

## THE INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE SCHOOL SYSTEM. A REVIEW OF THE RESEARCH LINES

*[Tecnologías de la información y comunicación en el sistema escolar.  
Una revisión de las líneas de investigación]*

by

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### Abstract

This paper offers a classification of research trends and perspectives about processes oriented to incorporate information and communication technologies (ICT) in schools. Identified are four research trends: a) studies about indicators of computers quantity in school systems; b) studies about computer effects in learning; c) studies about opinion, perspectives and attitudes of educational agents to ICT; and d) studies about computers' educational use in classroom and colleges. This paper finishes with a synthesis of current knowledge about projects and programs intended for the embodiment of ICT in school systems.

### Keywords

Information and Communication Technologies, Educational Technology, Internet in schools, Educational Computer.

### Resumen

Este artículo ofrece una clasificación de las distintas perspectivas y líneas de investigación que han analizado y evaluado los fenómenos vinculados con la incorporación y utilización de las tecnologías de la información y comunicación (TIC) en los centros y aulas de los sistemas escolares. Se identifican cuatro grandes líneas de investigación: a) estudios sobre indicadores cuantitativos del grado de presencia de las TIC en los sistemas escolares; b) estudios sobre los efectos de los ordenadores en el aprendizaje escolar; c) estudios sobre las perspectivas, opiniones y actitudes de los agentes educativos hacia las TIC; y d) estudios sobre las prácticas de uso de ordenadores en los contextos escolares tanto de centro como de aula. Finaliza el artículo con una síntesis del conocimiento derivado de dichos estudios en torno a los fenómenos que acompañan a los programas y proyectos de incorporación de las TIC a los sistemas escolares.

### Descriptores

Tecnologías de la Información y Comunicación, Tecnología Educativa, Internet en las escuelas, Informática educativa.-

### By way of introduction

We are attending, at the present time, to a productive period of elaboration of evalua-

tive studies, of research reports and of academic publications that have the aim to analyze the degree of availability, use and impact of information and communication technologies in the school system. This re-

markable increment of the intellectual production on this problem does not only happen in the areas of the Anglo-Saxon countries and of the north of Europe - in which there has always been a prominent tradition of on this matter -, but also in the academic context of Spain. In these last several years, we have generated a noticeable production of works that have explored how what the professors perceive and what they think with relationship to these technologies, as well as its use in the contexts of the school center

In this sense we could indicate that, in the international academic community, we begin to have a lot of data and empirical evidence obtained by studies carried out in a range of countries and with varied methodologies. We have data referring to available quantitative ratios of resources, of attitudes of the teachers, of ways to use in school contexts, of experiences more or less successful from a point of view of pedagogic innovation,... However, we lack a theoretical sufficiently systematized corpus that explains the group of phenomena and factors associated not only with the generalization of the TIC to large scale in the school systems, but to also explain or conceptualize how innovation processes and educational improvement are generated working with computers in the centers and classrooms. That is to say, we have a lot of empiric information on the TIC in schools, but we have yet to build a theory on this particular phenomenon of schools that allows us to understand what happens when the computers are introduced in the schools, the causes of the faculty's resistance to integrate these technologies in their teaching practice, or how to successfully implement strategies to incorporate the TIC school-wide in a determined national or regional context.

For a decade, in the international context, different works have been published that have tried to systematize or to identify the "state of art" on the integration factors and processes and school use of the digital tech-

nologies (Cuban, 2001; Grunberg and Summers, 1992; Reeves, 1998; Honey; Mcmillan, and Carrig, 1999; Mcmillan, Hawkings and Honey, 1999; Heinecke 1999; Ringstaff and Kelley, 2002, among others). In mentioned revisions evidence has shown that the use process and integration of computers in the school systems is a complex process, subjected to many tensions and pressures coming from multiple factors (of political, managerial, social, pedagogic nature) so that the problems and investigation methods have evolved from the concern of the individual learning with computers in concrete learning situations using experimental methodologies, towards kinds of studies more longitudinal and with qualitative techniques dedicated to the study of cases in real contexts of teaching. In respect to Mcmillan, Hawkings and Honey (1999), they affirm that the first studies in the Sixties and Seventies worried about the distribution and uses of the computers in the schools and about the results that the students obtained when they worked with the machines. The interest preferably consisted on measuring whether the computers were more effective than other means for the outcome. However, by the middle of the Eighties the situation changed quickly with the arrival of innovative electronic materials. "You began to understand that the effects of technology on teaching and learning could only be understood if it was analyzed as part of the interaction of multiple factors in the complex world of schools (p.1)."

What problems are investigated? Which are the main objectives and questions of study? What methodologies are used? What knowledge are we obtaining with relation to this problem?. This article proposes a classification of the different perspectives and trends of investigation that have analyzed and evaluated the phenomena linked with the incorporation and use of information and communication technology (TIC) in the centers and classrooms of the school systems. This group of works, studies, investigations, and evaluative reports developed in this last

decade could be classified in four large categories:

- a) Studies on quantitative indicators that describe and measure the situation of the introduction and use of computers in the school systems through ratios or concrete punctuations of a series of dimensions.
- b) Studies on the effects of the computers in the outcome and learning of the pupil.

- c) Studies on the perspectives, opinions and the external educational agents' (administrators, supervisors, support teams) attitudes and of the faculty toward the use and integration of technology in the classroom and school centers.
- d) Studies on the practices of use of the computers in the centers and classrooms developed in real contexts.

STUDIES ON THE DIGITAL TECHNOLOGIES IN THE SCHOOL EDUCATION		
<i>Type and study object</i>	<i>Technical methodological</i>	<i>Examples</i>
Quantitative indicators that reflect the degree of presence of TIC in school system	Statistical data. Surveys to administrators. Documental analysis	Euridyce 2001a, Cattagni and Farris, 2001 Twining, 2002 OECD, 2003
Effects of the TIC in learning. The student's outcome when he/she learns with computers	Experimental studies and metaanálisis	Kulik, 1994 Reeves, 1998 Parr, 2000 Blok and others, 2002
The educational (opinions, attitudes and expectations) agents' perspectives toward the TIC	Questionnaires of opinion and of attitude, interviews, groups discussion	NC, 2000 Solmon and Wiederhorn, 2000 Surround and Ward, 2002 Squire, 1989 Of Pablos and Colás, 1998 Cabero, 2000
Practices of use of the TIC in centers and classrooms. Culture, organizational forms and teaching methods with computers	Either center or classroom case studies (observations, interviews, documental analysis)	Zhao and others, 2002 Galician 1994 to, b Alonso, 1993 Bosco, 2000 Martínez, 2002

Next, I will develop with more detail the characteristics of each one of these categories, describing some studies, representative of as much the international environment as Spanish, through examples.

### 1. Studies on indicators of the degree of readiness and accessibility to the TIC in the school system

This type of study is utilized more in organizations and government institutions. They have, in most of cases, a quantitative nature and are developed with the investigation technique derived from the sociological investigation and statistics. Their advantage is that they offer concrete measures that allow the comparison of the situation of a determined school system lengthwise in the

time (that is to say, the evolution of a system throughout a specific period of years) with school systems of other countries and/or geographical regions. Their more outstanding limitations are:

- a limited reliability of the carried out measurements, since in occasions there are reports that offer different punctuations for the same phenomenon in the same period of time (for example, the quantity of computers in the schools of a certain country in a given temporary period) exist. It happens because in occasions these indicators are obtained through surveys of organizations or official administrations where they can "interpret" in a different way the form of punctuating or measuring a certain indicator;

- the other limitation refers to the quantitative data that contributes little information on the pedagogic use of the new technologies and on its potential impact in the improvement of the teaching quality. Sometimes, the statistical fact of the quantity of presence of computers is interpreted in the classrooms as an indicator of educational quality. However there is not any evidence that suggests that a higher quantity of technology increases the quality of the educational processes. As Means affirms (1998, p. 9) "It is evident that the simple hardware endowment, cables and software won't convert our students into more intelligent and more productive people. (...) We should not hope to find an impact of the presence *per se* of the technology in the same way that we don't with the presence of the slates or the books. What probably influences students and professors more is a particular type of educational innovation supported in the technology. It is the educational practice - that includes individuals, contents, instruments and activities - the one that influences the student's learning."

Numerous examples of this type of study exist that, as I have just indicated, are usually elaborated from administrative-government instances. Next I will briefly describe some of the most prominent and cited examples in our area that pertain as much to European organizations as North American and that are usually cited as points of reference.

The first example is the report of EURIDYCE (2001) entitled *Basic indicators on the innovation of ICT into European Education Systems. 2000/01 Annual*. The data of this report have been contributed by the national sections of Euridyce and by data taken from *Eurobarometer*. The most prominent conclusions of the mentioned report indicate that the TIC is at the center of the national policies of all the European countries, having at their disposal documents and national plans dedicated to promoting their use, which, the majority began to do after 1995.

They have a five year mean. Their ends are similar in all the countries not only pursuing the computerization of the schools, but also the educational application of these technologies. The learning the TIC has transformed into an integral part of the curriculum of several countries. In secondary education it is widespread. The ends to include them differ in curriculum from some educational levels to others. In the European Union during the school course 2000/01 71% of the professors of primary, and 60% of the general secondary say use the TIC with students regularly. The lack of access and equipment problems or resources is the main reasons outlined for not using the TIC in class. On the other hand, a growing number of countries (approximately half) include TIC in the curriculum of professors' initial training, but a lot of variability exists between some countries and others in the position, duration and methodology of this training.

The second example, refers to the *National Center for Education Statistics*<sup>[1]</sup> and it offers indicators of readiness and use of Internet in the North American public (Cattagni and Farris, 2001) schools during the period 1994-2000. This report has been elaborated through annually interviewing approximately one thousand schools distributed throughout the whole country. These questionnaires were answered by the directors of the centers. In their conclusions it is indicated that in the year 2000 98% of the educational centers had access to Internet while in 1994 it was 35%. They also offer data on such indicators as number of classrooms with access to Internet in the schools, the ratio of the number of on-line students with access to Internet (it has evolved in the primary education of 14 students in 1998 to 8 in 2000; and in the secondary education from 10 to 5 in the same dates). This data, as you can compare with the previous report of Eurydice, indicate to us that as much in the European measurement as in the Spanish context we are still very far from the North American situation. In the noted report there is also

quantitative data relative to the time that students spend connected to the Internet, the connection (LAN, modem), the temporary period in which they are allowed access to the Internet (inside or outside of the school schedule) among others.

Another similar study to the one also mentioned developed in the North American context is the one carried out by Anderson, R. and Ronnkvist A. (1999) in which they gathered data regarding the readiness of infrastructures and technological resources through the method of surveying the directors and coordinators of more than 600 schools both public and private of the USA

Another example of a comparative study of endowment indicators and readiness of technological resources in different countries is the one carried out by Twining (2002). This report is centered in the description of the introduction of the TIC in the school systems of England and U.S, although a section is dedicated to comparing both countries with statistical data obtained from *Eurobarometer* corresponding to the year 2001. Three types of indicators are centered in the study: carried out economic investment, on-line students' ratio, and Internet connection readiness. The conclusions are highly optimistic since the data indicates that in the European and North American orbit it economic investments have notably increased in order to provide the schools with infrastructures and resources as well as the accessibility to internet services.

As a final example I would like to mention the OECD report (2003) on indicators of school systems of diverse countries of the *Education at Glance* organization, which includes Spain, and which dedicates an analysis appendix of different aspects relative to the incorporation of digital technologies in schools. According to this report, the expense in education diminished in Spain from 5,5% of the dedicated GDP in 1995 to 4,9% in 2000. The average of the member coun-

tries of OECD is one point higher, 5,9%. In the public sector the expense went down from 4,6% to 4,3%. The expense for students increased, but remained at 5,000 dollars, much lower than the average 6,000 dollars and still much lower than the 10,000 of the USA.

As for the integration of the new technologies in the centers and classrooms, the statistics are unsatisfactory. In this report, compared with the previous (Euridyce, 2001), Spain is one of the countries with the worst ratio of on-line students in secondary education: 16, in front of the 9 of stocking of the countries OECD, and far from the 6 of France or the 3 of Sweden or Denmark. In the use of computer science tools it is indicated that 30% of the professors are users of the Internet and barely 11% use e-mail. In the charts on the use of computers for educational objectives, Spain invariably occupies the last position. To give an example, only 37% of our students are taught to habitually use the Internet to locate more information, while the average of the analyzed countries is of 67%.

## **2. Studies on the impact of the computers on the learning of the students**

The second type of studies to which I want to refer have at their center of interest the measurement of the effectiveness of the use of computers in the learning processes, and more specifically the yield of students in the acquisition of the knowledge of a specific topic. This line of investigation, consequently, has been concerned with determining in what ways computers have improved and/or the quality and quantity of the learning increased with relationship to other didactic means.

This line of study may be part of the oldest tradition since it has been ongoing since the 70s. However, nowadays, at least from the academic atmospheres linked with the study of the curriculum and the school systems, it

is not a more cultivated type of study. It is characterized from a methodological point of view to design studies of experimental court. That is to say, they are investigations with concrete hypotheses, measurable variables in a quantitative way and teaching situations in which there are experimental student groups and a control. The dependent variable that is manipulated by the researchers is, usually, the computer, or more concretely, the teaching program or software.

The interest of the investigators was, as we have indicated, to demonstrate the instructive effectiveness of the computer technology, and for this try probe it through experiments which were compared to students' groups who learned a certain content or matter (mathematics, language), in some cases without the presence of the computer, and in others, with its use in the classroom. Later on, a control test of knowledge was carried out with these each group of students and the results were compared.

Due to the large quantity of this type of work carried out, in a periodic way, they have continued publishing different meta-analysis studies which were intended to synthesize the obtained results and to conclude on the degree and conditions under which the computers have certain effects in the learning processes and in the school outcome of the students. As we will see next, the results have not reached definitive conclusions. As H. Kirkpatrick and L. Cuban (1998) affirm:

"In the last 30 years, the studies on the use of computers in the classroom have found moderate evidence on the academic outcome of the students that use them. Other times, there is a minimum effectiveness. And others, none."

Next, I will present some of these meta-analysis studies describing their characteristics and some of their conclusions. The first one that I want to mention is carried out by Kulik (1994) and one of those most mentioned, which summarizes and analyzes more

than 90 studies developed in the decade of the 80's<sup>[2]</sup>. Kulik found a measure of a standard deviation of 0.32 in favor of the use of computers. The effects vary according to the type of investigation design, the source of the study, the duration of the same one, the type of use of the computer (tutorial, management, simulation, programming, support), and of the educational level. Kulik points out that the average size of the positive effect of the teaching based on computers is superior if it is compared with other innovations developed in the schools. In synthesis, their discoveries indicate that the students that use computers learn quicker, they have more positive attitudes as much towards the computer as towards the courses. The study also found that the benefits of the computer are superior when it is used as a tutorial with regards to other types of applications. This tutorial use is an effective means of improvement on the outcome of the pupil. On the other hand, this meta-analysis allows one to affirm that the type of pedagogic use of the computer and the time or duration of it are highly relevant variables that affect the outcome of learning.

Another outstanding meta-analysis is the one signed by Reeves (1998) in which he carried out a revision of the current state on the contributions from technologies to teaching, classifying the gathered information in two large dimensions: the studies that examine the use of technology to make up the entire program or instructive course (it is what the author denominates "to learn from the technology" such as, for example, instructive television, or computer supported teaching), and studies that analyze the use of technology such as cognitive instruments (for example, databases or multimedia presentations) with the purpose of developing superior mental abilities. This is what designates "to learn with technology." The author concludes that ample evidence exists that supports the effectiveness of television as a resource that diffuses educational materials. Similarly, the computer based teaching pro-

grams are effective applications of the methods and technologies in class. Also, the cognitive resources are effective above all if they are used in the context of a constructivist methodology. The author considers that future investigation should develop longitudinal studies in this last area, pointing out that the underlying principles should be analyzed to the successful applications of the technology in education.

Parr (2000), in his meta-analysis study, evaluated the effectiveness of what Integrated Systems of Learning (ILS) designate in the teaching of reading and mathematics, concluding that ILS clearly favors the teaching of mathematical skills, but not of reading abilities. Parr is also skeptical with regards to the benefit in terms of cost-effectiveness of ILS for schools. On the other hand, he highlights the importance of the interrelation among the educational impact of these systems, the grade of integration of technology in class, and the use of pedagogic appropriate techniques. Hence, he considers that the use of these systems requires a great deal of design work on the part of the faculty to integrate computers in the process of the classroom.

Their conclusions point out that a series of factors that affect the successful development of educational programs based on the ILS systems as they are:

- adequate access for the student to technology
- adequate technological formation of the faculty
- adequate configuration of a technical support team
- high level of enthusiasm and motivation by the faculty
- high level of integration of technology in the classroom

The last work that I want to refer to, is the one developed by Blok, Oostdam, Otter, and Overmaat (2002) where they analyzed, by means of the technique of the meta-analysis,

a group of quantitative (n=42) studies published between 1990 and 2000 in English and German that measured the effectiveness of the use of computers to teach reading to children between 5 and 12 years. These authors found a moderate positive effect in favor of computer supported teaching when being compared to the groups that learned without computers. This effect was larger in the English language groups than in the German groups. Also, this effect increased in those groups that already possessed an initial advantage with regards to the control group. The size of the effect was an average of 0.19; that is to say, the students that learned under EAO scored about a fifth higher than the standard deviation than the other groups of students. For the English language groups this size was 0.5, which is similar to other previously elaborated meta-analysis.

In Spanish, this type of meta-analysis study or evaluation is untraditional; therefore, I cannot mention any completed work in our academic context in which the discoveries in relative experimental studies are measured and compared to the effects of the computers on the learning.

### **3. Studies about the perspectives, opinions and the educational external agents' (administrators, supervisors, support teams) attitudes and of the faculty toward the use and integration of technology in classrooms and school centers.**

The third type of studies focuses its interest on exploring, verifying and identifying the opinions, attitudes or points of view that the educators and other educational agents maintain toward new technology and its use with educational aims. The justification of the necessity of carrying out these studies relies on the assumption that teaching practices with computers are conditioned, among other factors, for what educators think about the pedagogic potential of this technology, for the attitudes that they maintain toward the

technology and toward the educational innovation, and for the expectations toward its impact in the learning and improvement of their teaching (Chiero, 1997; Windschitl and Salh, 2002).

According to Braak (2001), the study of the educators' attitudes towards computers has been an important tradition for more than twenty years, having developed different instruments for their identification. Some examples are "Computer Attitude Scale" of Loyd and Gressard (1984), "Attitude-Toward-Computer Usage Scale" of Popovich, Hyde and Zakrajsek (1987); or "Computer Attitude Measure" of Kay (1993). Most of these instruments measure attitudes towards computers generically, without concrete specifications towards particular computers applications. Methodologically, they are exploratory studies in which usually use the survey method through a questionnaire when they use wide samples of subjects, or the technique of the interview and/or group discussion when the participants in the study are a reduced number of individuals. This type of works is elaborated, in many occasions, for university teams well as investigation project, well as responsibilities of evaluative studies carried out from some government organism and/or private organization as they are the foundations with the purpose of having a "portrait" of the state of these educational agents' opinion. In other occasions this type of study completes the diagnosis paper or initial expensive evaluation to plan a program of incorporation of new technologies to great scale, or when it is sought to identify demands and well informed and professional necessities of the faculty.

Numerous examples of investigations of this nature exist. The first example is a study carried out by National Center for Education Statistics (NC, 2000) which asked to "identify the degree and types of use of the computers that the professors carry out, as well as the perceptions of the professors with relationship to its formation for the use of these

resources in their classrooms." In this work they offer relative data to the type of use of the TIC in the schools: to create didactic materials, administrative management, communication with other educators, prepare lesson planning, elaborate multimedia presentations, access investigations, communicate with parents and students, or to access examples of didactic units or experiences. There is also data with relationship to the formation or the faculty's preparation towards the use of new technologies.

Another relevant study was the one conducted by Solmon, L.C. and Wiederhorn (2000) and financed by Milken Family Foundation in which they investigated the situation of availability and use of the TIC in the educational centers through questionnaires dedicated to technology coordinators of school districts in 32 North American states. Among other matters, they explored the contexts or environments under which the students and professors use the computers in the classroom, the attitudes of the professors towards the information technology in teaching, the competency and professional preparation of the professors, the use of the computers in the evaluation, implication and support that the technological plans of the district receive from the educational agents and of the school community, and the degree of use of technology in the schools of the district.

Another example is the work developed by Surrounds and Ward (2002) in Australia. This work consisted of a qualitative study through interviews with an educational group of 15 which found that there is relevance with the professors' perceptions with relationship to the potentialities of technology in their students' learning. They conclude by pointing out that the "investigation of the interactions among students, professors, and technology in class is in its beginnings. The impact of the perceptions of the educators on technologies in teaching approaches, the approaches of the students' learning, the per-



ceptions of the students on the use of technology, and the quality of the learning results should be investigated" (p. 73).

In the Spanish academic context, we have been productive in the realization of this type of study. The first one that I want to mention, that was somewhat of a pioneer for the study on this subject matter that were developed in our country, was the one directed by the Squire (1989; 1991) in which they undertook the evaluation of the then named Project Atenea<sup>[3]</sup>. Although they used different evaluative instruments (classroom observations, and interviews), the fundamental support rested in the use of different questionnaires assigned to various educational agent participants in this Project: professors (participant and non participants in Atenea), coordinators, monitors or support agents.

Since then, different supporting studies have been developed with the use of questionnaires and/or interviews dedicated to identify the faculty's perspectives towards new technology and its incorporation into teaching. From the University of Seville, on the one hand, Cabero (1991; 1993; 2000) has investigated in different occasions the situation of use of audiovisual and computer means of the Andalusian centers using different data collection instruments: opinion questionnaires, measurement of attitudes towards information technology in a Likert scale, semi-structured interviews and classroom observations. Also in the same university, De Pablos and Colás (1998)<sup>[4]</sup> developed a study on the degree of implementation of the new technology in a sample of 125 school centers of primary and secondary in the county of Seville functioning in three conceptual categories: introduction, application and integration (De Pablos, 1998). In this case a questionnaire was used assigned to directors and school advice of each center.

Other works belonging to this typology have also been developed by Rodríguez Mondéjar (2000) who investigated the opin-

ions of the faculty of primary Education participating in the Atenea project in the Region of Murcia. In Galicia Fernández and Cebreira (2003) they developed a survey study of professors which explored their visions regarding the use of the audiovisual and computer resources with relationship to four dimensions: presence of the resources and NTIC in the educational centers, organizational aspects for the integration of the resources; professors' use of the resources in their practices; and professors' resource training. Also in the context of Gallego Iglesias and SanMamed (2001) they carried out an exploratory study on the situation of readiness and use of the new technologies in the schools of infantile and primary education in the municipality of Coruña.

In the Canary context, I have had opportunity in two occasions (Area and Correa, 1992; Area and others 1996) of investigating through the survey method directed to the faculty's wide samples the use of the means and teaching materials in the planning and development of the teaching. Finally I want to mention the work carried out by Castaño (1994) in the University of Basque Country on the identification of the faculty's attitudes before the teaching means.

#### **4. Studies on the uses and pedagogic practice with computers in real contexts of centers and classrooms.**

Finally, the objective of the fourth investigation line is to investigate and explore which phenomena surround and accompany the use of computers in the educational practice developed in centers and classrooms. This is a perspective from a relatively recent study but, in its development, has provided valuable knowledge regarding what happens in the school reality and the potential of the information being transferred from some contexts to others.

Methodologically they rely on qualitative positions of case studies taking unit analysis

as well as the entirety of a school center, a group of educational centers of the same curriculum or educational level, a professor or concrete classrooms. In consequence, the interviews, the discussions in group, the observations, the field newspapers, and the documental analyses are the most habitual investigation techniques.

The interest in the realization of this type of study, at the moment, rests in the search and identification of the factors or variables present in those situations or experiences that could be considered innovative or valuable from a pedagogic point of view. That is to say, study in depth under what conditions and in what concrete contexts function certain practices with evaluated “successful” computers<sup>[5]</sup>. Ultimately what is sought is to obtain a phenomenological knowledge of certain teaching-learning situations with computers that can be transferred to other centers and classrooms.

Through examples I want to mention a pioneer work developed during the 1980s by Olson and Eaton (1986) in which several case studies were carried out by individual professors on the use of microcomputers in the classroom with a qualitative methodology supported in interviews and observations in the Canadian context. In that moment, the work represented a rupture with the traditional positions of investigation on the educational applications of the computers since on the one hand it investigated in what way the technology generated changes and innovations in the educational practices as well as how they were related and/or conditioned by the professor’s thought.

The second example is the study developed in the United States by Zhao and others (2002), published in *Teachers College Record*. In this investigation they proposed to analyze and give an answer to the question of why professors do not innovate their educational practices when they have computers. In other words, they sought to identify the

conditions under which educational innovation using digital technology took place. During one year they carried out a pursuit of professors (n=118) K-12 belonging to different programs based on the incorporation of the technology. The collection of data was carried out through questionnaires, interviews and systematic observations of professors' cases. These authors detected 11 factors that affect the grade of developed innovation. Some of the same ones have already been identified in the pedagogic literature, but others are newer. The authors classified these factors in three big domains: the innovator / professor, the project or the innovation, and the context.

Of the obtained results they concluded that although the three domains affect from a significant way to the success of the pedagogic integration of the technology, the contribution of the same ones is not same. In this study, the factors associated with the innovative professor played a much more outstanding role than the other domains. That is to say, when the professor was highly enabled the projects were successful even with innovations that showed levels of high distance and dependence or that were developed in contexts with little support. This doesn't mean that the influence of the other factors should be underrated or undervalued since the innovative projects tend to be more successful in environments with good human and technical support. Also when a very rich and strong context exists those professors with little preparation tend to have more success in the integration of the technologies in their classes.

Finally I would like to mention the monographic number coordinated by Anderson (2002) and published in *Journal of Computer Assisted Learning* dedicated to presenting different case studies on the process of use of TICs in the classrooms of diverse countries (Great Britain, Chile, Finland, Canada and others). These works were part of the phase 2 of a wider denominated international project

SITES - Second Instructional Technology in Education Study -. These studies were developed in 28 countries during the course of 2000-01 under the coordination of International Association for the Evaluation of Educational Achievement. The first phase of this study was explained previously and corresponds with a quantitative approach through the use of questionnaires (Pelgrum, 2001). In the introduction of this monographic, Anderson concludes that this international study, among other things, has provided evidence that most of the classrooms in which innovative uses were developed from a pedagogic point of view of the computers, is carried out with a technology that was not of last generation, but with what could be considered "antiquated." It also points out that "the organizational processes described in these articles, probably, would be those to which more attention is paid" (p. 386) as soon as they are representative of pioneer practices, but with generalization potential. Besides those articles where they show up the case studies carried out in the educational context of certain countries, the methodological description of how these studies were approached are offered in Kozma and Anderson (2002). In this work the selection criteria of the cases, the forms of data collection, and the analysis of the same data may be consulted.

In the Spanish context, in these last years, several investigations have been developed on this matter. One of the pioneers, Squire, has already been mentioned with respect to the evaluation of the Atenea Project where, apart from the use of the questionnaire, interviews and classroom observations explored the subjective dimensions of the participating agents and practices that they implemented with their students when organizing teaching situations with the computers.

GallegoArufat (1994a, b) in the University of Granada has developed several studies of cases of the use of computers in the classroom following a qualitative methodology.

This investigator has supported her works in the contributions derived from the perspective of the denominated "professor's thought" and her conclusions are dedicated to obtaining a knowledge that allows the articulating processes dedicated to the professional educational development. On the other hand, Cabero and others (1994), in the work also mentioned previously explored through classroom observations the type of practices that the professors and students developed when they used computers in the classroom.

Similarly, in the University of Barcelona and under the direction of the professor J.M<sup>a</sup> Sancho, different doctoral theses have been developed in which case studies on the use of computers in educational practice have been carried out, using the school center as a unit of analysis. One of the first works was carried out by C. Alonso (1993) that was pioneer as much in its their narrative format as in the evolutionary-historical study of the appropriation process and use of the computers on the part of the educational of a school certain center. Later M. Guitart (1995) analyzed the use of telematic services with educational ends in an educational center. It is interesting to note that in the moment the data was collected, that is to say, in the early nineties, the Internet had not still been popularized nor had it adopted the graphic format of WWW. Basically, the available telematic resources for that center, was e-mail and file transfer. Also in this line it is necessary to name the doctoral theses of Bosco (2000), which analyzes the use of the computer tool in a center of Primary Education of Barcelona, defined like a symbolic tool following the sociocultural theses of Vigotsky.

Also, Urbina (2001), in the University of the Balearic Islands, developed a similar study to those commented here, but focuses on a classroom of infantile education. I also want to mention the work carried out by J. Walls (1998) in the University Of Alcalá de Henares of Madrid that, although it is not an

investigation exclusively centered on the use of computers in teaching but rather the group of didactic materials, it is a good example of ethnographic analysis of different cases. As much their theoretical foundation as their design and development of the investigation are illustrative of the work line in which we are commenting. The last example that I want to name (Martínez, 2002) consisted of a study of cases developed in a center of Adult Education in Bilbao which analyzed the design and implementation of a project of educational innovation supported in the use of the ITC carried out as an initiative of the educational centers themselves in a collaborative perspective. This last case may be one of the factors that allowed the successful development of this project.

One of the common conclusions in these studies is that the integration and use of the computer technologies in the schools are conditioned, as well as other factors of infrastructural nature and resources, by the attitudes, conceptions and the faculty's dexterities, by the organizational culture of the own school, and by the forms that interact the students. In this sense, the faculty, and specifically their training (as much technological as pedagogic) together with the organizational culture of the center, are key factors in the integration process and curricular use of the new technologies.

## **5. Synthesis: What we have learned and what we still need to know**

From the revision of the studies and previous investigations, some lessons can be extracted from the following conclusions that I have synthesized:

1. The results of the studies and evaluations of the incorporation of the TIC into the school systems indicate that, in spite of almost two decades of continuous efforts of impelled projects institutionally for the educational different administrations, the presence and pedagogic use of the computers (so

much in their dimension of personal machine, of multimedia or of telematic net) still has not generalized nor has it transformed into an integrated practice in school centers. Certainly we are before a complex problem in which multiple variables and factors of very diverse nature intervene. Different authors have proposed a hypothesis that explains the difficulties of the use and integration of ITC in teaching.

The work of Larry Cuban<sup>[6]</sup> (1986) *Teachers and Machines* was probably the work that set the master lines of which direction the development of these theoretical models should go. In the one mentioned work it analyzed the history and evolution of the technology in teaching throughout the XX century, identifying that a pattern or model exists which repeats several times when new technology is introduced into the incorporation of the teaching. It happened with the arrival of the radio, the cinema, the slide projectors, the television, the videotape, and in recent times, with the computer. In short, this pattern consists of new means which create high expectations that it will innovate the teaching-learning processes, subsequently, it is applied to the schools, and when its use is normalized, it is discovered that its impact has not been as successful as it was expected, due to diverse causes: lack of sufficient means, administrative bureaucracy, insufficient preparation by the faculty, etc. Consequently, the educators continue to maintain their traditional leaning routines, basically, with printed technologies. It is what Hodas (1993) designates the "culture of the rejection" that locates its roots in a crossing of a diverse type of variables, provoked by the interest of the market to incorporate new technology into schools. Consequently, when forcing the introduction of computers into school atmospheres, they run into an organizational educational culture that rejects them. Cuban (2001) also revisits this idea in one of his last essays in which he analyzes the socio-educational impact of computers on the school system, questioning the peda-

gogic benefits of computers publicized from the government and managerial means.

Resneir (2001) has also analyzed the historical evolution of the means and technologies in the North American school context concluding in a similar way. In short, he affirms that "when a new means enters in the educational scene, a great deal of interest and enthusiasm exists on its effects in teaching. However, this interest and enthusiasm decays and the exam reveals that the means has had a minimum impact on the practices" (p. 61). But this author launches the hypothesis that although this pattern has been repeated with audiovisual means and with the first computers, it won't happen this way with the Internet and digital technologies.

2. Other noted works exist which are the conditions and factors that influence either the facilitation or the impediment of the integration and use of digital technologies in schools in an educational innovation perspective (Squire, 1991; Zammit, 1992; Fabry and Figs, 1997; Richardson, 2000; Burbules and Callister, 2001; Cuban, 2001; Pelgrum, 2001; Zhao and other, 2002).

These studies and essays have analyzed not only the use of computers in the classrooms, but also the generalization processes and innovation of the school system through the incorporation of information and communication technologies. What these works show is that the successful process of the incorporation of technology in schools is a consequence of the crossing of variables of an educational policy nature, of economic and infrastructural nature, cultural nature, and of organizational-curricular nature. In other words, the large scale, institutionally motivated innovations, with the purpose of incorporating technology in schools, requires some basic conditions such as:

- The existence of an institutional project that motivates and endorses the educational innovation using computer technology

- The endowment of the infrastructure and sufficient computer resources in centers and classrooms
- The faculty's training and their bias favorable towards ICT
- The existence of a climate and organizational culture favorable to the innovation of technology in school centers
- The availability of varied and abundant didactic materials or curriculum of a digital nature
- The configuration of external support teams to the faculty and educational centers appointed to coordinate projects and to facilitate solutions to practical problems.

We have learned that the innovation of pedagogic practices and the adaptation of school systems to an education model support by digital technology are and will be a parsimonious and slow process with ups and downs, and with advances and setbacks (Area, 2002). To carry it out, amongst other measures, it will imply the need to achieve important economic investments of endowment of sufficient technological resources for educational centers and in the creation of telematic educational networks; to develop formation strategies of the faculty and advice to the school centers with relation to the use of information and communication technology with educational aims; to understand educational centers as cultural instances integrated in the area or community to which they belong, putting to the disposal of the community the available technological resources; to plan and to develop projects and virtual education experiences supported by the use of the telematic networks, as well as to propitiate the creation of virtual "communities of learning"; the creation of webs and online materials so they can be used and shared by different centers and classrooms.

The future challenge is that the educational centers not only innovate its technology, but also their conceptions and pedagogic practices which will mean modifying the teaching model in its entirety: changes in the role

of the educators, changes of the learning process and activities of the pupil, changes in the organizational structure of the class, changes in the tutoring disciplines... This use process and integration of computers in the educational practices of the classroom do not take place automatically, but rather there is a continuum that goes from incorporating technology as an ad hoc element that is foreign to the habitual forms of teaching class, until being integrated and diluted as a strategic element more than the developed methodology. Pudding (1999), in this respect, points out five phases or states of this process: entrance, adoption, adaptation, appropriation and invention.

In this sense, the current institutional programs at work, impelled as much by the central Administration as the autonomous ones, among them the Canary Islands, dedicated to the pedagogic integration of new technology should not be centered on a high-priority or almost exclusive way in the more quantitative dimensions (ratio of students to computers, number of trained teachers, or number of classrooms with Internet access, to mention some of the most common indicators). To do it in this way would offer a very superficial view or image of the reality in schools. The incorporation of new technology if they are not accompanied by pedagogic innovations in the educational projects of the centers, in the structures and ways of school organization, in teaching methods, in the type of activities and learning demands required by the pupil, in the systems and evaluative requirements, in manners of work and the faculty's relationship, in the shared use of spaces and resources such as computer rooms, in the organization structure and cluster of the class with relationship to the work supported by the use of computers... they will merely affect the surface of educational practices, but they will not represent substantial improvements of these practices.

3. In relation to the problems and investigation methods used by this type of study we

can indicate that an evolution has taken place from the analysis of the individual learning microprocesses in particular teaching situations using experimental methodologies toward the analysis of experiences of the use of computers, taking as the reference unit the center 7/o classroom and its organizational culture using ethnographic techniques. That is to say, the investigation lines of this subject were initially concerned with how students learned using computers and to what degree this technology facilitates or improves learning. As we indicate, it imposed an investigation method supported by the quasiexperimental approaches of comparing certain methods and teaching means with others to identify the most efficient performance. The theoretical support of this line of investigation was centered in the contributions of learning psychology in both behavioral theories as well as information processing.

However, in the 80s a research perspective began to emerge that was much closer to the ethnographic and anthropological postulates that were concerned with the contextual and cultural phenomena that surround the processes of school practice with technology. This way, the investigators began to research and explore what educators and students think, the talkative interactions between one another, the organizational and practical forms of work among educators, as well as the goals, strategies and teaching processes implemented in the classroom when the computers are used. More than looking for a precise knowledge of the impact of the technology on learning in individuals, it went further to discover what socio-cultural and curricular phenomena are present in certain integration experiences and use of computers in the schools.

In this sense, many researchers agree (Means, 1994; Dede, 1998; Honey and other, 1999; Oliver, 2000; Cuban et to the one.; 2001; Of the Tile and other, 2003) that directed investigation projects should be de-

veloped to obtain more of an understanding of the characteristics of successful technological innovations in local, regional, and national contexts that to try to identify the grade of effectiveness of computers in the performance of students when they learn a specific content or the quantitative measures of the ratio of computers present in schools.

4. Finally, I want to indicate that the previous four types of signal studies need to complement each other. Each one of them, in their own way, offers us an interesting, but partial, vision of the complex reality implied in the incorporation of new technologies to the school world. As I have previously pointed out, each type of study has some strong points of interest but also its limitations. The studies of indicators, in this way, are useful in obtaining a global or radiographic vision of the concrete situation of a school certain system in a national or regional environment and comparing it with other national systems or comparing it with other punctuations obtained before. However, their weaknesses are that they don't inform us of the pedagogic or psychosocial phenomena that surround the school practice developed with the technologies.

On the other hand, the studies centered in identifying the effects and impacts of the computers in learning are useful in the measure that they offer us knowledge about the "effectiveness" of certain forms of pedagogic use of these technologies and of the instructive potentiality of the different modalities of symbolic representation of the information through the computers. However, they are limited in explaining how educators organize the teaching situations because, among other reasons, this type of investigation does not consider contextual and cultural variables.

The referred studies dedicated to exploring the opinions and faculty attitudes, as well as educational agents, are useful in that they offer us a picture of the opinion or point of view of those subjects. Furthermore, this

information is the most important for articulating and planning any strategies of dissemination, training, support or evaluation of a project dedicated to the incorporation of new technologies in the schools. But it contributes a very limited amount of information of what really happens inside the classrooms and centers, of school practices with computers, and of the effects of these practices.

With relationship to the case studies of centers and classrooms, as I have already suggested, these are highly potent to discover the phenomenology that accompanies those innovative experiences in the educational use of the computers, and in this way, we obtain knowledge of that particular case that allows us to explain it from idiosyncratic features. The weak point of this type of study is, in fact, its limited capacity of generalizing the obtained results. The experiences are transferable, but the results cannot be generalized.

In conclusion, I believe that the eclecticism of methods and investigation approaches should be one of the characteristics of those studies dedicated to obtaining a global and integrated vision of the group of variables, phenomena, situations and practices that arise and accompany all processes of pedagogic innovation through school integration of digital technology <sup>[7]</sup>. As Mcmillan, K.; Hawkins, J.; Honey, M. (1999) suggest, we have learned to recognize that the impact of technology in learning in complex atmospheres cannot be approached by analyzing the technology in an isolated way. What is clear is that at the moment we should think about holistic investigations that pursue the analysis of how technology is integrated in groups and real educational contexts, how technological resources are interpreted and adapted by the users, how to relate the potential of the technology with needs and processes of learning, and how technological changes affect and influence the innovation of other dimensions of the educational process such as evaluation, management, communication or curriculum development

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## Notes

[1] The NCES regularly publishes information of this nature in relation to the presence and use of the ICTs in the North American educative system. You can see in papers like NCSE 1997; 2000

[2] Kulik is one of the more noticeable North American investigators in the meta-analysis accomplishment on the impact of the technologies on education and learning. Periodically he publishes different works on this matter. Other meta-analysis of he same author made in previous years are Kulik et al. (1983); Kulik et al. (1987); Kulik et al. (1991)

[3] As it is well-known, the Atenea Project was the first great institutional program impelled by Spanish Ministry of Education in

the middle and final Eighties with the purpose of generalizing the use of computer science at schools.

[4] A synthesis of this work was published in Colás (2001-02).

[5] Certainly the concept of "successful practice" is ambiguous and is put under the conceptual and ideological assumptions of the investigator. In main lines, usually one ties to innovating practices of computers of constructivist nature supported more in the development of processes and intellectual abilities than in the collection of information, as well as in the collaborative work between students.

[6] This author (Cuban, 2001), recently, has published another paper recently analyzing the socioeducative impact of the computers on the educative system pointing some hypotheses on the resistance at its total integration in teaching practices.

[7] The study denominated SITES (Second Information Technology in Education Study) impelled by the IEA (Association International the Evaluation of Educational Achievement) was developed in 3 phases (1999-2005). That's a good example of this juxtaposition and methodologic eclecticism where questionnaires of opinion to administrators and teachers through case studies in centers and classrooms. The phase 1, the quantitative approach, supported in the questionnaire use can be seen in Pelgrum (2001), and phase 2, based on the case study of classes, can be consulted in Kozma and Anderson (2002)

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<b>Abstract / Resumen</b>	<p><i>This paper offers a classification of research trends and perspectives about processes oriented to incorporate information and communication technologies (ICT) in schools. Identified are four research trends: a) studies about indicators of computers quantity in school systems; b) studies about computer effects in learning; c) studies about opinion, perspectives and attitudes of educational agents to ICT; and d) studies about computers' educational use in classroom and colleges. This paper finishes with a synthesis of current knowledge about projects and programs intended for the embodiment of ICT in school systems.</i></p> <p>Este artículo ofrece una clasificación de las distintas perspectivas y líneas de investigación que han analizado y evaluado los fenómenos vinculados con la incorporación y utilización de las tecnologías de la información y comunicación (TIC) en la los centros y aulas de los sistemas escolares. Se identifican cuatro grandes líneas de investigación: a) estudios sobre indicadores cuantitativos del grado de presencia de las TIC en los sistemas escolares; b) estudios sobre los efectos de los ordenadores en el aprendizaje escolar; c) estudios sobre las perspectivas, opiniones y actitudes de los agentes educativos hacia las TIC; y d) estudios sobre las prácticas de uso de ordenadores en los contextos escolares tanto de centro como de aula. Finaliza el artículo con una síntesis del conocimiento derivado de dichos estudios en torno a los fenómenos que acompañan a los programas y proyectos de incorporación de las TIC a los sistemas escolares.</p>

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