ELECTRONIC ROADS IN THE INFORMATION SOCIETY: SOCIAL, EDUCATIONAL AND TECHNOLOGICAL ASPECTS

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ABSTRACT
In this paper we present the major technological challenges to the formation of the Information Society and the ways in which social and pedagogical restrictions can serve to influence the outcome of those challenges from the design phase. We define the notion of electronic information roads and explore the form which these roads can take. Electronic roads can serve to define a new type of social group based on inherently different relationships centered around intellectual and other interests rather than the proximity of physical contact and direct communication. The implementation of electronic roads will require advancements in digital libraries, advanced networks and distributed systems programming.

KEYWORDS
Information society, learning technologies, electronic roads

INTRODUCTION

An important prerequisite to the formation of any social group is the capability of frequent and effective communication between the group members. For example, the formulation of jointly held objectives relies crucially on the ability of the group to exchange information and to debate. Traditionally, this requirement for communication is met when it is possible to meet frequently in person, within either a formal or an informal setting, in order to exchange information and discuss commonly recognized issues. For example, the strong social fabric that underlies a village is formed and subsequently maintained through continuous gatherings in the coffee shop or in village events. This permanent opportunity for open debate enables a regenerative process of a maturing debate leading to the emergence of new issues of common interest.

Recent developments in Information Technology and Communications now begin to offer another opportunity for the future development of social groups and indeed the formation of new social groups. Such groups are no longer restricted by close physical proximity but are now defined by the proximity in the type and nature of information that their members are interested in. One can thus recognize the emergence of thematic social groups which can now include members physically located in all regions of the world. Thus, interests and intellect tend to determine the boundaries enclosing social groups rather than physical proximity and direct communication. In other words, social groups can now be mapped on a new space, the **information space**, that replaces the physical map. The transition from today's society, which is strongly dependent on physical proximity, to the **Information Society** that is based on the notion of proximity of interests has already begun to form an alternative picture of the world.

With the emergence of this new information space it is important to design and develop its structure by suitably connecting its different parts. We therefore need to form information roads (the analog of physical roads) that would appropriately link together different information categories. These

information roads will provide the means by which one can acquire information, explore information and in general put themselves in contact with other people who are interested in traversing the same (or same type of) roads. Frequent visits on such particular roads will effectively result in the inclusion of this person within a social group that is defined by a mesh of such roads. In effect, these information roads will provide a new map of the world: a map very different from the physical map that we are used to and can perhaps be termed the **information map**.

Over the last year we have begun a project at the University of Cyprus titled "ERIS: Electronic Roads in the Information Society". The project aims to address the problem of electronic information roads at various levels and to develop a prototype system of such roads. The prototype will concentrate at first on cultural and historical information and the social relevance of such roads in education and training. The project will also investigate the long term potential and effect of such information roads on cultural integration and the formation of links amongst different existing social groups. Although the applied part of the project will initially refer to electronic roads in the vicinity of Cyprus, the underlying framework will be generic and capable of being used in a broader geographical context, namely the Euro-Mediterranean area and beyond (possibly with minimal modification).

The remainder of this paper firstly gives a short introduction to the information society setting the general context in which information roads need to be developed and then describes briefly the major aspects of the concept of an electronic information road and the main technological and social challenges that need to be tackled when building such information roads. The restrictions imposed on educational systems by the Information Society are described in a separate section before the general conclusions.

THE INFORMATION SOCIETY: ITS EXTENT AND IMPORTANCE

Our world is undergoing a new revolution: the information revolution that is shaping what is now called the **Global Information Society**. This information society rests on the new developments of computer systems and telecommunications that allow people from different societies, nations and countries dispersed all over the globe to communicate with each other effectively at a level comparable to that of personal contact. In its most advanced form this revolution aspires to transform the whole human race into a global village thus creating a truly international human community with common values in which people can effectively cooperate to solve common problems. In general, the information revolution adds huge new capabilities to human intelligence and constitutes a resource which changes the way we work together and the way we live together. We indeed have a quantum leap in our capabilities effected simply by the new extend to which we can now share information.

We are therefore living in a society that is changing and we are asked to adapt our living in such a way that we will benefit from these changes, contribute to new developments and be ready to face the future. The process of forming the Information Society has taken an irreversible turn since the technical boundaries between traditional forms of handling and distributing information are being abolished because all forms of information (written, voice, image) can be handled and processed simultaneously. In addition to this, information which was once distributed on paper, film, audio or video tape, can now be transmitted interactively through the same "multimedia" channel that is as simple as a telephone line or complicated as a satellite link. As a result of accessing this information and of changes in the form that organizational work is taking, the citizen will see at the end improvements in the quality of life in many areas.

In its first stages, the information society is expected to radically change most of the everyday facets of our lives. It will change the way we work, do business, administer, provide services and care, govern, educate and train and most importantly, as mentioned above, cooperate at local and international level. For example, in education we will move away from the traditional model of teacher-student and move more towards a model of active and lifelong learning. Learning can be done at a distance with access to expert up to date knowledge with many more opportunities for a complete exposure to the subject of interest. More importantly, the educational framework of the Information Society will be able to put

more emphasis on critical thinking about the issues at hand moving more away from the simple transferal of knowledge.

Another example concerns the changes that the Information Society will bring about on our work habits and environment. We are already experiencing a move towards teleworking from home with more emphasis on the actual work done rather than on the time spent at work in an office. Also, it is becoming more evident that the individual has now the opportunity to create his/her own work model, acting as an independent autonomous work unit offering services and work on demand by other working units. Public services from the very simple to the more complex will be affected significantly. Form filling and applications will be done from home with minimal effort and with on-line counseling and help on the procedures and relevant laws. Health care will be revolutionized with expert surgeons carrying out operations from their office at another hospital in a different country.

Exactly because of this wide extent of the information society the **information systems** that will be needed to achieve this need to be novel and capable of accommodating a wide spectrum of information and use. Unlike the information systems that we have been accustomed to until now, which are usually narrow and specialized in a particular field, information systems of the information society will need to be more heterogeneous in their content and capable of being used by a diverse set of users. This sets out a complex and demanding set of requirements for such information systems with many new technological problems to be addressed. One such complex information system is that of the electronic roads (see sections 3 and 4 below).

The dramatic changes in Computer Technology and Telecommunications that we have been experiencing for the last few years and the fact that predictions along those lines cannot be made easily, means that any plans for the future are in many cases subject to guessing that varies depending on the extent of optimism in one's views at any one time. Uncertainty, competition, luck of knowledge, threat etc., generate feelings that can trigger social problems. One may see and explain this phenomenon from a point of view of "choices" that are made available. If we claim for a moment that technological advances bring to society more choices for everything, this sounds promising because one of these choices will be the "best" one. On the other hand, if the mechanism for choosing and selecting the best one does not exist, the situation that is more problematic than the one that preceded it. Thus, technology should serve in providing choices, and in creating mechanisms for selecting among them.

Further to information, a global approach to the Information Society makes knowledge a universal resource, meaning that all nations and cultures can contribute to this pool of knowledge and draw from it at the same time. It is important to note that the cost of acquiring these new technologies is affordable and falling at high rates, thus enabling societies to "leapfrog" years of development that were originally required for building the infrastructure that carries the applications and services.

The impact that technological advancements have and will continue to have in our society hides the danger of the possible splitting of our societies isolating those who have no means to accommodate these advancements. The European Commissioner Martin Bangemann (Ministerial Declaration, Barcelona, 1995; Ministerial Declaration, Brussels, 1994) summarizes this social challenge: "The information society has the potential to improve quality of life of Europe's citizens, the efficiency of our social and economic organization and to reinforce cohesion. The Information revolution prompts profound changes in the way we view our societies and also in their organization and structure. This presents us with a major challenge: either we grasp the opportunities before us and master the risks, or we bow to them, together with all the uncertainties this may entail. The main risk lies in the creation of a two-tier society of have and have nots, in which only a part of the population has access to the new technology, is comfortable using it and can fully enjoy its benefits."

The commitment that many of the leading countries are now making to the Information Society reveals its importance. The Council of Europe and other bodies together with the countries involved have taken serious initiatives over the last few years for promoting the concept of the Information Society. The

European Union has recently announced that the title of the ESPRIT - 5th Framework Programme will be simply "Technologies of the Information Society". This shows that the EU is determined to become catalyst, co-ordinator, technical consultant, promoter of public awareness and international negotiator on information society issues. Along these lines Europe is playing its role in bringing neighbouring regions such as the whole Mediterranean region into a partnership. Efforts began as early as 1995 with the Brussels and Barcelona Conferences that established "The creation of the Euro-Mediterranean Information Society" (Ministerial Declaration, Rome, 1996) that was finally agreed officially in Rome in May 1996.

In the most recent conference at Ministerial level, Bonn, July 1997 on "Global Information Networks: Realizing the Potential" (Ministerial Declaration, Bonn, 1997) where Ministers from all over the globe were invited by the European Commission the creation of the Information Society was pursued further. In this conference, the objectives have been to broaden the common understanding of the use of Global Information Networks, to identify barriers to their use, to discuss possible solutions and to undertake an open dialogue on further possibilities for European and international co-operation.

ROADS IN THE INFORMATION SOCIETY

Electronic Roads can be thought of as the underlying fabric of the space of information and the Information Society at large. They shape this space and define a novel way of acquiring, using and exchanging information which ultimately can result in new social links between those who use these roads.

But what is, or more correctly what could be, an electronic road? An Electronic Road creates an information map with spatial, temporal and context or more generally semantic associations amongst different information elements. These electronic roads could be based on existing physical roads mirroring the information available in the physical area of the road or they could be completely thematic roads that traverse information that is semantically related but of different nature at different locations and time. Users who are interested in a specific topic would search for and take an appropriate Electronic Road. This will provide them with a traversal of a meaningful set of related information sites with each different user selecting a journey that suits their own interests and priorities in a dynamic way as they follow the road and discover new information that they judge useful. The user therefore is allowed or invited to explore the available information by dynamically selecting and forming a personalized information journey that suits their own needs and interests.

A central challenging issue in the formation of these information roads is to define what indeed is the appropriate way to link, structure and organize information together? What are the primary parameters that should be taken into account to achieve a network of information in which the traveler can:

- explore the information space in a natural way where the information offered remains continuously interesting,
- adapt his/her exploration mode according to personal preferences both at the start and during the journey,
- learn new information, particularly new relevant associations of her/his original domain of interest with other domains,
- offer as well as take information along his/her route.

In order to build such information roads one is faced with many challenging problems requiring a multi-disciplinary research effort from the very beginning. Some of the major areas of problems are the following:

- define the appropriate functionality of these roads in order to meet the social requirements,
- develop the necessary technology both in networks and multimedia digital systems that would enable the actual construction of the roads with continuous and fast communication for efficient availability of information flow,

- define a "legal" framework that governs the way we travel on (i.e. use) these roads.

One important aspect of the electronic roads relates to the pedagogical reorganization that will be inherent in any user interface that feeds on information in such an intensive way as that envisaged for the electronic roads. It is of paramount importance that electronic roads include multiple flexible features of pedagogical value, such as interactivity tools, modeling and simulation environments, information analysis and synthesis tools as well as training packages. In this manner the necessary flexibility that is required by the inherent complexity in the applications can materialize, built in from the beginning by design.

MAJOR TECHNOLOGICAL CHALLENGES OF ELECTRONIC ROADS

In order to address the above mentioned requirements a number of specific research problems need to be addressed:

- Develop adaptive to the user and intelligent in retrieval and presentation multimedia systems.
- Build digital libraries for heterogenous types of data and support sophisticated retrieval mechanisms.
- Examine the potential of state-of-the-art network technology (e.g. ATM and ISDN) and design reliable and effective networking algorithms.
- Design and implement a metacomputing environment for amalgamating into one entity all the resources comprising an electronic road system.

The overall system can be seen as comprising of three conceptual levels:

(I) The top level is effectively the one a user communicates with. It is basically a Multimedia based environment able to provide a user with sophisticated functionality which will enable the latter to travel through the electronic roads. The user will also be able to express a variety of constraints associated with some query such as Quality-of-Service Requirements, types of media the required information should be presented in, maximum cost of retrieving the required information, etc. Furthermore, the system itself will function as a distributed intelligent agent and will adapt a user's query and the underlying apparatus' response with respect to such issues as system performance, the user's profile, etc.

(II) The middle part comprises those entities which form in a distributed fashion the whole framework. These entities are typically dedicated data or media servers such as devices for capturing and/or presenting various types of media, digital libraries, databases, etc. At this level we also have the formation of the metacomputing environment.

(III) The bottom part consists basically of the communication component and is responsible for addressing the issues related to high bandwidth networks.

In the sequel we present in more detail a number of sub-components from the above three-level framework.

Network component

The network component may consist, at least initially, of interconnected homogeneous networks. That is, prior to the wide deployment of the Broadband Integrated Services Digital Network (B-ISDN), it may consist of, for example, Local Area Networks (LANs) based on different technologies (e.g. Ethernet, Token Ring, FDDI, DQDB, ATM), the Public Switched Telephone Network (PSTN), Cellular Mobile Telephone Network, satellite links, Narrowband-ISDN, and even Asynchronous Transfer Mode (ATM). Each one of these networks has been designed (and optimised) to cater for different services (consisting of different media, as e.g. voice, data, TV, and multimedia). Each service may have its own needs, which imposes different (sometimes conflicting) requirements from the network.

As for the underlying network, at one end of the spectrum, we have networks such as the PSTN designed to carry voice services with a known QoS (not doing well when transmitting other type of services, such as data, even at low bit rates, due to its burstiness), or LANs designed to carry efficiently bursty traffic, but offering no QoS guarantees. At the other end of the spectrum, we have Broadband-ISDN (ATM is the chosen transport technology) designed to carry multiservice and multimedia traffic with a known (guaranteed by the network) QoS. The interconnection of these networks raises additional problems with regard to the transfer of mixed (multimedia) services through the heterogeneous mix of networks. Note that even when the network is homogeneous, effective control and management of these networks is still an open issue (Pitsillides *et al.*, 1997). Selecting an "optimal" route to inteconnect two communicating parties can be a difficult (even NP complete) optimisation problem (Wang *et al.*, 1996).

Based on the information provided by the query agent, which includes the QoS, and cost constaints, the Connection Admission Control (CAC) and routing control functions of the network management, will attempt to route (Vasilakos *et al.*, 1997) the request through the "most appropriate" path to the digital library that can serve the request. (Note that the request need not be sent to one library only--many libraries may need to cooperate in order to optimise the response to the query.) Once a route is selected, the query agent is sent along that route to the destination. On route, the agent gathers information about the network elements (and their state), so that it can build the (dynamic) networking profile. Once it arrives at the digital library, the user profile and the networking profile may be used to optimise the response due to the query (e.g. based on the user profile, the appropriate medium can be selected but with a view also to the capabilities of the selected network profile for the particular route chosen). If the media chosen satisfies the user and network profile, then all is well. Otherwise, renegotiation, at each level may be necessary. For example the digital library may respond with a request to renegotiate user and network profiles. The CAC and routing control function at the edge of the network will receive this request, and attempt to find an alternative route, if possible to satisfy, the new offered media. If no other route can be found, then the renegotiation query will be sent to the user to renegotiate the user profile.

Digital Libraries

The general position of NSF, ARPA, and NASA on the Digital Libraries Initiative was described in the NSF Research on Digital Libraries Announcement, NSF 93-141, as follows:

To explore the full benefits of such digital libraries, the problem for research and development is not merely how to connect everyone and everything together in the network. Rather, it is to achieve economically feasible capability to digitize massive corpora of extant and new information from heterogeneous and distributed sources; then store, search, process and retrieve information from them in a user friendly way. Among other things, this will require both fundamental research and the development of "intelligent" software. It is the purpose of this announcement to support such research and development by combining the complementary strengths of the participating agencies in basic research, advanced development and applications, and academic / industry linkage.

Our specific interests in the development of digital libraries are concerned with the development of a media profile module consists of three sub-modules, the media broker, the intelligent media retrieval sub-module, and the digital library. More specifically:

Media broker

The media broker provides the interface between the media profile and the networking and user's profiles. It handles the requests of the user's profile subject to the networking profile constraints as well as to the digital library media availability and characteristics. Its target is to offer the best possible service, satisfying the user's requests. For example, a video object retrieved of high quality video can be highly compressed to achieve its transmission through a low bandwidth network. The mode of protocol behaviour of the media broker will be prescribed following multiple strategies of evolutionary programming based on multi-objective constraint optimization criteria.

Intelligent media retrieval

The information retrieval sub-module facilitates the efficient location and retrieval of a variety of multimedia heterogeneous data, including video, image, photographs, sound, speech, and text. A multi-feature / multi-classifier strategy will be implemented for the retrieval of video, images, sound and speech. Features based on the time domain, frequency domain, and time-frequency domains will be extracted. These features will be fed to multiple statistical and neural classifiers which will be asked to place their vote to a voting scheme. The voting scheme, provides the outcome of the decision making process for the availability of the media - service requested.

Digital library

The digital library provides the capture, compression and storage of digital data. Also, image and video enhancement takes place when necessary through digital image processing.

Metacomputing Environment

The amalgamation of the various resources (multimedia environments, software programs, dedicated servers and other devices, etc.) in a unified manner is effectively a case of providing a metacomputing environment - a coherent framework for utilizing the computational resources available on distributed heterogeneous networks. Such a coordination framework would identify and match user problems and distributed resources to build solutions for those problems. Through an iterative and interactive procedure, a meta-computing system, with its knowledge or its computational resources, would lead a user through a refinement process until the description of the problem matches resources available in the distributed environment.

This metacomputing environment would allow users to query the information roads system, search and retrieve needed information. It would also allow developers to expand the system by "plugging in" additional components as the latter become available. All this activity will take place in a coherent way, where geographical distribution, platform dependencies, pre- and post- processing filtering of information, etc. are made transparent.

A suitable paradigm for developing his distributed metacomputing environment is the coordination paradigm (Papadopoulos *et al.*, 1997) which separates communications from computations and is expressive enough to describe the dynamic nature of communication among a multitude of independent and distributed agents.

SOCIAL CHALLENGES OF THE INFORMATION SOCIETY

The study of the social impact of technology is as recent as the use of high technology in sociological research. It is generally recognized that the use of computer technology and, in particular, the use of software reduces the human members of any enterprise to a common status devoid of any social or organizational context which defines them (Salzman *et al.*,1994). The era of sociology and technology has also given rise to significant new issues, but, before discussing them, it is useful to briefly map sociological theory and empirical interpretation.

In general terms, sociologists examine and interpret scientific and research traditions. At least three such traditions exist within sociology: the conflict theory tradition stemming from Marx and Weber, the Durkheimian tradition with its functionalism and ritual solidarity wings, and the micro-interactionist tradition. Some sociologists have accepted action theory or structuralism, recognising the variety of world perspectives and domains of work.

The view, of academic sociology is that technology can be analysed as the outcome of social processes since productive techniques and its organisation are social products. Social scientific work has been much publicised in the past, (Katsikides, 1997) and turned into technological discourse. Authors concerned with the development of a sociology of technology have principally focused on the

development and the implementation of technology, as well as on the investigation of the further consequences of technology, primarily from a social and ecological perspective. For instance, some of the issues that are debated are:

- the evaluation of technology or technology assessment and technology monitoring .
- the origins of technology and initial analysis of technology through sociological factors which would determine the meaning of certain technological concepts within historically concrete societal development.
- the extension of scientific awareness to socially relevant areas, hitherto unrelated to the implementation and effects of technology upon everyday life, private life, biology and ecology, agriculture, the elderly, health, etc.
- the constructive approach, and the state as commonly accepted in the USA, the UK and Scandinavian countries. As Hochgerner and Berka (1994) have stated in sociotechnical studies of this kind, the combined effects of the protagonists, interests, technological and scientific traditions are investigated in the process of making a decision between different "technical" competing concepts of technology.
- the shaping of a new era which involves technological and informational reality as a real social awareness.

However, it is difficult to prove that any of the above concepts can by themselves or in synergy form a common sociology of technology. Hochgerner and Berka (1994) argue that acceptance of interrelating theories in the discipline of sociology of technology will emerge as a natural result of social processes. In the past however, much attention has been given to the effective implementation of technology as postulated by Adler and Helleloid (1987) and Majchrzack (1986). Accordingly, Salzman (1989) described the process of turning technology into tools, through the examination of the relationship between technology and culture, and by attempting to identify the forms which it may take.

Another interesting issue that social theorists are attempting to resolve is the following: Has technology emerged from the need for organisational systems to become more efficient and effective in order to surmount new issues of social and economic 'irregularities', or is it the case that the technological organisation of systems has contributed to social and economic instability? Each of these perspectives has generated different schools of thought concerned with the relationships between the individual, society, the state, organisation, and technology.

Furthermore, modern philosophy is dominated by several dichotomies: mind/body, reason/passion and nature/culture, all of which interact with, for example, the feminine / masculine dichotomy in complex ways (Katsikides and Pohl,1994). The associations between women, nature, passion and the body are very influential in contemporary thought and are based (along with theoretical tools) on the different cognitive styles as identified by Human Computer Interaction (HCI) which is consequently rebased on these dichotomies. The social consequences of such complexities can only be understood through examination of the way in which organisations and their structure are changing. Obviously the role of technology has been central, and has ultimately brought about the rational activities of the economic and social order.

M. Weber in Economy and Society, structured his analysis around the contradictions between the traditional and the modern. He argued that the transition from a predominantly traditional organisation to a rational organisation accounted for modernisation. Further into the twentieth century however, modern technology and organisations, characterised by sameness and worker alienation, began to be replaced by post-modern/post-industrial technology so that an organisation became characterised by its features of diversity and the challenge it could pose to the individual. Moreover, it is also important to note that if technology is to be seen as an element of social action, or as a process whereby social relationships are to be constituted, then it must be expressed by a theory of social change. Thus it becomes obvious that any distinction between models of technology as causal factors of social change and models of social determination of technology must be eliminated. A theory of social action should integrate and comprise both aspects, i.e., societal change and development of technology, as two

conflicting processes. The transition from the natural sciences to technology implies a simultaneous transition to sociality. Technology is a social reality and it therefore engenders a real sociality. On the contrary, it could be said that technology creates social reality and materializes a real sociality. This happens not afterwards but during social formation. That means, technology forms the society.

Organisation in whatever form, be it social, economic and political, is designed according to the technology available which is created in response to the perceived needs of those engaged in activity. All forms of human activity have to be understood within the terms of reference of the system under which they operate, which currently for all organisations is the free market system. Organisation, through technology, makes the free market system function, and as the system changes this is manifest in changes in technology and organisation. Interlinked with this is the relationship between state and society which is understood within the medium of ideology which interpellates the individual as subject. Sociology considers all these things and seeks to define and interprete the activities of individuals within such contexts.

EDUCATION IN THE INFORMATION SOCIETY

It would be somewhat of an understatement to say that the recent trend for societies to rely on information flow for their most basic functional structures has implications for the educational system. On the one hand, the technological prowess of the Information Society can render support to the educational process in ways that have the potential to bring deep and long lasting reform in a system that so obviously requires it (Jones and Scrimshaw, 1988; Mellar *et al.*, 1994). On the other hand, the Information Society imposes hitherto unprecedented restrictions on the objectives of any educational system which in turn have enormous implications on the structure, organisation and function of a system that is notoriously resistant to change and which is, by its very nature, incapable of accommodating revolutionary changes.

For centuries the industrial model has imposed its values on educational systems. Out of this influence has emerged a dominant emphasis on technical expertise: essentially educational systems everywhere are structured to stream people towards single areas of employment through an elaborate system that begins on humanitarian premises and increasingly leads towards greater vocational specialization (Boyd-Barrett and Scanlon, 1990).

Recent trends in the international economy, which tends to evidence the underlying shift towards the Information Society, have demonstrated abundantly that this model of educational preparation is unsustainable. The average person is expected to change at least seven jobs in their lifetime. Employers are increasingly subscribing to retraining and continuous education programmes in order to mould and nurture the expertise they require at any particular point in time. The same employers report looking for flexible people with basic numeracy, verbal, written and computer literacies, demonstrated thinking, learning, problem solving and decision making abilities, as well as strengths in inter personal relations and ethical values (Mellar *et al.*, 1994).

Education in the Information Society is required to reinvent itself in order to move away from its emphasis on expertise and center its attention on the development of thinking skills, openness and flexibility. New methodologies need to be formulated for developing metacognitive skills and decision and problem solving abilities.

In return, the Information Society is increasingly in a position to provide the technological tools that will support and expedite this transition. The technological prowess that has revolutionized the corporate world has now reached the point of maturity where it can be used to develop thinking and learning tools learning that will support the learner in gathering and analyzing information in order to construct meaning, resolve dilemmas and solve problems. At the same time it can offer new tools in the hands of the educator so that they can modify the learning environment to best guide and support the active learner in their attempts to develop mental constructs and apply them in increasingly elaborate

ways (Mellar *et al.*, 1994). Communication media, data gathering, handling analysing and presentation software as well as modelling and simulation packages are a substantial first step in this direction.

Given the fact that education, through whatever channels, can have a substantial and lasting influence on the nature and scope of future societies, it is of paramount importance that the technological gap that has haunted educational systems is rapidly overcome so that education can become an integral part of the Information Society. If this does not happen, education will function in ways to dampen and undermine the information revolution. However, in the opportune case that the Information Society can offer appropriate and substantial support so that educational systems can rise to the challenge, it is possible that a new feedback loop will come in place so that education can produce the citizens who will be in a better position to function and further advance the Information Society.

CONCLUSIONS

We have briefly presented how the Information revolution is leading to the creation of a new social standard. The technological challenges that have resulted from the Information Society are enormous and can only be usefully met by incorporating the complex social and pedagogical requirements from the beginning at the design stage. We have also defined the notion of the Electronic Roads system that can form the underlying fabric to the Information Society. Electronic roads can be envisioned in various forms and at various levels. However, at any level they tend to define the connections between classes of information, thereby lending structure to an information system and influencing its usefulness and usability. The notion of electronic roads can potentially have enormous implications on the organisation of the Information Society.

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