# THE INTEGRATION OF ICT TOOLS IN EDUCATION AS AN EXAMPLE OF THE INTERPLAY BETWEEN TECHNOLOGY AND SOCIETY

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ABSTRACT
Information and Communication Technologies (ICT) constitute an essential part of the infrastructure for modern societies, facilitating access, processing and storing of information and promoting communication between people within and across communities. ICT have been recognized also as important tools for enhancing teaching and learning processes. Despite this, educational practice has largely remained unaffected in most systems, with teachers mostly failing to incorporate ICT tools effectively in their teaching. This is due to a combination of several obstacles and problems such as lack of equipment, need for technical support, inadequate teacher training programs, some teachers' technophobic attitudes, a general lack of organizational structures for change management, and ineffective policy making and program planning. On the other hand, technology, in its essence, is considered to be a complex enterprise for solving social problems and fullfilling human needs. Its role in society could be studied through five perspectives: technology as a purposeful activity, a human endeavor, a set of processes and methods, an invention framework, or a set of knowledge and practices. An approach to study the educational problem from this theoretical perspective can yield useful insights. We suggest that technology and its social practice can provide a useful context to realize a more effective design of a solution to the problem of integrating ICT tools in education.

KEYWORDS
ICT tools integration, technology, technological design, educational technology.

## INTRODUCTION

In the past thirty years, modern society has witnessed important changes in all levels of human life. Technology is a crucial contributor to this, having an important and central function in contemporary life (Watson, 2001). In particular, many processes in people's everyday living are becoming increasingly automated, due to the rapid advances mainly in electronic and computing technology.

More specifically, the term *electronic and computing technology* is used alternatively among several terms, such as *electronic and information technology* or more simply *information technology (IT)* to include "computer hardware and software, operating systems, web-based information and applications, telephones and other telecommunication products, video equipment and multimedia products, information kiosks, and office products such as photocopiers and fax machines" (National Center on Accessible Information Technology in Education, 2006). *Information and communication technology (ICT) tools* is another broad term, standing for Internet and all other electronic technologies which facilitate the access, processing and storage of information and promote communication among people worldwide (Fors & Moreno, 2002; Heeks, 1999). All these terms are widely used nowadays indicating the pass to a modern society that is characterized by the prevalent use of ICT tools, namely the *Information Society.*

Education acquires an important role not only for training students to develop the required skills in using the new technologies, in order to participate effectively in the new Information Society in a long-life perspective, but also for exploiting these new technologies to promote more effective teaching. Therefore, a major interest among education researchers has been triggered during the last decades concerning the possible impact on learning outcomes from the integration of ICT tools in teaching. Findings have supported the belief that ICT can be an important means for encouraging educational reform, transforming students into productive knowledge workers (Pelgrum, 2001). When incorporated in teaching, ICT tools can bring reality in class and make the learning process more fascinating. Students are called to interact with complex phenomena and engage in solving real problems (Kozma, 2003). Teachers are able to enhance and support instruction with tools, organize tasks for their students to work autonomously in groups, arrange easily appropriate information resources, and gather data from students' work in order to monitor and study the several stages of their effort and also develop insights into the cognitive processes the take place inside their minds (Kozma, 2003; McDougall & Jones, 2006).

However, despite the constantly increasing investment in research about the integration of ICT tools in education and the optimistic conclusions about the additive value of ICT tools to the learning process, it seems that the traditional way of teaching resists change (Lim & Khine, 2006). That is, education, and specifically the classroom environment, have remained largely untouched by the rapid techological developments of the last century (Strommen & Lincoln, 1992). The most astonishing fact is the large gap between the status of ICT use in society and that in school leading to a dagnerous estrangement of the school setting from society (Strommen & Lincoln, 1992). Often, what children learn with the traditional way of teaching in school is dramatically diferrent from what they physically experience in modern society they live in so that education becomes seeemingly unable to prepare the furute citizens capable of understanding, using and thinking critically with the evolving new technologies.

In this article, we will discuss the major problems encountered by educational attempts to make use of ICT during the past three decades and, then, we will try to outline an alternative methodical approach to confront the problematic situation, informed through an examination of the actual role of technology in society.

## INTEGRATING ICT TOOLS IN EDUCATION: THE PROBLEMS

The disappointing reality in schools around the world is that our educational systems have often failed to exploit the potential of ICT tools for teaching and learning (Kiridis et al., 2006). The educational research literature provides evidence for the existence of various problems that impede the processes for incorporation of ICT tools in teaching.

Findings from a number of research studies have identified specific obstacles that constrain the effective integration of ICT tools in education (BECTA, 2004; Jones, 2004; Kiridis et al., 2006; Lim & Khine, 2006; Pelgrum, 2001; Selwyn, 2000; Watson, 2001). In general, obstacles can be devided in first– and second– order barriers to the integration of ICT tools (Brickner, 1995; Ertmer, 1999), inluding extrinsic and intrinsic factors respectively that shape the current educational status. External obstacles to teaching include all problems and difficulties that teachers cannot control when trying to incorporate ICT tools in their teaching routines. Researchers describe six main problems that belong to this category: lack of equipment, need for technical support, insufficient available teaching time, inadequate teacher training programs, obsolete or poorly designed curricula and irrelevant assessment practices (Ertmer, 1999; Kiridis et al., 2006; Lim & Khine, 2006; Pelgrum, 2001; Watson, 2001). In contrast, internal obstacles are directly related with teachers themselves and mainly encompass the technophobic beliefs about incorporating ICT tools in their teaching and their reluctance in changing their existing teaching styles (Lim & Khine, 2006; Mulkeen, 2005; Watson, 2001).

Moreover, while some researchers recognize the need and a relative willingness for forming appropriate strategies to deal with the obstacles to the integration of ICT tools in education (Lim & Khine, 2006;

Watson, 2001), others speak about the adoption of ineffective policies for doing so. Firstly, plans about the implementation of new technologies seem to be poorly designed and sometimes thoughtless, suffering from a lack of clarity in objectives which leads to a dichotomy in purposes (Watson, 2001). Thus, teachers often confuse the aim of exploiting ICT tools to enhance and support teaching and learning processes with that of helping out students to acquire basic computing skills. On the other hand, teacher training programs are carried out discontinuously in the form of a unique workshop or a series of seminars that often focus on basic computing skills (Kiridis et al., 2006; Lim & Khine, 2006; Mulkeen, 2005) paying tribute to the fallacy that increasing teachers' expertise on using ICT tools will automatically raise the level of ICT tools incorporation in teaching. Research findings show that this is not the case (Kiridis et al., 2006; Mulkeen, 2005). Teachers need much more than just knowing how to operate the computer or specific software. They need to be convinced about the value of ICT tools in supporting and enhancing teaching and learning (Kiridis et al., 2006) and, after that, tutored about their pedagogical usefulness (Jones, 2004). They need specific examples demonstrating the added value of ICT in teaching and learning. They also need pedagogical content knowledge on the role of ICT tools in the respective disciplines and how that influences how we formulate learning objectives. In this context, professional development programs suffer from a lack of careful planning and continuous implementation in order for teachers to become aware and take advantage of the great potential of ICT tools.

Generally, little has been done in order to completely understand the problematic situation concerning the integration of ICT tools in education (Watson, 2001). In fact, many of the present problems will probably remain as long as research about the integration of ICT tools in education continues to take place in laboratory-style environments (Kiridis et al., 2006) following a rather idealist viewpoint, distant from educational realities, which fails to take into consideration the "whole case" of the integration of ICT tools in education. Moreover, "the development of a technology is reliant on social and technological factors, resulting in a direction, or `trajectory', of development shaping both the content of the artefact and potential technological outcomes (Selwyn, 2000)." The incorporation of ICT tools in education then is influenced by "a web of mediating factors that technology comes into contact with once it is placed in educational settings (Selwyn, 2000)."

Consequently, the integration of ICT tools in education constitutes a complex technological problem since it concerns the development and particularly the implementation of new technologies. Levine (1998) in an attempt to give an alternative approach to coping with the matter of beneficial use of new technologies supported the belief that all problems of realizing the maximum benefits from new technologies could be effectively faced through appropriate strategic planning that includes:

- Formulating a planning team
- Collecting and analyzing data
- Formulating the vision, goals, and objectives
- Exploring available technologies
- Determining training and staffing needs
- Determining a budget and funding sources
- Developing an action plan
- Implementing the plan
- Evaluation

In our view, what (Levine, 1998) has implied constitutes an alternative approach to the design of a solution to a technological problem. We will extend this idea by studying the process of incorporation of ICT tools in education through understanding the role of technology in society and interpreting the processes and procedures that are met in the technological field. We will also extend this approach horizontally to identify the various actions that need to be co-ordinated for effective educational use of ICT.

## THE ROLE OF TECHNOLOGY IN SOCIETY

Technology can be viewed as a creative and purposeful social process that aims to promote the development of products, systems and environments in order to solve problems concerning human needs and desires (Arageorgis & Baltas, 1989; Gardner, 1994; ITEA, 2000). As a complex social enterprise, technology may encompass research, design, crafts, finance, manufacturing, management, labour, marketing, and maintenance (AAAS, 1990) and may refer to a final product, the procedure of technological development, the necessary knowledge and skills to make technology or the relative school subject.

People live in a world surrounded by technology. Actually, technology and humans coexist continuously for thousands of years, appearing to be closely interrelated and interdepended and, moreover, interacting widely with great benefits for the advance and prosperity of humanity. (In contrast, science as an organized enterpise is a much more recent activity in history.) In the past, technology has progressively shown various faces in regard to its context of implementation, the practices and the dimensions of it, though always evolving at an extraordinary rate, with new technologies being created and existent technologies being improved and extended (ITEA, 2000). Nowadays, technology appears to have extreme potential that, sometimes, goes beyond human imagination and includes unexpected benefits, costs, and risks (AAAS, 1990).

However, while all recognize the complexity of what the word "technology" entails, only few people can successfully describe what technology really is and how its actual role in society is shaped (Barnett, 1994). More specifically, the attempt to answer such questions is actually an epistemological activity that seeks to determine the characteristics of the technological endeavor which constitute what we call the "*Nature of Technology.*" These characteristics are interrelated making up a complex and sophisticated structure of concepts as presented in *Figure 1*. In particular, this structure constitutes "a concept map" and attempts to portray in detail what the term technology entails, and what the nature of technological endeavor and its role in society are.

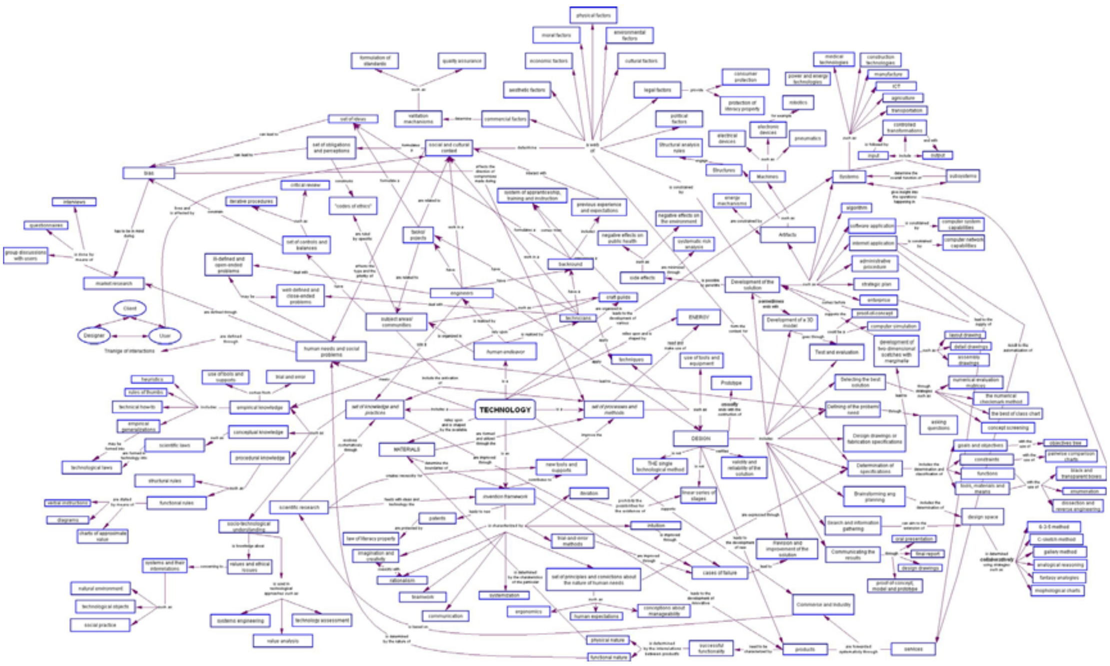

Figure 1. The Nature of Technology

### Technology as a purposeful activity

Through technology, humans extend their ability to accomplish certain purposes by altering the physical world (AAAS, 1990; ITEA, 2000). More specifically, people develop technologies in order to solve problems in their daily living in society. Generally, a problem is defined as an unknown situation in which people seek to fullfill a need or desire, or accomplish a goal (Jonassen, 1997), hence a problem may concern a single person or the whole society.

Problems may be categorized into ill-defined and well-defined. When the problematic situation is not clearly understood and the necessary information to solve the problem is unknown and vague, then this is an ill-defined problem, otherwise called open-ended. Such problems have no specific, optimal solution, but it is possible to achieve various, different and equally satisfactory solutions (Hew & Knapczyk, 2007; Jonassen, 1997; Seitamaa-Hakkarainen, 2000). In contrast, well-defined or closed problems have a single solution, a clearly specified and optimal path to the solution, a certain goal state and all the required information for the succesful working-out of the problem (Hew & Knapczyk, 2007; Seitamaa-Hakkarainen, 2000). Accordning to Jonassen (1997), this type of problems "require the application of a finite number of concepts, rules, and principles being studied to a constrained problem situation."

Social problems generate human needs which are identified through the study of the interactions between three contributors to the development of technology, namely the client, the designer and the user. Each contributor has a different role in the process of fulfilling a particular human need: the client is the person or group or company that desires the development of a solution to the problem in order to satisfy the user's need - the person who will take advantage of it, hence the client will eventually ask the designer to develop the solution which is usually a sort of artifact (Dym & Little, 2004). Furthermore, social problems and human needs can be recognized by carrying out a market research. This is done with the use of special tools and instruments like questionnaires, interviews and group discussions with (potential) users (Dym & Little, 2004).

**Technology as a human endeavor**

Technology is considered to be a human activity that is methodically realised through the action of specialized groups of people: engineers and technicians. Engineers are considered to be the professionals who are more closely associated with technology (ITEA, 2000) and focus on the growth of solutions to social, ill-defined problems and the satisfaction of human needs through the systematic use of scientific knowledge (AAAS, 1990). Technicians, on the other hand, rely upon empirical knowledge and apply techniques on the basis of the relation between "method and result", or "trial and error", struggling to solve well-defined problems by constructing and trading specific material products (Epstein, 1998; Russo, 1986). Moreover, engineers and technicians are organized in certain subject areas and communities of activity having particular tasks to accomplish. Each subject area or community has its own set of controls and balances to ensure the success of the project undertaken and it is ruled by specific "codes of ethics", which are ethical standards, concerning the diverse obligations that a technologist must meet during the progress of the particular task (Dym & Little, 2004).

The "codes of ethics" are directly originated from the socio-cultural context in which engineers work that is shaped by a web of intervening factors such as politics, law, culture, ethics, environmental issues, physical properties, economics, aesthetics and commerce. These factors determine values which consist of a set of obligations and perceptions that imply to the technologist what the proper kind of behavior would be towards a particular design situation. Values also provide a framework for choice, decision making and action (Pavlova, 2005). Furthermore, during the realization of a technological project, technologists generate ideas and beliefs about the various processes and procedures of the project, which, along with the set of obligations and perceptions, can lead to bias – a key concept in technology.

Bias is a kind of presumption concerning the current project conditions (Dym & Little, 2004). Bias may often be inaccurate, affecting the direction of compromises made during the progress of the technological methodology (Garmire, 2002). Consequently, bias must be checked and, if possible, eliminated by the implementation of appropriate sets of control and balance. Particular communities of technologists develop and utilize such sets in order to provide the best optimized results for the technological project.

**Technology as a set of processes and methods**

Despite the fact that the methodological aspects in technology have been traditionally associated with design, the use of tools and equipment and techniques are considered to be technological methods as well. However, *design* is the core process in technological problem solving (ITEA, 2000; Williams, 2000) including a number of essential characteristics, such as systematization, dynamism and iterance, which verify the validity and reliability of the final solution. Moreover, design consists of a collection of processes which are not linear and they do not befall with a constant step-by-step sequence, not always beginning from a human need (Baynes, 1992; ITEA, 2000). Instead, “they are reiterative, spiralling back on themselves, proceeding by incremental change and occasional flashes of insight” (Baynes, 1992).

Therefore, the total of all the design activities, through which the designer proceeds in order to achieve an end to a practical problem (Johnsey, 1995), are better called *aspects* than *stages*, thus avoiding the possibility to denote a rather sequential view of design (Williams, 2000). We summarize the aspects of technological design to the following:

- Defining the problem or need
- Determining the specifications
- Brainstorming and planning
- Searching and gathering information
- Selecting the best solution
- Generating design drawings or fabrication specifications
- Modeling and developing the solution
- Testing and evaluating the solution
- Revising and improving the solution
- Communicating the results.

The designer activates specific strategies during each particular design phase on the way to the finalization of the solution and the fulfillment of the given need. For example, the definition of the problem is done through asking the client questions about the user’s need or desire in order to clarify the problematic situation (Dym *et al.*, 2005). Likewise, the determination of specifications is done via specific tools such as the objectives tree, the pairwise comparison charts, the black and transparent boxes, the enumeration method, and the reverse engineering method (Dorner, 1993; Dym & Little, 2004). This means that the designer will activate all or some of these tools in order to deal with the identification of the objectives of the design set by the client, the constraints that preside over the design, the functions that the final product will serve and the tools, material, and means of performing these functions.

Furthermore, the process of brainstorming makes possible the development of the design space which is the mental site where all the possible solutions to a technological problem are included. Brainstorming is accomplished by means of certain thinking tools such as the 6-3-5 method, the C-sketch method, the gallery method, several analogical reasoning strategies, fantasy analogies and morphological charts (Dym & Little, 2004). Planning is about managing the whole project of the design and is defined as “an on-going, cybernetic process of governance (Rittel & Webber, 1973)”. The selection of the best idea for solving the problem is attained through particular strategic tools as well, such as the numerical evaluation matrices, the numerical checkmark method, the best of class chart, and the concept screening (Dym & Little, 2004). The best idea is to be developed to become the final solution to the initial problem.

One of the essential parts of the design is the communication and reporting of the results in several points of the process in order to inform and discuss with the client and others about the outcomes of the project. There are several common ways to do this, such as an oral presentation and a design review or a final report (Dym & Little, 2004). Furthermore, communication usually includes the generation of design drawings, otherwise called fabrication specifications, that is the development of two-dimensional sketches of the suggested solution with marginalia. Design drawings can also be the point of reference for the designer, providing instruction on how to carry out the development of the solution. If needed, the demonstration of a model, a prototype or a proof of concept may sometimes constitute another means of communicating the outcomes of a design project.

The development of a new technology has been traditionally related to the construction of artifacts, such as a structure or machine. Though, a solution to a technological problem may also be a system, an algorithm, a procedure, a strategic plan, an enterprise, a software application or an internet application. More specifically, a technological solution may become any kind of product, provided that it solves successfully a social problem by fulfilling the related human need. Since it is society that will determine the problems to be worked out and the needs to be satisfied, this, in turn, shapes the paths that technological growth will take (ITEA, 2000). That is to say, advancements in technology occur in a social and cultural context in which the development of the solution is determined by political, legal, environmental, physical, moral, economic, aesthetic, and commercial factors. These factors are to be taken into account and compromised, in order to succeed the optimum design solution (AAAS, 1990). Conversely, new technologies often create problematic situations for the society and the environment, namely unexpected side effects. Systematic risk analysis is then operated to minimize, if possible, the impact from such side effects (AAAS, 1990).

Almost always, the developed solution requires testing (AAAS, 1990). For that reason, the development of the solution sometimes ends with making a three – dimensional model of the solution to be tested in laboratory environments (Dym & Little, 2004), giving the designer the opportunity to evaluate the behavior of the modeled solution and make particular improvements, if needed. This is more complex in the cases where a solution is a service or a process when model solutions need to be situated in authentic contexts. The whole design project also may come out with the construction of a prototype, which is then tried out in "real world" conditions intended to evaluate if the solution will work as designed (Dym & Little, 2004). Besides, testing could be applied not only after but before the development of the solution by means of a proof-of-concept demonstration, which is supposed to be a scientific endeavor of setting out controlled experiments to test the validity of the concept underlying the solution (Dym & Little, 2004). The results from all testing processes can be used to determine how well the solution responds to the initial design specifications (ITEA, 2000). Moreover, designers engage in a continuous revision and improvement of the solution. This could be supported by information gathered from the testing phases of the project providing feedback about the functionality of the solution.

**Technology as an invention framework**

Hill (1998) recognizes creativity as a main feature of design, especially in the early stages, and interprets technological design as a set of processes for creation and invention for real human needs, featured by a shift from the inception of an idea to the reflection state and the development of the solution to satisfy the particular needs. On the other hand, the American Association for the Advancement of Science (AAAS, 1990), in their work named "Project 2061", denote that design "often involves great creativity in inventing new approaches to problems, new components, and new combinations, and great innovation in seeing new problems or new possibilities." From these two perspectives, technology can be seen as a framework for invention, providing opportunities and means for the creation of innovative designs to work out real human problems. In this way, when an innovative artefact is invented, the inventor is said to own the patent of the new product, which is considered to be a kind of literacy property in technology.

Despite the fact that the word "invention" transmits a notion of autonomy and lack of restrictions in contriving a solution to a social problem, the framework is actually bordered and affected by certain features. In the first place, it is characterized by creativity and imagination, meaning that while technologists search for the best solutions, they rely on intuition, feelings, fantasy and impressions gained from prior experience to determine which directions to follow (ITEA, 2000). Moreover, creativity and imagination continuously coexist with rationalism in the form of interplay without necessarily precluding each other (AAAS, 1990; Lewis, 2005). Rationalism is considered to be the way of thinking that encompasses such characteristics as the objective observation and the logical analysis, which, in technological problem – solving will "lead to general, formal design models and pave the way for objective interpretation (Ankiewicz *et al.*, 2006)"

The framework is also characterized by a large amount of work. As Thomas Edison said, "Invention is 99 percent perspiration and 1 percent inspiration (Dym & Little, 2004)". Apart from creativity and rationalism, it is typified by iteration, implying that practitioners do return back to previous phases of the project to rethink, revise, remake, plan again how to continue, and, finally, explore different options in a pragmatic way (ITEA, 2000). Iteration is an integral part of the framework (Dym & Little, 2004), prohibiting the possibility for the existence of a single technological method with a linear series of stages. Besides, it is characterized by intuition and trial-and-error when there is lack of useful technological or scientific knowledge (Gardner, 1995). It is admirable that many inventors in the past – like Thomas Edison, Chester Carlson, and James Watt – were constantly employing methodical trial-and-error approaches, spending a lot of time and hard work in combining together thousands of materials again and again (Gardner, 1997). Today technologists often have to work in this way. Nevertheless, intuition and methods of trial-and-error are continuously improved through cases of failure. Failure is a key characteristic of the framework as well, which stimulates the processes of evaluation, revision and improvement leading to the upgrading of existing knowledge and, sometimes, the learning of new knowledge (Lewis, 2006).

Communication and teamwork are also very important features of the framework. More specifically, communication certifies that, through all the phases of the design, the artefact being developed will be described and "talked about" in many ways (Dym & Little, 2004), while teamwork "allows individuals to pool their strengths in order to arrive at better solutions to problems" (ITEA, 2000). Furthermore, the framework is bordered and affected by a well – tested set of principles and convictions about the nature of human needs, developed over time by technologists, such as issues of ergonomics, particular human expectations and conceptions about manageability. Systematization is another key characteristic of this framework, meaning that technologists must rely upon certain rules in order to cope with the huge number of different possible designs and approaches to solve a problem, thus avoiding facing the prospect of wandering endlessly to invent a solution (ITEA, 2000).

**Technology as knowledge and a set of practices**

Practitioners in technology draw upon pre-existing knowledge and a set of practices in order to accomplish their goals. Custer (1995) suggested that this set exists on a continuum of knowledge that draws from practical experience with technological problem - solving. He further claims that, at the one end of it, there is the systemized and formalized knowledge of professional engineers and, at the other, the tacit knowledge of technicians, tradespersons and artisans, and explains that the set of technological knowledge practices emerges from a convergence of this spectrum of activity, experience, and practice. With this in mind, technological knowledge and practices can be classified in four general categories: empirical knowledge, conceptual knowledge, procedural knowledge, and socio-technological understanding.

Empirical knowledge comes directly from experience during practical work from the use of tools, supports and trial-and-error. It is an informal type of knowledge and is developed in an implicit mode, becoming some kind of personal and subjective tacit knowledge that cannot be easily expressed formally, but is mainly transmitted from one person to another (Pavlova, 2005). Empirical knowledge in technology includes heuristics (Lewis, 2006), rules of thumb, technical how - to (Ropohl, 1997) and empirical generalizations.

On the other hand, conceptual knowledge is concerned with the "items" of knowledge and the interrelations between them (McCormick, 1997). Particularly, mainly in a formal and explicit format, conceptual knowledge is a kind of theoretical technology knowledge about "the physical, chemical or electrical laws and principles which allow any given technology the capacity to do what it does (Ihde, 1997). As implied, conceptual knowledge is closely related with scientific laws which, when integrated in technological practice, are converted into technological laws. In some cases, a technological law may often constitute nothing more than just an empirical generalization (Ropohl, 1997).

Procedural knowledge is regarded as the engineer's or technician's knowledge of how an artefact is made and how it functions (Ihde, 1997), consisting primarily of two kinds of knowledge expressed explicitly, namely the structural and functional rules. At first, structural rules describe how the components of a technical system will be assembled and interconnected. On the other hand, functional rules specify what to do, if a certain outcome is to be attained under given conditions and are usually stated as verbal instructions, or diagrams, or charts of approximate values (Ropohl, 1997).

Socio-technological understanding is what Pavlova (2005) has described as knowledge about technology and, in particular, values and ethical issues in the relationships between technology and society, technology and nature, technology and the person. Besides, this kind of knowledge may be considered to include knowledge about specific systems that are involved in technological practice and their interrelations. Ropohl (1997) describes three such systems which are similar to what Pavlova (2005) has portrayed: technological objects, natural environment, and social practice. Moreover, he further explains that socio-technological understanding has not yet been elaborated adequately, though he lists three new approaches in technology that work relying on this sort of knowledge, namely systems engineering, value analysis, and technology assessment.

## THE INTEGRATION OF ICT TOOLS IN EDUCATION AS A TECHNOLOGICAL PROBLEM

One of the main goals of the European Union, set with the turn of the new century, was to become within ten years "the most competitive and dynamic knowledge – based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" (Commision of the European Communities, 2005). At the same time, UNESCO (2002) recognizes that information and communication technology (ICT) has become one of the major building blocks of the modern society, so that countries must be capable of taking the advantage of the modern technological development.

In attaining these ambitious goals, education receives great importance. Teaching practices must be properly adapted to modern trends to be able to face these challenges, thus reflecting a necessity for effective integration of ICT tools in education. However, evidence repeatedly suggests that educational systems around the world fail to incorporate ICT tools in teaching practices (Kiridis et al., 2006; Lim & Khine, 2006; Watson, 2001). The main request is now to consider "when and how to integrate technology", and ICT tools in particular, "so that it will benefit all the parties concerned – students, teachers, administrators, parents and the community (Jhurree, 2005)."

### The educational integration of ICT tools as a technological problem

We generally defined technology as the social process of developing solutions to a social problem and satisfying the corresponding need. We further explained that the solution to a problem could not be a simple artifact but also a system, an algorithm, a procedure, a strategic plan, an enterprise, a software application or an internet application. We suggest that the request for finding a way to efficiently integrate ICT tools in education constitutes a social problem. Consequently, the involvement in a process of working out this complex problem and satisfying the subsequent need forms a hard task of giving a solution to a technological problem by designing a specific product, that is, a strategic or program plan for integration of ICT tools in education.

In designing an ICT tools integration program plan, the users are educational institutions and teachers themselves who will apply and utilize it, while the client is the local educational authorities, such as the school district or the Ministry of Education. Local educational authorities tend to take on both the whole design and supervision of the project, resulting in purposeless, unconsidered and long-term planning that does not really reflect users' needs (Levine, 1998). In contrast, the design of the program should draw on independent expertise in the fields of educational technology, education and change management. The diversity in the members of the design team is to verify that the group will be characterized by the necessary variety in background, previous experience and set of ideas to eventually work unaffected and impartially, and incorporate the necessary communication processes during design.

The users hold a stake during a design project because the final product will not take hold if its design does not respond to their needs (Dym & Little, 2004). Therefore, it is very important to undertake a careful research activity about users' actual needs and desires in order to completely understand and define the problematic situation and social demand so that the program plan will finally meet their actual needs. In fact, teachers work in a particular social and cultural context formulating a personal collection of obligations and perceptions. Hence, they will be somehow biased against implementing new educational ideas and philosophies in their practice, depending on the nature and strength of their beliefs. All sorts of biases of users must be detected during research so that they will be in mind when determining the exact problems and needs originating from educational institutions and teachers, when asked to realize the incorporation of ICT tools in their practice. Moreover, the continuous contact with the client, in particular the local educational authorities, is indispensable in order to constantly aligning the design processes with what the client really wants.

The design group must be ready to embody in their effort some basic characteristics of technological practice. The problem of integrating ICT tools in education has an ill – defined and open – ended nature. As mentioned previously, this kind of problems have no specific, optimal solution, but it is possible to achieve various, different and equally satisfactory solutions (Hew & Knapczyk, 2007; Jonassen, 1997; Seitamaa-Hakkarainen, 2000). Therefore, to cope with such a hard problem, the design team must work with systematization and trial and error together. It would be possible for their efforts to fail at some point. In any case, they have to be able to iterate the processes by continuously evaluating and improving what might have gone wrong. When innovative ideas are required about what the best solution would be or how to proceed, then creativity, imagination and intuition could also be put into practice, but always together with logical and critical thinking. Besides, effective, continuous communication between the members of the design group or the group and the client is of utmost importance. This could be done in several ways, either in a formal or informal manner, by means of a written report or an oral presentation or even electronic mail, and through a text or graph representational media.

The development of an educational innovation is always realized through "a series of technical and cultural influences from its conception to implementation (Selwyn, 2000)." On the one hand, if one tries to describe how the design of the program plan unfolds within the design team, she must be able to consider the team as a little community with its own culture and recognize the role of the members' personal ideas and beliefs in the development of the program plan. Thus, not only teachers as the users of the program plan, but also the members of the design team are biased towards particular subjective obligations and perceptions, so that the design group must define a specifec set of control and balances in order to constrain the impact from individual biases. On the other hand, the developed solution is to be finally utilized in a social and cultural context governed by a web of mediating factors, such as politics, law, culture, ethics, environmental issues, physical properties, economics, aesthetics and commerce. The design team must identify these factors and, then, having them in mind, should determine the specifications of the design, that is the goals and objectives, constraints, and functions of the solution, and also the means for succeeding the operation of it. The successful and effective unfoldment of the subsequent phases of the design of ICT tools integration program plan will be based on these specifications.

**Some existing difficulties and problems**

When one compares the theoretical analysis on the nature of technological design, as presented above, with existing local or national programs to promote the integration of ICT in teaching and learning, a number of common problems become apparent:

- Roles of unrealistic complexity attached to teachers

It is commonly the case that such programs treat teachers as the professionals who need to rise to the challenges of making ICT integration a reality in schools. As a result, teachers are left with the task of taking on the role of computing technicians, educational designers and change managers all at once. More careful planning will identify the need for a diverse range of new roles and will create structures both within and outside school that will enable the identification of the right caliber of people for each of these roles.

- Failure to draw up plans that co-ordinate all the necessary changes that need to be taking place at the same time
  In a typical educational setting, it is futile to attempt to change teaching practice without professional development and parallel attempts to modify the curricula and the assessment practices. Yet, it is common practice that these are treated as independent tasks and are sometimes attempted sequentially, if at all. This places the educational system and educational professionals in an impossible situation of having to implement a change in one aspect without the prerequisite modifications in all other aspects that would make that change possible. In contrast, any attempt to promote systemic change needs careful planning and co-ordination of all these tasks so that at each step of the way the educational change does not lose sight of the main goals and can also be sustained through rigorous support structures.

- Undue attention to issues of scale
  ICT integration programs often fail to take into account the significance of experimentation in any attempt at technological innovation. One commonly witnesses a confusion between pilot projects and educational policy, scale-up attempts with no pre-existing demonstrators, lack of transfer of expertise across institutions and across phases. It is unrealistic to expect whole parts of an educational system to change without carefully developed and well tested change management procedures.

- Unrealistically low emphasis on the importance of educational design at multiple levels and the need for sustained innovation
  Educational systems often try to use existing administrative structures and hierarchies in implementing projects that require fundamental innovation at a number of levels. It is not possible to achieve innovation without planning for it. It is also not possible to influence teaching and learning without explicitly taking into account how learning objectives are formulated and what their impact is on planning and implementing activity sequences and assessment.

## CONCLUSION

Modern society is characterized by rapid technological advancements, especially in the field of information and communication technologies, which lead to tremendous changes in all aspects of life. The Information Society as an alternative construct is largely used today to indicate that ICT constitute the backbone of every aspect of modern life. However, contemporary technological developments have not been passed through educational systems (Strommen & Lincoln, 1992), leaving education away from an important and extremely useful tool for supporting and enhancing teaching and learning processes.

A lot of barriers have been identified which may characterized to be first –, or second – order (Brickner, 1995; Ertmer, 1999). First – order barriers are extrinsic to teaching (Ertmer, 1999), including lack of equipment, inadequate teaching time, need for technical support, obsolete or poorly designed curricula and irrelevant assessment practices. In contrast, second – order barriers are intrinsic to teaching (Ertmer, 1999), comprising teachers' technophobic beliefs and their reluctance in changing their teaching styles. In addition, ineffective poor policy making and program planning, dichotomy in general goals, discontinuity in training programs, and unsuccesful teacher training programs are further problems that block ICT tools integration in education.

In this article, we suggested that ICT tools integration in education could be regarded as a social need which could be met through technological problem solving, thus succeeding to overcome barriers and problems and effectively incorporate ICT tools in teaching. Technology is defined as a human endeavor which provides a framework of inventing appropriate solutions to social problems with the exploitation of a set of processes and methods and a collection of specific knowledge and practices. In this context, a program plan for ICT tools integration could be designed through the action of a specialized and independent design group, consisting of practitioners in education and experts in educational technology and policy – making. This program plan would take into account the actual needs and desires of the users, that is, the particular educational institutions and teachers, and also the social and cultural context in which the solution would be developed and implemented. The whole process of development of the solution has to be characterized by all those essential features of technological practice which lead to the successful and effective design and development of products to satisfy particular human needs, such as the urgent need to effectively integrate ICT tools in education.

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