ASSESSMENT OF THE CURRENT STATUS OF INFORMATICS IN COLOMBIA'S UNIVERSITIES AND SOCIETY

DISSERTATION

Presented to the Graduate Council of the University of North Texas in Partial fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Eusebio Jose Cabrales, B.S., M.S.

Denton, Texas

August, 1991
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This study tries to delineate the paradigms of opinion among Colombian Computer Industrialists with respect to the role of informatics in national development especially (1) their estimation of the performance of the informatics in the modernization process, (2) the perceptions on which this attitude was based, (3) their ability to integrate the informatics instruction into the development process, (4) their ability to establish the need of doctoral programs in informatics into the development process, and (5) their ability to recognize the importance of the network communication as a medium of knowledge exchange among higher education institutions.

The data was gathered by a mailed questionnaire from a population of 346 chief executive officers of software and hardware companies. Personal and mailed interviews were performed with 10 Chairmen of the systems engineering departments from a selected group of Colombian universities to get an insight view of the Colombian informatics instruction scenario. The sample size selected was 25 percent of the population size which totaled 87 persons with 62 persons responding. In addition, 11 different chief executive officers of Colombian companies were interviewed.
Findings of this study include: (1) the need for the Colombian government to invest more in informatics development at all levels of instruction, (2) the need to build the infrastructure to educate masses of programmers needed by an increasing demand of the national and international software market, (3) the need of an official support for the creation of Doctoral and research programs in informatics, (4) the interconnection of the Colombian higher education institutions by electronic mail as a short-term goal, (5) the joint venture between Colombian official companies and institutions of higher learning as a way to supply the Colombian information society with powerful tools like supercomputers needed for optimization of natural resources utilization, and (6) the inclination of the Colombian industrialist to prefer fully connected Local Area Networks (LAN) rather than supercomputers and mainframes of the same memory capacity.
ACKNOWLEDGMENTS

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I also extend my appreciation to my mother, my sister, my brother and his family, and friends for their help in distributing, administering, and collecting the questionnaires. At a personal level, I have been blessed with a full complement of my dearest mother, my sister, and my brother and his family. They supplied me with limitless emotional and intellectual support.

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The means of subsistence in our society have changed several times during the history of mankind, but basically these changes can be divided into three stages (Sculley, 1989): the first stage was when human beings changed from a nomadic life to a sedentary society; the second stage was when technological advancements allowed man to change from an agricultural society to an industrial society. This important step took place during the nineteenth century, but it was not the result of a sudden event. This change was a consequence of the intellectual knowledge accumulated in man's mind since the beginning of human existence.

The third stage was when man developed machines that could take over physical labor. This freed his mind to start thinking about new ways to improve machine production and complex mathematical models were developed to simulate machine performance. The creation of these new paradigms originated the need for powerful number-crunching that could solve the complex mathematical equations obtained from abstract models created by the human mind. This was the beginning of a new science, informatics, that has revolutionized the world during the last forty-five
years, so we are living in a new stage of transformation in our society. The most developed countries around the world are evolving from industrial societies toward information societies (Toffler, 1983). Computer literacy is an important topic that each individual should be aware of; this knowledge will be more important in future societies.

The mass production of computer chips has contributed to the dissemination of computer usage in the classroom. Third World countries face the possibility of falling behind if they do not keep up with new technological changes. The prices of agricultural products that have been the main source of foreign currency for these countries have had the tendency to deteriorate, leaving the economy of these countries without the reserve of hard currency needed to function in the commercial world. Noteworthy is the fact that less developed countries must improve their computer education if they want to function successfully in the commercial world of the future. With these ideas in mind, the Colombian government has begun working to improve the informatics knowledge of its people (Palacios, 1990).

Computer instruction at the university level started in Colombia in 1963 with the beginning of the undergraduate program at the Universidad de los Andes (Martínez, 1989). After twenty-eight years of continual teaching of computers in some institutions of higher education, computer instruction is now developing rapidly (A. Echeverri, personal
communication, December 14, 1990). This study will assess the opinions of the Colombian industrial sector concerning the strengths and weaknesses of computer instruction in Colombia. The actual tendency of the Colombian educational system has been to emphasize the preparation of students in the technological field. Thus, so more government resources and efforts have been placed on the development of technological institutions at the high school level. As a consequence of this diversification of funds, most state universities lack resources to maintain an adequate academic level.

Since 1984, the Colombian government increased the utilization of informatics as an instrument for development. Various actions have been taken by the national government in order to strengthen and update the actual informatics programs according to the existing Colombian situation. Government projects can be divided into the following areas: informatics education, informatics industry promotion, public administration information system modernization, and justice administration information system update (ACUC, 1988).

The informatics secretary of the Colombian presidency has worked in the subareas of informatics diffusion and pilot projects in the area of informatics education. Knowing that informatics is present in all sectors of national life and that its introduction creates deep changes in society, special attention has been given to supply Colombians with an adequate
level of informatics knowledge (ACUC, 1988). Today, several specific actions have shown results. The government has established twenty-one Informatics Diffusion Centers (IDCs) in different cities around the country. Through these IDCs the Colombian government intends to enable (in information systems) all Colombians and give them the opportunity to get closer to the new technological advances in this field (ACUC, 1988).

According to this national democratization policy of information systems knowledge, the Colombian government through the Secretary of Informatics started creating Informatics Diffusion Centers in 1983 in collaboration with other official institutions such as: the National Service for Learning (Servicio Nacional de Aprendizaje: SENA), state universities, and some government offices.

The service supplied by the IDCs is free; it is an open door program. It gives priority to government programs, looking especially for the people that do not have easy access to computer technology. The IDCs try to educate the general public, giving everybody the opportunity to get some basic knowledge in this field. The IDCs are equipped with the necessary elements that allow the user direct contact with the technology. Computers, basic software, didactic material for computer instruction, and the human resources needed to achieve computer literacy of the Colombian people are available (ACUC, 1988). The courses that are taught in the IDCs are introductory in nature. These courses give the student a beginning
education in different computer languages and general applications programs such as data bases, wordprocessors, and electronic spreadsheets among others. The IDCs have a time schedule that public entities, especially educational institutions, can use to develop their own programs using the IDC installations.

In Bogotá, there are three IDCs that started before 1985. Eighteen more were created between 1985 and 1988 in the rest of the country. The experience with these centers has been satisfactory; the IDCs have been received positively throughout Colombia. During the year 1987 alone, 101,477 persons attended the existing centers (ACUC, 1988). The interest in the program in informatics in Colombia is stronger and the number of persons working at the centers is increasing every day.

The informatics secretary of the Colombian presidency has developed this program step by step, planning, assisting, and controlling the centers' operations since their creation. Today there is a clearer idea of the importance of informatics for communities in Colombia. The Colombian society hopes that this state operation will continue to give the tools needed to educate the Colombian people in one of the most important areas of contemporary science.

Informatics has also been used as a learning tool by the government. Moreover, several pilot projects have been developed in private and public schools around the country. It can be shown that the findings of these
projects will be important in the development of the students' academic life. As Colombian universities begin to fully incorporate computers in every aspect of the educational process, students will graduate better prepared to deal with the socioeconomic realities of the future. These projects should contribute to innovation in the educative process and to modernization of school equipment. In this study, the investigator not only tried to assess the opinion of persons in the Colombian information sector on informatics, but also to identify whether or not the actual status of informatics in Colombia is fulfilling the needs of the industrial sector.

**Definition of Terms**

**Artificial intelligence:** The study of how to make computers do things to improve the ability of persons (Rich, 1983).

**Computer literacy education:** Basic computer studies as part of general education in order that students may have knowledge of (1) the development of information processing, (2) the basic concepts of computer hardware and software, (3) the social impact of computer usage, and (4) the ways in which computers are applied (Sanders, 1977).

**Curriculum model:** A symbolic representation of the curriculum content and the implementation strategies for an educational program (ACM, 1968).

**Colombian industrialist:** The subject of this study, a Colombian
industrialist is a person who has computer expertise and is employed as an executive in a Colombian computer company.

**Computer science:** The art and science of representing and processing information and, in particular, processing information with the logical engines called automatic digital computers (Forsythe, 1967).

**Informatics:** A discipline which includes structure and properties of information and communications as well as theory and methods for the transfer, storage, retrieval, evaluation and distribution of information. It also includes the process and activities that mediate knowledge from source to user and are based on systems, cybernetics, automation and technology for human work environments in timely and current praxis (Samuelson, 1978).

**Local Area Network (LAN):** A communication network linking a number of nodes in the same local area, variously defined as the same building, a radius of one kilometer, or a single plant (Oxford Dictionary of Computing, 1990, p. 257).

**Microcomputer:** A general term referring to a complete tiny computing system, consisting of hardware and software, and whose main processing blocks are made of semiconductor integrated circuits (Gupton, 1980).

**Simulation:** The process of designing a mathematical or logical model of a real system and then conducting computer-based experiments with the
model to describe, explain, and predict the behavior of the real system (Naylor, 1966).

**Supercomputer:** A computer with extremely large direct-access storage capacity, low storage-access time, ultra-high switching speeds, and fast operational speeds, perhaps using optical storage, rather than traditional magnetic storage (Hwang, 1984).

**Workstation:** A relatively large (greater than 50 pounds) and expensive ($10,000 to over $100,000 in 1985) personal computer, with the appropriate transducers, used by a professional to carry out generic (e.g., calculation, mail, and communication) and profession-related activities such as music composition, financial modeling, or computer-aided design of integrated circuits (Bell, 1988).

**Statement of the Problem**

The objective of this study is to determine the Colombian industrialists' opinions about the status of informatics in Colombian universities and society.

**Purposes of the Study**

1. To evaluate the Colombian industrialists' opinions on a series of questions regarding computer science instruction in Colombia.

2. To investigate the opinions of Colombian industrialists toward computer technologies regarding the current level of development in Colombia.
3. To investigate to what extent computer instruction is providing professional computer training according to the needs of Colombian industry.
4. To investigate if Colombian industrialists favor the use of simulation in computer instruction.
5. To trace the paradigms of opinion among Colombian computer industrialists with respect to the role of informatics in national development.

Research Questions

In order to accomplish the purposes of the study, the following research questions were utilized:

1. What are the Colombian industrialists' opinions about the computer instruction at Colombian universities when evaluated by gender?
2. What similarities will appear in the opinions of the Colombian industrialists toward the utilization of computer technologies when evaluated by sex, age, education, and professional experience?
3. Do the industrialists believe that Colombian universities are fulfilling the needs for informatics in instruction, funding, curriculum and degree programs?
4. Do the people in the industrial sector believe that supercomputers are important in improving Colombian technology?
5. What is the Colombian industrialists' preference regarding network systems or supercomputers when referring to computer utilization?

6. What do industrialists think about using simulation for instruction?

7. What are the Colombian industrialists' opinions about the worldwide sharing of information among institutions of higher learning?

8. Do the industrialists believe that Colombian universities can produce quality software for the external market?

**Significance of the Study**

Expectations are that the results of this study will provide useful information to help educational administrators make decisions concerning computer literacy at the university level and aid curriculum designers in planning an instructional program of computer literacy to cope with Colombia's societal and technological environment. In summary, the goal of this study is to develop a framework and procedure for the design and implementation of a curriculum according to the needs of the Colombian information society.

**Limitations of the Study**

Limitations of this study are:

1. The study cannot control the bias, expectations and perceptions of the Colombian industrialists responding to the instrument.

2. The instrument was designed by the researcher and reviewed by a group of ten Colombian students attending the University of North Texas.
Five Spanish and 2 statistics professors at the University of North Texas and a group of department heads, selected from 10 Colombian universities, also reviewed the instrument. The instrument was standardized by a pilot study performed in Colombia at the Colmotores Company Systems Department during the Summer of 1990 (Wiersma, 1986).

3. The representatives of the Colombian industrial sector were selected from the Colombian Industrial Directory.

4. The study only considers the computer companies in the following Colombian cities; Bogotá, Medellín, Cali, and Barranquilla where 90% of the Colombian computer industry is located.

**Basic Assumptions**

During the development of this study it has been assumed that:

1. There is a need for computer literacy at the general higher education level in Colombian universities (A. Echeverri, personal communication, June 6, 1990).

2. The academic goals of the computer studies can be derived from subjects identified as relevant to computer literacy (Neill, 1977, p. 37).
INTRODUCTION

The need for computer literacy among the college and high school student population throughout the world is something that no one can deny. Less-developed countries need to adapt their educational systems to meet the technological challenges or changes that the next decade is going to bring to human society.

The importance of communications in our modern era has been increased with technological advances. The facility with which a researcher can obtain information plays a key role in the development of any scientific project. A world map showing the flux of electronic information indicates that the distribution pattern and the exchange of this information obey the same model that has been governing the economic world for the last hundred years. The amount of data transferring among countries that constitute the northwestern hemisphere of the planet is more intense than among countries of the southern hemisphere. The South-American, African, and some Asian countries seem excluded from the
knowledge exchange that is happening every second via electronic mail among the world's main research centers.

One might ask what the necessity of electronic mail is if we can obtain the same results via ordinary mail? Sending and receiving information via electronic mail is going to increase the information handling of the organization. In the long run the investment in a Message Handling Service (MHS) is going to return a profit because of the time saved and for the opportunity to exchange actualized information with other researchers, something that is difficult to quantify with material goods in a short time (Gurbaxani, 1990).

The ideas that come to the mind of a scientific researcher in a developed country are not a product of improvisation or pure intuition. Almost always this creative process has passed through a maturation phase of several years where the scientist considered has been exposed to the most sophisticated technological advances in his/her field. The facility of handling information will be a key factor in the role that a particular society is going to play in the future (Toffler, 1990).

Mahabala (UNESCO, 1985), speaking about the impact of microcomputers on less-developed countries (LDCs), expressed that users in developed countries see microcomputers as personal computers. In contrast, the view is different in less-developed countries where they have
been viewed as inexpensive replacements for mainframe computers. Microcomputers in LDCs are the most important tool for information processing for small businesses. With the new workstations' processing power, the paradigm for informatics development adopted by these countries is the Local Area Network (LAN).

Computers are invading daily lives more, in such a way that to function successfully in a developed society, every person has to have some kind of computer knowledge and skills. Otherwise, that person will be relegated to perform menial jobs due to the lack of computer skills. Creativity and critical thinking are two competencies that every nation that is interested in the development of its own people must incorporate into the school and college curriculum. Techniques like computer simulation, artificial intelligence, and robotics will permit scientists to reduce the cost of experimental studies. In order to develop these techniques in a Third World country, it will be necessary to create a community of computer scientists. These scientists will develop the models necessary to represent different real situations for a determined environment. Watt (1980), speaking on enhancing computer literacy, suggests the creation of an on-campus paradigm of society to investigate the mental effects of increased student interaction with computers. This paradigm should reflect the social and administrative changes that computers can bring to the school
organization; this scenario will give the students a good preparation for the real world.

Higher education institutions play a significant role in this kind of development. Massachusetts Institute of Technology (MIT) is an example of how an institution of higher learning can contribute to the scientific development of a society. Shrock (1982), describes the contribution of the Department of Geology at MIT to the development of this field in the United States. During the last forty-five years many research projects have been conducted in a wide practical and theoretical aspect there. MIT's experience with joint-industry ventures is extensive and reaches virtually every program area in the Institute. More than 300 joint programs are currently sponsored at MIT by industrial firms. Federal sources nonetheless provide the bulk of funding for research. In 1983, only 10% of MIT's sponsored research was funded by industry. Estimations are that support from industry will not grow beyond 15 or 20%. However, MIT faculty point out that industry involvement is important because it provides exposure to and understanding of industrial concerns, motivations, and needs. This interaction is seen as critical for the future of most students who graduate from the university to work in the information technology field. Equally important, it provides necessary expansion of academic research concerns that would otherwise be guided primarily by the interests of particular federal funding agencies.
With this in mind, Third World countries should create technological institutions of higher learning oriented toward the preparation of engineers, computer scientists, and mathematics teachers in order to prepare new generations for the next century. Eisemon (1982), speaking about the scientific communities in Africa, Asia, and Latin America comments about the difficulties of scientists in less-developed countries where the common denominators are poor facilities, scattered and insufficient research support, and bureaucratized government agencies administering science funds, which are assigned by capricious political manipulation.

A good way to start an evaluation of the current status of informatics in a society is to perform a self-assessment survey among the different members of this particular society. This survey would reveal whether or not the education system is fulfilling the needs of the community. The survey must include suppliers and consumers of the education system, and must compare their opinions with the existing situation. The identification of the technological gap that exists between developed societies and underdeveloped societies ought to be one of the topics investigated by this survey.

The changes influenced by modern technology have brought about the development of computer aided teaching facilities on and off college and university campuses. An era of transition began almost fifty years ago with
the development of the first computer. Our society is rapidly changing from an industrial society to an information society. Capital, labor, and raw materials will no longer be key factors of our development. Knowledge, creativity, and information are the roots of any cybernetics transformation. For that reason, what should be included in an academic program of computer science is a very controversial issue which has been debated in many papers (Abshire, 1981; Beck et al., 1989; Denning et al., 1989; Koffman et al., 1984).

The National Council of Supervisors of Mathematics in 1978 considered computer literacy as one of ten basic skills in which an individual should have to satisfactorily function in a technological society. Students should be conscious of the many applications of informatics in their communities and schools should make computer instruction a primary target when considering individuals' knowledge. Individuals who lack computer knowledge will be functionally illiterate because they will not be able to fulfill the requirements of government, industry, or business job demands.

From an epistemological point of view, the Association of Computing Machinery (ACM) curriculums of 1968 and 1978 are the most thorough papers on this subject (ACM, 1968, 1979) and have been the main sources of reference for this study. The 1968 report is one of the most rigorously scrutinized studies in this area and has been the bedrock in the
development of most university computer science undergraduate programs in the United States. The 1978 report has received much criticism for the lack of mathematics credit hours in its content (Ralston & Shaw, 1980). Both reports expose in a detailed manner how and why some subjects should be included in the undergraduate computer science curriculum.

Many experts believe that the notion of a core and canon curriculum is not applicable as a general idea because there are so many variables involved that the model applied in a determined situation may not include the behavioral variables that define that particular situation. Furthermore, the dependency of external variables like, for example, the needs created by the corporate world, defines the kind of specialization necessary for a computer science professional to be competitive in the job market. Couger and McFadden reported in 1981 that computer systems were involved in almost every event of daily human activity. Today, computer intervention has increased dramatically and computer skill is a basic requirement to function successfully in our modern times. In The Occupational Outlook Handbook 1990-1991, the U. S. Department of Labor expresses its opinion about the use of computers in a modern society. The department emphasizes that when users develop a more advanced knowledge of computers, they become more conscious of the machine's potential and better able to suggest ideas that will increase their own productivity and that of an organization. Furthermore, decreasing
prices of computer hardware and software are encouraging more small businesses to systematize their operations, creating more demand for systems analysts.

White and Hubbard (1988), in attempting to peer into the future of education, said that the technological influence in schools and schooling will depend on the human factor. And while it is imperative that teachers face the challenges electronic technology places before them, being knowledgeable, responsible and committed educators is the most important element regardless of the particular technological advances that appear in the years ahead.

Computer chip design improvements have occasioned a fall in computers prices. Nowadays, computer designers are working on computers that can perform functions in parallel, but the common user is more interested in reliability and low cost than in how the function is performed inside the computer (Singleton, 1989). This special circumstance has created a heavy demand for software developers. The use of microcomputers to facilitate learning has yet to make an appreciable inroad into the teaching-learning process in most developing Third World countries. The purchase cost and maintenance expenses of the equipment are the major inhibiting factors related to the adoption of this high technology in these countries. However, studies performed in these countries have indicated that the interactive use of the computer resulted in
significant attitude changes and higher scores (Okebukola & Jegede, 1990). There is a study (Yuexiao, 1988) that clarifies the idea of information by dividing the range of definitions into different parts and identifying several points of misunderstanding. It covers the sciences relating to the concept of information, the nomenclature of informatics, informatology, information science, and the multidimensional properties of information. These concepts have been subjects of study in several parts of the world.

**European Studies**

The impact of technology on society has been discussed by the Dutch-Speaking Society of Comparative Education in a Pre-Congress Reader (Van-Poucke, 1985) prepared to stimulate discussion about the impact of technology on society and on education in general, and to provide some insights into the opinions of Dutch and Flemish researchers working in the field. This publication addresses topics such as what information technology instruction should encompass in general compulsory education and in vocational education; discusses the complex issues involved in the development of educational policies in the study of science, mathematics, and technology; describes the knowledge of information technology needed by future teachers, the teaching of informatics in Flanders, and the computer and teacher training in Flanders; and examines changes in secondary education caused by the introduction of information technologies.
New developments in mathematics, informatics, physics, chemistry, biology, and related fields will impact curricula in the 1990s. New interdisciplinary approaches to science instruction, more flexible forms of education, and improved science teacher education are needed. All of these topics have been addressed in previous studies (Malitza, 1982). Six research studies relating to computers in education have been summarized in the article "Research Windows" (Collis, 1988). The research areas include the use of computer generated graphs in critical evaluation and in learning distance and velocity concepts, sex differences in graphing skills, student evaluation of courseware, career paths of women with technological education, and characteristics of effective in-service programs.

A description of the experiences of the Research Group on Education (RGE) at the Bulgarian Academy of Sciences and the Ministry of Education in using limited computer resources when teaching informatics is the main topic for the article published by Nikolov and Sendova. Topics discussed include group projects, the use of Logo, ability grouping, and out-of-class activities, such as publishing a student magazine (Nikolov, 1988).

Cognitive-development, informatics, concept-formation, epistemology, and sex differences are interrelated in the paper "Information Technology and Education: The Developing Perspective" (Nielsen, 1986). The general stem of education is seen as building possibilities for obtaining experiences and acquiring knowledge, hence the
development of cognition. The knowledge ideal in education is understood within the framework of the historically produced scientific ideal, which also indicates the road by which knowledge may be obtained. This historical production may be characterized by a growing polarization in gender where the qualifications ascribed to the feminine ideal become devalued and repressed, whereas those ascribed to the masculine become ennobled as the road to knowledge. It is in relation to this that the computer as a tool in informatics— the embodiment of the masculine ideal— is comprehended. Nielsen argues that in order to ensure the development of knowledge, the feminine universe of interpretation is a necessary complementary approach. The point of departure for this shift is a greater emphasis on the uniquely human modes of cognition: the sensorimotor, the emotive, and the symbolic.

A theoretical discussion of what information science can contribute to the health professions written by Lunin and Ball (1989) addresses questions of definition and describes application and knowledge models for the emerging profession of health informatics education. A review of existing programs includes curriculum models and provides details on informatics programs emphasizing information and computer science, health sciences, and specialized informatics programs.

Based on the results of an assessment of 241 teaching-learning programs in basic and applied sciences, Lauterbach (1989) discusses
possible criteria for the assessment of educational software. He also offers suggestions for potential users, for practitioners of teacher education, and for the developers of educational software.

The European study entitled "New Information Technologies in Higher Education: Studies on the Introduction of New Information Technologies in Higher Education in the European Region" is an overview of the current status of new information technologies (NIT) in teaching, training, research, and the administration of higher education internationally. The study includes 25 papers (Calude, 1989).

A West German study (Fauser & Screiber, 1989) deals with the interviews of 2,645 eighth-grade West German male and female students to determine: (1) the computer experience gained by students in their leisure time; (2) the knowledge they would like to acquire at the school; and (3) the influence of vocational orientation on students' readiness to learn about computers. It describes preconditions and develops arguments for instruction in computer and information science.

An annotated bibliography contains 302 references to materials in English and in French that deal with the introduction and development of computer technology in secondary education systems in various countries. Topics covered by the bibliography include national policies, teacher training, human resources development, informatics as a subject, and computerized ways and means in education (Baron, 1989).
Educational objectives and practices related to computer technology in the Hessen (Federal Republic of Germany) schools are outlined, with an emphasis on secondary education. For the past decade, a new school subject, informatics, has been promoted by the State Ministers of Education and Cultural Affairs. The objectives of this course are to provide students with a familiarity with algorithms and their programming, insight into the construction and functioning of a computer, and knowledge of the applications and effects of informatics. In Hessen, information technology is currently treated as a separate subject only in certain branches of schools, because of the need for teacher training and considerable investment costs of equipment. However, over half of the gymnasiums and vocational schools and 26% of the comprehensive schools have computer equipment. Informatics is considered a school subject for senior gymnasiums and can be chosen as the third or fourth subject in the university entrance examination. Informatics classes are also offered in some junior high schools. Vocational schools stress the use of computers as tools for data processing and programming and for job training in the business sector. The future tasks of the State of Hessen will be to develop relevant teaching courses and to provide schools with contemporary equipment (Vilmar, 1983).

Several studies have been performed in Eastern Europe. A Bulgarian study describes how informatics is being integrated into
Bulgarian schools' curricula through the use of microcomputers, Logo, and appropriate software. A set of problems that could be used for introducing informatics is presented, based on the programming notions of loop, recursion, and coding (Nikolov, 1987). Because of the widespread use of microcomputers in Bulgaria, informatics education for all college students is considered both possible and necessary. Uses of microcomputers in various disciplines are described in the paper "Microcomputers and Informatics Education at the University Level," including those in mathematics, mechanics, the experimental sciences, and humanities. Brief comments on computer-assisted learning and teacher education are also provided (Boyanov, 1984).

Bollerslev describes a Danish program designed to provide future teachers with practical knowledge about information technology and the ability to assess the impact on school and society. He also discusses promoting the use of computers across the curriculum and elaborates on problems that were encountered in planning the program (Bollerslev, 1988).

Van-Weert reviewed in-service programs and school programs in vocational higher education, primary and special education, and secondary education in The Netherlands. He describes the goals and results of the Informatics Stimulation Plan (ISP) and suggests priorities for new policies of the Ministry of Education (Van-Weert, 1988). Another Dutch study describes the organizational structure and activities of the Center for
Education and Information Technology (Netherlands), a national organization for exchange and distribution of the latest scientific and technical developments in information technology and its application in education and a service institute to better the use of educational technology and stimulate its functioning (Moonen, 1985).

A report that contains the proceedings of a regional workshop on the training of secondary school teachers in the use of computers in general education was written to launch a pilot project for the countries of Europe and to stimulate international cooperation in the field. Introductory materials note that the tasks set for workshop participants included the examination of 11 case studies prepared under contract with UNESCO; the identification of innovative trends in pre- and in-service training of secondary school teachers in this area; and the development of proposals for regional and international cooperation in the implementation of the regional pilot project for the biennium 1988-1989. The report is divided into three parts: (1) background of the workshop, including objectives, participation, documentation, and organization; (2) results of the workshop proceedings, including examinations of the case studies, strategy guidelines, resource implications; and (3) proposals for regional and international cooperation, including criteria, principles, application areas, institutions, and cooperation (UNESCO, 1986).

A survey of informatics development within Danish schools
discusses the report of the Johnsen Committee, which was mandated to undertake an assessment of public teaching of informatics; computer education in primary schools, general secondary schools, and secondary vocational schools; computing capacity; the situation of the municipality of Odense; and system software and programming languages. Another European study (Gwyn, 1982) describes ways in which educational policies are seeking to meet the challenge of new information technologies which have emerged and are emerging in three educational systems in the United Kingdom. Curriculum, funding, strengths and weaknesses of the British approach, and the strategy paper of the Microelectronics Education Programme are highlighted. Gorny (1982) discusses the development of informatics and computer-assisted learning for general and vocational education in German schools. This included policies and trends, curriculum development, activity at different school levels, technical prerequisites, teaching staff prerequisites, adult education, and teacher training and research development trends in higher education.

A brief overview of the state of the art in computer education in the schools in the Federal Republic of Germany covers both the extent and areas of use and research and development. Frequent comparisons are made with educational computer usage in other countries, including the United States, Japan, Great Britain, and Norway. The curriculum for computer education in upper secondary schools, which is called
informatics in Europe and computer science in the Anglo-Saxon world, is then described. Noteworthy is that all schools at this level have been equipped with computers. The current status of computer education in grades 5 through 10 is also described, including the educational orientation and curricular guidelines. Three reasons why programming is not considered a central focus for students at this level are discussed: (1) user software and software tools make personal programming for the majority of the population superfluous; (2) students do not have enough time for training and practice; and (3) programming courses cannot be required with the idea that they promote cognitive development. Noteworthy is that there is very little going on in computer education in West German primary schools. A brief review of computer usage, including comparisons with activities in other countries, and an outline of areas of research that are of special interest to West Germany conclude this paper (Frey, 1986).

An overview of the use of computers in education in three developed countries (the United States, the United Kingdom, and France) begins by tracing the history of its development. Significant research and programs, general trends, the current situation, plans, and problems in each of the countries are discussed, including statistics on the number of schools with computers, the amount of student usage, and the cost of programs. Ways in which computers have been introduced in these countries are compared, and differences in the strategies used are discussed. A more general
discussion of the situation in other developed countries covers problems with hardware, software, teacher training, and evaluation of the effectiveness of computers for improving the educational process. A discussion of the use of computers in developing countries addresses similar problems in different cultural environments and educational systems. Policies and strategies for introducing computers in education at any level are also discussed, including policies for professional training, use of computers in schools, hardware, software, teacher training, and research. Final remarks are that, although there is a definite danger of increasing the gap in the level and quality of education between those countries that make massive use of computers in education and those that do not, the appropriate use of computers in developing countries can be a way of decreasing the gap (Hebenstreit, 1986).

An evaluation of an informatics program in several European countries was based on students' academic success from 1973 to 1979. Four main influences in the course's success were analyzed: curriculum development, qualifications of students applying for the highly-mathematical course, increase in faculty, and correlation of curriculum and student qualifications (Ulricht, 1982).

Experiences in the development of educational software in The Netherlands have included the use of individual and team approaches, the determination of software content and how it should be presented, and the
organization of the entire development process, from experimental
programs to prototype to final product. Because educational software is a
relatively new phenomenon in education itself, it is not easy to determine in
advance the actual desires of the potential user; current production
strategies are based on either an individual approach, a team approach, or
a project approach. None of the educational sectors has reached the stage
at which it would be profitable to publish the materials developed.
Guidance tools, project management and system development
methodologies, and the organization of education into macro, meso, and
micro levels have been developed to support software development.
Working out problems has led to (1) the separation of different subsystems;
(2) determining detailed pedagogical design; and (3) designing the system
by which the encoding takes place. In order to stimulate the introduction of
computers in education, the Dutch government established the 5 year
"Informatics Stimulation Plan"; three development centers, each one
specifically aimed at a particular sector of education; 28 regional centers for
education and information technology; and a clearinghouse for educational
software. The need for teacher training programs to include courses
illustrating the use of computers as educational aids is noted (Moonen,
1986).

By the year 2000, European higher education institutions must
achieve many aims. These include the following: resolve the conflict
between the social demand of education and the costs of higher education without lowering standards; provide continuing education to deal with the rapid changes in technology and increased periods of leisure and/or unemployment; build even closer links between industry, public services, and higher education in the field of informatics; and infuse new talents into static academic manpower. Informatics may enable the achievement of those aims. The move to distance education and independent learning will accelerate through computer conferencing, cable television and videocassettes, computer-based audiographic systems, and interactive videodiscs. New technologies offer an alternative model to the large, centralized specialist system, because they are both easy to access and easy for teachers to use. The technology needed to achieve these aims is here now, and will become increasingly easier to use. The main barrier is the inability of large institutions to carry through the fundamental changes in organization, financial arrangements, and teaching strategies that are essential if flexible, off-campus teaching is to be achieved (Bates, 1984).

The citizens of tomorrow need to understand the role of information in political systems; computer technology and information storage, retrieval, and use; the implications of information systems for individual rights; the impact of computer crime; and databanks and systems analysis on the social, economic, and political spheres (Glenn & Klassen, 1983). Malitza believes that new developments in mathematics, informatics,
physics, chemistry, biology, and related fields will impact curricula in the future. He recommends new interdisciplinary approaches to science instruction, more flexible forms of education, and improved science teacher education (Malitza, 1982).

The new institutional ordering between university and industry in the European scenario, as well as those among university, industry, and government, is manipulated by many elements. These include the need for new knowledge and the application of advancing technologies in new products and processes; the efficient use of high technology manpower and ensuring a renewable supply of manpower resources; and economic survival and future industrial growth.

Latin American Studies

The findings of a survey of 474 Latin American projects that used educational technology at all educational levels are discussed by Chadwick. The successes and failures of projects using television, radio, audio-visual materials, film, computers, and printed materials are described in his article (Chadwick, 1982). The influence of information policies in Mexico is described by Montoya (1988). Three basic considerations are examined in this study: "(a) The factors producing this qualitative technological change, and the economic and political consequences of its social uses, (b) the notion of associated-dependent capitalist development, and (c) the analyses and explanation of State policies in independent capitalism.". It is stated in his
conclusions that state policies should be oriented towards building this national technological capacity and the number of specialized technicians increased. He also discusses how the role of education is subordinated to the political decision for building an informatics industry.

"Creating a Global Agenda: Assessments, Solutions and Action Plans" by Howard F. Didsbury is designed for educational policymakers and researchers. This volume on global issues is divided into four sections. The first and second sections of this report deal with subjects that are not related to informatics. For that reason, only the third and fourth parts are considered. In the third section, "Responses to Technological Change," the author covers a wide variety of issues including capitalism in the Information Age, the future of the humanities, technological change and employment policies, lifestyle changes, and informatics-based mass education. The fourth section, "Early Warning Signals," contains two papers concerning computers and the future of privacy (Didsbury, 1982).

A discussion of personnel development and inexpensive equipment needed for successful educational technology programs in economically hard-pressed areas in the United States and in Third World countries is presented in the article "Suggestions for Maintaining Educational Technology Programs in Hard-Pressed Areas" (Green, 1984).

An article written by H. Arzinian in 1988 describes the national policy on informatics in Argentina, lists government efforts to enhance
computer literacy, and discusses the social context of computers. It also calls for teacher training in computer techniques and highlights the importance of computer resource specialists in schools.

The Academy for Educational Development's Clearinghouse on Development Communication (1985) has summarized what this agency has learned about communication and informatics from various perspectives, and discusses the future use of new technologies, such as telecommunications and computers in its paper "Beyond the Flipchart. Three Decades of Development Communication."

The use of informatics resources in educational testing in different areas of the world is discussed in "Changing World Patterns of Machine-Scored Objective Testing: The Expected Impact of the Multi-Digit Method." Three paradigms are described: the first pattern refers mainly to American universities where maximum current usage of machine scoring is found in introductory courses with large numbers of students; the second paradigm highlights universities found throughout Europe and some United States schools, pointing out that these universities make little use of machine scoring in spite of financial resources to do so; and the third paradigm mainly addresses developing countries in Latin America, Africa, and Asia where the limited use of machine scoring and little financial support are found (Anderson & Saliba, 1987).

"Informatics and Small Computers in Latin America" is the title of
an article that highlights potential benefits and more pressing social and legal problems facing Latin American nations in the area of informatics and small computers. Discussion covers potential uses (education, office applications, agriculture, national planning); the role of central governments; implications for economic development; and transborder data flows (Alvarez, 1985). The impact of informatics and its role in education in Latin America and the Caribbean is described in this document. Some Latin American educators think that computer literacy can give new generations better working opportunities in the society of the future and improve the level of education in general. An article by Martin Carnoy, Hugh Daley, and Liza Loop, "Education and Computers: Panorama and Reality," evaluates these arguments. The relation between the cost effectiveness of education in Computer Assisted Instruction (CAI) is compared to the rates of student success and future employment. Research indicates that only a small fraction of jobs require higher skills, and that CAI seems to promote faster learning, especially among slow learners. However, the cost of equipment and capable personnel may be too great in countries with a low per capita income (UNESCO, 1987).

The topic of informatics in Latin America is discussed by Correa in his article "Informatics in Latin America: Promises and Realities." This report examines the current status and future directions of information technologies and informatization processes in Latin American countries.
Topics discussed include the diffusion of information technologies, foreign trade, local production of computer hardware and software, information policies, and regional cooperation (Correa, 1989). Some Latin American countries have established a national policy for informatics. Brazil, for example, which has restricted foreign involvement in the national computer industry (Figueiredo, 1987). In this study the governing agencies are described, controversies and debates surrounding the policy are summarized, and the reaction of the American government is discussed.

A case study on Brazil describes the use of microcomputers for library automation, and the relationship of this application to that country's national policy on informatics. The discussion begins by comparing applications of computers in libraries in developed and developing countries. Several barriers to library automation in developing nations are noted, e.g., the lack of the sophistication of users, the lack of specialized human resources and equipment, the high cost of developing computer systems, and the lack of agreement on a common bibliographic format. Still, it is observed that library automation has been proceeding in Brazil since the 1960s, and encouraging signs are noted, including the implementation of guidelines developed by the Brazilian Institute for Information Science and Technology (BIIST). It is suggested that although BIIST has recently undergone internal restructuring, the most difficult initial steps in library automation have already been completed in Brazil,
and it remains to be seen whether "political fluctuations" so common to developing nations will interrupt the planned steps for library automation in the country.

The computer education in Brazil is examined by Machado (1985). A complete assessment of the Brazilian situation was made based on the naturalistic mode by conducting interviews with Brazilian decision makers from the computer industry, education, and the National Congress. Findings of the study include the need for more government investment for research and development. Implementation should be aimed at secondary schools. Policy needs to be decentralized and designed to correct socioeconomic imbalances.

Schrader sets forth the chronology of disciplinary names that have been used in scholarly literature over the past 80 years to characterize information science and its antecedents: bibliography, documentation, scientific information, information retrieval, information science, informatics. Future research needs are also discussed (Schrader, 1984).

"Informatics and Telematics in Health: Present and Potential Uses" is a World Health Organization (WHO) report that focuses on technical issues associated with informatics, a term covering all aspects of the development and operations of information systems, the supporting computer methodology and technology, and the supporting telecommunications links. The first of six chapters discusses the purpose
of the report together with basic assumptions about health care systems as related to informatics and the use of computer-based information processing and transfer in telecommunications, key computer applications in health, and current trends in these rapidly evolving technologies as they apply to health. The following chapters deal with a national health informatics policy and strategy; informatics support for health programs and the provision of health care; informatics for health manpower development; and the choice of informatics technology. It is concluded that informatics will be increasingly used in all organizations and that its use must be managed. Three appendices contain a list of participants in the international consortium on application of informatics, brief descriptions of sample curricula, and an eight-page glossary (WHO, 1988).

**Asian Studies**

The results of a seminar in which representatives from Australia, New Zealand, and eight Asian countries discussed interdisciplinary research in education have been published. In a report, types of interdisciplinary research were identified and the conditions necessary for its development were examined. The recent impetus toward interdisciplinary research has emanated from concerns about economic and national development, social justice, implications for national unity of linguistic and ethnic diversity, and a representation in schools of continuing cultural and social traditions. In some nations, there is limited
knowledge on the part of educational researchers; for instance, researchers need to know more about informatics and communications technologies (UNESCO, 1984).

A case study on the importance of telecommunications in improving access to specialized information needed for development was conducted by a national team and carried out through a series of meetings in Jakarta and Bandung. The people contacted included Indonesian officials responsible for national development in information and telecommunications, actual and potential major users of data communications, and officials of two regional organizations. A general description of the Indonesian situation is followed by a review of current data communication technology, including computer networks, data networks, and ISDN (Integrated Services Digital Networks); packet switched data networks; and tele-informatics services (Battu, 1984).

An investigative study whose main purpose was to identify and analyze computer literacy and general attitudes toward computers of students at Thai public universities found that there was a strong positive relationship between Thai students' knowledge and their attitudes toward computers. Education majors displayed higher computer literacy levels than mathematics majors and science majors (this result shows a strong divergence when compared with the environment in the United States). It was recommended that computer literacy should be seen in relation to its
contribution to the educational process as a whole (Skulkhu, 1989). A purpose of an Iranian study was to identify the attitudes of Iranian scholars regarding computer use in Iran. The objective was to look for any relationship between attitudes toward general use of computers and demographic variables such as age, education, subject area of teaching and professional experience. The findings revealed that the majority of academicians believed that Iran needs computers to achieve modernization (Family, 1980).

**American and Canadian Studies**

Stanford University has created an interdisciplinary program to train researchers and academic leaders in the field of medical information sciences. This program is described in "Research Training in Medical Informatics: The Stanford Experience," identifying experiences of interest to people developing such programs (Shortliffe & Faggan, 1989). The program's background and history, students, curriculum, philosophy, and lessons learned are discussed.

A review of the impact of informatics in medical education is given in "A Review of Medical Education and Medical Informatics." This article suggests that information technology may help physicians to manage information more effectively through more accessible clinical indexes, databases of diagnostic test characteristics, computerized audits of clinical activities, and on-line access to medical literature. Medical Informatics, a
new discipline dedicated to the solution of information problems in health care, is discussed (Haynes, 1989).

The annual Canadian Conference of Information Science held in Toronto in 1984 produced seventeen papers presented in four broad topic areas. The first area, which focuses on the changing roles in information access, includes the keynote address by Charles Meadow, "Integrating Access to Information Utilities: Promises, Problems, and Profiles of the Future." Other papers in this area are concerned with office automation, the role of the corporate database administrator, and database generation by end-users. The second area consists of two papers that describe the potential impact of fifth-generation computers on library and information services, and a description of the proposed computerization of document management in a specialized center in Quebec. The third area deals with database applications. The fourth section focuses on the impact of information technology on society (CAIS, 1984).

The product of advanced information technology and digital transmission capabilities, transborder data flow (TDF) -- the flow of information across national borders via computer and other electronic communications systems-- has considerable political, social, economic, and legal implications. Important issues in TDF include: (1) the regulation of telecommunication planning and development among various nations without stifling innovations; (2) the protection of personal privacy; (3) the
impact of TDF on the cultural identity of information receiving nations; (4) the expatriation of national information; (5) the treatment of information as a commodity; (6) the impact of TDF on developing nations' balance of trade, employment, and infant information services; and (7) the restriction of competition and market entry of transnational corporations through such legislated and non-legislated barriers as tariffs and prohibitive pricing. While current international legislation on TDF may appear excessive to those hoping to profit from expanding telecommunications systems, but to people wanting to improve privacy protection or protect fledgling information economies, it seems minimal. Greater international cooperation is needed to balance the need for a free flow of information with other needs for personal and national protection and benefit (Wigand, 1983).

The main goal of "A Proposed Computer Science Curriculum for Computer Professionals" is to help students acquire a high level of competence by giving them the opportunity to add to their formal education and expand the opportunities provided by their job assignments. It describes a proposed computer science curriculum tailored for computer professionals (Abshire, 1981). Eddy suggests computer tutorials represented by general programs in which all students receive identical instruction, or more complex and specific programs in which instruction is individualized for each student (Eddy, 1984).

An analysis of the organizational approaches to faculty
microcomputing was performed in the Graduate School of Business and the Schools of Education and Law at Stanford University. This study highlights how an academic subunit (school or college) affects response to technology. Study results demonstrate that an early organizational plan, incentives for faculty microcomputer adoption and accessible support services are key implementation factors that motivate individuals to participate with the systematization of the organization (Schmidt-Posner, 1989). According to Eddy, computer assisted test construction (CATC) may consist of large data banks of test questions and models that can be accessed and assembled. This kind of facility will speed-up the student-instructor feedback relationship and will allow more free faculty time to be spent in research (Eddy, 1984).

"A Comparison of Male and Female Computer Science Students' Attitudes Toward Computers" describes a survey in which students in introductory and advanced computer science classes were asked to fill out questionnaires concerning their attitudes toward computers. The author was interested in two questions: Are there differences in the male-female composition of introductory courses? and are there differences between men and women in their attitudes toward computers?, and, if such differences do exist, how are they related to male-female enrollment ratios in computer science courses? (Ogozalek, 1989). Beck suggests that colleges and universities examine their core requirements for liberal arts and sciences
students. He suggests that the core curriculum should include computer science as a discipline whose study will not meet many of the goals of liberal arts and sciences education (Beck, 1989).

A survey was conducted to determine the experiences and perceptions of 60 graduates of the graduate curriculum in finance offered at Ferris State University and among 47 of their employers located in Michigan during Fall, 1988. The objective of the study was to determine the adequacy of the scholastic preparation of finance graduates for professional positions in the finance field, and (b) the extent to which finance professionals use computer applications in their work. Findings stated that the corporate executives noted the graduates to be deficient in the area of computer knowledge for their first professional position. The employer group viewed the need for computer literacy to be more important for career progress than did the graduates. The industrialists' group also believed applications would be used more in the future than did the graduates (Smith, 1989).

The results of a survey mailed to the chairs of 301 computer science departments listed in the 1988 ACM Administrative Directory as offering master's programs are described in a paper that examines the current status of the master's degree in computer science. The survey examined eight distinct areas: program type, entrance requirements, curriculum, program setting, program history, faculty, and students/support (Eerkes,
An assessment of computer literacy courses in higher education in California found: (1) Few institutions require computer literacy as a graduation requirement at the present time. (2) Emphasis appears to be on practical experience in microcomputer usage rather than the theoretical aspects of computing. (3) Limitations that campuses face are budget crises combined with the heavy demand of computer facilities by students. Competency in computer allows the students to access essential information for future opportunities (Ashley, 1989).

The major focus of the research study "Factors Which Influence Women's Decision to Major in Computer Science in College" was the experiences and attitudes of college women computer science majors. Family background and life experiences were explored in an interview in which twelve women who elected to major in computer science at a state university participated. Findings indicate that the women who were of an independent and pragmatic nature, had had a positive educational experience in the area of computer science (Goodness, 1990).

An investigation evaluated the statistically-related computer applications tasks which were deemed to be important to the graduate curriculum of doctoral students who major in education. This study identified seven clusters of computer applications which were considered basic to curriculum inclusion in doctoral programs for education majors. The findings present a valid paradigm for the setting of objectives which
should be part of the curriculum of these doctoral programs (Starmach, 1988).

A case study was implemented to investigate the impact of a faculty development project on the attitudes and computer usage behaviors of faculty members at a liberal arts college in a large metropolitan area. Information was collected from ten faculty members from various disciplines that participated in the faculty development project from its beginning. The results reveal that the majority of faculty members had many concerns about computers prior to beginning the faculty development project. All of the faculty members reported that their fears have greatly diminished as a consequence of participating in the project (Algren, 1989).

**African Studies**

The following represent a selected group of African studies on informatics. A UNESCO report, not a detailed analysis, indicating trends summarizes information on computer application in primary and secondary education in 43 countries including technical and vocational training. The information was obtained from surveys made for differing purposes, monographs produced for various bodies, and reports prepared for meetings and conferences. The summary reviews the subject under two main headings: project policies and their economic considerations, and their educational significance. The first section discusses the existence and content of national policies on informatics, the institutional
arrangements set up as a result of the policies, and the financial and technological investments that have been made. The second section deals with the types of computer applications at the various educational levels, software and teacher training, and attempts to identify trends for each level of education. The range of research activities reported is summarized under six headings: (1) Logo applications, (2) computers in special education, (3) general education research, (4) subject teaching, (5) language teaching, and (6) computer processing of national languages. The third section, which constitutes over half of the report, presents summaries of data for the 43 countries studied, including data on the school population, educational budget, structure of the educational system, computer policies, computer applications, and research activities of each country (UNESCO, 1986).

El-Sherif conducted a study in Egypt that deals with an informatics development strategy for developing countries. The goal of this study was: (1) identify the basis of an accelerated development approach, (2) formulate an accelerated development strategy, and (3) test the applicability of this strategy in a developing country context. Three main phases are defined in this study: a descriptive phase, a normative phase, and an action-strategy phase. A case study illustrates the benefits of an accelerated development strategy in identifying the process and products needed to support
management decision making and improve the efficiency and effectiveness of organizational activities in a developing country (El-Sherif, 1983).

The paradigms of social interactions between teachers and students who are exposed to computers in the classrooms in Kenya are described by Kirmani (1987). Ethnographic methods of research were used to collect data as the teacher and students worked with computers through the introduction, development, and conclusions of lectures. The test score analyses indicate that: "(1) There is no overall significant difference between girls and boys in their performance on the mathematics test. (2) The computer classes performed significantly better on two of three geometry questions. (3) There is no "spill over" effect of improvement on the other areas of mathematics namely, arithmetic and algebra. With personal computers decreasing in price, and Third World countries working to improve their education, this study can be a valuable tool for education administrators.

**Informatics Studies in Colombia**

While educational investigation and development and economic development are separate functions in Colombia like the organizations that foster them, they are becoming increasingly interrelated. Concepts in advanced computer software taught in a university program or course are dependent upon the rapid advance in research and development at both the university and industry levels (Cabrales & Eddy, 1991). Similarly, the
development of new industries and their subsequent growth are related to the products resulting from university research as well as advances and offshoots coming directly from the industry.

In examining the institutional players, in terms of their relationship to education, research, and economic development, both the university and industry are directly involved in the creation of new knowledge through research. Universities, state, and local governments are directly concerned with the educational process and the provision of a renewable supply of trained graduates. State and local governments along with industry are directly concerned with economic health and growth (Miller et al., 1983).

There are also important indirect relationships. The educational programs and knowledge resources of the university can influence the economic well-being of the region. Industry is indirectly involved with education through the training and resources that it offers to other participants. Industry is also a consumer of talent and new ideas -- the products of the university (Miller et al., 1983). States and municipalities are finding that they have to be concerned with research not only because the creation of new knowledge can lead to the development of new processes and products by industry, but because the quality and scope of university research efforts can strengthen the educational program and in turn provide the region with a renewable supply of highly trained manpower.
This study is a general view of the current status of informatics as a discipline in Colombia. The opinions of a number of international experts were considered during this study and a 1990 trip was made to Colombia to interview authorities there. Many concepts were extracted from current literature about this topic. Special attention was given to the organization, staff requirements, computer facilities, and other resources needed to implement informatics educational programs in Colombia.

Generally, in Colombian universities students follow two years of general education and move on to their special studies. After graduation, almost every student becomes a doctoral student in a foreign country, or a master's degree student, or a government employee, or a teacher at a high school or middle school, or an employee of a commercial or industrial company. The Colombian educational system consists of public and private institutions. Public institutions obtain their financial support from the government (85% or more of their budget). Private institutions get their funding from the tuition and fees collected from the students. A joint venture for the development of research projects and financial forms is being sought as an important source for acquiring new functioning resources. Current thought assumes that universities and productive sectors are working together to share knowledge and practical experiences in the real world.

One of the main problems faced by higher education in Colombia is
its isolation. The lack of foreign exchange has made higher education programs obsolete. There is no foreign exchange program in the country that involves higher education students or higher education professors. There exists some mobility mainly from Colombia to foreign countries but as a product of programs designed for Latin America and underdeveloped countries. Noteworthy is the fact that some of the best Colombian undergraduate students pursue graduate studies in the US, France, or other European countries.

In general, the Colombian higher educational system is designed toward the practical application of the knowledge acquired. There are very few cases where the program is research-oriented. Usually the university provides the society with the manpower needed for its improvement. New technology is a problem for higher education in Colombia and it is also a problem for the productive sector. The country needs to make many improvements in its educational system but does not have the funds to do so, because in order to achieve this goal it is necessary to achieve better productivity. Pure science has received more support in Colombia than other learning areas. Mathematics and research in agriculture were among the first scientific subjects introduced in institutions of higher education. Since the 1970s, science planning has favored the applied sciences but increased support of the pure sciences in an effort to place
Colombia in a better world position in a few selected fields, mathematics, agriculture, and molecular biology among them.

The Basic Plan for Colombian Higher Education, elaborated at the University of California, Berkeley, under the sponsorship of the Agency for International Development (AID), is a prime example of efforts to reform Third World education. Gonzalez (1982) describes how the orientation of this plan reflects the United States policy of alliance with the political right-wing in Latin America since the end of World War II; "the cooperation of U.S. universities with the State Department has added weight to the alliance, and has, therefore, strengthened the position of the political forces of the status quo in those countries." The Berkeley Plan was the model used in the creation of Law 80 of 1980.

In their study, Franco and Tünnermann (1978) describe the panorama of the Colombian higher education system. This study is divided into four parts. In the first part, the problems and challenges that face the Colombian higher education system are examined. A brief description of solution models applied in other parts of the world is given. In the second part, the historical evolution of the Latin American university is examined. The third part of this work describes higher education in Colombia by considering the general characteristics of Colombian higher education institutions and the assessment of some answers that can contribute to the analysis of the problem. The fourth part consists of the study's general
conclusions and the authors' proposal for the improvement of the higher education system in Colombia.

Another study that deals with the Colombian university system is divided into two sections. The first section gathers descriptions and analyses of the different situations of university education. This includes the cultural shock that faces current Colombian society, the challenges that face the intellect with the development of new technologies, the development of a new values order, and the task that represents the individual development at all levels of knowledge. The second part consists of a study that a research team, directed by the author, performed covering a 17 year period (1970-1987) (Ferro-Bayona, 1989).

Many Colombian scholars perceive that analytical thinking in science can be complemented by algorithmic thinking. Computer education at Colombian universities has expanded as a natural course of events in line with the progress of computer technology. Education has produced some good results and has met the needs of students. However, due to the rapid development of computer technology, the demand for computer education is still increasing. In the future, computer-related courses will be further expanded. Careful decision making will be important in developing computer curricula. Computer education is important for everyone now; it will become increasingly important as we
move into the future. In Colombia, the term "computer literacy" is used in
the same sense as knowledge of reading and writing.

Some Colombian universities do not teach programming languages
such as Pascal or C. They only teach courses in algorithmia. Expectations
are that the students with tutorial aid learn how to handle the software
packages and learn the computer languages needed to overcome the
curriculum requirements. Mainframe computers are used in some cases
for school administration and research, while microcomputers are used for
academic purposes.

With respect to the research areas that are based on departmental
organization, the investigation is performed in accordance with the
knowledge area object of the study. For instance, in the Department of
Electric and Electronic Engineering, work is done in microelectronics,
robotics, digital circuits, and networks. The Department of Systems
Engineering is mostly oriented toward software engineering, data bases
and information systems. In electric, mechanical, and industrial
engineering, courses such as computer languages, software engineering,
and compilers are offered (M. Millan, personal communication, December

The use of microcomputers for teaching at Colombian universities
offers many advantages. Informatics for all students is both possible and
necessary in view of the advent of the widespread use of microcomputers
(Eddy, Martin, & Semones, 1983). Teacher education in Colombia requires new methodology and pedagogic strategies of teaching. Many Colombian faculties believe that a rapid introduction of computers into the educational system without any planning or preparation may disappoint these teachers and make them reject the technology. Therefore, we find teacher computer usage training one of the most important and essential aspects that must be dealt with. A study that tries to assess the potential contribution adult education can make to technological self-reliance, in the particular case of Colombia, was performed by Peña (1988). Findings of this study are based on information gathered directly in the country, mainly by conducting open-ended interviews and by analyses of the current literature about this topic. Peña's study concludes that there exists "communication gaps in the conventional knowledge-creation-diffusion-adoption model of applied research".

Computer aids for introductory writing and reading courses should be developed, according to Colombian needs, with the support of multinational computer manufacturers. Young children should be taught with reasonable tools to learn to type what they can say and to read what they type. Phonetic systems using digitalized voice and attractive graphics should be developed. The same applies to arithmetic courses (Eddy, Miller, Martin, & Stilson, 1985).

The Colombian higher education system is directed and controlled by
the Colombian Institute for Higher Education Development (ICFES). Any new undergraduate and graduate higher education institutions in Colombia have to have ICFES approval. After an institution starts functioning, the ICFES will review all its academic programs on site. These academic programs could be 4, 6, 8, 10, or 11-semester programs. Graduate programs also require ICFES approval. The academic programs are approved currently for a finite period of time. During that time, the university or higher education institution is free to administer its own programs according to Colombian Law 80 of 1980.

In this decree (Law 80 of 1980), all the procedures that direct higher education in Colombia were established. This document is based on the constitutional mandate that authorizes the President of the Republic to exercise inspections and control of the entire educational system. Noteworthy is that the National University of Colombia is not under the control of ICFES, due to a rule stated in Law 81 of 1980 in which the National University is autonomous in the administration of its academic activity. In other words, Law 80 of 1980 applies to the remainder of higher education institutions in Colombia but not to the National University (A. Echeverri, personal communication, December 14, 1990). Gonzalez (1979) gives an analysis of the social and political context of education through the Colombian history that shows the relationships between educative concepts and the development of political ideas. Highlighting the key historical
moments of Colombia's social and economic history is the development of the fight for power among political parties. This study gives a special emphasis to the conflicts between church and state for predominance in the academic field.

A description of the Colombian professoriate and its role in higher education is made by Larsen-Pusey (1988). Interviews and a mailed questionnaire were used to collect the information. The findings of this study include: "(1) A two-tiered public university system exists. (2) The academic career in Colombia is a male-dominated profession. (3) The professoriate is graying, and highly-trained academicians will be needed to replace retirees during the next 15 years. (4) The professorial role is primarily teaching. (5) The majority of the professors are not trained to conduct research. (6) Serious barriers exist for realizing both teaching and research roles. (7) Natural and physical scientists with Ph.D degrees and more modern facilities publish more than other professors.". This study also provides "philosophical and methodological implications for cross-national research". Such a study establishes that an acceptable response rate in Colombia is possible with a "design sensitive to the concerns of the subjects and the way they conduct themselves in their cultural environment".

Currently, the Colombian people have elected a National Constitutional Assembly whose main aim is to modify the Constitution to
update the Colombian judiciary and administrative systems according to modern tendencies in the international community. The educational system is one of the many areas that is going to be studied by this group.

Informatics Research at Colombian Universities

Informatics research at Colombian universities is in an early stage. This was verified by the researcher's visit to several Colombian universities during the summer of 1990. During this visit, the researcher had the opportunity to interview some faculty members and department heads of the systems engineering departments of the National University of Colombia, the University of North Colombia, and EAFIT University.

In their own words, one of these department heads stated that "research funding is sporadic and inadequate and is the subject of political auditing and interference. The government administration of science is bureaucratized and also subject to whimsical political influence" (J. J. Martinez, personal communication, June 22, 1990). Private institutions have more freedom to handle their budgets than do state institutions. For that reason, private philanthropists prefer to fund private institutions rather than public institutions. There are some faculties in private and public universities working on the development of some educational tools for elementary education (A. Ruiz, personal communication, August 9, 1990). Others, as in the case of EAFIT University, are working mostly in the development of applications for the commercial and business world.


Universidad Nacional de Colombia

The National University of Colombia, the largest public institution in the country, is under funded by the government. Very few research activities are performed in the area of informatics due to lack of resources. Special emphasis is given to the instruction of algorithm development, computer architecture, networks and communications, and cybernetics.

Systems engineering students at this university have to share the computer facilities with the members of other engineering departments which gives its 4,000 students access to only 16 terminals at its Bogota main campus. Faculties at this university work with insufficient computer resources to implement their ideas and to accomplish their projects. As one of the Systems Engineering Department heads stated, "We have the manpower to develop and implement any software and hardware application, but sometimes our hardware projects end with the drawing of the particular implementation on the board because we do not have the means to get the chips and all others tools that we need to manufacture it" (J. J. Martinez, personal communication, June 22, 1990).

Most of the chief executive officers (CEO's) at Colombian private and public industries complain about the lack of support, quality, and documentation of the locally produced software. In the words of these CEOs, "software companies appear and disappear every day in the Colombian information society." Those that disappear leave their product
behind without any user support (A. Maz, personal communication, August 2, 1990). For that reason, most of the Colombian industries are reluctant to invest in software and equipment produced locally due to the lack of confidence in the local software and hardware companies.

None of the Colombian universities visited had developed their own operating systems. They were all relying on operating systems developed in other countries. Some universities have some research in artificial intelligence, but these institutions lack the LISP and Prolog tools that allow them to create competitive applications for the real world (J. J. Martinez, personal communication, June 22, 1990). The EAFIT University library receives several refereed journals in computer science and in general terms could be considered adequate for the current level of informatics development in Colombian society.

Universidad de los Andes (UNIANDES)

This university can be considered the leading institution in this field in Colombia through its Engineering School Research Center "Centro de Investigaciones de las Facultades de Ingeniería" (CIFI). There are several research projects now in progress such as the development of new computer-aided tools for design and manufacture, telematics, microelectronic, robotics and digital control, and biomedic engineering. These projects have been implemented through several specializations that the school offers and are oriented toward filling the needs of the private and
public industrial sector. This center receives funds from the government agency COLCIENCIAS and from some private sources (Martínez, 1989). In the field of microelectronics, some work has been done in the design of gates arrays. The center has a VAX 730 with an interactive operating system. The university computer center has an IBM 9337, and a Burroughs B6800 and other mainframes. The undergraduate program has an Ethernet network with two micros VAX II, a workstation VAX II and a VAX 11730 with enough secondary storage for running students' work. The microlabs are well-equipped according to national standards with different brands of microprocessors such as Apple Macintosh, Texas Instruments, IBM XT, and IBM AT.

The master's program offered by UNIANDES is oriented toward research in the following areas: algorithm development and symbolic informatics, computer aid design, and computer aid manufacture (CAD/CAM), educational informatics, software engineering, computer networks and communications, and operating systems and databases. The university has had some international exposure through a studies exchange agreement with the following institutions: University of Paris, and University of Grenoble in France; University of Illinois at Urbana Champaign, and Stanford University at Palo Alto in the United States (Martínez, 1989). A 1989 Colombian study concerning the status of development and social insertion of electronic engineering and informatics
conducted a series of interviews with the department heads of a selected group of Colombian universities (Martinez, 1989). Part of the information obtained is shown in the following Table 1:

Table 1

Student Enrolment and Full-time faculty in a Selected Group of Colombian Universities

<table>
<thead>
<tr>
<th>University</th>
<th>Type of Program</th>
<th>Starting year</th>
<th>Students</th>
<th>Full time faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonoma</td>
<td>Undergraduate</td>
<td>1977</td>
<td>1400</td>
<td>11</td>
</tr>
<tr>
<td>Andes</td>
<td>Undergraduate</td>
<td>1963</td>
<td>700</td>
<td>19</td>
</tr>
<tr>
<td>Andes</td>
<td>Graduate</td>
<td>1968</td>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td>Antioquia</td>
<td>Undergraduate</td>
<td>1975</td>
<td>462</td>
<td>10</td>
</tr>
<tr>
<td>Central</td>
<td>Undergraduate</td>
<td>1985</td>
<td>570</td>
<td>N/A</td>
</tr>
<tr>
<td>Distrital</td>
<td>Undergraduate</td>
<td>1976</td>
<td>600</td>
<td>9</td>
</tr>
<tr>
<td>EAFIT</td>
<td>Undergraduate</td>
<td>1976</td>
<td>1100</td>
<td>12</td>
</tr>
<tr>
<td>Col. Sch. E.</td>
<td>Undergraduate</td>
<td>1985</td>
<td>195</td>
<td>N/A</td>
</tr>
<tr>
<td>Incca</td>
<td>Undergraduate</td>
<td>1967</td>
<td>2000</td>
<td>10</td>
</tr>
<tr>
<td>U. National</td>
<td>Undergraduate</td>
<td>1978</td>
<td>750</td>
<td>28</td>
</tr>
<tr>
<td>U. National</td>
<td>Graduate</td>
<td>1967</td>
<td>47</td>
<td>23</td>
</tr>
</tbody>
</table>

Source: (Martinez, 1989).

Table 1 illustrates how the professor/student ratio is low in the Colombian higher educational system going from approximately 1/40 for well-financed programs to programs with a ratio of one full time faculty for
every 200 students. In the case of universities with graduate programs, the number of students per faculty member is very high, not giving the faculty time flexibility for research.

Table 2 and 3 summarize some of the statistics collected by the questionnaire sent to the head of the Systems and Electronic Engineering Departments in Colombia.

Table 2

Budget and Salaries Statistics from a Group of Selected Colombian Universities' Electronic and Systems Engineering Departments

<table>
<thead>
<tr>
<th>University</th>
<th>Budget *</th>
<th>Avg. salary*</th>
<th>Num. Terminals/Num. students</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCCA</td>
<td>&lt;50</td>
<td>120</td>
<td>&lt;1/50</td>
</tr>
<tr>
<td>Nacional</td>
<td>&lt;50</td>
<td>200-300</td>
<td>&lt;1/50</td>
</tr>
<tr>
<td>Andes</td>
<td>200-600</td>
<td>400-500</td>
<td>1/10</td>
</tr>
<tr>
<td>EAFIT</td>
<td>100-200</td>
<td>300-420</td>
<td>1/25</td>
</tr>
<tr>
<td>Del Norte</td>
<td>&lt;50</td>
<td>200-300</td>
<td>1/50</td>
</tr>
<tr>
<td>U. Distrital</td>
<td>&lt;50</td>
<td>300-400</td>
<td>1/10</td>
</tr>
</tbody>
</table>
Table 2—Continued.

<table>
<thead>
<tr>
<th>University</th>
<th>Budget *</th>
<th>Avg. salary*</th>
<th>Num. Terminals/ Num. students</th>
</tr>
</thead>
<tbody>
<tr>
<td>UIS¹</td>
<td>&lt;50</td>
<td>200-300</td>
<td>1/50</td>
</tr>
<tr>
<td>Del Valle¹</td>
<td>&lt;50</td>
<td>200-300</td>
<td>&lt;1/50</td>
</tr>
<tr>
<td>UPB²</td>
<td>&lt;50</td>
<td>200-300</td>
<td>1/50</td>
</tr>
<tr>
<td>S. Tomas²</td>
<td>N/A</td>
<td>200-300</td>
<td>&lt;1/50</td>
</tr>
</tbody>
</table>


The information in Table 2 indicates that, with the exception of the Universidad de Los Andes and Universidad EAFIT, the rest of the Colombian universities' Electronic and Systems Engineering Departments have a low budget and low faculty salary.

Table 3

Faculty Members with Ph.D. Degrees, Inbreeding, and Personal Computers (PC) From a Group of Selected Colombian Universities' Electronic and Systems Engineering Departments.

<table>
<thead>
<tr>
<th>University</th>
<th>Ph.D*</th>
<th>Inbreeding</th>
<th>Num. of PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCCA</td>
<td>0</td>
<td>10-15</td>
<td>20-50</td>
</tr>
<tr>
<td>Nacional</td>
<td>4</td>
<td>1-5</td>
<td>10-20</td>
</tr>
</tbody>
</table>

¹ Graduate program only

² Electronic Engineering Department
Table 3—Continued.

<table>
<thead>
<tr>
<th>University</th>
<th>Ph.D*</th>
<th>Inbreeding</th>
<th>Num. of P C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andes</td>
<td>15-20</td>
<td>&gt;20</td>
<td>&gt;50</td>
</tr>
<tr>
<td>EAFIT</td>
<td>0</td>
<td>5-10</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Del Norte</td>
<td>0</td>
<td>5-10</td>
<td>10-20</td>
</tr>
<tr>
<td>U. Distrital</td>
<td>0</td>
<td>5-10</td>
<td>20-50</td>
</tr>
<tr>
<td>UIS3</td>
<td>5-10</td>
<td>5-10</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Del Valle3</td>
<td>N/A</td>
<td>N/A</td>
<td>&gt;50</td>
</tr>
<tr>
<td>UPB4</td>
<td>5-10</td>
<td>5-10</td>
<td>10-20</td>
</tr>
<tr>
<td>S. Tomas4</td>
<td>0</td>
<td>5-10</td>
<td>20-50</td>
</tr>
</tbody>
</table>

*Faculty with Ph.D degrees.
Source: Researcher's mailed questionnaire (December-January 1991).

Table 3 illustrates how the number of faculty members holding Ph.D. degrees is larger in well-sponsored universities. Furthermore, the inbreeding problem is very common at Colombian universities.

The largest existing computer system in the country is the IBM 3090 that ECOPETROL (The Colombian Petroleum Company) uses to control exploration, drilling, production, and operation of its organization.

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3 Graduate program only

4 Electronic Engineering Department
Conclusion

To summarize what is known about informatics studies in Colombia is difficult because information is scattered and scarce. Few studies have been done in this field in Latin America that can serve as a reference. The majority of studies about the importance of the computer in our modern society has been performed in developed countries. Therefore, further research is needed to be done by Latin American scholars. Secondly, funding from developed countries is needed for such research. Thirdly, studies such as this underscore the importance for the dissemination of information regarding computer science educational programs.
CHAPTER 3

METHOD AND PROCEDURES

Introduction

This chapter explains the methodology and research approaches that were applied in this study. It contains four parts: (a) a description of the population considered in the study, (b) a description of the survey instrument, (c) the methodology for data collection, and (d) an explanation of the statistical treatment of the data.

Population and Selection of Sample

One of the requirements for making accurate inferences regarding population characteristics when using only the values obtained from the sample is that the sample represent the population as much as possible. The most common method for obtaining a representative sample from a population is to select members randomly from the population. Each individual in the population has an equal opportunity of being selected because a random sample consists of one choice by chance selection (Ferguson, 1971). This was the procedure utilized in this study. It is obvious that a small group cannot be an exact representation of a much
larger one, thus sampling error is present whenever samples are selected. The population considered was the chief executive officers of Colombian industrial companies that work in the software or hardware fields and have their addresses in the Colombian Industrial Directory.

The sample size selected was 87 out of a population size of 346 which corresponds to 25% of the population size. The members of the sample were selected using a table of random numbers.

The sample was collected from the cities of Bogotá, Medellín, Cali, and Barranquilla, where the majority of the Colombian computer businesses are located. The sample size for each city corresponds to 25% of the computer companies considered (ACUC, 1988).

Table 4
Sampling Table

<table>
<thead>
<tr>
<th>City</th>
<th>Population</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogotá</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>Medellín</td>
<td>58</td>
<td>14</td>
</tr>
<tr>
<td>Cali</td>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>Barranquilla</td>
<td>28</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>346</td>
<td>87</td>
</tr>
</tbody>
</table>
Description and Validation of the Survey Instrument

After a thorough search of the current literature and consultation with others who have been working in the field of international studies in computer education, informatics education, and computers in society, the researcher could not find a survey instrument that fit the requirements of the Colombian environment. For that reason, it was decided to design an instrument that was suitable to the current level of informatics instruction, informatics technology, and informatics communication.

The design of the survey instrument mainly addresses three areas: (a) informatics instruction, (b) informatics technology, and (c) informatics communication. During the design of the questionnaire a great mental effort was made to create rapport between the researcher and the respondent. As a communication tool, a questionnaire provides a means of interface, so the departure point for all questionnaire design is concern for and identification with the respondent in order to provide the means for a dialogue rather than a monologue (Labaw, 1980). If the instrument is seen as a communication tool, it is not difficult to understand the common mistake made by researchers by the application of instruments developed for the United States' environment in foreign countries without a deep analysis of the society where the instrument is going to be used. To open the channel of communication and allow the semantic, gestalt, and internal view to come through from respondent to researcher and vice
versa, it is necessary that the instrument be adaptable to the community for which it was developed. As Benedict (1961) suggested:

No man ever looks at the world with pristine eyes. He sees it edited by a definite set of customs and institutions and ways of thinking. His very concepts of the true and the false will still have reference to his particular traditional customs. (p. 2)

In short, the surroundings of the respondent play an important role in his values and perceptions. The instrument was designed by the researcher and reviewed by a group of ten Colombian students attending the University of North Texas (UNT) during the spring semester, 1990. It was also reviewed by several Spanish and statistics professors. Further review was also given by a group of department heads selected from ten Colombian universities. This group represents the state of the art in teaching computer science in the Colombian higher educational system. The instrument was standardized by a pilot study performed in Colombia at the Colmotores Company Systems Department during the summer of 1990.

A panel of experts was selected for the purpose of revising and validating the survey instrument. These panel members were selected on the basis of their expertise and reputation in computer science education. The questionnaire was sent to ten Colombian universities by the researcher on June 3, 1990. The response rate was 80%. The questionnaire was modified according to the recommendations given in their answers. The modified instrument was utilized to perform a pilot study in the Colmotores
Company Systems Department during the researcher’s trip to Colombia during the summer of 1990. The data obtained in this study were used to check the reliability of the instrument using the SPSSX reliability procedure.

**Data Collection**

Colombia is a nation that tries to optimize its economic resources investment. For that reason, conducting a complete survey among the suppliers and consumers in a field in order to assess the needs of that particular field is very often the most logical tool that the Colombian government uses to pursue its administrative objectives. This kind of polling supplies them with the necessary information about which facilities should be improved, whether new education technologies should be introduced or designed, and whether they should redistribute the resources to improve the current situation.

Polling in Third World countries could be difficult due to the lack of infrastructure that makes public opinion unfeasible, expensive, and limited. Colombia has an expert, reliable office of census, DANE (Departamento Nacional de Estadísticas), that provides useful data on population growth, changes, location, and demographics to enable projectable national probability samples to be drawn. The need to identify priorities, combined with its inexpensive local mail, creates a favorable climate for the implementation of public opinion polling and the design of
questionnaires suitable for its environment (Larsen-Pusey, 1988). However, questionnaire rate of return is low due to the slowness of the national mail and the fact that the people are not accustomed to survey studies.

The data collection process was performed by dividing the country into two areas: (a) the capital Bogota where an assistant researcher was appointed to assess the effects of questionnaire mailing, send follow-up letters, and make phone calls to motivate the answering of the survey, and (b) Medellin, Cali and Barranquilla where the same procedure was executed.

Within two months, the assistant researchers collected the questionnaires from the respondents. Non-respondents received a phone call. All answered questionnaires were mailed to the researcher in Denton. After gathering the related data and questionnaires, the researcher conducted a mailed interview with the heads of systems engineering departments of seven Colombian universities to gain additional insight into the actual situation of informatics in Colombia's universities and society.

In summary, the procedure utilized consists of a copy of the survey instrument which was distributed to each of the survey participants together with a cover letter and a self-addressed postage-paid return envelope. The cover letter explained the purpose of the study and the importance of the participant response. All respondents mailed the
questionnaire back to the researcher's agent in Bogota and Barranquilla, Colombia. As long as the rate of return was lower than the anticipated percentage (60%) a follow-up letter was mailed to the respondents. If there was still no response, a phone call was made by the researcher's assistant indicating in a polite way the importance of their participation in this study.

The Statistical Treatment

The completed questionnaires were manually checked for accuracy. The information obtained from the returned questionnaires was utilized to create a computer file. This file was processed using the Statistical Package for the Social Sciences (SPSSX) utilizing the University of North Texas' HDS-8083 mainframe.

To answer Research Question 1 (What are the Colombian industrialists' opinion about the computer instruction at Colombian universities?), the Kruskal-Wallis (K-W) one-way analysis of variance by ranks was used to test the significant differences between male and female. Kruskal-Wallis analysis of variance is the nonparametric version of parametric ANOVA. This test works on the same principle as ANOVA except that ranks rather than interval level data are used; the Kruskal-Wallis test is used when there are separate comparison groups (Hájek, 1969; Hollander, 1973; Sowell, 1982). The K-W test is a reasonable alternative to the one-way analysis of variance when assumptions of the
parametric F test cannot be met (Kruskal-Wallis, 1952). With Research Question 2, the same statistical technique (Kruskal-Wallis) was used.

For Research Question 3, the Kruskal-Wallis one-way analysis of variance by ranks among professional experience was used. To test Research Questions 4, 5, and 8, the chi-square analysis was used to check significant differences. For Research Question 7, the Kruskal-Wallis analysis of variance by ranks was used to test the significant differences among age, education, and professional experience. The chi-square analysis among education background was used to check the significance of Question 6.

Summary

The data were analyzed using SPSSX. For the items evaluated with a Likert scale, the mean rating was calculated and the frequency distribution was analyzed. For the research questions linked to more than one question of the survey instrument, the Kruskal-Wallis one-way analysis of variance by ranks was performed to test whether or not there would be significant differences among ratings by the groups (Manoukian, 1986). For the remaining items, percentage frequencies were used to analyze data. The chi-square test was used to test whether or not the frequencies observed in two groups differed significantly.
CHAPTER 4

ANALYSIS OF DATA

Introduction

The purpose of this chapter is to present major results from a survey completed by Colombian industrialists during March, 1991. These results describe the Colombian industrialists' opinions regarding the status of informatics in Colombia's universities and society as perceived by the CEOs of Colombian software and hardware companies. The data were obtained by administering a survey questionnaire to the population mentioned. Returns were received from 1 Ph.D., 6 Master's, 44 with the equivalent of a United States B.S. and 11 holding a technical degree. A total of 62 questionnaires were returned (71%). The percentage obtained was greater than the one established (60%). The accuracy of this study depends, of course, on the accuracy with which the questionnaires were filled out by the individual companies (Kidder, 1986). The researcher's goal was to make this study consistent, clear, and simple, without modifying the overall results in any way.

The data were analyzed using SPSSX. For the items evaluated with a
Likert scale, the mean rating was calculated and the frequency distribution was analyzed. For the research questions linked to more than one question of the survey instrument, the Kruskal-Wallis (K-W) one-way analysis of variance by ranks was performed to test whether or not there were significant differences among ratings by the groups. For the remaining items, percentage frequencies were used to analyze the data. Then, the chi-square test was used to determine whether the frequencies observed in two groups differed significantly.

The Kruskal-Wallis (1952) one-way analysis of variance by ranks is a rank test for k non-dependent samples. It is a generalization of the Wilcoxon rank sum test to k groups. The test is based on the following assumption: The null hypothesis is that the k independent samples of \( n_1, n_2, \ldots, n_k \) members are from the same population. To be consistent, the tests with all observations for the k samples are classified. The lowest value is assigned a rank of 1, the next lowest 2, and so on. "The sum of the ranks \( R_i \), for each of the k samples is calculated. If all k samples are from the same population, the expectation is that the mean rank sums \( R_i \), will be equal for the k groups, and equal to the mean of the N ranks, which is \((N+1)/2\)." The null assumption in this case has a necessary consideration of the N! arrangements of ranks in k groups. Each deliberate order is considered as equiprobable (Ferguson, 1981).
Research Question 1

What are the Colombian industrialists' opinions about the computer instruction at Colombian universities when evaluated by gender? This question corresponds to the academic informatics area of the survey instrument (Questions 6 through 18). The statistical technique used was Kruskal-Wallis (K-W) to test the significant difference between male and female.

After having performed the K-W test for the information collected that related this question, the only significant difference found was in the answer regarding the curriculum taught at Colombian universities. The value of the chi-square obtained was 3.952 and the level of significance was 0.0468 (p < 0.05). The results are presented in Table 5.

Table 5
Research Question 1. K-W Individual Variable Analysis. Results Obtained for the Items Included in the Informatics Instruction Area

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic by sex</td>
<td>0.009</td>
<td>0.942</td>
</tr>
<tr>
<td>Hardware by sex</td>
<td>0.074</td>
<td>0.0786</td>
</tr>
<tr>
<td>Assembly by sex</td>
<td>0.086</td>
<td>0.7697</td>
</tr>
<tr>
<td>Academic level by sex</td>
<td>1.242</td>
<td>0.2652</td>
</tr>
<tr>
<td>Referred journals by sex</td>
<td>0.107</td>
<td>0.7436</td>
</tr>
</tbody>
</table>
Computer shop by sex

Table 5—Continued.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer aided instruction by sex</td>
<td>0.969</td>
<td>0.3249</td>
</tr>
<tr>
<td>Preparation by sex</td>
<td>1.276</td>
<td>0.2587</td>
</tr>
<tr>
<td>Curriculum by sex</td>
<td>3.952</td>
<td>0.0468*</td>
</tr>
<tr>
<td>Research by sex</td>
<td>0.038</td>
<td>0.8451</td>
</tr>
<tr>
<td>Doctoral program by sex</td>
<td>0.574</td>
<td>0.4485</td>
</tr>
</tbody>
</table>

* Significant

Although the variable curriculum was significant when considered individually, according to Table 5, the final results for the K-W analysis for all the variables dealing with the academic area were not significant. This is illustrated by the K-W results in Table 6: chi-square: 1.288, significance: 0.2564.

Table 6

Kruskal-Wallis Results for the Informatics Instruction Area When Considered by Sex

<table>
<thead>
<tr>
<th>Kruskal-Wallis results: Mean Rank</th>
<th>Cases</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 1.2880</td>
<td>33.49</td>
<td>50</td>
</tr>
<tr>
<td>Significance: 0.2564</td>
<td>23.21</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 7

Chi-square for Curriculum Opinion by Professional Degrees for Male and Female Respondents

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Male</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strng. dis.</td>
<td>Disagree</td>
<td>Undecided</td>
<td>Agree</td>
<td>Strng. agree</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>31</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>% of Male</td>
<td>0</td>
<td>10</td>
<td>8</td>
<td>62</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>% of Female</td>
<td>0</td>
<td>17</td>
<td>33</td>
<td>42</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td>36</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

According to Tables 6 and 7, fifty males answered the survey. These tables illustrate that 82% of the respondents agreed or strongly agreed that the informatics curriculum taught in most Colombian universities is more advanced than the current level of development in Colombia. The results obtained from the female respondents are also presented in Tables 6 and 7; these tables illustrate that 50% of the female respondents agreed or strongly agreed that the informatics curriculum is more advanced than the current level of development in the country (a difference of 32% when compared with the answer obtained from the male population).

Research Question 2

What similarities will appear in the opinions of the Colombian industrialists toward computer technologies when evaluated by sex, age,
education, and professional experience? The statistical analysis used was Kruskal-Wallis. The K-W test of the Colombian industrialists' opinions about the concept of future impact of artificial intelligence with relation to the respondent's age was significant as it is presented in Tables 8 and 9.

Table 8

K-W Chi-square Significance for Individual Items Included in the Research Question 2

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation by sex</td>
<td>0.06</td>
<td>0.806</td>
</tr>
<tr>
<td>Artif. intel. by sex</td>
<td>0.35</td>
<td>0.555</td>
</tr>
<tr>
<td>Comp. knowledge by sex</td>
<td>6.47</td>
<td>0.011*</td>
</tr>
<tr>
<td>Simulation by age</td>
<td>5.64</td>
<td>0.130</td>
</tr>
<tr>
<td>Artif. intel. by age</td>
<td>8.60</td>
<td>0.035*</td>
</tr>
<tr>
<td>Comp. knowledge by age</td>
<td>6.18</td>
<td>0.103</td>
</tr>
<tr>
<td>Supercomp. vs network by age</td>
<td>13.52</td>
<td>0.004*</td>
</tr>
<tr>
<td>International network by age</td>
<td>4.91</td>
<td>0.179</td>
</tr>
<tr>
<td>Worldwide data banks by age</td>
<td>15.29</td>
<td>0.002*</td>
</tr>
<tr>
<td>Standard of living by age</td>
<td>3.83</td>
<td>0.281</td>
</tr>
<tr>
<td>Third World doc. prog by age</td>
<td>16.42</td>
<td>0.001*</td>
</tr>
<tr>
<td>Worldwide data banks by comp. experience</td>
<td>9.65</td>
<td>0.047*</td>
</tr>
<tr>
<td>Multinational by comp. experience</td>
<td>0.86</td>
<td>0.930</td>
</tr>
</tbody>
</table>
Table 8—Continued.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supercomp. vs network by comp. experience</td>
<td>11.51</td>
<td>0.021*</td>
</tr>
<tr>
<td>International Network by Comp. experience</td>
<td>6.74</td>
<td>0.150</td>
</tr>
<tr>
<td>Simulation by computer usage</td>
<td>5.00</td>
<td>0.288</td>
</tr>
<tr>
<td>Art. intel. by computer usage</td>
<td>10.38</td>
<td>0.034*</td>
</tr>
</tbody>
</table>

* Significant

Table 8 is a summary of the results obtained regarding the K-W significance of the different sets of variables covered in the survey instrument. An analysis of the most important individual items follows.

Table 9

K-W Results, Artificial Intelligence by Age Considered Individually

<table>
<thead>
<tr>
<th>The K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 8.60</td>
<td>38.43</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>Significance: 0.035 (p &lt;0.05)</td>
<td>26.67</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td></td>
<td>35.42</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td></td>
<td>56.50</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Group</td>
<td>Strng. dis.</td>
<td>Disagree</td>
<td>Undecided</td>
<td>Agree</td>
<td>Strng. agree</td>
</tr>
<tr>
<td>20-29</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>30-39</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>40-49</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>50-59</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
The K-W test for the same question regarding computer usage was also significant. As it is illustrated by the values of the mean rank in Table 10, respondents that use the computer for independent work disagree with the statement "Artificial intelligence is finally taking off."

Table 10

K-W Results for Individual Variables. Artificial Intelligence by Computer Usage

<table>
<thead>
<tr>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Comp. Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 10.38</td>
<td>34.29</td>
<td>29</td>
<td>Commercial</td>
</tr>
<tr>
<td>Significance: 0.035 (p &lt; 0.05)</td>
<td>30.21</td>
<td>7</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td>32.09</td>
<td>22</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>33.50</td>
<td>1</td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>3</td>
<td>Independent</td>
</tr>
</tbody>
</table>

Level of Agreement

<table>
<thead>
<tr>
<th>Profession</th>
<th>String dis.</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>String. agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Educational</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Industrial</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Government</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Independent</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The answer to the question: "Does Colombia need to implement a Ph.D. program in Computer Science in order to develop the students' potential in this field?" was significant with relation to the respondents' ages. The computer technology area was not significant when considered by the demographics of gender, age, and computer experience, but it was
significant with respect to education and computer usage.

Table 11

**K-W results for individual variables Doctoral program by Age**

<table>
<thead>
<tr>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 16.42</td>
<td>45.64</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>Significance: 0.0009 (p &lt; 0.001)</td>
<td>28.67</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td></td>
<td>21.17</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td></td>
<td>56.50</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age Group</strong></td>
</tr>
<tr>
<td>20-29</td>
</tr>
<tr>
<td>30-39</td>
</tr>
<tr>
<td>40-49</td>
</tr>
<tr>
<td>50-59</td>
</tr>
<tr>
<td>&gt;60</td>
</tr>
</tbody>
</table>

The values of the mean ranks in Table 11 illustrate that 91.7% (negative responses / total number of respondents in the age group 40-49) of the respondents in the age group 40-49 years old disagreed or strongly disagreed with the need for informatics doctoral programs in Colombia; the same analysis applies to 60% (21/35) of the respondents in the age group 30-39.
Table 12

K-W Results for Individual Variables Supercomputers vs Networks by Age

<table>
<thead>
<tr>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 13.52</td>
<td>31.04</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>Significance: 0.0036 (p &lt; 0.001)</td>
<td>26.27</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td></td>
<td>45.25</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td></td>
<td>56.00</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

Level of Agreement

<table>
<thead>
<tr>
<th>Age group</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>30-39</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>40-49</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>50-59</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The mean rank values of Table 12 indicate that 100% of the respondents in the age group 40-49 prefer a fully-connected network rather than a supercomputer of the same capacity. Thus, 69.35% (43/62) of the total respondents agree with this statement.

Table 13

K-W Results for Individual Variables. Supercomputers vs Networks by Computer Experience

<table>
<thead>
<tr>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Yrs of Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 11.51</td>
<td>49.86</td>
<td>7</td>
<td>0-5</td>
</tr>
<tr>
<td>Significance: 0.02 (p &lt; 0.05)</td>
<td>34.50</td>
<td>4</td>
<td>5-10</td>
</tr>
</tbody>
</table>
From Table 13's mean rank results, it can be deduced that 72% (18/25) of the respondents in the 15-20 years of experience group prefer a fully-connected network of microcomputers than a supercomputer of the same capacity. The K-W chi-square final results by area of analysis for Research Question 2 are presented in Table 14.
Table 14—Continued.

<table>
<thead>
<tr>
<th>AREA</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI &amp; Informatics knowldg. by comp. usage</td>
<td>11.051</td>
<td>0.0260*</td>
</tr>
<tr>
<td>Technology Informatics by sex</td>
<td>0.000</td>
<td>0.9928</td>
</tr>
<tr>
<td>Technology Informatics by education</td>
<td>10.392</td>
<td>0.0155*</td>
</tr>
<tr>
<td>Technology Informatics by age</td>
<td>13.689</td>
<td>0.0034</td>
</tr>
<tr>
<td>Technology Informatics by comp. experie.</td>
<td>7.236</td>
<td>0.1239</td>
</tr>
<tr>
<td>Technology Informatics by comp. usage</td>
<td>7.953</td>
<td>0.0933</td>
</tr>
<tr>
<td>Supercomputers &amp; Comm. by sex</td>
<td>1.250</td>
<td>0.2636</td>
</tr>
<tr>
<td>Supercomputers &amp; Comm. by education</td>
<td>8.032</td>
<td>0.0454*</td>
</tr>
<tr>
<td>Supercomputers &amp; Comm by age</td>
<td>8.322</td>
<td>0.0398</td>
</tr>
<tr>
<td>Supercom &amp; Comm. by comp. experience</td>
<td>6.146</td>
<td>0.1885</td>
</tr>
<tr>
<td>Supercomputers &amp; Comm. by comp. usage</td>
<td>6.613</td>
<td>0.1578</td>
</tr>
<tr>
<td>AI &amp; Simulation by sex</td>
<td>0.429</td>
<td>0.5124</td>
</tr>
<tr>
<td>AI &amp; Simulation by education</td>
<td>11.095</td>
<td>0.0112*</td>
</tr>
<tr>
<td>AI &amp; Simulation by age</td>
<td>10.060</td>
<td>0.0181*</td>
</tr>
<tr>
<td>AI &amp; Simulation by comp. experienc.</td>
<td>9.984</td>
<td>0.0407*</td>
</tr>
<tr>
<td>AI &amp; Simulation by comp. usage</td>
<td>9.688</td>
<td>0.0460*</td>
</tr>
</tbody>
</table>

* Significant

The results presented in Table 14 indicate the K-W chi-square values corresponding to the different areas of the survey instrument considered. As it is illustrated in this table, the area of AI & informatics knowledge
was significant when considered by the demographics of education and computer usage; the group of informatics technology was significant only when considered by education. The group of questions about supercomputers and communications also were significant when considered by education; the area of AI & simulation was significant when considered by education, age, computer experience, and computer usage. The mean ranks table that follows illustrates these results.

Table 15
K-W Mean Ranks Table for AI & Informatics Knowledge by Education

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Professional degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.00</td>
<td>11</td>
<td>Technical</td>
</tr>
<tr>
<td>32.61</td>
<td>44</td>
<td>Bachelor's</td>
</tr>
<tr>
<td>12.92</td>
<td>6</td>
<td>Master's</td>
</tr>
<tr>
<td>22.50</td>
<td>1</td>
<td>Ph.D.</td>
</tr>
</tbody>
</table>

The expectation is that the mean rank sums would be equal for the groups. Table 15 results illustrate that there is a different perception of the need for computer knowledge as the level of education increases. Individuals holding a higher level of education have a greater tendency to disagree with the statement: "Computer knowledge is critical for contemporary society," and with the statement: "Artificial intelligence is finally taking off."
Table 16

K-W Mean Ranks Table for AI & Informatics Knowledge by Computer Usage

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Computer usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.64</td>
<td>29</td>
<td>Commercial</td>
</tr>
<tr>
<td>29.71</td>
<td>7</td>
<td>Education</td>
</tr>
<tr>
<td>34.34</td>
<td>22</td>
<td>Industry</td>
</tr>
<tr>
<td>3.50</td>
<td>1</td>
<td>Government</td>
</tr>
<tr>
<td>3.50</td>
<td>3</td>
<td>Independent</td>
</tr>
</tbody>
</table>

Computer applications are diverse in our modern society and influence the user's opinions about what knowledge a person should have to successfully perform in society. The different opinions of the Colombian industrialist participants in this study are illustrated in Table 16 where the mean rank values of people working in government and independent jobs indicate their tendency to disagree with relation to the need to increase computer knowledge at all levels of instruction.

Table 17

K-W Mean Ranks Table for Informatics Technology by Education

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Professional degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.41</td>
<td>11</td>
<td>Technical</td>
</tr>
<tr>
<td>32.22</td>
<td>44</td>
<td>Bachelor's</td>
</tr>
<tr>
<td>11.92</td>
<td>6</td>
<td>Master's</td>
</tr>
<tr>
<td>19.50</td>
<td>1</td>
<td>Ph.D.</td>
</tr>
</tbody>
</table>
The Colombian industrialists’ views about how computer technology has affected the Colombian scenario is reflected by the respondents’ distribution according to their level of education. Respondents with Master’s and Ph.D. degrees tended more often to answer that computer technologies have not contributed to an increase in the Colombian standard of living.

Table 18

**K-W Mean Ranks Table for Informatics Technology by age**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.64</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>24.46</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td>37.08</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td>00.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td>55.00</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

In this set of questions, respondents in the age group 30-39 had the tendency to disagree regarding the importance of computer technology for improving the Colombian informatics instruction environment.

Table 19

**K-W Mean Ranks Table for Supercomputers & Communication by Education**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Professional degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.14</td>
<td>11</td>
<td>Technical</td>
</tr>
<tr>
<td>31.00</td>
<td>44</td>
<td>Bachelor’s</td>
</tr>
<tr>
<td>17.50</td>
<td>6</td>
<td>Master’s</td>
</tr>
<tr>
<td>20.50</td>
<td>1</td>
<td>Ph.D.</td>
</tr>
</tbody>
</table>
The mean rank values of the Table 19 indicate that Colombian industrialists holding Master's and Ph.D. degrees have the tendency to disagree regarding utilization of supercomputers and electronic communication in Colombia.

Table 20

**K-W Mean Ranks Table for Supercomputers & Communication by Age**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.29</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>26.34</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td>38.63</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td>00.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td>59.50</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

Table 20 does not present a clear definition regarding supercomputers and communication use according to age group. The only respondent in the age group > 60 strongly agrees with the need for these tools for informatics improvement in Colombia.
Table 21

**K-W Mean Ranks Table for AI & Simulation by Education**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Professional degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.55</td>
<td>11</td>
<td>Technical</td>
</tr>
<tr>
<td>32.03</td>
<td>44</td>
<td>Bachelor's</td>
</tr>
<tr>
<td>11.00</td>
<td>6</td>
<td>Master's</td>
</tr>
<tr>
<td>42.50</td>
<td>1</td>
<td>Ph. D.</td>
</tr>
</tbody>
</table>

The results in Table 21 illustrate how respondents holding Master's degrees tend to disagree with the use of computer tools for informatics instruction.

Table 22

**K-W Mean Ranks Table for AI & Simulation by Age**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.18</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>25.69</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td>38.54</td>
<td>12</td>
<td>40-49</td>
</tr>
<tr>
<td>00.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td>57.00</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

The mean rank values of table 22 indicate that most of the respondents in the older groups tend to favor the use of computers as an instructional tool.
Table 23

K-W Mean Ranks Table for AI & Simulation by Computer Experience

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Years of experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.79</td>
<td>7</td>
<td>0-5</td>
</tr>
<tr>
<td>24.50</td>
<td>4</td>
<td>5-10</td>
</tr>
<tr>
<td>29.36</td>
<td>18</td>
<td>10-15</td>
</tr>
<tr>
<td>29.66</td>
<td>25</td>
<td>15-20</td>
</tr>
<tr>
<td>28.69</td>
<td>8</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>

Table 23 indicates that less experienced respondents tend to favor the use of computer techniques for instructional purposes than do the more experienced Colombian respondents.

Table 24

K-W Mean Ranks Table for AI & Simulation by Computer Usage

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Computer usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.24</td>
<td>29</td>
<td>Commercial</td>
</tr>
<tr>
<td>30.07</td>
<td>7</td>
<td>Education</td>
</tr>
<tr>
<td>32.73</td>
<td>22</td>
<td>Industry</td>
</tr>
<tr>
<td>23.50</td>
<td>1</td>
<td>Government</td>
</tr>
<tr>
<td>2.0</td>
<td>3</td>
<td>Independent</td>
</tr>
</tbody>
</table>

This table illustrates that respondents working as independent researchers and with the government tend to disagree with the use of computer aided instruction in Colombia.
Research Question 3

Do the industrialists believe that Colombian universities are fulfilling the needs for informatics in instruction, funding, curriculum, and degree programs? The statistical analysis used was the Kruskal-Wallis one-way analysis of variance by ranks among professional experience levels.

The only significant result obtained for this research question was in the relationship between computer experience and curriculum. Forty-seven people think that the computer science curriculum taught in most Colombian universities is more advanced than the current level of development in Colombia. Eight people were undecided, and 7 people disagree with this statement. The results are presented in Tables 25 and 26.

Table 25

Research Question 3. K-W Chi-square Item Analysis for Informatics Instruction

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum by education</td>
<td>2.39</td>
<td>0.4949</td>
</tr>
<tr>
<td>Research by education</td>
<td>4.14</td>
<td>0.2467</td>
</tr>
<tr>
<td>Doctoral prog. by education</td>
<td>3.47</td>
<td>0.3251</td>
</tr>
<tr>
<td>Comp. inst in High school by education</td>
<td>4.19</td>
<td>0.2420</td>
</tr>
<tr>
<td>Third World &amp; doc. prog by education</td>
<td>1.15</td>
<td>0.7659</td>
</tr>
</tbody>
</table>
Table 25—Continued.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum by computer experience</td>
<td>10.03</td>
<td>0.0389*</td>
</tr>
<tr>
<td>Research by computer experience</td>
<td>1.43</td>
<td>0.8382</td>
</tr>
<tr>
<td>Doctoral prog by computer experience</td>
<td>7.52</td>
<td>0.1108</td>
</tr>
<tr>
<td>Comp. inst in High school by comp. exp.</td>
<td>7.63</td>
<td>0.1060</td>
</tr>
<tr>
<td>Third World &amp; doctoral prog. by comp. exp.</td>
<td>5.26</td>
<td>0.2615</td>
</tr>
</tbody>
</table>

*Significant

Table 26

K-W Results for Individual Variables Curriculum by Computer Experience

<table>
<thead>
<tr>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Yrs. exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square: 10.03</td>
<td>33.07</td>
<td>7</td>
<td>0-5</td>
</tr>
<tr>
<td>Significance: 0.04 (p &lt; 0.05)</td>
<td>39.38</td>
<td>4</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>33.89</td>
<td>18</td>
<td>10-15</td>
</tr>
<tr>
<td></td>
<td>33.32</td>
<td>25</td>
<td>15-20</td>
</tr>
<tr>
<td></td>
<td>15.13</td>
<td>8</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>

Level of Agreement

<table>
<thead>
<tr>
<th>Yrs. exp.</th>
<th>Strng. dis.</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strng. agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>5-10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10-15</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>15-20</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>&gt;20</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

The mean rank values of Table 26 indicate that the significant difference obtained was due to the low value of the mean rank of the respondents in the >20 experience group.
Table 27

Research Question 3. K-W Chi-square Significance by Area of Analysis

<table>
<thead>
<tr>
<th>AREA</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum, funding &amp; degrees by sex</td>
<td>0.0020</td>
<td>0.9640</td>
</tr>
<tr>
<td>Curriculum, funding &amp; degrees by educat.</td>
<td>3.9836</td>
<td>0.2632</td>
</tr>
<tr>
<td>Curriculum, funding &amp; degrees by age</td>
<td>10.4894</td>
<td>0.0148*</td>
</tr>
<tr>
<td>Curriculum, funding &amp; deg. by comp. exp.</td>
<td>0.8551</td>
<td>0.9309</td>
</tr>
<tr>
<td>Curriculum, fund. &amp; deg. by comp. usage</td>
<td>2.5573</td>
<td>0.6344</td>
</tr>
</tbody>
</table>

* Significant

The results in Table 27 present the chi-square value for the academic area of the survey instrument when considered by all the demographic variables involved in the study. The chi-square value for the curriculum, funding and degrees area was significant when it was analyzed with relation to the respondent's age. The mean ranks and the respondents' distribution according to age group is illustrated in Table 28.

Table 28

K-W Mean Ranks Table for Curriculum, Funding & Degrees by Age

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.21</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>28.26</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td>25.29</td>
<td>6</td>
<td>40-49</td>
</tr>
<tr>
<td>00.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td>55.50</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>
In this table, the mean rank values indicate that the respondents in the middle age groups differ in opinion regarding academic informatics with relation to the 20-29 age group and the >60 group.

**Research Question 4**

Do the people in the industrial sector believe that supercomputers are important in improving Third World countries' technology? The statistical analysis used was chi-square. Results: 44 people answered that supercomputers are important for improving developing countries’ technology and, therefore, the investment in supercomputers is not a waste of economic resources; 7 responses were undecided, and 11 answered that supercomputer investment in a Third World country is a waste of economic resources. The Chi-square value is 40.097, df = 4, significance p < 0.001.

From the above results, it is logical to conclude that there exists a high level of certainty among Colombian industrialists about the importance of using supercomputers to improve information handling in the country. The high chi-square value indicates the level of agreement among the respondents.

**Research Question 5**

What is the Colombian industrialists' preference regarding network system or supercomputer when referring to computer utilization? The statistical analysis used was chi-square. Results: 43 people agree that a
fully-connected network has more advantages, 11 were undecided, and 8 preferred supercomputers. The chi-square value obtained was 39.129, df = 4, significance p < 0.001. The results indicate that there is a marked preference for the fully connected-network rather than for a supercomputer.

**Research question 6**

What do the industrialists think about using simulation for instruction? The statistical analysis used was chi-square. Results: 60 respondents answered that computer simulation techniques can improve the quality of instruction, 2 were undecided. These results speak for themselves; the high value of the chi-square (86.064) and the high significance are indications of how aware Colombian computer industrialists are of the importance of computer simulation for instruction in today's society.

**Research Question 7**

What are the Colombian industrialists' opinions about the worldwide sharing of information among institutions of higher learning? The Kruskal-Wallis one-way analysis of variance was used to test the significant differences among age, education, and professional experience levels.
Table 29

Research Question 7. K-W Chi-square Significances

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. network by education</td>
<td>2.15</td>
<td>0.5423</td>
</tr>
<tr>
<td>Worldwide data banks by education</td>
<td>5.92</td>
<td>0.1157</td>
</tr>
<tr>
<td>International network by age</td>
<td>4.90</td>
<td>0.1789</td>
</tr>
<tr>
<td>Worldwide data banks by age</td>
<td>15.26</td>
<td>0.0016*</td>
</tr>
<tr>
<td>International network by comp. exp.</td>
<td>6.74</td>
<td>0.1504</td>
</tr>
<tr>
<td>Worldwide data banks by comp. exp</td>
<td>9.64</td>
<td>0.0468*</td>
</tr>
</tbody>
</table>

* Significant

In this question, the only two significant results obtained were these: worldwide information sharing related to age with a chi-square value of 15.2878 and a significance of 0.0016 and to computer experience with a chi-square value of 9.64 and a level of significance of 0.0468 (p < 0.05). These results are presented in Tables 29, 30, and 31.
Table 30

**Worldwide Database by Age**

<table>
<thead>
<tr>
<th>Age group</th>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>Chi-square : 9.64</td>
<td>42.36</td>
<td>14</td>
<td>0 0 0 1</td>
</tr>
<tr>
<td>30-39</td>
<td>Significance: 0.047 (p &lt; 0.05)</td>
<td>24.90</td>
<td>35</td>
<td>0 0 2 20</td>
</tr>
<tr>
<td>40-49</td>
<td>37.00</td>
<td>12</td>
<td>40-49</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td>0.00</td>
<td>0</td>
<td>50-59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>44.50</td>
<td>1</td>
<td>&gt;60</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Strng. dis.</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strng. agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>30-39</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>40-49</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>&gt;60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 30 indicates that there is a general consensus among Colombian industrialists regarding the importance of information sharing on a worldwide database.

Table 31

**K-W Individual Variable Results. Worldwide Database by Computer: Experience**

<table>
<thead>
<tr>
<th>Yrs of Experience</th>
<th>K-W results:</th>
<th>Mean Rank</th>
<th>Cases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Chi-square: 9.65</td>
<td>44.50</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5-10</td>
<td>Significance: 0.047 (p &lt; 0.05)</td>
<td>22.00</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>10-15</td>
<td>27.83</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-20</td>
<td>29.58</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;20</td>
<td>39.13</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results from Table 31 indicate that 87.5% (7/8) of the respondents in > 20 years of experience group strongly agree with the following statement: "The connection of worldwide data banks should be a goal for the year 2000." The same applies to 100% (7/7) of the respondents in the 0-5 years of experience group.

Table 32

Research Question 7. K-W chi-square Significance by Area of Analysis

<table>
<thead>
<tr>
<th>AREA</th>
<th>CHI-SQUARE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intl. Informatics by sex</td>
<td>1.940</td>
<td>0.1637</td>
</tr>
<tr>
<td>Intl. Informatics by education</td>
<td>4.518</td>
<td>0.2107</td>
</tr>
<tr>
<td>Intl. Informatics by age</td>
<td>11.499</td>
<td>0.0093*</td>
</tr>
<tr>
<td>Intl. Informatics by comp. experience</td>
<td>8.977</td>
<td>0.0617*</td>
</tr>
<tr>
<td>Intl. Informatics by comp. usage</td>
<td>5.153</td>
<td>0.2719</td>
</tr>
</tbody>
</table>

*Significant

Table 32 is a results summary of the opinions of the Colombian industrialists regarding the survey instrument questions that
deal with the need for sharing information on a worldwide basis. This table presents that this area was significant regarding age group and computer experience. The following tables (33 and 34) deal with these two factors independently.

Table 33

**K-W Mean Ranks Table for Intl. Informatics by Age**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>41.68</td>
<td>14</td>
<td>20-29</td>
</tr>
<tr>
<td>25.43</td>
<td>35</td>
<td>30-39</td>
</tr>
<tr>
<td>35.92</td>
<td>6</td>
<td>40-49</td>
</tr>
<tr>
<td>00.00</td>
<td>0</td>
<td>50-59</td>
</tr>
<tr>
<td>48.50</td>
<td>1</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

The mean rank values of Table 33 indicate that 56.5% (35/62) of the Colombian respondents have the tendency to disagree with the need for openness to the international informatics environment in Colombia.

Table 34

**K-W Mean Ranks Table for Intl. Informatics by Computer Experience**

<table>
<thead>
<tr>
<th>Mean rank</th>
<th>Cases</th>
<th>Years of experience</th>
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<tbody>
<tr>
<td>42.79</td>
<td>7</td>
<td>0-5</td>
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<tr>
<td>20.75</td>
<td>4</td>
<td>5-10</td>
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<tr>
<td>27.31</td>
<td>18</td>
<td>10-15</td>
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<tr>
<td>29.86</td>
<td>25</td>
<td>15-20</td>
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<tr>
<td>41.56</td>
<td>8</td>
<td>&gt;20</td>
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</tbody>
</table>
The K-W mean rank distribution for the questions dealing with the need for Colombian openness to the international informatics world by years of experience of the respondents gave the results presented in Table 34. This table illustrates that 75.8% (47/62) of the Colombian industrialist respondents tend to disagree regarding the Colombian exposure to the international informatics scenario.

Research Question 8

Do the industrialists believe that Colombian universities can produce quality software for the external market? The statistical analysis used was chi-square. The results obtained were a chi-square value of 33.645, df= 4, and a significance level of 0.000 (p < 0.001). Almost 68% (67.7) of the respondents think Colombian universities can produce quality software for the external market; 6 were undecided, and 14 believe that Colombian universities cannot produce quality software for the external market.

Summary

The academic area of the survey instrument was not significant when considered by sex. The area of artificial intelligence was significant when considered by age and computer usage. The questions dealing with a doctoral program were significant when considered by age; 91.7% of the respondents disagreed or strongly disagreed with the need for informatics doctoral programs in Colombia. The majority of Colombian industrialists (72%) in the 15-20 years of experience group prefer a fully-connected
network of microcomputers to a supercomputer of the same capacity. The same trend was observed regarding all age groups.

The mean rank values of respondents working in government and independent jobs indicate their tendency to disagree with relation to the need to increase computer knowledge at all levels of instruction. There were different perceptions of the need for computer knowledge as the level of education increased. Individuals holding a higher level of education have a greater tendency to disagree with the statement: "Computer knowledge is critical for contemporary society." Respondents with Master's and Ph.D. degrees had a greater tendency to answer that computer technologies have not contributed to the increase in the Colombian standard of living. Respondents holding a Master's degree tended to disagree with the use of computers as tools for informatics instruction. The same tendency was presented by Colombian industrialists working as independent researchers or with the government.

The respondents in the middle age groups deferred in opinion regarding academic informatics with relation to the 20-29 age group and the group older than 60. Colombian computer industrialists are aware of the importance of computer simulation for instruction in today's society. A general consensus exists among Colombian industrialists regarding the
importance of information sharing on a worldwide database. Lastly, 67.7% of the respondents think that Colombian universities can produce quality software for the external market.
Summary

The department heads and the industrialists manifested a strong inclination to support computer literacy in education at all population levels. This report is a summary of the study's findings. A 71% rate of return was obtained, a result greater than the one expected (60%).

The level of education of the respondents: 1 Ph.D., 6 Masters, 44 BS/BA, and 11 holding technical degrees. Most of the respondents belong to the 30-40 year age group. This is a clear indication that informatics and computer studies are in the domain of the generation born in the 1950s and 1960s.

Most of the respondents agreed that the Colombian government is not giving adequate support to the national education system. Another relevant result was the high significance shown by the age of the respondents and their disagreement regarding the need to implement an informatics research plan oriented toward the program granting Ph.Ds.
Research Question 1

What are the Colombian industrialists' opinions about the computer instruction at Colombian universities when evaluated by gender? There was no significant difference between male and female in research Question Number 1 regarding computer instruction at Colombian Universities. Most of the respondents agreed that the universities are producing a good quality undergraduate degree and that the curriculum taught is fulfilling the needs of the Colombian community.

Research Question 2

What similarities will appear in the opinions of the Colombian industrialists toward computer technologies when evaluated by gender, age, education, and professional experience? The K-W test of the Colombian industrialists' opinions about the concept of artificial intelligence finally emerging was significant with relation to the respondent's age. The area of AI & informatics knowledge was significant when considered by the demographics of education and computer usage; the questions on informatics technology was significant only when considered by education. The group of questions about supercomputers and communications also was significant when considered by the education variable; the area of AI & simulation was significant when considered by education, age, computer experience, and computer usage variables.

The distribution of the Colombian industrialists' views about how
computer technology has affected the Colombian scene was reflected by the respondents' level of education. Respondents with Master's and Ph.D. degrees had a greater tendency to answer that computer technologies have not contributed to the increase in Colombia's standard of living.

The question about assembling microprocessors on campus in order to provide for themselves and to supply the rest to the external market received mostly negative answers. One of the respondents expressed his opinions about this subject in the following way: "I believe that the role of the Colombian university is to teach and transfer the knowledge into Colombian manpower, not to compete with the private industry in the world market" (J. J. Martinez, personal communication, June 22, 1990).

**Research Question 3**

Do the industrialists believe the Colombian universities are fulfilling the needs for informatics in instruction, funding, curriculum, and degrees? The only significant result obtained in this research question was in the relationship between computer experience and curriculum. Forty-seven people thought that the computer science curriculum taught in most Colombian universities is more advanced than the current level of development in Colombia. Eight respondents were undecided, and 7 disagreed with this statement. The chi-square value for the curriculum, funding and degrees area was significant when it was analyzed with relation to the respondent's age.
Research Question 4

Do the people in the industrial sector believe that supercomputers are important for improving technology in Third World countries? Results: 73.3% of the respondents answered that supercomputers are important for improving developing countries' technology and, therefore, the investment in supercomputers is not a waste of economic resources.

Research Question 5

What is the Colombian industrialists' preference regarding a network system or a supercomputer when referring to computer utilization? Results: 69.3% of the participants agreed that a fully-connected network has more advantages, 17.7% were undecided, and 13% preferred supercomputers to a fully-connected network. Results were determined by the fact that there is no supercomputer in the country, and local area networks (although not fully connected) are the most common computer architecture imposing its paradigm on the Colombian environment.

Research Question 6

What do the industrialists think about using simulation for instruction? The statistical analysis used was chi-square. Results: 96.8% of the respondents answered that computer simulation techniques can improve the quality of instruction, 3.2% were undecided. These results indicate the high value of the chi-square (86.064) and the high significance is an indication of how aware Colombian computer industrialists are of the
importance of computer simulation for instruction in today's society.

Noteworthy is the fact that were no negative responses.

**Research Question 7**

What is the Colombian industrialists' opinions about the worldwide sharing of information among institutions of higher learning? The Kruskal-Wallis one-way analysis of variance was used to test the significant differences among age, education, and professional experience. In this question, the only two significant results obtained were: worldwide information sharing related to age with a chi-square value of 15.2878 and a significance of 0.0016. The same variable with relation to computer experience had a chi-square value of 9.6451 and a level of significance of 0.0468 (p < 0.05). Almost 57% (35/62) of the Colombian respondents had a tendency to disagree regarding the need for openness in Colombia to the international informatics environment. These results indicate that there is not a general consensus among Colombian industrialists regarding the importance of information sharing on a worldwide database.

**Research Question 8**

Do the industrialists believe that Colombian universities can produce quality software for the external market? Almost 68% (67.7) of the respondents thought Colombian universities can produce quality software
for the external market: 9.7% were undecided, and 22.6% believed that Colombian universities cannot produce quality software.

The majority of the respondents believed that Colombia has the human resources for an outstanding development in informatics, but lacks the hardware resources for research and development in the software field.

**Discussion of Findings**

The high significance of the research question dealing with computer technology indicates the willingness of the Colombian industrialists to adopt new methods for improvement. In the academic field, the need for teaching computer courses at the high school level was identified as critical by the members of the industrial and educational communities. This topic is being pursued by the Colombian government through its National Service for Learning (Servicio Nacional de Aprendizaje: SENA) which has created Informatics Development Centers (IDCs). However, there is still not a decree or law that makes computer teaching compulsory in the basic curriculum of private and public secondary schools.

The question about teaching digital logic at the university level did not present a significant difference for any of the demographic variables. The question about whether or not artificial intelligence was an important issue in the development of computer technology was significant when considered by respondents' age and computer usage. With respect to
Research Question 3, the majority of those surveyed felt that Computer Aided Instruction is a technique that should be adopted by the Colombian education system. For Research Question 3, most of the respondents answered that the Colombian computer instruction curriculum is more advanced than the current level of development in the country.

Most of the participants suggested that Colombia has the economic resources to start some kind of informatics research. In the personal interviews that the researcher made with some department heads, the most common complaint was that government administrators of national resources lack the appropriate knowledge to assign funds for acquisition of new technology. In short, they are afraid to make costly decisions that could jeopardize their life appointment to government posts.

With regard to Research Question 7, dealing with electronic communication, most respondents felt that although there is now a node connected to the international BITNET network, there is still a long way to go since there are only two universities connected to this communications system. All respondents felt that the connection to the worldwide data banks is a necessity that should not wait until the year 2000; it is a commitment that should be accomplished now. The success of BITNET and other commercial and academic networks is a testimony to the offset of a new era in electronic communication. Research indicates that with the growing internationalization of business and the popularity of personal
computing, similar networks may become as routine as the telephone system (Gurbaxani, 1990).

Most of the respondents answered that the sponsoring of Colombian national studies in foreign countries by multinational corporations is a good way to contribute to the development of Colombian society (Research Question 7). However, some fear was expressed regarding the possible intervention by corporations into national educational policies. The risk is that importing policy rationales and making decisions based on developed countries paradigms may work to preserve the current predominance that industrialized countries have in the field of informatics with relation to Third World nations. Few articles were found containing discussions of issues about informatics educational policy in developing countries (Research Questions 1 and 2). Abass (1981) reports that during an international seminar held in Australia in 1980, one of the conclusions was "developing countries should concentrate on applications." Indicating that, developing countries take advantage of already existing informatics technology instead of investing their scarce resources in trying to develop a technology that already exists.

With regard to Research Question 4, several Colombian industrialists and scholars believed that it is time for Colombia to acquire a supercomputer. They believe that a supercomputer can be utilized in research like the search for a malaria vaccine and that simulation
techniques applied can be to experimental tropical agriculture. A major use for the petroleum industry is processing seismic data, which must be analyzed to determine an area's underlying geology and likelihood of containing petroleum deposits. Profit can justify investment in a supercomputer. Such computer programming used in flow simulation of underground petroleum reservoirs is expected to increase the yield of secondary and tertiary recovery (Dallaire, 1984). A supercomputer can also be useful in the field of social sciences, engineering, and other technical fields. Scientists anxious to pursue great endeavors want to use computer simulation to solve some of the most acute national problems. For instance, a supercomputer could be used for studying river flows to avoid periodic floods, developing weather patterns, and optimizing power grids.

With relation to the question "How many years do you think Colombian computer technology is behind the more advanced countries in this field?" 44 people gave an answer of 10 years. Several of the respondents made the comment that the question should be more specific because they feel that the gap between developed and developing countries is wider in the hardware field than it is in the field of software.

Conclusions and Recommendations for Future Research

From the results of the survey and interviews conducted, it can be deduced that informatics is playing and will play an important role in the
future of Colombian society. Already, the view of systems engineering as a profession dealing with the applications of a general theory of systems has been losing acceptance in favor of increased emphasis in specialization in the different fields of information and computation. Perhaps this has been motivated by the demands of the Colombian informatics environment.

The author advises each university program to establish an orientation toward informatics and a profile more suitable to its physical and human resources. Special emphasis should be given to the depth of the courses taught and their application in the local environment. The need for government sponsoring of local, national, and international conferences for professionals working in the field of informatics may promote the formation of scientific communities that can improve the level of investigation in this field in the Colombian community. These scientific communities are the seed that will produce quality human resources for the future Colombian information society.

Inbreeding is a serious problem at Colombian Universities. The majority of the country's universities hire their own graduates instead of graduates from other institutions. Therefore, the exchange among different institutions is almost nil. This kind of behavior has caused a deterioration in the educational system in Colombia because there is not a healthy exchange of ideas among institutions of higher learning (Moe, 1988). Sometimes the lack of exposure to other points of view makes the
institutions remain attached to ideas, models, and teaching tools that are no longer in use in other parts of the world. The Colombian Ministry of Education needs to address this problem by creating an institute like MIT or CIT (Colombian Institute of Technology), where students with outstanding achievement at the undergraduate level can continue graduate studies in the sciences. This institute could orient its curriculum to prepare Ph.D.s for research and teaching in different institutions of higher learning in the country. This idea could be implemented by promoting one of the regional institutions to a higher level or by creating a new institution. This new institution could be situated in a smaller city. Colombia should try to avoid the increasing tendency to concentrate all the educational, human, and technological resources in the capital. Cost effectiveness would be realized in setting up this institution as a supercomputer center. University computer users, anywhere in the country, could then connect into these supercomputers via data networks. Centralizing supercomputers would allow for a number of savings: inexpensive manpower, in the use of peripheral equipment, and so forth. Such centralization would allow many universities and industries to have access to a good supercomputer service at the end of a phone line.

Detected during this study was the fact that almost all the Colombian universities lack the hardware and software computer resources to improve the quality of instruction. Assembling clones on campus could be
a temporary solution to the hardware problem relating to terminals and microprocessors. In the last twenty years, the Colombian government has been addressing the need to create a research program for all the scientific areas. The objective is to improve national development, however very few efforts have shown any positive results. One problem that affects the implementation of research programs is the high student/faculty ratio, especially in most of the private institutions (Martinez, 1989). Another problem is the lack of graduate programs oriented to the development of professionals in the area of informatics research.

In the long run, informatics education may determine the future role of a country. As long as a country, like Colombia, is only educating a few elite programmers, such programmers will be very good and very scarce. Therefore, the role of the country in the software world market will remain the same (Press, 1991). A recommendation that additional investigations be carried out to pursue more deeply the issues related with the evaluation of the SENA’s Information Diffusion Centers (IDCs). Further study is needed to determine if Colombia can build the infrastructure to educate the masses of average programmers needed by a growing software industry. The improvement and price reduction of personal computers will influence the education system of developing countries by decreasing the hardware budget to support teaching and research.

The Colombian government should implement a pilot research
program aimed at the implementation of informatics education in Colombia based on the SENA IDCs. This pilot program should take advantage of the experiences of other Latin American countries with this kind of experiment (Machado, 1985; Adler, 1986). Various universities should be contacted to submit proposals, and national meetings should be held in order to discuss these proposals. Such dialogues would produce models and software that would help the government to implement policy for a broader informatics education program in Colombia.
APPENDIX A

NAMES AND COMPANIES OF COLOMBIAN INDUSTRIALISTS INTERVIEWED
Names and Companies of Colombian Industrialists Interviewed.

1. Argemiro Echeverri  
   Director of Development,  
   ICFES, Bogotá D.E., Colombia

2. Alfredo Fajardo R.  
   Director, Industrial Security,  
   Elf-Aquitaine, Bogotá D.E., Colombia

3. Rodrigo Fuenmayor R.  
   Commercial Vice President,  
   Monomeros Colombo-Venezolanos,  
   Barranquilla, Colombia

4. Diego López Arango  
   Vice President, Operations,  
   Compañía Colombiana Automotriz,  
   Bogotá D.E., Colombia

5. José J. Martinez Paéz  
   Chairman, Systems Engineering,  
   Department, Universidad Nacional  
   Colombia, Bogotá D.E., Colombia

6. Alvaro Maz  
   Manager, Systems Department,  
   Colmotores, Bogotá D.E.,  
   Colombia

7. Ernesto Prieto  
   Head, Technical Division, Systems  
   Department, Colmotores, Bogotá D.E.,  
   Colombia

8. Hector Rodelo S.  
   Manager, Accounting Department,  
   Monomeros Colombo-Venezolanos,  
   Barranquilla, Colombia.

9. María T. Rodriguez  
   Director, Corporate Services,  
   CARBOCOL, Bogotá D.E.,  
   Colombia

10. Alvaro Ruiz B.  
    Chairman, Systems Engineering  
    Department, Universidad del Norte  
    Barranquilla, Colombia

11. Rodrigo Wadniper  
    Systems Department,  
    Monomeros Colombo-Venezolanos,  
    Barranquilla, Colombia
APPENDIX B

JURY PANEL FOR INSTRUMENT VALIDATION
Jury Panel for Instrument Validation

1. Juan G. Arango V.  
   Director, Student Affairs, 
   Universidad EAFIT, Medellín, 
   Colombia

2. Hernando Gamboa G.  
   Chairman of Informatics Graduate 
   Studies, Universidad Industrial de 
   Santander, Bucaramanga, Colombia

3. José V. García P.  
   Dean, Engineering School, 
   Universidad Distrital "Francisco 
   José Caldas", Bogotá D.E., Colombia

4. José D. Martinez M.  
   Chairman, Electronic Engineering 
   Department, Universidad Santo 
   Tomás, Bogotá D.E., Colombia

5. José J. Martinez P.  
   Chairman, Systems Engineering 
   Department, Universidad Nacional 
   de Colombia, Bogotá D.E., Colombia

6. Marta Millan G.  
   Director, Systems Engineering 
   Graduate Program, Universidad del 
   Valle, Cali, Colombia

7. Luis E. Orozco S.  
   Vice President for Academic Affairs, 
   Universidad de los Andes, Bogotá D. 
   E., Colombia

8. Orlando Ortiz S.  
   Chairman, Abaco Project, 
   Pontificia Universidad Javeriana, 
   Bogotá D.E., Colombia

9. German Urrego G.  
   Professor, Systems Engineering 
   Department, Universidad de 
   Antioquia, Medellín, Colombia
APPENDIX C

ENGLISH VERSION OF THE SURVEY INSTRUMENT
English Questionnaire

This questionnaire attempts to trace the models of opinion among Colombian computer industrialists with respect to the role of Informatics in national development.

General Information:
Please select the number that best fits your circumstances.

1. Education:
   1) High school
   2) Technical
   3) Bachelor's
   4) Master's
   5) Doctoral

2. Sex:
   1) Male
   2) Female

3. Age group
   1) 20 - 29 years
   2) 30 - 39 years
   3) 40 - 49 years
   4) 50 - 59 years
   5) 60 and above

4. Computer experience:
   1) 0 - 5 years
   2) 5 - 10 years
   3) 10 - 15 years
   4) 15 - 20 years
   5) more than 20 years

5. Computer usage:
   1) Commercial
   2) Education
   3) Industry
   4) Government office
   5) Independent research/Personal
Directions: Please choose from one of the following: strongly agree (5), agree (4), undecided (3), disagree (2), strongly disagree (1).

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<tbody>
<tr>
<td>1. Teaching computer logic in a higher education institution is a waste of time.</td>
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<td>2. Some Colombian universities have enough know-how to develop their own computers.</td>
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<td>3. Some Colombian universities have enough knowledge to assemble their own microcomputers.</td>
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<td>4. The academic level and the existing facilities in Colombian computer science departments do not have the potential to develop computer software for the foreign market.</td>
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<td>5. Subscriptions to prestigious journals are important for the development of computer scientists.</td>
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<tr>
<td>6. Colombian universities should have their own computer shop in order to compete with the private sector in this business.</td>
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<td>7. Computer aided instruction is a technique that is far beyond that of the actual situation of Colombian technology.</td>
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<td>8. The graduates from the Colombian programs of computer science are well prepared for real world applications.</td>
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<td>9. The computer science curriculum taught in most of the Colombian universities is more advanced than the current level of development in Colombia.</td>
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10. Computer research is so costly that the Colombian education system cannot afford it.

11. Colombia needs to implement a Ph.D. program in Computer Science in order to develop the students' potential in this field.

12. High school graduates should have a basic understanding of computers.

13. Computer simulation techniques can improve the quality of instruction.

14. Artificial intelligence is finally taking off.

15. Computer knowledge is critical for contemporary society.

16. With the power of the new workstations, it will be better to have a fully connected system than a supercomputer of the same capacity.

17. The connection of higher education institutions through an international network is a necessity for Third World countries.

18. The connection of worldwide data banks should be a goal for the year 2000.

19. Multinational corporations should be sponsors of technological specialization in foreign countries.

20. Supercomputers belong to such a high technological field that having one in a Third World country would be a waste of economic resources.
21. Computer technology has contributed to the development of a better standard of living in Colombia.

22. Third World countries are so far behind that a Ph.D. in Computer Science does not have practical application in their educational systems.

23. How many years do you think Colombian computer technology is behind the more advanced countries in this field?

1) 20 years  2) 15 years  3) 10 years  4) 5 years  5) 0 years
APPENDIX D

SPANISH VERSION OF THE SURVEY INSTRUMENT
Este cuestionario intenta trazar los modelos de opinión de los industriales colombianos de la Informática, con relación al papel de la informática en el desarrollo nacional.

Información general:
Encierre en un círculo el número correspondiente a la respuesta que mejor se acomoda a sus circunstancias.

1. Educación:
   1) Bachillerato  2) Técnica  3) Grado profesional  4) Maestría  5) Doctorado

2. SEXO:  
   1) Masculino  2) Femenino

3. EDAD
   1) 20-29 años  2) 30-39 años  3) 40-49 años  4) 50-59 años  5) más de 60 años

4. Experiencia con computadores:
   1) 0-5 años  2) 5-10 años  3) 10-15 años  4) 15-20 años  5) más de 20 años

5. Uso del computador en su empresa:
   1) Comercial  2) Educativo  3) Industrial  4) Oficina gubernamental  5) Investigación independiente/personal
(6-13) Instrucciones: Por favor escoja una de las siguientes opciones: Completamente de acuerdo (5), De acuerdo (4), Indeciso (3), En desacuerdo (2), Completamente en desacuerdo (1).

1. La enseñanza de la lógica de los computadores es una pérdida de tiempo en una institución de educación superior.  
   5 4 3 2 1

2. Algunas universidades colombianas poseen suficiente conocimiento para desarrollar sus propios computadores.  
   5 4 3 2 1

3. Algunas universidades colombianas tienen suficiente conocimiento para ensamblar sus propios microcomputadores.  
   5 4 3 2 1

4. El nivel académico y las facilidades existentes en las facultades de ciencia de la computación en Colombia no permiten el desarrollo de programas de computadores para el mercado externo.  
   5 4 3 2 1

5. Las subscripciones a revistas de reconocido prestigio científico son importantes para la formación de científicos en la ciencia de la informática.  
   5 4 3 2 1

6. Las universidades colombianas pueden tener sus propios talleres de ensamblaje y reparación de computadores para competir con la industria privada.  
   5 4 3 2 1

7. La instrucción con la ayuda de los computadores es una técnica que está más allá de la situación tecnológica actual de Colombia.  
   5 4 3 2 1

8. Los egresados de los programas de ciencia de la informática de Colombia están bien preparados para llenar los requerimientos del mundo actual.  
   5 4 3 2 1
9. El curriculum de la ciencia de la informática enseñado en la mayoría de las universidades de Colombia es más avanzado que el nivel actual de desarrollo del país.

10. La investigación en el área de ciencia de la informática es tan costosa que el sistema educativo colombiano no puede costearla.

11. Colombia necesita desarrollar un programa de doctorado en informática con el fin de mejorar su potencial humano en este campo.

12. Los egresados de las escuelas de enseñanza secundaria deben tener un conocimiento básico de la ciencia de la informática.

13. Las técnicas de simulación usando computadores pueden mejorar la calidad de la instrucción.

14. La inteligencia artificial está finalmente en una etapa de desarrollo.

15. El conocimiento de computadores es crítico en nuestra sociedad contemporánea.

16. Con la potencia de las nuevas estaciones de trabajo es mejor tener un sistema totalmente conectado que un supercomputador de la misma capacidad.

17. El enlazamiento de las instituciones de educación superior por medio de una red internacional de comunicación es una necesidad para los países del tercer mundo.
18. El enlazamiento de los bancos de información alrededor del mundo debe ser una meta para el año 2000. 5 4 3 2 1

19. Las corporaciones multinacionales deben ser patrocinadores de la capacitación en el exterior en informática del personal nativo de una nación del tercer mundo. 5 4 3 2 1

20. Los supercomputadores pertenecen a un campo tecnológico tan avanzado que tener uno en un país del tercer mundo sería un desperdicio de recursos económicos. 5 4 3 2 1

21. La tecnología de los computadores ha contribuido al desarrollo de un mejor nivel de vida en Colombia. 5 4 3 2 1

22. Los países del tercer mundo están tan atrasados que grados de doctorado en informática no tienen aplicación práctica en su sistema educativo. 5 4 3 2 1

23. Cuántos años de retraso cree usted que tiene la tecnología de computadores en Colombia comparada con los países más avanzados en este campo?

1) 20 años  2) 15 años  3) 10 años  4) 5 años  5) 0 años
APPENDIX E

ENGLISH VERSION OF THE INTERVIEW QUESTIONNAIRE FOR
SYSTEMS ENGINEERING DEPARTMENT
Systems Engineering Departments Questionnaire Evaluation.

Please select the number that best fits your circumstances.

1. How long ago was your department implemented?

   1) 1-5 years  4)  20-30 years
   2) 5-10 years  5)  more than 30 years
   3) 10-20 years

2. Mathematics requirements of the CSCI department:

   1) Algebra  4) Differential equations
   2) Calculus  5) Advanced mathematics
   3) Special mathematics

3. Computer languages taught:

   1) Pascal, Fortran  4) All of the above
   2) Pascal, Fortran, C  5) Teaching of a particular language
   3) Cobol, Modula, Ada  depends of the instructor

4. Does your department have advanced courses in operating systems in its curriculum?

   1) Yes  2) No

5. Does your department have advanced courses in computer architecture in its curriculum?

   1) Yes  2) No

6. Does your department have advanced courses in software engineering in its curriculum?

   1) Yes  2) No
7. Does your department have advanced courses in programming language design?
   1) Yes  2) No

8. Does your department have advanced courses in communications and network in its curriculum?
   1) Yes  2) No

9. Number of available terminals / Number of students:
   1) 1/5  4) 1/50
   2) 1/10  5) less 1/50
   3) 1/20

10. Academic mainframe capacity:
    1) Less than 10 megabyte  4) 40 megabyte
    2) 20 megabyte  5) more than 40 megabyte
    3) 30 megabyte

11. Number of personal computers available:
    1) 1-5  3) 20-50
    2) 5-10  4) more than 50
    3) 10-20

12. Number of refereed journals in the library:
    1) 1-5  4) 15-20
    2) 5-10  5) more than 20
    3) 10-15

13. Does your department have a designated computer for research?
    1) Yes  2) No
14. Research areas in which the department is involved:

   1) Educational software
   2) Operating systems, parallel processing
   3) Hardware design
   4) Software engineering, Data base design
   5) All of the above

15. Average number of scientific articles produced annually by the faculty members:

   1) 0
   2) 1-5
   3) 5-10
   4) 10-15
   5) 15-20

16. Number of annual conferences organized by the computer science department:

   1) 0
   2) 1
   3) 2
   4) 3
   5) more than 3

17. Annual department budget in millions of Colombian pesos.

   1) less than 50 millions
   2) 50 - 100 millions
   3) 100-200 millions
   4) 200-600 millions
   5) more than 600 millions

18. Number of full-time professors:

   1) 1-5
   2) 5-10
   3) 10 -15
   4) 15-20
   5) more than 20

19. What number of full-time professors are graduated from the same University?

   1) 1-5
   2) 5-10
   3) 10-15
   4) 15-20
   5) more than 20
20. How many Ph. Ds or doctors are full-time professors in your department?

1) 0  
2) 5-10  
3) 10-15  
4) 15-20  
5) more than 20

21. Monthly average salary of the full-time faculties in thousands of Colombian pesos:

1) 200,000 - 300,000  
2) 300,000 - 400,000  
3) 400,000 - 500,000  
4) 500,000 - 600,000  
5) more than 600,000

22. Number of students hired/ number of students graduated one year after graduation.

1) 1.0 - .90  
2) .90 - .80  
3) .80 - .70  
4. Less than .70  
5. Not available

23. Number of students graduated from the program/ number of students admitted to the program.

1) 1/1  
2) 1/2  
3) 1/4  
4) 1/5  
5) Less than 1/5
APPENDIX F

SPANISH VERSION OF THE INTERVIEW QUESTIONNAIRE FOR SYSTEMS ENGINEERING DEPARTMENT
Cuestionario de evaluación de facultades de ingeniería de sistemas.

Información general:
Encierre en un círculo el número correspondiente a la respuesta que mejor se acomoda a sus circunstancias.

1. Educación:
   1) Bachillerato
   2) Técnica
   3) Grado profesional
   4) Maestría
   5) Doctorado

2. SEXO:
   1) Masculino
   2) Femenino

3. EDAD
   1) 20 - 29 años
   2) 30 - 39 años
   3) 40 - 49 años
   4) 50 - 60 años
   5) más de 60 años

4. Experiencia con computadores:
   1) 0 - 5 años
   2) 5 - 10 años
   3) 10 - 15 años
   4) 15 - 20 años
   5) más de 20 años

5. Uso del computador central en su facultad:
   1) Académico exclusivo
   2) Académico, administrativo
   3) Académico, administrativo e industrial
   4) Investigación básica
   5) Investigación aplicada
(6-12) Por favor encierre en un círculo el número correspondiente a la respuesta que mejor se acomoda a sus circunstancias.

1. Cuantos años de fundada tiene su facultad?
   1) 1-5 años  4) 20-30 años
   2) 5-10 años  5) más de 30 años
   3) 10-20 años

2. Nivel matemático requerido en la facultad de ingeniería de sistemas:
   1) Algebra  4) Ecuaciones diferenciales
   2) Cálculo  5) Matemáticas avanzadas
   3) Matemáticas especiales

3. Lenguas de computadores enseñadas:
   1) Pascal, Fortran  4) Todas las de arriba
   2) Pascal, Fortran, C  5) El aprendizaje de una lengua
   3) Cobol, Modula, Ada en particular depende del instructor

4. Tiene su facultad cursos avanzados de sistemas operativos en su currículum?  
   1) Sí  2) No

5. Tiene su facultad cursos avanzados de arquitectura de computadores en su currículum?  
   1) Sí  2) No

6. Tiene su facultad cursos avanzados de ingeniería de Software en su currículum? 
   1) Sí  2) No

7. Tiene su facultad cursos avanzados sobre diseño de lenguas de programación?  
   1) Sí  2) No
8. Tiene su facultad cursos avanzados de Comunicaciones y redes en su currículum?
   1) Sí   2) No

   1) 1/5   4) 1/50
   2) 1/10  5) menos de 1/50
   3) 1/20

10. Capacidad de la memoria principal del computador central.
    1) menos de 10 megabyte        4) 40 megabyte
    2) 20 megabyte                 5) más de 40 megabyte.
    3) 30 megabyte

11. Número de computadores personales disponibles.
    1) 1-5                          3) 20-50
    2) 5-10                        4) más de 50
    3) 10-20

12. Número de revistas acreditadas en la biblioteca.
    1) 1-5                        4) 15-20
    2) 5-10                      5) más de 20
    3) 10-15

13. Posee el departamento un computador exclusivo para investigación.
    1. Sí        2. No

14. Areas de investigación en las cuales se concentra su facultad.
    1) Software Educativo        4) Ingeniería de Software, Diseño
    2) Sistemas operativos       de bancos de datos
    3) Diseño de Hardware        5) Todas las mencionadas
(20-25) 15. Número promedio de publicaciones científicas producidas por los profesores anualmente.

1) 0 4) 10-15
2) 1-5 5) 15-20
3) 5-10

16. Número de conferencias anuales organizadas por la facultad de ingeniería de sistemas.

1) 0 4) 3
2) 1 5) más de tres
3) 2

17. Presupuesto anual del departamento en millones de pesos colombianos.

1) menos de 50 millones 3) 100-200 millones 5) 600 o más
2) 50-100 millones 4) 200-600 millones

18. Número de profesores de tiempo completo.

1) 1-5 4) 15-20
2) 5-10 5) más de 20
3) 10-15

19. Qué número de catedráticos egresados de la misma universidad están enseñando en la misma universidad?

1) 1-5 4) 15-20
2) 5-10 5) más de 20
3) 10-15

20. Cuántos Ph.D o doctores están enseñando tiempo completo en su facultad?

1) 0 4) 15-20
2) 5-10 5) más de 20
3) 10-15
21. Salario mensual promedio de los profesores de tiempo completo

1) 200.000 - 300.000  4) 500.000 - 600.000
2) 300.000 - 400.000  5) mas de 600.000
3) 400.000 - 500.000

22. Relación del número de estudiantes empleados al número de estudiantes egresados un año después de la graduación.
   Empleados/Egresados.
   1) 1.0-.90  4) menos de .70
   2) .90-.80  5) Informacion no disponible
   3) .80-.70

23. Relación del número de estudiantes egresados al número de estudiantes admitidos al programa.

   1) 1/1  2) 1/2  3) 1/4  4) 1/5  5) menos de 1/5
APPENDIX G

LETTER SENT TO THE PRESIDENT OF COLOMBIAN UNIVERSITIES
April 27, 1990

Dr. Ricardo Mosquera Mesa  
Rector de la Universidad Nacional de Colombia  
Bogota D. E.

Dear Rector,

Eusebio Jose Cabrales is a Colombian student and also one of my advisees in the Ph.D program of Higher Education Administration at the University of North Texas. His main interest is to perform a study that can contribute to the improvement of the computer instruction in Colombia. In order to perform this study, he needs to test the reliability and validity of the enclosed questionnaire.

I would ask you for your collaboration in this study by the appointment of one of your faculty who is an expert in the field as a jury member for this instrument. Please return the evaluated survey and an official letter with your comments to us in the enclosed, self-addressed, stamped envelope. Your response will be confidential and will be seen only by the researcher. Others questionnaires are being mailed to other university presidents; and all surveys will be evaluated collectively. Your collaboration and prompt reply will be appreciated.

Thank you for your cooperation.

Sincerely yours,

Dr. John P. Eddy  
Professor, Higher Education Department  
University of North Texas  

Eusebio J. Cabrales  
Ph. D. candidate  
University of North Texas
REFERENCES


Martínez, J. D. (1989). *Estudio sobre el estado de desarrollo y de inserción social de la Ingeniería Electrónica e Informática* [A study about the status of development and social insertion of the Electronic Engineering and Informatics]. Universidad Santo Tomás, Decanatura de Ingeniería Electrónica, Bogota.


Nielsen, Janni. (1986). "I trusted the measurements more than my foot" - said the man. Copenhagen, Denmark: Information Technology and Education.


