computer and think that a computer can do everything, or nothing. If they want to use a computer, they hire someone to find out what he can use it for. So computing specialists should have an understanding of the organisation, and should be able to explain and motivate necessary actions. They are the ones to do proposals. So in developing countries it might be good to include theory of application areas in the computing education.

In Western countries the users have more computing knowledge, so the co-operation between users and computing specialist is easier. Therefore there is an opinion that the pure computing science should be independent of the area it is applied to. Especially because there are so many areas where computing science could be applied, and you can not teach classes in all these fields. People in the other fields should be able to co-operate in developing systems.

5.3 PERSONNEL DEMANDS

Should the educational supply be equal to the demand? As already mentioned in 2.1.4, training and educational needs are different for the different stages of development, implying that the facets of computing education and training should progress gradually as the development continues [13].

But estimating the demand will be difficult. Even if it can be estimated, will it be desirable that the education fulfils the demand exactly?

Why is it difficult to estimate the demand?

* One of the reasons is that there are so many different companies where computing specialists can work, every company will have its own demands for what a computing expert must be able to do. So grouping the different demands will be a job which has to be done first.
  For this reason a diversity of education is logical. Not only because you need people on all levels, but small companies also need people who can do all the jobs while the computing experts in big companies can be specialised in a certain area. So there is just not one good type of education.

* Many jobs are occupied by unqualified people because there are no qualified people, So there are no vacancies for these jobs and there is no direct demand.

* In Holland there are problems in estimating the demand too. One once tried to estimate the demand by calculating the amount of computers. How many people were needed at the different levels per 1000 computers? This idea could not be used [31].

* No exact demand for computing personnel can be estimated from interviews with companies, when there is a great gap between supply and demand (like in Bolivia). The estimates will always be too low [31].

* Not only education is important in the level and type of the demand, but also experience. Experience can become more important than education. How can one include the type of experience in the demand? One cannot set up education based on this demand for experienced people.

A few other problems, specific for developing countries, with estimating the demand are mentioned in the next chapter "Role of education in computing in Cochabamba".

Should one look only at the demand in making plans for education?
A first issue is that, in order to stimulate new applications, the education should not be the same as the demand. For example, in countries where there is no production automatization it might still be interesting to include this subject in the curriculum, to stimulate the use of it. Maybe in developing countries there is no demand now, because this type of automatisation is not yet efficient with the level of wages they have, but one can apply the knowledge in other areas and there might come a demand in a few years. So one should be guided by a view of what is needed tomorrow [31].

A second issue is that many people think that computing science education should be more fundamentally orientated, because things are changing rapidly in this area and it is important to keep up with new developments. Practical knowledge is very soon out of date. A fundamental orientated education will help you keeping up with the changes, more than a practical orientated education. The "courses" for people working in the computing area can be more job-applied and fulfil the demands from business.

Computer programming is considered by some to be a new fundamental resource for developing intellectual skills such as structured thinking and heuristic problem solving. But by just learning a language, and not going deeply into the underlying ideas, people will not improve their thinking skills. The focus is often on a language, not on its usage as a means for learning problem-solving skills [5].

Sculley states that in general, education is not a prelude to a career but a lifelong endeavour [32]. One should learn in an explorative way, so that creative people are formed. In the rapid changing area of computing the contribution of creative individuals, who learn quickly, is very important. In educational institutions there should be no difference between research and instruction, it should be integrated. One way to create a learning environment like this is with the use of hypermedia systems. Hyper media systems are computer systems, in which the delivery of information is in forms beyond the traditional information organisation, one is not limited by a certain order, organisation nor by the type of information.

People trained on a high level are desirable because they can keep up with the changes on the international level, they can inform other people working in this area and they can make policy.

Computing personnel trained on a lower level could be used to fulfil the demand from businesses. These lower level trainings will have to include some new developments in computing science to stimulate the use of new developments in business and to anticipate on the future demand. To make the education more business orientated, (applied) research should form an essential component of educational institution's activities. Organisations using computers might look to these institutions for guidance (consultancy). Also a mechanism of receiving advice from the local data processing industry

should not be left out of consideration. This arrangement should also lead to the placement of trainees and students in an actual working environment to do their practical work [13]. Also scanning new Western developments for inventions they can use, might be more interesting in early development phases than starting with own fundamental research for which a lot of money and knowledge is needed [33].

Said was that diversity in the computing trainings would be desirable, in level and in specialisation [13]. The most common grouping of education is: the areas of pure computing science (software), computing engineering (more system orientated) and business data processing curriculum (information science). The first is to produce graduates to occupy positions relating to computer software design. The second leads to jobs relating to hardware of computer systems. Students from the last training are to start as application programmer and then with experience to move on to do design, development and implementation of user-orientated computer systems. This information science training should essentially be offered by business schools.

There should be training for specialists, responsible for the presence of hardware and the good functioning of the system programs. These people need less knowledge about areas of application but more detailed system knowledge [31].

Is the demand for computing specialists changing very rapidly? One thing is for sure: courses will be more expensive when they are up to date. From Western history one can observe a continuing move through different education levels. By existence of examples and prescriptions, the work, formerly done by highly educated, can now be done at a lower level. But, every year there are more sophisticated systems, so more people on a high level are needed every year [31].

birds'eye view of situation

A country needs computing personnel to fulfil the demand from companies, but there should also be a training for people who can keep up with the international level. Responding to the question whether users should be informed, it is concluded that the priority is to inform managers. Decissions have to be made, because of the lack of computing personnel. Whether computing education should include courses about application areas, depends on the situation in a country. In Bolivia this has not the priority, an exception are the management educations.

6 ROLE OF EDUCATION IN COMPUTING IN COCHABAMBA

6.1 WHO HAS TO BE TRAINED?

Computing experts have to be trained. Whether or not users should be informed about computing is not a point of discussion in Bolivia. There is no organisation in which discussions can take place and no thoughts about this are imported due to isolation from the rest of the world. The educational institutions will have discussions within the organisation.

The last few years more and more schools appeared in Cochabamba which give courses for users.

Users
It was already stated that colegios give courses now and then. The institutos often give courses for operadors and in the secretary courses some computing is included. At the universities courses are given in some fields, but on a level of learning a software package or a language without looking at computing from that specific field.

Managers
There are communication problems between computing experts and users, in particular with managers, because they are the ones to make decissions about computing. The opinion among computing personnel is that especially managers should know something about computing. But in general, there are no ideas about what kind of education managers should have.

At the UMSS they are discussing to include "applied" computing courses in the training of business administration.

Courses for managers about the modern possibilities of computing, for example about multimedia, educational software and expert systems, to stimulate the demand for modern applications, are missing. Computing experts express this demand, but managers do not seem to be willing to go. IDEA, an organisation giving management courses, stated that they were not interested in computing courses. UMSS gave courses like this but most people who came were computing personnel.

Conclusion
Concludes is that besides the computing experts, managers should get training.

6.2 THEORY APPLICATION AREAS INCLUDED?

All the courses given by the institutos are computing courses. In general courses in bookkeeping, information science, etc. are not included in the trainings for programador and operador.

In the universities the situation is different. All trainings include at least english and often physics. English is necessary, because students lack this knowledge and have to read books and manuals in english. The training at UMSS does not include a lot of courses in other areas, just econometrics, economical information systems and book-keeping systems. There are a few more of these courses in the trainings, tele-computing at UPB, computacion cientifica at UCB and, Ingeniero de sistemas and ingeniero de sistemas computacionales y electronicos at Del Valle. Trainings including a lot classes about areas of application are the studies informatica and gestion empresional of UPB, UCB and Del Valle.

6.3 PERSONNEL DEMANDS

The information in this section is obtained by comparing:

* The difference in computing education between The Netherlands and Bolivia (section 4.3).
* The difference in computing education in Cochabamba and the situation in companies (section 3.4 and 3.5).
* The general role of education with respect to the demand for computing personnel in the business sphere (section 5.3).

In Bolivia there is a big difference between the international level of computing knowledge and the national level of use. In general there is the opinion that education should provide people for national companies. There are no trainings at an international level.

To have a more fundamental orientated education in computing is difficult because the whole educational system does not support that. Memorising is very important in colegios and universities. According to Gerrisson, UMSS, this is one of the reasons why educational institutions are often not considered, by companies, to have a lot of usable knowledge. One of the consequences of this is that it is hard to establish applied research in co-operation with companies. The companies are not used to profit by collaboration with educational institutes.

Personnel demand and enterprises
To set up a training to provide people for enterprises, one should know what these enterprises need. There is no uniform idea about what type of education is needed in Cochabamba. So, a more serious study has to be done in this area.

In chapter 5.3 problems were already mentioned in estimating the demand for computing personnel. Stated was that making different categories of computing personnel will be difficult. But in the enterprises in Cochabamba there is no job-related categorisation at all. One uses the type of education to categorise personnel. There are not a lot of different functions within a company while in Western countries there are. So concluded cen be that it is not possible to copy the Western groupings of computing personnel. If the different kind of jobs are not very diverse, the education does not have to be either.

Other problems estimating the demand are:

* A structured market study about the needs of computing personnel is not possible because the managers within a company have little knowledge in the area of computing. There is no demand for (more advanced) computing products from that angle and therefore no specific demand for computing personnel. The computing expert often decides what they can do with computers. The impression that there is not an actual gap between demand and supply is supported by the fact that there are no big jumps in the salaries for computing professionals and the salaries are not very high.

* Most of the time there are no real plans/policies in hiring personnel.

* Because enterprises in developing countries in general only have very short term planning, it is difficult to estimate the demand on a longer term.

Personnel demand and education
Taking in consideration, all these difficulties in estimating the demand and the disadvantages in comparing the demand and the supply of computing experts, impressions of the differences in supply and demand will be stated.

Education/knowledge lacking in Cochabamba:

Market orientated:

* A formal hierarchy in education is missing. The impression is that the training of Tecnico Medios is often at a too low level for the work to be done in enterprises while the Lic./Ing. are working below their level. Because there is almost no training on the level of Tecnico Superior stated is that the most important level is lacking.
  The Lic. and Ing. are less practical orientated and others can do their jobs better. Lic./Ing. could have their hands free with this type of personnel, to work at their own level to stimulate more modern uses in computers.
  These Tecnico Superiores should be able work alone in a company and do all the jobs, but not really on a high level. The training needed for this type of people should include information science courses, software, hardware courses, business administration, security aspects, etc. They should be able to read English manuals so that they can collect computing information with which they can advise managers and make decisions.

* Low level specialisation courses are missing. For example, advanced courses in database packages, courses about networks, theory behind databases, etc. One can already use knowledge like this in the Bolivian enterprises. Documentation knowledge of programmers is lacking.

* Users and managers do not know a lot about computing. Therefore it is very likely that computing experts have to do the information analysis and system analysis as part of their work. Most systems made at the moment are administrative systems. Therefore most computing experts think that courses about application areas, like business administration, bookkeeping or information science should be included in the computing education. This idea is used in some new universities.

* A common complaint was the lack of ethics of computing experts. Further none of the companies had their programs documented. In Chile there are ideas to include ethics, marketing and documentation in some of the educational programs, because these are demands from business.

* Computing specialists need classes in ergonomics, effects of automatisation on the company, security aspects, methods and tools for system development, etc., to widen their view.

* There is a demand for up-to-date computing courses of people working in companies.

International level:

* There are no high level educated people, up to now, who can scan the international developments for usable interesting developments. These people are also needed to teach in the universities where they lack personnel. This type of personnel is not yet necessary in the companies in Cochabamba. But there are a few companies where they could stimulate new applications. Distributed systems, modern programming languages, networks or production automatisation are, in general, not used in Bolivian enterprises.

bird's-eye view of situation

In Bolivia the educational goal is, in order to make money, to fulfil the demands from business. But the ideas about the demands from business are far from uniform. A fundamental orientated education is hard to implement due to the custom of memorising.

7 STRATEGY

7.1 POSSIBILITIES IN COMPUTING FOR BOLIVIA

There are some non-common uses in computing in Cochabamba, most advanced uses thrive on foreign aid:

Non-common uses in Cochabamba

* For example, there is a student in the university Mayor de San Simon who is doing his graduation project in expert systems. He is doing this for a bank and this expert system will help the accountants to check approved credit-requests.

* Elfec, the local power company has a graphical software package (quickbase), with the electrical infrastructure of Cochabamba and by clicking the mouse on the different taps you can open en close them (via radio, the signals are send to the specific tap!).

* Chapare project, a program to calculate the costs and profits of building a certain crop in a particular area of the Chapare, a subtropical zone of Cochabamba.

* Tax system, remarkable for its size and impact. Designed by a foreign software house and partly financed by the world bank. The programming was done by local people.

Advanced uses for Cochabamba

One can never say that there are no uses for computers in a certain area. Western history has learned that it is always possible for creative people to come up with very usable new uses.

Possibilities for more advanced uses of computing science in Bolivia are:

* A major use for the petroleum industry is in the processing of seismic data, which must be analyzed to determine an area's underlying geology and likelihood of containing petroleum deposits [15].

* In the tourist industry: hotel reservation systems, train reservations en bus reservations [34].

* In the industry: microelectronic technology, computer aided design etc. If they persist in building factories which are obsolete before they begin producing, there will be no hope of competing with imports or ever breaking out into export markets. The local consumer must pay more highly for an inferior product than he needs to do if the latest technology is used from the start [34].

* In economies with a shortage of good managers, the emphasis should be placed on improving managerial productivity by providing them with computer-based tools such as management information systems and decision support systems. A good manager will then be able to supervise more subordinates and increase the employment at the lower levels [5]. Systems that support strategic planning and management control, are often developed for personal decision support and for ad hoc decision tasks. This fits in the type of management that exists in developing countries [1].

* Educational software. First research should be done about how the education can be improved and secondly software can be developed as a tool. For example, software that will teach mathematics. One can stimulate the creativity of the students this way. One of the complaints is that the education in Bolivia does not stimulate the creativity of the people and that it is memorising. One should be aware of the fact that educational technology products are not context free. They bring embodied

educational ideas which need to be transparent if a discriminative transference is to be done. Adaption and application to the satisfaction of our own educational needs is required: complete technological transfer must include the underlying concepts, not just the product [5].

* Robotics: These might be usable in the mines, where the working conditions are not very good for human labour. A country that has no intention whatsoever of introducing robots into its own labour--surplus economy, would still be well advised to monitor world developments in industrial automatisation because advantages of indigenous low cost labour might be quickly eroded by cheaper robot based production abroad.

* Applications in agriculture, education, energy, health, industry, nutrition, population, transport and urban planning [5]. One can never say that there are no applications possible in a certain area. Experience shows the use of computers in areas where one never thought computers could be applied.

* Expert systems contain expertise and can replace human specialists They may well be the ideal tool for technology transfer for developing countries. Expert system characteristics, such as the ability to explain the logic used in an answer and the low cost of duplication, contribute to its desirability [8].

* User friendly micro-computer software packages and advanced fourth generation languages should be developed and imported. Modern tools.

* The adjustment of foreign programs to the Bolivian users could also be an area of research in the different developing countries: how can products be adjusted to a culture. What are the characteristics of this country, which influence needs and impressions.

* Monitor current stocks of natural resources (minerals, timber) and land use. Monitor information about the population and make a database of the species living in Bolivia [21].

7.2 PROPOSED STRATEGY

7.2.1 General

Based on the considerations in the previous chapters a strategy has been made made which Bolivia can use to come to development in the area of computing.

One of the big advantages in making a strategy is that one can state our perception of the factors which play a role in our argumentation. One can state arguments which, one thinks, will play a role in the future and which one can already use in our developing plan now. For example, one can take into account our opinions about whether education should fulfil the demand from business or should be more fundamental.

First one has to look at the possibilities of computing for Bolivia. Does one want to create a hardware industry, stimulate software production or only stimulate the use of IT products? Stated was that to develop an IT industry a policy is needed (paragraph 2.1.2.2). So for one of these three events to happen a government policy is needed.

The goal in the presented strategy is to stimulate the use and the production of software. Per actor (educational institutions, enterprises and government) there is decided what has to happen, taking into consideration the present situation. In the last paragraph these policies are integrated to a comprehensive strategy.

To stimulate the goals, the use and production of software, view w.r.t. computing is needed and one has to stimulate this development of view in the strategy.

The first thing which has to be done for all the actors is to stimulate computing related organisations: organisations of educational computing institutions, of software houses, of IT users, an academic society, etc. In these organisations discussions can take place to develop ideas about the necessities in their field and strategies to accomplish them. The organisations can publish articles about subjects relating to the discussions. The academic organisation could be a member organisation of ACM, which would increase the advantages. These computing related organisations could advise the government in making computing related laws.

One of the dangers in creating or subsidizing organisations like this, especially in Bolivia, is that not the best people will participate and that the organisation will fall asleep very soon. Some of these problems can hardly be solved but one could try to reduce them by for example:

* Oblige people to be active: organising courses and seminars
* Let the management of the organisations be people of different ages and different backgrounds in computing science.

7.2.2 Enterprises

IT consumer

Stimulate the demand for software is wanted. The demand for products can be stimulated in two ways. First, one can inform the users and companies, or second, one can offer good computing education. The emphasis of this strategy is to improve education of computing personnel. These better educated people go to work in companies where they can stimulate the IT demand by advising users. Furthermore the government can play a great role in demanding products. By reducing costs of hardware (import tariffs), one decreases the costs and stimulates the use.

IT producers

At the moment only tailor made small programs are made. One has to improve the quality of these programs and stimulate the development of more advanced software. Wanted for them is to finally develop standard software and advanced tailor made software. The demand for these products will be

stimulated. It should be avoided that this demand for products is fulfilled by buying software abroad or pirating software. One can try to avoid the first by offering good computing education. Piracy should be fought.

7.2.3 Educational institutions

Computing education has to be improved. One has to make an educational hierarchy, in which one can use the existing titles (Tecnico Medio, Tecnico Superior and Lic./Ing.) and state the contents and level of the different trainings and what kind of educational institutions can give these trainings. One has to think of a way to "enforce" these recommendations/rules.
One could do this through rules, which can be enforced, but it would be more flexible to do it through recommendations and acknowledge the educational institutions who follow the recommendations. The recommendations should be adjusted every year, if necessary, in the fast changing area of computing.

Education should be more fundamental oriented. This would first require a change in primary and secondary education. A strategy how to do this is beyond the scope of this thesis.

To realise better education, adequate personnel is needed. The current computing experts have to be upgraded and updated and new ones have to be trained. To train the first generation of these experts, there are several options. One is, to send students abroad to do their studies, but this action has too many disadvantages Better is to establishing a regional training centre with neighbouring countries. This training centre could serve as a knowledge transfer point. International help in setting up this centre is preferred.

One of the big problems in education is the low salary level of the teachers. Partnerships between educational institutions and enterprises, in which one can make money, could solve this problem. One can also finance equipment by this. To be able to establish these contacts, companies should already have an initial interest in computing, have a demand for products and think that the educational institutions have something to offer. Stimulating practical working periods of students in companies, courses given by the universities to the companies, can already be started and in later stage, applied research. A long term goal is to establish a Master program and initiating research in computing. First an applied research program, because it is easier to get finances for that.

7.2.4 Government

The role of the government is to support the already mentioned desires from enterprises and educational institutions. These were:

* Support the creation of computing related organisations.
* Set up an educational hierarchy if the computing organisations do not come to one.
* Support education financially; for upgrading and updating they will need money, the teachers should get better salaries so that they do not go the enterprises. This will be a problem because of the lack of money. One could apply for international help.
* Help the national educational institutes in the negotiation with foreign schools to setup a regional school.
* Lower the import tariffs on computer hardware to stimulate the use of computers.
* Demand IT systems from private companies. Nowadays a lot of the software is made within the public companies.
* Make a legal framework, a.o. piracy laws. Piracy might be solved by making rules and enforcing these: One could make a difference between piracy and intellectual property. The policy could be to forbid (and enforce this) software piracy, but accept violation of intellectual property rights for a few years. This could be done in combination with a software import restriction for software. In these years locally standard software can be made in the areas where it is applied most at the moment. Through this policy, the development of an own software industry will be stimulated and in these years they will build up experience in this area. Piracy can not be eliminated by just forbidding it.

Software, manuals and computing science books should be made available at reasonable costs.

Most important however is that the government starts to stimulate a reform of primary and secondary schools. These schools should be more fundamental oriented in stead of the memorising.

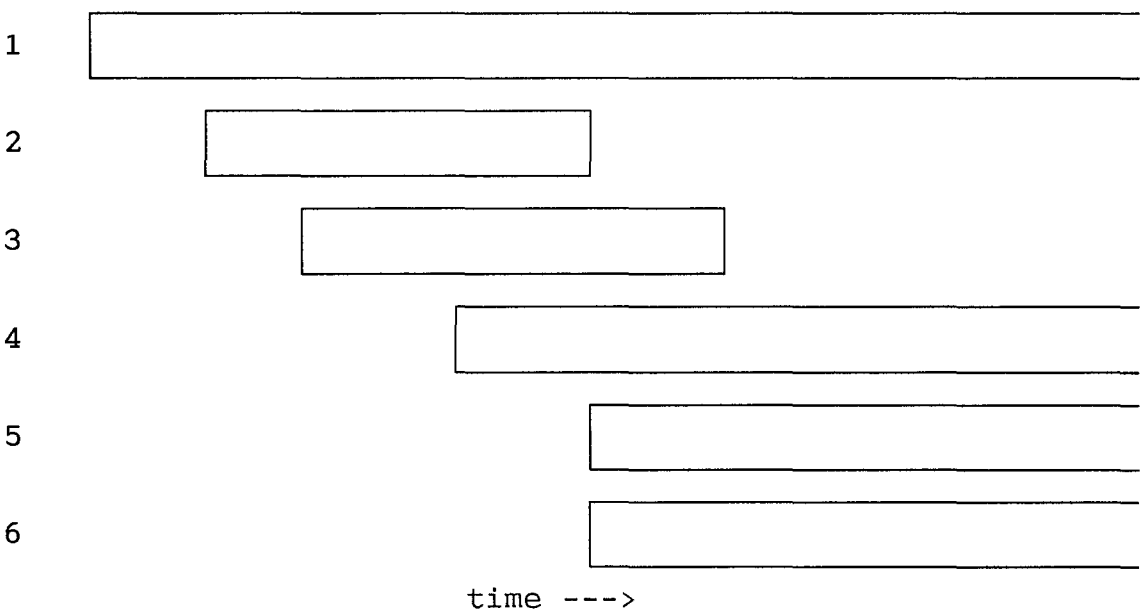
7.2.5 Integration previous sub-strategies

The strategy consists in 6 tracks:

1. Initiating computing organisations.
2. Organising the computing education.
3. Updating and upgrading the current computing experts and train new ones.
4. Establish partnerships between educational institutions and enterprises.
5. Establish a Master program.
6. Initiating research in computing.

The initation of some computing organisations has to be done first. These organisations can give advise on the implementation of the following tracks and help in the implementation. During the first track the government can already work on a reduction of the hardware import tariffs, improve teacher's salaries, make a legal framework and start demanding IT-products from private companies. Track 2 and 3 can be started after the creation of at least a few organisations. One can organise education but without computing experts to fulfill new demand from education it does not mean much. On the other hand it is good for the educational institutions to know the future rules for them, so that they can anticipate in training personnel. For the establishment of partnerships in track 4, companies will have to have some faith already in educational institutions. That is why track 2 and 3 precede track 4. On the other hand educational institutes have to start as soon as possible with these partnerships to earn money and further improve their situation. Track 5 and 6 can start at the same time.

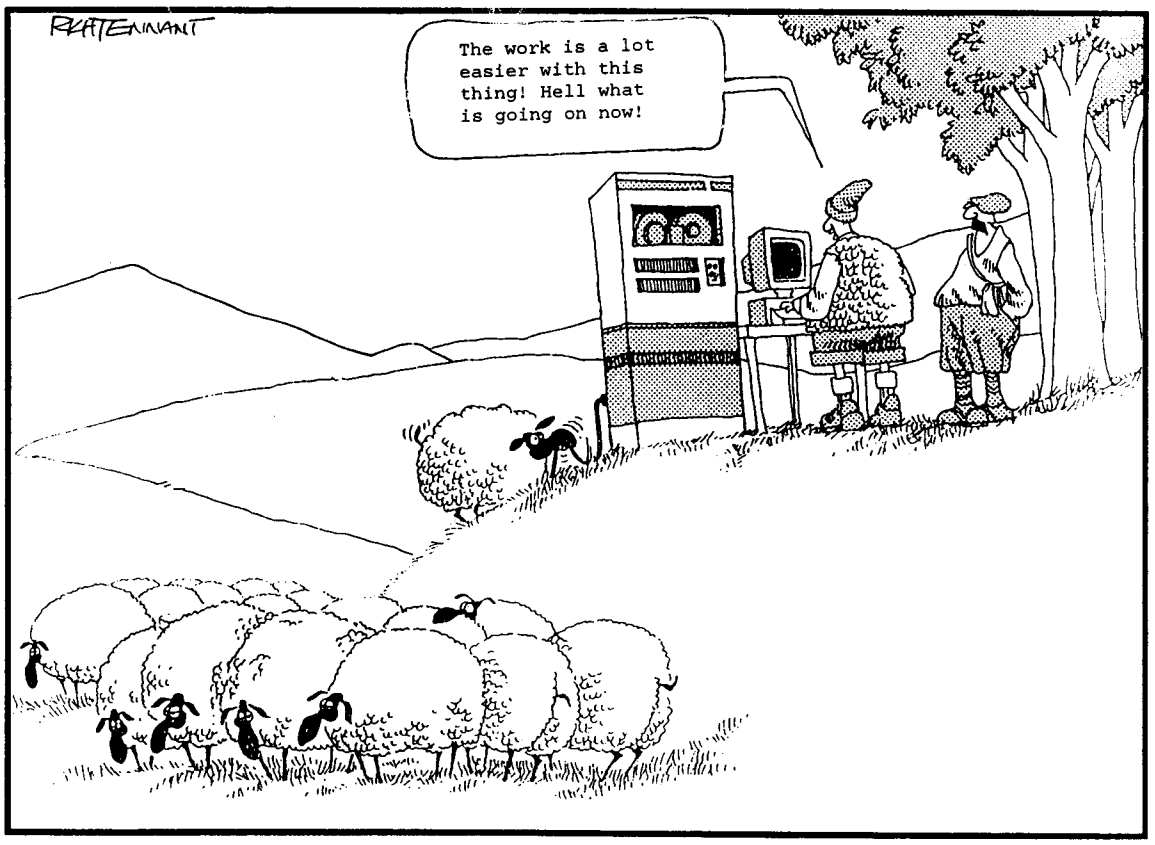
The planning in time for the defined six activities is given in the next diagram:



8 AREAS OF FUTURE RESEARCH

Suggestions for future research are:

* Investigate the possible uses of computers in this country in the process of development. One can start by looking at the major problems of developing countries like the lack of view or the bad management.
* Design a system to collect statistical information about computing related issues, from which one can draw conclusions. Policy can be made using these results.
* A business economic research to investigate the advantages and disadvantages (included a cost-benifit analysis) for a type of IT production in a particular country or region.



REFERENCES

1 Ming-Te Lu and C. Farrell, "Information Systems Development in Developing Counties: An Evaluation and Recommendations", International Journal of Information Management, 1990, 10 (288-296).

2 S.C. Bhatnagar, "Informatics for system analysts and managers in developing countries", 3th world conference on computers in education, WCCE '81 Lausanne.

3 S.S. Agha and S. Akhtar, "the responsibility and the response: information systems in developing countries", Journal of Information Science 18 (1992) nr. 4, 283-292, Elsevier.

4 S.E. Goodman, "Computing in a less Developed Country", Communications of the ACM, December 1991/Vol.34,No.12.

5 Mohan Munasinghe, editor, "Computers and Informatics in Developing Countries", Third world academy of Sciences, Trieste, Italy '89.

6 R.A. Baeza-Yates, D.A. Fuller and J.A. Pino, Innovation as a Critical Success Factor for the Development of an Information Technology Industry in Chile, IFIP 12th World Computer Congress, Madrid, Spain, September 1992.

7 O. Hegazy, M.S. Al-Akabaoui and M. Boshra-Riad, Proposed curriculum for Information Science Education in Developing Countries Environment", 3th world conference on computers in education, WCCE '81 Lausanne.

8 Melissa Rigg and Roberto Mejias, "Information Technology in Uruguay and Paraguay: a study in contrasts", IFIP conference on Social Implications of computers in Developing Countries, Nairobi (Kenya), March 1992.

9 O. Abass, "Problems of Education and Training in Informatics in some African Countries", 3th world conference on computers in education, WCCE '81 Lausanne.

10 Drs. S.B. Luitjens, "informaticadeskundigen: het verhaal van de witte raaf, koning eenoog en de charlatan" Informatie Jaargang 30 nr. 6 pag.393 t/m 460 '88.

11 L. Press, "Strategies for Software Export".

12 G. Jordahl, "Developing Nations consider Market Protecting", IEEE Software, January 1989.

13 D.V. Gulati, "computer education and the needs of developing countries", 3th world conference on computers in education, WCCE, '81 Lausanne.

14 R.W.Zmud, W.W. Cotterman, "A national informatics educational strategy for developing nations", 3th world conference on computers in education, WCCE '81 Lausanne.

15 E.J. Cabrales and J.P. Eddy, "informatics education in Colombia", Journal of information Science volume 18, number 3, 217-224, 1992.

16 S.P. Weisband and S.E. Goodman, "International Software Piracy".

17 M. Quirino and J.M. Graca Martins, "Integrated Education with Informatics: Its Implementation in Developing Countries", 3th world conference on computers in education, WCCE '81 Lausanne.

18 L. Bouras, "training, an essential condition for data processing development in developing

countries. The role of co-operation", 3th world conference on computers in education, WCCE '81 Lausanne.

19 United Nations, "Development and Transfer of Technology Series" no 22, "informatics for industrial development" '85.

20 L. Press, "computing in Chile: Leading the Way for Other South American LDCs", Communications of the ACM. December 1991/Vol.34,No.12.

21 R.L. La Rovere and S.E. Goodman, "International Perspectives: Computing in the Brazilian Amazon", Communications ACM, Vol 35, nr.4 1992.

22 J. Palmer, "Computer Education in Ecuador: preparing for a competitive future", T.H.E. journal, january 1986.

23 Europe World Yearbook 1992.

24 Landerbericht, Bolivien 1991, Statistisches Bundesamt.

25 The American Review 1991/1992, twelfth edition, the economic and business rapport.

26 Bolivien, Fernando Soria.

27 Proposal Informatics Law, Bolivia: Camara de diputados comision de informatica, proyecto de ley nacional de informatica, juli 1990.

28 Bolivian newspapers 28-04-93.

29 Lenny Sanabria, Mery Rocha y Jaqueline Maranon, "Investigacion de la Computacion en Colegios e Institutos" private rapport UMSS 1992.

30 Rules for the institutos, Resolucion Ministrial No 64/84 januari 1984.

31 "Over informatics onderwijs", een verkenning in opdracht van de ministers van Buitenlandse zaken, Economische zaken en Onderwijs en Wetenschappen.'81

32 J. Sculley, "the relationship Between Business and Higher Education: a Perspective on the 21st Century", Communications of the ACM, September 1989, volume 32, number 9.

33 R.B. Reich, "The Quiet Path to Technological Preeminence", Scientific American, October 1989.

34 R.B. Davison, Information Technology in the third world, University of Manchester, Manchester Training Handbooks '83.

35 Communications of the ACM, may 1993.

APPENDIX 1

Curriculum UMSS:

The "old" program of UMSS contains:

* semester 1: combinatoria 1, calculo 2, algebra lineal, informatica 1, ingles 2.
* semester 2: combinatoria 2, informatica 2, calculo 3, probabilidad y estadistica 1, sistemas contables.

* semester 3: sistemas de procesamiento de datos, estructuras de la informacion 1, analisis numerico 1, calculo 4, probabilidad y estadistica 2.
* semester 4: programacion de sistemas 1, estructuras de la information 2, probabilidad y estadistica 3, investigacion operativa 1, analisis numerico 2.
* semester 5: cibernetica 1, bases de datos 1, analisis de sistemas 1, teoria de la computacion, investigacion operativa 2.
* semester 6: base de datos 2, diseno de compiladores, cibernetica 2, analisis de sistemas 2, sistemas de informacion economica.
* semester 7: sistemas operativos, recuperacion de la informacion, simulacion de sistemas, econometria.
* semester 8: redes de ordenadores, ciencias de la computacion 1, planificacion de tesis de grado.
* semester 9: evaluacion de sistemas de computacion, ciencias de la computacion 2, tesis de Licenciatura, electiva.

APPENDIX 2

Curriculum UPB:

* semester 1 : algebra y logica formal, quimica, matematicas para ingenieria 1, computacion para ingeniera, comunicacion oral, ingles. * semester 2: matematicas para ingeniera 2, mecanica clasica, probabilidad y estadistica, programacion 1, comunicacion escrita, ingles 2.
* semester 3: ecuaciones diferenciales, electricidad y magnetismo, metodos numericos, programacion 2, estructura de datos.
* semester 4: circuitos electricos, campos y fis del edo solido, programacion lineal, fundamentos de ing. de sistemas, contabilidad basica, administracion de empresas 1.
* semester 5: circuitos electronicos, electronica digital, investigacion de operaciones 1, analisis y diseno de sistemas 1, base de datos 1, administracion de empresas 2.
* semester 6: arquitectura de computadores, sistemas digitales, simulacion, analisis y diseno de sistemas 2, contabilidad de costos, topicos selectos 1.
* semester 7: microprocesadores, redes de computadores 1, fundamentos de inteligencia artificial, analisis y diseno de sistemas 3, sistemas admitivos e industriales, topicos selectos 2.
* semester 8: liderazgo y direccion, sistemas operativos, proyecto de diseno 1, analisis y deseno de sistemas 4, topicos selectos 3, optativa 1.
* semester 9: taller del ejercicio profesional, sistemas distribuidos, proyecto de deseno 2, administracion de centros informaticos, topicos selectos 4 y 5, optativa 2.

For the topicos selectos, it is possible to choose courses out of the two areas of specialisation.

The courses in tele computing are : transmission de datos, comunicacion digital, redes de computacion 2, configuracion y manteniento de hardware, control de calidad y confiabilidad.

Courses in gestion empresional are: bases de datos 2, analisis financiero, auditoria financiero, auditoria de sistemas de informacion, politicas y estrategias empresiales.

There are obtional subjects like: derecho laboral, psicologia, mercado tecnica, administracion de recursus humanos, preparacion y evaluacion de proyectos, produccion.

APPENDIX 3

Curriculum UCB:

* semester 1: algebra basica, introduccion a calculo, introduccion a la informatica, introduccion a la economia, introduccion a la administracion, lenguage.
* semester 2: estructuras discretas, calculo 1, fisica 1, ingles tecnico, lenguajes computacionales.
* semester 3: calculo 2, algebra lineal, probabilidad y estadistica 1, fisica 2, programacion 1
* semester 4: calculo 3, probabilidades y estadistica 2, sistemas digitales, estructura de datos, taller de programacion.
* semester 5: calculo 4, analisis de algoritmos, investigacion operativo 1, tecnologia de computadores, organizacion del computador.
* semester 6: analisis numerico 1, investigacion operativa 2, teoria de sistemas, sistemas operativos 1, lenguajes de programacion.
* semester 7: investigacion operativa 3, sistemas de informacion, ingeniera del software 1, sistemas micro economicos 1, organizacion y manejo de archivos.
* semester 8: simulacion y modelaje, sistemas contables, diseno y administracion de una base de datos, optativa 1 y 2.
* semester 9: sistemas financieros, marketing, redes y sistemas distribuidos, optativa 3 y 4.
* semester 10: seminario de tesis, optativo 5,6,7 y 8.

From the 8th semester on one can choose out of two areas: computacion cientifica or gestion de empresas.

Courses in the first area are: calculo 5, programacion 2, sistemas operativos 2, lenguages formales, automatas finitos, analisis numerico 2, ingenieria del software 2, teoria de compiladores y inteligencia artificial.

Courses in the second area are: muestreo estadistico, sistemas microeconomicos 2, sistemas de produccion, analisis de decisiones, planicacion y control estrategico, organizacion y comportamiento en la empresa, formacion y evaluacion de proyectos and sistemas macroeconomicos.

APPENDIX 4

Curriculum Universidad Del Valle:

A) ingeniera de sistemas :

* semester 1: algebra 1, calculo 1, informatica 1, computacion1, elementos de logica 1, quimica general, ingles 1.
* semester 2: algebra 2, calculo 2, informatica 2, computacion 2, elementos de logica 2, fisica 1, ingles 2.
* semester 3: estructura de datos 1, programacion logica 1, sistemas operativos 1, sistemas contables, ecuaciones diferenciales, fisica 2, ingles 3.
* semester 4: estructura de datos 2, programacion logica 2, sistemas operativos 2, sistemas administrativos, cicuitos electronicos, sistemas digitales 1, ingles 4
* semester 5: diseno de bases de datos 1, analisis y diseno de algoritmos, computabilidad y lenguages formal, sistemas deductivos, methodos numericos, sistemas digitales 2, ingles 5, taller informatica 1.
* semester 6: diseno de bases de datos 2, redes locales y com. de datos, diseno de compiladores 1, inteligencia artificial 1, estadistica computacional, microprocesadores 1, ingles 6, taller informatica 2.
* semester 7: diseno de compiladores 2, recuperacion de information, inteligencia artificial 2, optimizacion de sistemas 1, sistemas paralelos 1, microprocesadores 2, taller informatica 3.
* semester 8: ingenieria de software 1, ingeniera de informacion 1, diseno de sistemas expertos 1, optimizacion de sistemas 2, sistemas paralelos 2, taller informatica 4.
* semester 9: ingenieria de software 2, ingeniera de informacion 2, diseno de sistemas expertos 2, ingenieria economica, sistemas distribuidos, taller informatica 5.
* semester 10: tesis de grado.

B) Licenciatura en informatica de gestion

This program has the about the same elements as the program ingeniera de systemas, but the pure ingeneering courses like fysica, quimica, sistemas digitales, microprocesadores, circuitos electronica are more or less replaces by courses in gestion.

* semester 1: algebra 1, calculo 1, informatica 1, computacion 1, elementos de logica 1, contabilidad 1, ingles 1.
* semester 2: algebra 2, calculo 2, informatica 2, computacion 2, elementos de logica 2, contabilidad 2, ingles 2.
* semester 3: estructura de datos 1, programacion logica 1, sistemas operativos 1, contabilidad administrativa, ecuaciones diferenciales, informatica 3, ingles 3.
* semester 4: estructura de datos 2, programacion logica 2, sistemas operativos 2, sistemas administrativos, methodos numericos, modelos economicos 1, ingles 4
* semester 5: diseno de bases de datos 1, analisis y diseno de algoritmos, sistemas deductivos, modelos economicos 2, informatica administrativa 1, estadistica computacional, ingles 5, taller de sistemas 1.
* semester 6: diseno de bases de datos 2, redes locales y com. de datos, inteligencia artificial 1, metodos econometricos, informatica administrativa 2, optimizacion de sistemas 1, ingles 6, taller de sistemas 2.
* semester 7: recuperacion de information, inteligencia artificial 2, optimizacion de sistemas 2, sistemas paralelos 1, sistemas de administ. financiera, informatica economica 1, taller de systemas 3. * semester 8: ingeniera de informacion 1, diseno de sistemas expertos 1, sistemas paralelos 2, sistemas de gestion de empresas 1, informatica economica 2, taller de systemas 4.
* semester 9: ingeniera de informacion 2, diseno de sistemas expertos 2, sistemas distribuidos, preraracion y evaluacion de proyectos, sistema de gestion de empresas 2, taller de systemas 5.

* semester 10: tesis de grado.

C) ingenieria de sistemas computacionales y electronicos

* semester 1: algebra 1, calculo 1, fisica 1, computacion 1, quimica, ingles 1.
* semester 2: algebra 2, calculo 2, fisica 2, computacion 2, ingles 2.
* semester 3: calculo 3, ecuaciones diferenciales, fisica 3, circuitos 1, estructura de datos 1, ingles 3.
* semester 4: circuitos 2, electronica basica 1, medidas electronicas, sistemas digitales 1, estructura de datos 2, methodos numericos, ingles 4.
* semester 5: diseno de bases de datos , computabilidad y lenguages formal, electronica basica 2, sistemas digitales 2, estadistica computacional, ingles 5, taller computacional 1.
* semester 6: redes locales y com. de datos, sistemas operativos 1, diseno electronico, diseno de compiladores 1, microprocesadores 1, ingles 6, taller computacional 2.
* semester 7: sistemas CAD electronicos, sistemas operativos 2, diseno de compiladores 2, arquitecturas del computador 1, metodod de inteligencia artificial, microprocesadores 2, taller computacional 3.
* semester 8: electronica industrial, microprocesadores 3, ingeniera de software 1, arquitecturas del computador 2, metodos de sistemas expertos, taller computacional 4.
* semester 9: robotica 1, ingenieria economica, arquitectura avanzado del computador, ongenieria de software 2, taller computacional 5.
* semester 10: robotica 2, tesis de grado.

D) Tecnico Superior This program contains classes out the program of Licenciatura en informatica de gestion. The program is not only less years but also the amount of courses per semester is less.

* semester 1: algebra 1, informatica 1, computacion 1, elementos de logica 1, ingles 1.
* semester 2: algebra 2, informatica 2, computacion 2, elementos de logica 2, matematica discreta, ingles 2.
* semester 3: estructura de datos 1, programacion logica 1, sistemas operativos 1, sistemas contables, informatica 3, ingles 3.
* semester 4: estructura de datos 2, programacion logica 2, sistemas operativos 2, sistemas administrativos, ingles 4, taller tecnico.
* semester 5: diseno de bases de datos 1, analisis y diseno de algoritmos, computabilidad y lenguages formal, informatica administrativa 1, taller tecnico 2.
* semester 6: diseno de bases de datos 2, redes locales y com. de datos, diseno de compiladores, informatica administrativa 2, proyecto tecnico informatico.

APPENDIX 5

Curriculum institutos:

CEIN/CENACO
The courses in the program for programador are: Introduccion a la informatica, calculo1, algebra1, ingles technica, arguitectura de computador, programacion modular, sistemas operativo: DOS/WANG, algebra lineal, lenguaje Basic, programacion estructura, language essemble, organizaciones, estructuras de datos, language Cobol, base de datos, aplicaciones (Contab, Estad), recursividad, lenguaje C, metodologia WARNIER, introduccion al diseno de sistemas, lenguage Clipper, Laboratorio de aplicaciones.

Gemicon
The program for programador includes:
pascal, cobol, c, fortran, prolog, languajes formal, paquetes de applicacion (hojas electronicas, bases de datos, procesadores de palabras), systemas operativas (Unix and Dos) and metodologias.

Del Valle
The first year of the program for tecnico superior is the equal to the program for programador (this year is about equal to the other for programador). The second year includes classes like matematica aplicada 1 (algebra), turbo Pascal, matematica aplicada 2 (calculo), lenguage C, diseno de sistemas, estadistica basica, introduccion al assembler, introduccion a la intelegencia artificial, proyecto de grado.

Instituto Latino Americano
The courses in the program analista in systemas are:
introduction a la programacion, calcula1, algebra, sistemas contables, traduccion tecnico1, calcula 2, informatica 1, algebra lineal, sistemas administrativos, traduccion tecnica 2, estadistica descriptiva, informatica 2, probabilidad y estadistica 1, sistema de procesamiento de datos, combinatoria, programacion de sistemas, estructura de informacion, probabilidad de estadistica 2, sistemas economicos, programacion de sistemas 2, cibernetica 1, sistemas de informacion 1, investigacion operativa 1, analisis numerico 1, sistemas de informacion 2, analisis de sistemas 1, investigacion operativo 2, proyecto de grado.

APPENDIX 6

List educational institutions:

Los Universidades
1 Universidad Mayor de San Simon
2 Universidad Del Valle
3 Universidad Catolica (participante al sistema Universitario Boliviano)
4 Universidad Privada Bolivia

Los Institutos
1 Instituto Latino Americano, Uruquay entre 16 de julio y Oguendo
2 Jaime Carranza Siles, Heroinas 471 entre 25 de Mayo y San Martin, Tel. 2-6282
3 Westinghouse, Calle Baptista 132 entre Heroinas y Colombia. Tel. 2-2725
4 Bits, Calle Espana 442. tel. 2-6295
5 ING. Data, esquina Espana y Colombia
6 Olac, Ladislao Cabrera 308 esquina Estevan arce
7 ASC2, San Martin 161 entre Heroinas y Colombia. Tel. 24374
8 ICI, (Instituto de Computation Integrada) Baptista entre Heroinas y Ecuador
9 Gemicom, Heroinas y Tumusla
10 Instituto America de Computacion, 25 de Mayo 628 entre Ladislao Cabrera y Uruguay. tel: 2-5018
11 Siscomp. L Cabrera 378, entre Estevan Arce y 25 de Mayo
12 CENACO/CEIN, G. Acha entre Junin y Hamiraya
13 Centro Computacional Del Valle, Ave. San Martin esq Venezuela 504. tel. 24649
14 Centro de Educacion Informatica Aplicada "San Pablo", Columbia-Tumuzla
15 Cipec, Ayacucho entre Calama y Jordan
16 Univalle, dependiente de la Universidad Del Valle
17 Cursos UMSS
18 Instituto Educacion Mercantil, IDEM Antezana-N 584
19 Academia Comercial "14 septiembre", Bolivar entre Lanza y 16 de julio
20 Ilvem, Bolivar 573 entre Lanza y San Martin tel 28080
21 Instituto Westinghouse 2, Heroes de Chaco 43 Quillacollo tel 60243
22 Ibatur tel 24556
23 Centro Educativo Adventista de Bolivia, San Martin entre Bolivar y Heroinas
24 Boliviano/Argentino
25 Instituto de Computacion Blas Pascal
26 Bolivian Comercial Institute
27 Instituto Comercial "Prado"
28 Escuela Comercial Contable y Computacion
29 Infonet, calle pacheco tel 60394, Quillacollo
30 Instituto de Computacion "Epson System/2"

APPENDIX 7

List of interviewed persons:

* Pablo Artero, director de Femco (manufacturer a roofs with a medium size) , director Empresarios Privados de Cochabamba, 1-04-93.
* Arturo Camacho, director de Centro Nacional de Computacion de Cochabamba, 30-03-93.
* Ronny Baldivieso, works in the computing department of the regional electricity company, ELFEC, 19-05-93
* Rolando Jaldin, works in the computing department of the national electricity company, ENDE. Has a Lic. in computing science, 14-05-93.
* Felipe Guzman Brockman, the Bolivian representative of Clei, an organisation for computing science in Latin America, working in CORDECO, the state planning institute, 5-04-93.
* Emma Laredo, works in the computing department of the Bolivian state airline, Lloyd. Has a Lic. in computing science, 07-4-93.
* Fernandez Lopez, works in the computing department in the university Del Valle and he is owner of the Instituto Informatica Ltd, which just started giving courses, 6-04-93.
* Luis Jaurequi, owner of an one-man software house. Lic. in computing cience 28-04-93.
* George Pero, works in the computing department of Manaco (shoe manufacturing, part of the Bata. Manaco has about 500 employees. 13-05-93.
* Jose Pacheco, director the CENACO La Paz, 13-04-93
* Samuel Lujan, works in the computing department of Promotora, a financial institute, 11-05-93.
* Jorge Lopez, owner of software house Simec where work 4 people, Lic. in computing science, 10-05-93.
* Marco Peredo, works for Systeco, the largest hardware dealer in Cochabamba, 29-04-93.
* Miram Uscamaita, works as a programmer for the Administracion Regional de Impuestos, student Lic. computing science, 7-05-93.
* Antonio Anaya, works in the computing department in Taquina, the beer factory with 400 employees, 19-05-93.
* Peter Weiss, director of a medium leather factory who is part time teacher in the computing department of the state university, 16-04-93.
* Jose Anez, works in the computing department of Coca Cola, 3-06-93.
* Roberto Torres, head of the computing department of Yacimientos, 1-06-39.
* Gonzalo Cespedes, head of the computing department of Lloyd, 16-07-93.
* Ing. Jose Morales, owner of EME, a hardware dealer, 16-07-93.
* David Escalera, Lic. in Analasis de Systemas, Argentina. Works in South American Corp., a hardware dealer, 13-07-93.
* Eric Peredo, 8-07-93.
* Vladimir Amurrio Albarracin, 12-07-93.
* Dr. Jack Gerrisson, dutch expert in the MEMI project, UMSS, several meetings.
* Lic. Ramiro Fernandez, head of the department of business administration, UMSS, 11-8-93.
* Lic. Pablo Azero, working in the computing department of UMSS.
* Oscar Pino, head of the computing department of UCB, 17-03-93.
* Juan Carlos Gaphard, head of the computing department of UPB, 19-03-93.

APPENDIX 8

List of concepts:

Colegio is the primary and secondary school in Bolivia.

Computing, information technology (IT) and computing is the design, implementation and maintenance of a computer-supported information system.

Computing personnel, computing experts are the people working on all levels in computing. This can be in the IT producers, enterprises who use computers, research, education, policy making etc. Someone who enters data in the computer has nothing to do with the design, implementation or maintenance of a computer-supported information system and therefore is not a computing expert. In Bolivia however one does include this type of personnel in the definition. Therefore at some points they will be included, but it will be mentioned explicitly.

Egresados are students in a Ing./Lic. program, who have finished all there courses and can start their thesis.

The *GNP* is the gross national product.

HBO is a certain type/level of education in The Netherlands.

High level computing personnel in Bolivia stands for personnel, often with a university degree, working on a higher level than a programmer of simple office automatisation. Included are system analysts, computing division manager, policy makers etc. A problem with the use of this concept is that most computing experts do all types of work within companies and there is not a real job division in Bolivia like in The Netherlands.

Information management, information policy is a policy directed at obtaining, storing and distributing information in a certain area. The storing and distribution can be done with the help of computers.

Ing. or Ingeniero is the title one gets after finishing a technical study at a Bolivian university.

Instituto is the educational institution in Bolivia in which trainings are given for tecnico medio and tecnico superior.

The *IT producers* include hardware producers (producers of computer components and related equipment like e.g. printers and modems), software houses, hardware shops and computer service agencies. Computing education will not be included.

Lic. or Licenciatura is the title one gets after finishing a study at a Bolivian university.

MBO is a certain type/level of education in The Netherlands.

Operador is the job of managing a computer, e.g. entering data.

Programador means programmer.

Tecnico medio is the title students get in Bolivia after finishing a certain type/level of education.

Tecnico superior is the title students get in Bolivia after finishing a certain type/level of education.

UCB is the Catholic university in Bolivia.

UPB is the private university in Bolivia, founded by the "Federacion de Empresarios Privados"

UMSS stands for Universidad Mayor de San Simon, the public university of Cochabamba.

People having *view* w.r.t. computing are people who have developed opinions about computing related issues like the possibilities of computing for a company, the possibilities of computing for a specific country, what computing education should look like and how a government can stimulate computing. People having view w.r.t. computing do not have to be computing experts.

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