

Information and Communication Technology and the Problem of Teacher Training: Myths, Dreams, and the Harsh Reality

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ABSTRACT

There is a widespread belief that the mere introduction of ICT is going to restructure education and encourage students to be more critical and thoughtful. This is the myth referred to in the title of the paper. It is argued that although ICT has certain important characteristics that can be used to facilitate learning, these characteristics can only be taken advantage of if they are accompanied by major changes in our educational objectives, in teacher training, and in our national curricula. In this paper we examine the evidence from various evaluation studies done in Greece and we conclude that the reality indicates that the introduction of ICT has not brought about significant changes in teacher practices in the Greek schools. We continue by arguing that it is relatively easy to educate teachers about the technical aspects of ICT. The difficult part is to educate teachers to change their pedagogy so that they can take advantage of those aspects of ICT that can facilitate learning. In the latter case, we propose that teacher training should address explicitly teachers' beliefs that their role requires the transmission of information as opposed to that of developing students' own skills to learn. We argue that this is not an easy task because it conflicts with teachers' perceived need not to "lose control of their class" and their perceived need to "cover the material". We conclude by describing certain characteristics of the Greek educational system that hinder changes in teacher training along the lines mentioned above and by providing recommendations for changes in our educational objectives at the national level in order to take advantage of the characteristics of ICT that facilitate learning.

INTRODUCTION

In the 90's the Greek Government launched an ambitious program of ICT introduction, under the name of "Odysseia". This program vouched to use computer and network technologies to produce radical changes in the Greek educational system (i.e, "to cultivate the faculty of critical thinking and change the practices of teaching, learning and communication in the Greek schools", <http://odysseia.cti.gr/English/ODYSSEIANEW/about.htm>).

We will argue that the goal of transforming educational practices through the mere introduction of ICT is a myth and a dream. Computers did not change education in the 80's and the introduction of ICT cannot by itself restructure education now. It is true that Information and Communication Technology has certain important characteristics that can facilitate learning and are consistent with a more student-centered learning environment, but these characteristics can only be taken advantage of if they are accompanied by major changes in teacher practices. Although some measures have been taken to change teacher practices, we will argue that these measures have not succeeded

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in modifying the existing teacher-centered, transmission-oriented teaching environment in Greece².

We are now at a critical stage in ICT introduction in Greece. Many schools have been equipped with multimedia computers and a great deal of money have been spent and will be spent in the next years on equipment and educational software. The question of teacher training is of vital importance if we would like to use ICT to produce lasting changes in educational practices consistent with the goals of the information society.

Teacher training in ICT can proceed in two ways, complementary to each other: One is relatively simple and not too difficult to accomplish. Teachers will require training in the technical aspects of ICT. We do not plan to discuss this type of training here, since we consider it to be rather straightforward. The second type of training is not so simple. It is training in pedagogical uses of ICT. Teachers will need to adjust their teaching practices to create technologically supported learning environments that are different from the ones we have now. We will focus on this second type of teacher training in this paper: Is it possible to take advantage of teacher training for ICT to change the practices of learning and teaching in the Greek schools? We believe that some measures can be taken in this direction but that the harsh reality is that ICT will not change educational practices unless it is accompanied by fundamental changes in our educational objectives and teacher practices at the National Level. Teachers are important mediators of uses of technology and thus a great deal of the change depends of teacher training.

More specifically, the structure of this paper is as follows: First, we briefly review the history of the introduction of ICT in education. We argue that computers failed to bring about the desired educational changes in the 80's for many reasons. One of the reasons was the lack of clearly articulated educational objectives to accompany the technological innovations. Such educational objectives have now been formulated at the European level and can be used to guide educational reforms related to teacher practices facilitated by ICT use.

In the second section of this paper we review the studies that provide information about ICT uses in Greek education: the attitudes of teachers, evaluation studies of current ICT use, and studies that attempt to introduce innovation. We argue that these studies show that ICT has not been incorporated in the subject matter teaching activities of the great majority of the Greek public schools today. In the cases where ICT is used in the schools, the innovation usually stays in the periphery and does not touch the usual teaching of subject matter. The teaching environment in the Greek schools is dominated by a transmission-oriented philosophy and the teachers' perceived need to "cover the material". Teachers shy away from more student-centered learning environments for fear

² We would not like to create the impression that no improvement has been made in education with the measures taken so far. We think that a lot has been achieved towards the goal of making students and teachers ICT literate and more will be achieved in the years to come as the Odysseia program is having its effects felt. In the present paper we will be looking at the specific issue of teacher practices. It is with respect to this issue that we claim that there has not been any significant change so far.

of losing control of their class and for the pressure to follow a very constraining program of studies³.

In the third section of this paper we discuss our recommendations for teacher training in ICT. We believe that teachers should be trained on using ICT to create more student-centered learning environments that focus on the development of students' skills as learners. However, we also claim that given the centralized nature of our educational system, this training will not be successful unless it is accompanied by major changes in our educational objectives at the national level. More specifically, we think that the following changes need to take place: a) a change from a philosophy of transmission of information to a philosophy of empowering the individual student as a learner, b) a change from obscure, sterile, abstract, and difficult to understand content, to teaching content and skills that are meaningful and relevant to life out of school, and c) a change from a highly centralized system of education to a more flexible educational system that gives greater authority and decision making power to local districts, school principals, and especially to teachers.

COMPUTERS IN EDUCATION: LEARNING FROM THE PAST

In the 80's when computers were first introduced in schools in the US and Europe it was believed that appropriate uses of this technology would produce the radical and lasting changes needed to make educational systems more responsive to the needs of the information society. These needs called for an educational system capable of producing technologically literate individuals, who are independent and life-long learners, capable of adjusting to continuous technological changes in the job market (European Commission 1995; European Commission 1996a; European Commission 1996b)

The citizens of the information society do not need to rely on memorization. Rather they must develop the critical thinking skills necessary to access, evaluate, and use the wealth of information that the new technology has made available. They need to develop proficiency on how to manage their disciplinary learning by developing metacognitive and epistemological sophistication. They need to learn to collaborate efficiently with others in different communicational environments, and they need to learn to negotiate about values in order to develop consensus and accepted ways of living in multicultural environments. This is particularly the case if we would like to educate individuals who are not passive consumers of information, but capable of knowledge construction and of understanding. These new skills are described in great detail in various European and American reports (European Commission, 2000; United States Department of Education, 2000; Web-based Education Commission, 2000)

These changes are by no means easy to make. They require fundamental restructurings in existing educational systems, an "educational paradigm shift", which past experiences have shown is a formidable task. Unfortunately, so far, the introduction of ICT has not

³ The reference is mostly to secondary school teachers.

become the force for producing the revolutionary changes in education it was supposed to produce. The introduction of computers in the schools in the 1980's did not become a tool of innovation. Instead, ICT was mostly assimilated into current educational practices. Larry Cuban summarizes this conclusion nicely in the Epilogue of his book "Teachers and Machines", where he says "*This study illustrates that the search for improving classroom productivity through technological innovations has yielded very modest changes in teacher practice without any clear demonstration that instruction is any more effective or productive after the introduction of radio, films, instructional television, or computers*". And he adds, a few lines later "*Policy makers need to understand that altering pedagogy requires a change in what teachers believe. Getting professionals to unlearn in order to learn, while certainly not impossible, is closer in magnitude of difficulty to performing a double bypass heart operation than to hammering a nail*" (Cuban, 1986, p. 109).

In recent years a new euphoria has re-emerged and expectations are again high regarding the potential of ICT for education. The reasons for the new expectations appear to be the technological developments that make it possible to have increased access to information via the World Wide Web and the new possibilities for communication. As a result of these new technological developments there is a new emphasis on ICT, and the European countries are determined to equip their schools with new multimedia computers and with access to communication networks and the Internet (European Commission, 1996; United States Department of Education, 2000; Web-based Education Commission, 2000). How well is this new effort going to succeed in producing the educational paradigm shift?

Researchers seem to agree that one of the main reasons why the introduction of computers in schools in the 80's did not produce the expected changes in education was the lack of well-articulated educational objectives (Pelgrum, 1997; Vosniadou, 1997). Teachers could not change their educational practices because there were no well-accepted and clearly defined alternative practices that were consistent with the goals of the information society and with ICT. It has become increasingly obvious that ICT will have a better chance of facilitating changes in the school environment if it is based on a clear vision of what the new school learning environment should be.

International developments in learning and instruction are now converging on a set of principles for learning in school settings that seem to provide the needed educational objectives (Bransford et al., 2000; Glaser et al., 1996; Vosniadou, 1996; Vosniadou, 2001a). It is not our intention here to describe these principles in any detail. It suffices to say that they are centered around the ideas of a) increasing the active, constructive engagement of the students in the learning task, b) paying greater attention to the social aspects of education (i.e., increased communication and collaboration of all the parties involved in an educational community-students, teachers, principals, parents, local and national community officials, universities), and c) calling for more meaningful and authentic school tasks that bring school activities closer to the kinds of skills and tasks needed for functioning in real life (see also Feldman, 1997, and Roth and Tobin, 2001, for the application of similar principles to teacher training itself).

These goals are generally consistent with the goals of the European Union's Lisbon Meeting in March 2000, where the future goals of the educational systems of Europe were considered⁴. For example, we read in the report of the European Union (European Commission 2000) that schools and universities should increase their links and relationships with the communities to which they belong, re-examine their curricula and skills and bring them closer to the ones needed for functioning in today's information society, and take measures to increase student motivation in learning. Another related goal is to increase student participation in learning. There, the idea is that schools should not only teach students more meaningful and authentic skills and knowledge but also pay attention to the development of the individual students themselves, by teaching them the skills of learning to learn, thinking, and reflection; skills that are indispensable for life long and independent learning. Special attention is paid to this latter point. In other words, the goal of education should not be (as it has been in the past) the transmission of certain facts and skills but also the development of the individual student as a person capable of critical, independent, and self-reflecting learning. These directions should indeed guide the training of the teachers themselves.

There is no indication so far that these educational goals of the European Union have affected our national curricula or that they have been made known to the teachers themselves. Most of the teachers we have been in contact with seem to believe that they are doing a good job in educating their students. They seem to believe that the introduction of ICT will at best speed up their work but not that it will change their teaching practices. Given this situation there should be little expectation that ICT use has actually changed teacher practices in Greece.

STATE OF THE ART IN EDUCATIONAL PRACTICES AND ICT USE IN GREECE

In this section of the paper we review studies of teacher attitudes and teacher practices with respect to ICT, in order to better understand what is the state of the art in this area in Greece today. We believe that it is very important to identify the factors that can facilitate or hinder the use of ICT to design more constructivist learning environments and to take them into consideration in our recommendations.

Secondary School Teachers' Attitudes in Macedonia and Epiros

The introduction of ICT in education seems to be welcomed by the majority of secondary teachers involved as positive and much needed. A series of empirical studies (Bikos 1993, Emvalotis and Jimoyiannis, 1999) supports the claim that the introduction of ICT in schools is widely accepted by secondary school teachers.

⁴ At the Lisbon summit of 23 and 24 March 2000, the heads of states and governments launched an appeal for the design of a European framework for the new basic skills in the knowledge society (European Commission 2000).

A questionnaire about the attitudes of secondary school teachers relative to the introduction of ICT in education given to 200 male and 266 female secondary school teachers in the prefecture of Macedonia (Bikos 1993) and a similar one given to 111 male and 75 female secondary school teachers in the prefecture of Epiros (Emvalotis et al. 1999) shows that although teachers recognize the importance of introducing ICT in education, they are far less convinced about the potential of ICT to improve the teaching of specific subjects. For some secondary school teachers, e.g., mathematicians, the majority thinks that ICT has nothing to offer to teaching. For example, 65% of the secondary school teachers in Emvalotis and Jimoyiannis (1999) sample believe that the introduction of New Technologies is necessary in the Greek schools and that it should play a more important role in schools today. Yet, an average of 52% of the secondary school teachers (and more specifically 64,5% of the mathematicians), are uncertain as to whether the new technologies can provide valuable support to the teaching of their subject matter within the confines of the Greek school. In general it appears that the secondary school teachers in the sample were not very well acquainted with what the new technologies have to offer for education. About 32% of the teachers were familiar with word processing, while 97,3% reported no familiarity at all with spread-sheets, databases, internet use and applications of multimedia to education.

The teachers also report that they are not well prepared for introducing ICT in their classes and that they do not have the specific teaching materials needed to guide them in using ICT to teach different subject matter areas. We note the anxiety of teachers to have specific guidelines for teaching in the different subjects and fear of open systems that they cannot control fully. It seems that the introduction of ICT also causes anxiety to teachers relative to class management. Finally, the vast majority of the teachers think that ICT implementation in Lyceum is impossible except maybe for the courses that do not get examined at the national level (and therefore their grades are not as significant for entrance to the University). Teachers seem to believe strongly that ICT cannot really support a better performance (grades) relative to traditional practices.

From these studies it could be concluded that:

- There is a general positive attitude of the secondary school teachers towards the students' training in ICT, but there is little information about what actually ICT has to offer to education.
- Many secondary school teachers believe that ICT cannot really help in the teaching of subject matter.
- Teachers have strong beliefs that ICT cannot help in preparing students for the national examinations. As a result they do not want to use ICT in the Lyceum.
- ICT causes anxiety to teachers because it introduces changes in teaching and class management practices that they feel they do not know how to control.

It should be taken into consideration that these studies were conducted some years ago, before the major initiative for ICT introduction in secondary education, Odyseia, came into effect, and that the situation may be different now.

The attitudes of teachers trained in ICT through the project “Odysseas”

The project “Odysseas” which started in 1996, was the initial project out of which “Odysseia” emerged. Its purpose was the introduction of ICT in 19 secondary schools in an integrated way, which included a teacher-training component. A paper by Kynigos et al., (Kynigos et al. 2001) reports a study that investigated the attitudes of the teachers that participated in this project. The results are based on a questionnaire in which 119 of the 270 teachers that participated in the project responded.

The results of this study point to the following conclusions

- There is a positive reaction of the teachers to the use of ICT in schools
- The teachers think that the available educational software is limited both in terms of its quantity and in terms of the variety of the subject matter that it covers.
- The teachers are not pleased with the technical and pedagogical support currently available at the schools. They need better training in ICT as well as continuous pedagogical and technical support.
- One of the most important problems is that there is currently no provision and no framework for the introduction of ICT in the analytical program. Given the hierarchical structure of the Greek educational system this is a significant problem that stands in the way of the widespread use of ICT in the classroom.

Preparing in-service teacher trainers for the schools of “Odysseia”

One of the projects of “Odysseia” (project E42), had as goal the training of in-service teacher trainers of ICT implementation. E42 provided training to 120 ICT “animators” in the pedagogical uses of ICT. The goal of E42 was that the ICT teacher trainers would become able to perform in-school training of the secondary school teachers towards establishing new teaching and learning practices in the classroom by use of the ICT technology. Their training lasted for a full year and was directed by three Universities in three different locations. Their training time included courses in the University campus and supervised mentoring activity in the schools they were responsible for. The teacher trainers were taught about constructivism and about how to use the available technology to realize it in real classrooms. These teacher trainers are currently supporting, at different levels of thoroughness, teachers of many disciplines (Computer Technology Institute 2001a; Computer Technology Institute 2001b; Computer Technology Institute 2001c; Kynigos (in press)).

It should be mentioned here that the teacher trainers were selected according to quite stringent criteria from active teachers of secondary schools. Most of the teacher trainers had some kind of graduate studies in education, previous experience with computers, a great deal of teaching experience, and a good command of the English language. Moreover through participating in interviews they were questioned on their pedagogy and teaching methods.

Our research team (University of Athens, Cognitive Science Laboratory) participated in the training of 40 ICT teacher trainers and we use our experience from their training and the reports from the schools they were mentoring, to point to problems and opportunities that emerged during their work. While in the schools of their responsibility, the ICT teacher trainers had to report regularly to the teachers in the University Training Centers. The reports were done by electronic mail on a weekly basis, and their purpose was to help the teachers plan their classes better and discuss about their experiences and the problems that they were facing in their work. The teacher trainers used a variety of context-sensitive approaches in order to support the teachers in their tasks.

The teacher trainers report that the teachers in the schools had a positive attitude and were interested in learning how to use general-purpose software not only for their professional duties but also for their own use. The high profile of computer literacy in the broad society was often presented as the reason for that. The teachers were, however, anxious since many of them were not initially comfortable with computers and the teacher trainers found that introducing them to ICT was quite a challenging task. The teacher trainers developed their strategies of introducing innovation in relation to the feedback that they got from the teachers. They seem to come to a consensus that the introduction to Internet resources and the combination of instruction in specific ICT software with the use of worksheets, are efficient strategies of ICT introduction in the classroom.

The teacher trainers noticed that in their training the secondary school teachers reproduced the learning environments that they implemented in their classrooms for their own students. They generally felt more comfortable with accepting “ready made projects” for use in the classrooms, or by following detailed orders on what to do, and less comfortable with taking initiatives or with working in groups towards learning.

In some cases, teachers, with the guidance and support of the teacher trainers, have used the computer classroom while teaching their subject-matter course. In these cases the teachers usually formulated rather low standards, such as to simply familiarize students with the new medium. There also appeared to be a strong tendency to treat the computer as a demonstration device. It is very rare that the teachers themselves proposed passing from a lecture empowered by the demonstration facilities of computers to collaborations where students take more of the initiative in constructing shared knowledge.

Out of the “negotiation” between teachers’ desires and the students’ interests the following sorts of activities emerged as the most popular:

- 1) the localization of rich multimedia material through navigation in the internet
- 2) the completion of worksheets in the process of an activity where some educational software was used.

However these activities can be implemented in many different ways particularly with respect to the degree of responsibility a teacher wants to give to students for their own learning. Indeed, the teacher trainers report that the teachers transfer the ways of

distributing leadership in learning in the classroom from the traditional learning environments that they have been used: The teacher keeps the control on the planning of the activities that lead to learning and on the evaluation of the results. Many times the teacher selects both the web pages and the path that the students will have to follow. When using the worksheets teachers often work under the assumption that all the students should be at the same spot at the same time and that they should report to them so that they make sure that things are under control. Therefore students do not get support to develop into self-regulated learners and the ICT technology does not change the traditional teacher-centered, information transmission environment.

Finally we repeatedly had reported issues of lack of flexibility in dealing with organizational challenges within the school. There was often difficulty in accommodating the ICT trainers (who did not go to the schools from the beginning of the year) and providing time for collaborative work of the teachers who were on training.

The teachers desire well defined activities and guidance that fits closer to their usual ways of classroom management. Teachers transfer teacher-centered teaching and management practices in the new learning environments and need a great deal of support in passing to a vision self-regulated learners for their students.

General Conclusions

The studies of the teacher attitudes as well as the reports of the in-service Odysseia ICT teacher trainers point to the following conclusions.

Although the teachers (mostly secondary school teachers) are positive about the introduction of ICT in the schools they are not very well informed about what ICT has to offer to education. There seems to be a strong belief that ICT cannot help much in the teaching of subject matter and a fear that it is going to affect class management in ways that contribute to the teachers' losing the control of the class. When they are taught ways to incorporate ICT in teaching of subject matter, they prefer specific software designed to meet the demands of the curriculum, well-defined teaching activities, and the reproduction of traditional teacher-centered management styles. As a result the capabilities of ICT to produce more student-centered teaching environment are not utilized.

EVALUATION OF USES OF ICT IN PRIMARY AND SECONDARY EDUCATION

The Center for Educational Research Study

In this section we will report the results of a study that evaluated current uses of ICT in the Greek Educational system during the academic year 1999-2000. The study was funded by the Center for Educational Research under the General Program "Research" and was conducted by the Departments of Informatics and Philosophy and History of the

University of Athens, the Department of Elementary Education of the University of Thessalia, and the Lambrakis Research Foundation. We will start with a discussion of the results on primary education and will continue with the evaluation of uses of technology in the Greek high school. (Center for Educational Research 2000a; Center for Educational Research 2000b; Center for Educational Research 2000c)

Primary Education

ICT has not yet been introduced officially in Greek primary schools, as is the case in secondary education. Nevertheless, many private and public primary schools have multimedia computers that they use in various kinds of activities. The University of Thessalia research team, which was responsible for the study of the primary schools for this research project, distinguished five groups of primary schools that use ICT (Center for Educational Research 2000a).

The first group consisted of primary schools that participated in the pilot program TILEMAXOS, the first program that introduced ICT in Greek primary schools, about a decade ago. This program provided 34 schools, most of them located in remote areas of Greece, with one or two multimedia computers and some educational software, like the software Logomatheia, a well-designed drill and practice software for teaching the Greek language to young children. Twenty-eight of these 34 schools were located and visited by members of the research team to find out the extent of ICT use today. The results were rather disappointing. In most schools the use of ICT was nonexistent. While there were a few schools where some ICT was used, in many cases this consisted mainly in the use of Logomatheia. In some schools the Parent Association paid for the hiring of special computer teachers to teach the students in the afternoon.

The second group consisted of public schools equipped with multimedia computers with the initiative of some teachers and the help of the parents and the local authorities. Twenty-six schools that belong to this category were visited. The number of primary schools in this category is increasing from day to day as there is great desire on the part of both teachers and parents for primary schools to become equipped with computers and internet connections. The observations of the use of ICT in these public schools showed that ICT is used in various ways depending on the abilities and knowledge of the responsible teachers. Some of the uses of ICT observed were the following: to help in the teaching of Greek, arithmetic, geography, history, etc.; to create school web pages and school newspapers; to communicate with other schools in Greece or abroad; to initiate projects dealing with local history and culture; and to search for information in the internet.

The third group consisted of schools that participated in innovative programs recently funded by the Pedagogical Institute (programs like SEPPE and ISTOS). Ten different such programs were followed in which 46 primary schools participated (sometimes in collaboration with high schools). These schools were equipped with multimedia computers and software in the context of a specific program. Unfortunately, these programs run for a limited period of time and usually stop when the funding is over.

There seems to be no assurance that the equipment and software will be used to improve teaching and learning in the classroom.

The fourth group consisted of 14 schools that participated in the pilot program “The island of Faiakon” the only “Odysseia” program that had as explicit goal the introduction and pedagogical use of ICT in the primary school curriculum. At the time of the investigation the schools had been equipped with labs of ten computers each but the networking was not yet completed. The training of teachers in both technical (use of computers) and pedagogical (use of the software and activities that have been evaluated and sent in schools) uses of ICT was still under way. As a result there was no educational activity involving ICT in these schools at the time when the study was completed.

Finally the fifth group included private schools. Five private schools were visited, two in Athens and three outside the Athens area. The study of the schools in this category revealed that in some of the schools, especially those in Athens, there was extended use of ICT. These schools introduced ICT at earlier times than the public schools and have implemented it in a wide range of educational activities related to the teaching of school subjects or to extracurricular activities.

In conclusion, the results showed that despite the lack of official mandate, a large number of primary schools have introduced ICT in their practices. There appears to be great desire on the part of teachers and parents to use ICT in primary education. The results of the study also showed that the most successful cases of ICT use were the cases where knowledgeable and motivated teachers who wanted to have ICT in the school and knew how to use it. These teachers will go out of their way to get the funds to equip their schools with computers even in the absence of support from the Ministry of Education. When the teachers are not educated in the use of ICT they cannot use the equipment that is provided to the schools. This conclusion can be inferred from the situation today in the schools that participated in the program TILEMAXOS, where there was no continuation in the use of ICT in the schools after the initial support was stopped.

Secondary education

Two studies had as focus the evaluation of ICT in secondary education (Center for Educational Research 2000b). The first study investigated the teaching of Computer Science in secondary education and the second investigated the use of the computer laboratories in the schools by teachers other than the computer science teacher. This study also took place during the academic year 1999-2000. Thirty-four schools were investigated, mostly in the Athens area and the periphery around Athens. At the time of the investigation some schools were being equipped with Odysseia computer laboratories, which, however, were not yet in use.

The teaching of Computer Science. The results of this study were based on the answers of the 34 computer science teachers (in a few cases the school’s principal) to a questionnaire. The results showed that the computer science teachers were very supportive of the introduction of ICT in the Greek secondary schools but felt that they were not adequately prepared to become the major forces of this changes as they would

like to. The reason is that computer science teachers have a very limited pedagogical training and, in some respects (25% of the sample), limited background even in computer science.

The computer science teachers voiced many complaints regarding equipment and technical support. The computer laboratories were not usually equipped with multimedia computers and faced all sorts of technical problems. There was often conflict between the computer science teachers (who have laboratories with older generation computers) and specialty teachers who become responsible of the new “Odyssea” laboratories with more advanced computers. Finally there were some schools that had no computer laboratories at all or had computers that are so old that are essentially useless. Common to all schools is the problem of upgrading the equipment and of continuous technical support, since this was not taken care of in the initial design.

The teachers also voiced concerns about the computer science books and the lack of enough time to “cover the material”, but these are not relevant for the purposes of the present paper.

The use of computer science laboratories to help in the teaching of subject matter. This study was based on visits to 24 of the computer science laboratories to which questionnaires had been given earlier. During the visit the experimenters discussed with the teachers of the schools and observed some of the lessons given in the laboratories. The results of these visits showed that the use of the computer laboratories that schools may have is usually limited to teaching computer science. As mentioned earlier, the computer laboratories have technical problems and old equipment. There is also lack of educational software, but most of all there is lack of both technical knowledge and pedagogical training on the part of teachers who could use these laboratories. Usually only the computer science teachers and one or two other teachers (usually mathematicians or physicists) feel comfortable in using computers, because they have the technical knowledge. But even then they are limited by the lack of knowledge about the educational applications of ICT.

Although both students and teachers look for the use of ICT in the classroom teachers feel unprepared for this due to lack of training and do not want to risk failure. Moreover the lack of technical support may lead to severe time delays as it happened in a case of a school where laboratory operations stopped for 20 days due to a virus! In the case of Lyceums an obsession with final examinations creates an environment that is not conducive to inquiry learning and uses of ICT. It is only in the high schools that we find some leeway towards such innovations. Finally, in all secondary schools computers are used for administrative reasons and many computer science teachers complained because they had to do the work of school secretaries.

There were, however, a few cases that differed strongly from the above. These were cases where modern hardware was purchased either through parents’ initiative or through pilot projects of the Pedagogical Institute or through other initiatives and was used for the didactics of other subject matter. In these cases we saw collaborative learning, richer interactions between students and students and students and teachers, pursue of inquiries,

projects, etc. Both the motivational and the learning climate were much better. The use of educational software, the communication with other schools, the searching for information in different sources, makes the educational environment richer and more student-centered. Basic characteristics of such classrooms are the existence of dialogue in the classroom, the information search by students and the coaching from the side of the teacher. As in the case of the primary schools, these cases existed as isolated instances, led by educated and progressive teachers.

To summarize, the following conclusions could be drawn from the results of these two studies: Many computer laboratories are equipped with old generation equipment that need to be replaced or upgraded; there is no technical support for the equipment that exists and very little available educational software. Most secondary teachers do not have the technical training needed to know how to use ICT in the classroom, and the computer scientists responsible for the laboratories do not have the pedagogical training needed and in some cases not even the computer science training needed. At the same time computers are used broadly for administrative purposes in the schools and the computer scientists often do the work of school secretaries. There is widespread belief that in Lyceums the curriculum and the goals that are set make ICT innovations impossible. Finally, there were a few cases where individual teacher involvement resulted in schools participating in European projects, equipped with modern computer laboratories through private, local or European funds, and with a variety of very interesting, collaborative and constructive educational activities going on.

ICT and the Quality of Learning Study

“ICT and the Quality of Learning” is a major international initiative organized by OECD/CERI within its work on Schooling for Tomorrow. This initiative is designed to study the profound implications that ICT has for education and learning and involves many of the 29 OECD member countries. In the “research and evaluation” part of this initiative leading examples of good practice in the use of ICT in schools were to be analyzed. In the case of Greece five schools were studied. (Chatzilakos et al. 2001). The schools that were chosen belonged to two categories: two private schools that had long prior experience in the use of ICT, often under a University guidance, and three “Odysseia” public schools.

As in the other studies, this study also confirmed the support in the use of ICT from the side of the teachers. A significant number of them put great deal of effort to develop the necessary ICT skills and to try to introduce their students to the computer classroom and use the computers to support some of their teaching. Especially in inexperienced schools, the researchers found that technical support in combination with available training on pedagogical issues on computer use, and a positive school climate were important factors to motivate the non-enthusiastic teachers to use computers in their teaching

The results of the study showed that in the three public schools, the introduction of ICT was a relatively recent innovation. As a result, both the teachers’ own training in the use

of ICT and their experimentation with their classes was limited. In these schools, teachers did not seem to implement any real didactic innovations in their classrooms. ICT was used instead “as a modern dynamic teaching aid or as an information source”. Moreover, although the experimental lessons were designed by the teachers themselves without having set directions, most of the time the class instructions supported a face-to-face teaching where the teacher played the central role. The authors conclude that “it seems that teachers did not have the time to reflect on the computer use in their teaching and integrate new ideas of its use.”

In the two private schools where ICT innovation has been on for a much longer period of time, and the teachers had been involved in pedagogically-minded ICT projects supported either by a collaboration with a University (in the one case) or by the school’s own initiative (in the second case), more significant changes in teaching styles were observed. Hence in these two schools the pedagogical use of ICT grew deeper. An interesting difference between the two private schools is that in the case of the one school the administration had a clear pedagogical agenda that included the use of ICT for didactic innovation. In this case there was an even engagement of teachers in an effort for pedagogical improvement through ICT in their classrooms. In the other school, there was a great deal of variability among teachers in the depth and quality of ICT implementation.

In comparing the two groups of schools the researchers are not sure whether it was the sheer amount of time or the intentional pedagogical support that was responsible for their differing pedagogical performances. Finally, the researchers point to the importance of the interaction with university research teams with educational expertise. However their research data do not allow them to assess the significance of strong pedagogical commitment and clear pedagogical agenda relative to ICT introduction on the side of the school administration. This would be in any case a lesson difficult to transfer to public schools where the school’s principal has less authority.

The project EMILE

EMILE is a European (Socrates/Minerva) project in which five European countries (France, Greece, Italy, Norway, and Hungary) (Vosniadou 2001b; Wegerif 2001) are collaborating, using similar methodologies, to observe and analyze the uses of ICT in primary and secondary schools (<http://www.emile.eu.org>). In the context of this project, a research team from the University of Athens (Vosniadou, Ioannides, Kalaitzi, Apostolopoulou, Gartzopoulou, Kanidis, and Malliou) has chosen to observe four schools (two from the area of Athens and two from other areas of Greece). Four schools were selected – all public schools – on the basis of their participation in ICT related activities. All the schools had active web sites, participated in many European projects, had won awards for ICT related projects, etc. At this point in time, three of these schools have been visited and observed twice – we have not yet done a full observation of the fourth school.

The results so far show that the ICT related activities in two of these schools are very much centered on the activities of one individual. The first case involved a large high school in which a very active and knowledgeable computer teacher managed to obtain local funds to upgrade the computer lab in the school. He worked with a group of students to create a very good school newspaper. The school also has an excellent web site, and participates in many European projects. All these projects and activities are a source of pride for the school, which is located in a relatively small provincial town, the students and parents are very enthusiastic about them, and everybody hopes that they will continue. ICT use however has not been transferred to the rest of the school. The other teachers are not using ICT in their classes, with the exception of very few cases in which computers are used mainly for power point presentations of school material. The Odyssea laboratory in the school is not yet operating.

The second school we observed is a small primary school in which the principal has managed to obtain local funds to buy a few computers and video-conference equipment which are used a few times each year to communicate with European schools in the context of a European program. The school also has an interesting web site. ICT has not transferred to the rest of the school and is not used by the other teachers.

The third school is an exceptional public primary school in which many project-like activities were going on before the introduction of ICT. As ICT came in, it became incorporated in the school life, in many ways: to help in the preparation of materials, to communicate with other partners, to create a web site and a school newspaper, etc. ICT is also used in teaching subject matter with existing software (mainly in teaching math and Greek), but in addition the teachers themselves are creating their own unique ways for utilizing the computer lab they have in the school (the school participates in the Island of Faiakes program) for the purpose of teaching. It is clear that in this school it is not ICT that has changed the teaching practices but has rather been assimilated into a progressive constructive and student-centered environment, helping it to evolve even further.

To conclude, so far the EMILE project has shown that:

- a) ICT activities are initiated and sustained in the schools by principles or teachers who are ICT literate and have a progressive pedagogy.
- b) These activities do not usually transfer to the rest of the school without substantial teacher training in ICT
- c) In progressive schools, schools that already participate in many activities, initiate collaborative projects, and sustain a good working relationship and collaboration amongst teachers, ICT can easily be assimilated in the school life.

The Computer Supported Collaborative Learning Network (CL-Net)

In this section we report on the results of on a project to establish and evaluate a computer supported collaborative learning environment. The Computer Supported Collaborative Learning Networks Project (CL-Net), was funded by the European Targeted Socioeconomic Research program and involved research groups from five European countries that participated in the project to investigate the cognitive and metacognitive effects of CSCL networks (Kollias et al, 1999; Vosniadou et al., 2000; Kollias et al, 2001). Different groups implemented CSCL environments in primary and secondary schools focusing on different subject matter. The Greek researchers focused on teaching science to 6th grade students. The Greek research group had previous experience with designing science-teaching environments by integrating the results of current cognitive science research into teaching practices (Vosniadou et al., 2001), and wanted to investigate the effect of ICT on these environments.

The research was conducted in one of the best private schools in the Athens area. In this school high technological expertise and infrastructure is combined with highly motivated teachers and an integrated approach to the teaching of sciences throughout primary and secondary level. During the implementation of the project the students participated in various communication environments: face-to-face discussions in the classroom, collaboration in dyads in front of the computers, communication with other dyads through the computer database. The students, while collaborating in dyads constructed notes in which they answered teacher questions, expressed their opinions, and commented on other students' opinions. A variety of projects were initiated, such as "how an internal heating system works", "choosing a place in the solar system to build a hotel", "alternative energy sources for heating and their operation".

In the new learning environment the researchers tried to pass learning responsibilities to the students, to foster collaboration amongst the students and to support the development of reflection and metacognition. The communicational and expressive landscape of previous science-teaching environments that the group had designed was enriched by the use of a multimedia data base (WebKnowledgeForum). This database is especially designed to support the written public expression of students' opinions and their collaboration in knowledge building.

The researchers wanted to replace the traditional teacher-centered environment where the teacher is the main source and transmitter of information with a more student-centered situation. In view of that goal, teachers were asked not to tell the students what was the "correct" answer but rather to direct them to sources of information (which could be books or internet sites) where they could find information to answer their questions. It was hoped that such practices would facilitate students to start on the process of knowledge building, in collaboration with the other students in their group.

The researchers report that there was success in student engagement and enjoyment of learning. Testing revealed improvements in students' understanding of the concepts involved. The researchers also report improvements in students' awareness of the value

of multiple information sources and in their ability to assess their own level of understanding (i.e., to know when they do not understand, when they need to study more etc.).

The analysis of the data-base showed many interesting metacognitive comments that students exchanged (“I do not understand what you are saying”, “your explanation is not a good one”, etc), while a study of the relationship between the cognitive and metacognitive comments in the intra-dyad interactions of students revealed a clear positive correlation with the quality of collaboration. In other words, the dyads that succeeded in collaborating were also the ones that made cognitive and metacognitive gains.

The above results demonstrate that there is educational potential in combining learning environments informed by cognitive research with ICT technology to create a situation where students are encouraged to develop their own skills as learners (such as the skills of collaborating with others, of locating relevant information, of critically evaluating this information, of organizing a project/report and presenting it to an audience). This educational intervention focused on aspects that are not traditionally salient in Greek education, such as providing students with rich ICT environments where they can develop communication and collaboration skills, and which encourage reflection and understanding.

One should take into consideration that this research project took place under optimal conditions with respect to the hosting school both in terms of the technical infrastructure available and in terms of teacher training and motivation. Even within such a privileged environment there were certain problems that surfaced, as described below:

- The teachers expressed their uneasiness with students unchallenged expression of alternative opinions about scientific issues: “If you leave them alone they may end up saying false things”
- The teachers questioned the ability of students to maintain a cognitively demanding inquiry and to maintain collaboration, carrying themselves the big part of inquiry leadership: “You need to continually attract students’ attention with something impressive. Otherwise they get bored”.
- The teachers seemed to experience a sense of role confusion in the new environment. : “We do not have a clear role... I feel like my only role in the classroom ends up being keeping them relatively disciplined”.

The teachers clearly felt that such activities could maybe supplement regular instruction (projects in the afternoon), enriching it, but in no way they could replace the traditional knowledge transmission efforts, encouraged by the analytical program. It appears that the role of the teacher as the transmitter of information in the curriculum is extremely well

ingrained in the teachers' minds and supported by the Greek educational system as a whole (the idea that teachers must "cover the material") and very difficult to get rid of.

These results point to challenges for the continual professional development of teachers.

With respect to the students we detected:

- Students' confusion with the assessment structure of the new environment. Traditional practices with respect to classroom grading were interfering with making collaboration and sharing of knowledge difficult: "If I learn something from another student and then write this down, this does not count in my grade".
- Students' lack of experience with evaluating arguments was leading them sometimes to interpret different arguments as different opinions, thus avoiding the challenge of cognitive conflict: "Well, they think this. It is their opinion".
- Students' lack of experience on how to direct their own learning and not to depend on teacher's evaluation was interfering with the even flow of the activities. (Students were initially asking for teacher's reassurance at all times, to ensure that they were doing well).

It is obvious however that these difficulties are challenges for real educational gains that are sidestepped in the traditional classroom.

WHAT KIND OF TEACHER EDUCATION DO WE PROPOSE?

The results of the evaluation studies and innovative projects showed that ICT has not been incorporated in the everyday educational activities of the great majority of the Greek public schools today. The study of these cases where systematic attempts have been made to introduce ICT shows that in most cases ICT becomes assimilated in the existing teacher-centered transmission oriented philosophy of teaching. Exceptions to this can be found in the example of some individual teachers with a progressive pedagogy who are knowledgeable about ICT uses in education and a few schools (mostly private). Even in these cases, the innovation usually stays in the periphery and does not affect the usual teaching of subject matter. In view of this situation, what is the kind of teacher training in ICT that we would propose?

Recently, the Pedagogical Institute has issued a call for teacher training in the context of a program for the preparation of teachers in the Information Society, in agreement with the European Council resolution of 13 July 2001 on e-learning (2001/C 204/02). This call has many positive aspects. It asks for teacher training in basic ICT literacy (48 hours), in

training in successful cases of ICT implementation in schools (24 hours), and in the design of efficient use of ICT in the classroom (40 hours duration).

Although under the present implementation the duration of the program is quite limited, it provides opportunities for teachers to realize the potential and difficulty of pedagogically efficient teaching that integrates ICT. We believe that these are very positive measures that are certainly going to increase ICT literacy in the teacher population. We also note some very positive additional measures, that are fundamental in facilitating ICT use, such as the creation of a network of ICT experts, school networks and networks of teachers, the facilitation of the purchase of computers by teachers who have been trained in the program, etc.

Although the above measures are indispensable they still do not go far enough to change teacher practices. We believe that in order to use ICT to change the learning environment in the Greek schools we need to move in two directions. The first is more local and is related to teacher training that will allow teachers to give their students greater control of their learning. The second is more fundamental and involves changes in our national curricula and educational goals along the lines described in the European Union's Lisbon Meeting (COM 2000).

Step #1: Change teachers' perceived role as transmitters of information to that of empowering the individual student as a learner.

The goal of education is to develop the individual student as a person and as a learner. In the reality of the classroom, this goal is often forgotten as the individual teacher strives to do his or her job. When the work of teaching is defined in terms of the amount of material from the specified curriculum that has been covered, something in the educational process has gone wrong.

The results of educational research show that material is easily forgotten when what has been memorized has not been understood. What has been understood, however, stays and can transfer to other areas of knowledge (Bransford et al., 2001, Vosniadou, 2001a). Why submit our students to the torture of memorization, when they are going to forget what they have memorized anyway? Teaching for understanding is based on respect for the individual student as a learner and building on what he/she already knows. It requires allowing students time to practice and a collaborative peer environment, to engage in discussions and debates. It requires meaningful tasks and a friendly, encouraging teacher. The teacher must take on the role of a coach that helps students develop their own skills as learners and as thinkers in the process of acquiring subject-matter knowledge.

ICT can facilitate in this process, because ICT uses in education can individuate instruction and move the emphasis from the presentation of information to the development of students' skills to find and critically evaluate the available information. More specifically, teachers need to be shown how to use ICT

- a) To develop students' skills that are useful in inquiry oriented activities in many lessons, such as searching for information in the web, evaluating this information and using it in projects and other activities.
- b) To collaborate with other students, in order to develop collaborative learning skills but also in order to use collaborative dialogue to facilitate perspective taking, metacognition and self-understanding.
- c) To connect school to the community outside school through communication with parents, cultural organizations, scientists, students and teachers from other schools and from other countries.

In some schools such activities are already used though the teachers' own initiative. The problem is that such activities are usually considered extracurricular either in the sense of taking place after regular school hours, or in the sense of being considered a break from the normal school work. For many teachers, particularly secondary school teachers, the above-mentioned change of roles is not easy at all. Many secondary school teachers in Greece have inadequate pedagogical training. They have not been taught much about how to teach and how to maintain control of their class. When they are sent to the schools to teach they are faced with an impossible situation. Difficult teenagers, disorganized schools, tones of uninteresting and difficult material to be covered, etc. It is understandable that they often develop teacher-centered management styles that help them maintain control of their class. These teachers need to be given specific instructions as to how to teach in ways that give students greater initiative over their learning but without losing control of their class as a result of that.

This brings us to a second related point. In our opinion, in order to use ICT training to change the learning environment in our schools, we need to develop clear, research based examples or prototypes of how to create ICT supported student centered learning environments without the teacher losing control of his/her class. For this a great deal more research and development is needed than is currently available.

Step #2: Changes in national educational objectives

All the studies we reviewed in the previous section show that both primary but especially secondary school teachers are caught in the nets of the "analytical program" and are anxious about teaching the subject-matter they are supposed to teach and covering the material.⁵ To the extent that ICT is going to be used, they want the development of educational software that is close to the material to be taught, with specific instructions about how to use it.

⁵ This applies less to primary schools than secondary schools and for this reason we believe that there is greater potential that ICT use together with appropriate teacher training can produce important changes in teacher practices in primary education. The situation is also better in high schools as compared to lyceums. As we described before, there is a widespread and strong belief amongst lyceum teachers that ICT cannot be used in the lyceum to improve the teaching of subject matter.

On the basis of the above we have come to the conclusion that another major obstacle that stands in the way of utilizing ICT to create a more student-centered learning environment in the Greek school today is the teachers' perceived need to "cover the material",

The emphasis of the analytical program on covering a great deal of subject matter information in a short period of time places teachers, particularly secondary school teachers in a very difficult situation. Teachers see themselves mainly as transmitters of information included in the national curriculum books and feel that if they tell the students the information included in the national curriculum they have accomplished their mission. Given the centralized nature of our educational system, it is very difficult, if not impossible, to change this perceived need to "cover the material" without significant changes in our National Curricula and specification of our National Goals for Education.

Student-centered environments require spending a great deal more time than it is now the case on tasks that allow students to think, to critically evaluate information, to discuss with other students, etc. The development of learning how to learn skills takes time and time is not available in the Greek classrooms today, when the teacher is anxious and concerned about covering the material. *Therefore in the spirit of setting priorities, we believe that changes in mode of teaching will not succeed unless they are accompanied by major changes in our educational objectives at the national level.* These changes should be reflected in a new analytical program, a curriculum that also clearly specifies the role of ICT in both primary and secondary education.

We believe that there are at least two major changes that need to be made in our National Educational Goals, following the results of research on learning and instruction, in light of the perceived needs of the citizens of the information society:

1. *Re-examine the knowledge and skills needed in light of social changes and in light of what is known about learning and instruction.*

Everybody in Greece understands that serious work needs to be done to restructure our curricula. The results of educational research show that there are certain principles that can guide us in this process:

- a) Meaningful materials and tasks: we need books and educational activities that are meaningful to students. Meaningful not only in the sense that students understand what they read but also understand why they read and do what they do at school.
- b) Bring schools closer to real life: schools cannot continue to be detached from real life. Students go to school to acquire knowledge and skills that will be helpful to them when they get out of school. During the last years many western nations have radically restructured their educational systems to bring school closer to real life. It is about time we think about this issue in Greece. What is needed is to engage the shareholders of education in a discussion that could be used as initiator for a process of continuous improvement of our curricula.

- c) Less breadth and more depth: educational research shows that learning is difficult and takes a lot of time to be accomplished. It is better to design curricula that cover fewer topics in greater depth, than cover a great deal of material in a superficial way. Covering fewer topics in greater depth also has greater potential that this material will be understood and not forgotten easily. We still need to produce a demanding curriculum that makes it necessary for students to study hard if they want to succeed. But, they should study for understanding and not for memorization.
- d) Test for understanding and not for memorization: It is not only important to teach for understanding but also test for understanding. International organizations like the OECD, IEA, and the UNESCO have made progress in designing tests that attempt to capture students' understanding of material and their problem solving skills. We should learn from these efforts and move in similar directions. This is also important if we want our students to exhibit better performance in international tests, rather than be at the bottom of the list of the advanced countries, as we presently are.

2. *Move us towards a more decentralized system of education; encourage teacher development.*

We live at a time when fast social changes create the need for fast changes in educational goals. We need educational systems that are flexible and that can easily adapt to the changing needs of our society, just as we need cognitively flexible learners who can easily adapt to the changing needs of a job market. In Greece, there seems to be a tremendous desire on the part of local school districts, parents, teachers, and school principals to do something about ICT in the schools. Why not encourage this desire? School networks, networks of teachers, technical and pedagogical support can function better at the local level rather than at the central level. Special programs, competitions and awards can be used as external motivators. But most important, what should be cultivated is the feeling of local pride in having good schools and being excellent in education. By giving more responsibility to local districts, principals, and teachers we increase the level of participation, involvement, responsibility and effort for the improvement of education.

Last but not least, it is of vital importance to give more freedom to individual teachers to do the job of educating. Teachers should be trusted not only for their moral behavior and for their disciplined application of higher mandates from the Ministry, but for making pedagogical decisions themselves. Gains in leadership can motivate teachers to do the hard job of re-education needed to meet the challenges of the schools in the information society.

REFERENCES

- Bransford, T.D., Brown A.L., and Cocking, R.R. (1999), *How People Learn: Brain, Mind, Experience and School*, National Academy Press
- Chatzilakos, T., Kynigos, C., Vavouraki, A., Ioannides, C., Papaioannou, P. and Psycharis G. (2001), *A Case study of ICT and School Improvement*, OECD/CERI ICT PROGRAMME, <http://bert.eds.udel.edu/oecd/cases/casesframe.html>
- Cuban, L. (1986), *Teachers and machines: the classroom uses of technology since 1920*, Teachers College Press
- Bikos, K., (1993), *Teachers and Computers: Teachers' attitudes relative to the introduction of computers in education*, Thessaloniki (in Greek)
- Center for Educational Research (2000a), *Study of the prototypes for the introduction and evaluation of educational technologies and innovation in primary and secondary education: Deliverable A1: Primary Education*, University of Thessaly, Department of Primary Education (in Greek)
- Center for Educational Research (2000b), *Study of the prototypes for the introduction and evaluation of educational technologies and innovation in primary and secondary education: Deliverable A2: Secondary Education*, University of Athens, Department of Informatics and Department of Philosophy and History of Science (in Greek)
- Center for Educational Research (2000c), *Study of the prototypes for the introduction and evaluation of educational technologies and innovation in primary and secondary education: Deliverable D1: Proposals for the more efficient use of ICT*, University of Athens, Department of Philosophy and History of Science (in Greek)
- Computer Technology Institute (2001a), *Project E-42: Graduate training of teacher trainers: Deliverables PE3 (#3, #7): Implementation of the training program*, University of Athens, Department of Philosophy Pedagogy and Psychology, Department of Philosophy and History of Science, Department of Informatics (in Greek)
- Computer Technology Institute (2001b), *Project E-42: Graduate training of teacher trainers: Deliverables PE4 (#4, #8): Practical training and continuing support*, University of Athens, Department of Philosophy Pedagogy and Psychology, Department of Philosophy and History of Science, Department of Informatics (in Greek)
- Computer Technology Institute (2001c), *Project E-42: Graduate training of teacher trainers: Deliverables PE5 (#9): Evaluation and diffusion of the research results*, University of Athens, Department of Philosophy Pedagogy and Psychology, Department of Philosophy and History of Science, Department of Informatics (in Greek)
- Emvalotis, A. and Jimoyiannis, A. (1999), *Teachers' attitudes relative to Computer Science and the New Technologies in the Lyceum*, In A. Jimoyiannis (Ed.), *Panhellenic Conference "Computer Science and Education"*, Ioannina (in Greek)
- European Commission (1995), *Teaching and learning: towards the learning society*, Brussels
- European Commission (1996a), *Report of the Task Force "Educational Software and Multimedia"*, Brussels

- European Commission (1996b), *Learning in the information society: action plan for a European education initiative*, Brussels
- European Commission (2000), *e-learning: Let us think of tomorrow's education*, COM 2000, 318
- European Council (2001), *The Council resolution of 13 July 2001 on e-learning(2001/C 204/02)*, http://europa.eu.int/comm/education/elearning/reso_en.pdf
- Feldman, A. (1997), Varieties of wisdom in the practice of teachers, *Teaching and Teacher Education*, 13 (7) 757-773
- Glaser, R., Ferguson, E. L. and Vosniadou, S. (1996), Cognition and the Design of Environments for Learning, In S. Vosniadou, E. De Corte, R. Glaser and H. Mandl (Eds.), *International Perspectives on the Design of Technology-Supported Learning Environments*, NJ: Lawrence Erlbaum
- Kollias, V., Vosniadou, S. and Ioannides, C. (1999), Designing a computer supported collaborative learning environment for science teaching, *Abstracts of the 8th European Conference for Research in Learning and Instruction*, Goeteborg, Sweden
- Kollias, V., Vlassa, M. and Vosniadou, S. (2001), Design and evaluation of a CSCL environment for the learning of science, In P. Dillenbourg, A. Eurelings and K. Hakkarainen (Eds.), *Proceedings of the First European Conference on Computer-Supported Collaborative Learning*, Universiteit Maastricht , Maastricht, The Netherlands
- Kynigos, P., Karageorgos, D., Vavouraki, A. and Gavriliis, K. (2001), The opinions of the teachers of "Odysseas" relative to the use of new technologies in education, In V. Komis (Ed.), *Proceedings of the 2nd Panhellenic Conference "Information and Communication Technologies in Education"*, Patras (in Greek)
- Kynigos, P., New practices and new tools in the classroom: Training of teacher mentors for the creation of communities of ICT implementation in school, In C. Kynigos, E. Dimaraki (Eds.), *Tools and Means; Pedagogically applicable uses of ICT in basic education*, Kastaniotis (in press)
- Pelgrum, W. J. (1997), *The application of multimedia technologies in schools: their use, effect and implications: Technology Assessment of Multimedia Systems for pre-primary and primary schools*, STOA, Directorate General for Research, European Parliament
- Roth, W. and Tobin, K. (2001), Learning to teach science as practice, *Teaching and Teacher Education*, 17, 741-762
- The European eLearning Summit (May 2001), Summit declaration, <http://europa.eu.int/comm/education/elearning/summit.pdf>
- United States Department of Education (2000), *e-learning: Putting a World-class Education at the fingertips of all Children*, Washington DC: Office of Educational Technology, <http://www.ed.gov/Technology>
- Web-based Education Commission (2000, December), *Report to the President and the Congress of the United States: The Power of the Internet for Learning: Moving from Promise to Practice*, Washington, DC <http://interact.hpcnet.org/webcommission/index.htm>
- Vosniadou, S. (1996) Learning environments that promote conceptual change. In S. Vosniadou, E. De Corte, R. Glaser, & H. Mandl (Eds.) *International*

- perspectives on the design of technology-based learning environments.*
Hillsdale, N.J.: Erlbaum
- Vosniadou, S. (1997), *The application of multimedia technologies in school: Their use, effect and implications: The scientific approaches to new learning models for new learning environments*, STOA, Directorate General for Research, European Parliament, Elsevier Science.
- Vosniadou, S., Kollias, V., Vlassa, M. and Mamalougos, N. (2000), *Analyzing socio-cognitive effects of computer supported collaborative learning*, AERA 2000, New Orleans, Louisiana
- Vosniadou, S. (2001a), *How Children Learn*, Educational Practices Series, The International Academy of Education (IAE) and the International Bureau of Education (UNESCO)
- Vosniadou, S. (2001b), EMILE in Greece, *Abstracts of the 9th Conference of the European Association for Research on Learning and Instruction*, Fribourg, Switzerland
- Vosniadou S., Ioannides C., Dimitrakopoulou A. and Papademetriou, E. (2001c), Designing learning environments to promote conceptual change in science, *Learning and Instruction*, 11, 421-429
- Wegerif R. (2001), Symposium: EMILE: A comparative study of ICT use in Europe, *Abstracts of the 9th Conference of the European Association for Research on Learning and Instruction*, Fribourg, Switzerland