# Computer-Based Cognitive Tools in Teacher Training: The COG-TECH Projects[1]

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**Abstract.** The COG-TECH (Cognitive Technologies for Problem Solving and Learning) Network conducted three international projects between 1994 and 2001 under the auspices of the European Commission. The main purpose of these projects was to train teacher educators in the Mediterranean countries to use computers as effective pedagogical tools. The summer schools and local workshops organized by COG-TECH introduced teacher educators and teachers to a set of computer-based cognitive tools. Applied research in the projects addressed such issues as the development of appropriate content and effective methods for training teacher educators to use cognitive technologies in teaching, the identification of the strengths and limitations of several cognitive tools for different learning situations, and the factors affecting implementation of information and communication technology innovation in education.

Keywords: ICT in education, Computer-based cognitive tools, ICT innovation in education

## 1.    Introduction

The last two decades have seen major developments in computer hardware and software and increasing attempts worldwide to integrate computers into education. It is now considered vital to "modernize educational systems on the basis of information and communication technologies" (ICT), as globalization and transformation to the information society "call for new literacy for the information society" (UNESCO, 2002).

> … projects of building a new society heavily rely on the introduction of information and communication technologies into education. The alternative is to lag behind these developments chronically and, in effect, fail to meet the challenges of the 21st century. (p.9)

Nevertheless, the impact of computers on education has been limited (e.g., Pelgrum and Plomp, 1991; Baron and Bruillard, 1994; Williams and Mos, 1993; HMI, 1992), despite technological advances, encouraging research results on the impact of information technology on learner outcomes, and national and international initiatives to provide schools with computers and teacher training. Results of the research studies attribute this situation, to a large extent, to a lack of sufficient understanding and expertise on the part of teachers as a result of inadequate training and models of curriculum development. The IEA study (Pelgrum and Plomp, 1991) of 21 countries has reached the following conclusion:

> . . . the three most important reasons for not using computers, as well as the problems experienced as most serious in using computers, are the lack of teachers' knowledge and skills and the lack of hardware and software. (p. 103)

The IEA study showed that "pedagogical/instructional aspects are the least mentioned topics" in the training the teachers received. The conclusion reached in an OECD report entitled "Education and New Information Technologies: Teacher Training and Research" is in agreement with the IEA study:

> . . . the potential of the new information technologies for improving learning and teaching will not be realised [sic] unless teachers are well trained and retrained in the pedagogical use of technology in the classroom. (OECD 1992)

Theories of educational change point to the central role of teachers in the implementation of educational change in general and in the integration of information technology into teaching in particular. According to Fullan (1991):

> Educational change depends on what teachers do and think—it's as simple and as complex as that.  (p. 117)

The complexity of the training needed and the scarcity of the skills to deliver it "even in the industrial nations" is stressed by Hawkridge et al. (1990). Other research (e.g., Veen, 1993) has shown the importance of teachers' existing beliefs with respect to the content and pedagogy of their subject matter and practices for adoption of new media. Because these beliefs and models for practices are formed during initial teacher education, it is essential that computers are integrated into teacher education programs. This paper describes an international collaboration

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initiative that addresses the issue of teacher training in information technology use in education. This initiative has been developed by the COG-TECH (Cognitive Technologies for Problem Solving and Learning) Network, which aims to foster collaboration among the European and the Mediterranean countries in the field of information technologies in education. The initiative has included three projects (MED-CAMPUS Project B-359 and C-359, 1993-1995, and INCO Project 973367, 1998-2001) funded by the European Commission. The main purpose of these projects was to train teacher educators in the teacher education institutions of the Mediterranean countries to use computers as effective pedagogical tools. It is, however, a challenge to "define the best use of ICTs for improving the quality of teaching and learning" (UNESCO, 2002, p.22).

The COG-TECH initiative has originated from the idea that a set of cognitive tools and appropriate pedagogical strategies should be part of pre-service teacher education. Cognitive tools are devices learners can use to transcend the limitations of the mind in activities of thinking, learning, and problem solving (Pea, 1985). Computer-based cognitive tools are believed to serve as catalysts for facilitating development of metacognitive awareness and generalized self-regulatory skills (Lajoie and Derry, 1993). Examples of computer-based cognitive tools that have been used to support learning include Logo, microworlds, semantic nets, concept mapping, idea processors, hypermedia, knowledge-based/expert systems, Prolog, and computer-supported cooperative work applications (Kommers et al., 1992; Orhun et al., 1997). In addition to being based on a more sound epistemology, cognitive tools are also more generalizable and transferable tools that can support multiple outcomes (Jonassen, 1992).

## 2.    Aims and Objectives of the Projects

The purpose of the projects was to contribute to the improvement of education systems in countries in the Mediterranean and Europe through research, innovation, and dissemination of good practice, with a particular emphasis on the use of ICT in teaching and learning. The overall aim of the projects was to improve teaching and learning processes and environments so that students acquire flexible knowledge and skills, self-direct their learning under teachers' guidance and in co-operation with peers to become life-long learners, and can pose and solve problems collaboratively using information and communication technologies. This aim was served mainly through training activities that encouraged teacher educators and practicing teachers to use ICTs as teaching and learning tools. The main specific objective defined in connection with this aim was to facilitate acquisition of a knowledge base, outlined below, by the target group of teacher educators.

- Knowledge of a set of computer-based cognitive tools and an understanding of their potential and limitations for teaching and learning.
- Knowledge of learning theories such as constructivism and their implications for teaching and learning with computer-based cognitive tools.
- Knowledge of a set of pedagogical strategies and didactic scenarios that will foster meaningful learning and development of metacognitive skills.
- Competency in using one or more computer-based cognitive tools for a range of pedagogical goals.
- Awareness of the importance of viewing ICTs in education as *computer-based cognitive/learning tools*.
- Knowledge of criteria for selecting and assessing educational software.
- Knowledge and skills sufficient to join or form networks among schools of education and primary and secondary schools in EU and MNC using information and communication technologies.
- Awareness of the need for changes in the roles of teachers toward facilitators and managers of learning, encouraging self-directed learning and co-operation, and away from just transmitters of knowledge.

The activities aimed at achieving the project objective included international summer schools and local workshops as well as research. Research in the two Med-Campus projects addressed issues such as the development of appropriate content and effective methods for training teacher educators to use cognitive technologies in teaching, the identification of the strengths and limitations of several cognitive tools for different learning situations and the factors affecting the implementation of ICT innovation in education.

An additional objective of the INCO project of 1998-2001 was to develop a pilot teachers' support system on the Internet that will facilitate collaboration among teachers attempting to integrate ICT into their teaching after participating in the training activities.

## 3.    Training programs

The main assumption of the training programs was that the role of information technologies in education should be as a tool for learning rather than a vehicle for knowledge transmission. The training activities of the projects included international summer schools and national follow-up workshops that introduced the participants to a set of computer-based cognitive tools. One of the goals of the summer schools was to train some of the participants to a

level sufficient for conducting similar training in their countries. Three summer schools and six workshops entitled "Computer-Based Cognitive Tools for Teaching and Learning" were organized between 1994 and 2001 in Turkey and Jordan. Altogether, 110 educators from 16 countries took part in the summer schools and 140 teachers were trained in the workshops.

Training in the workshops was largely conducted by participants of the summer schools, with the support of project partners. A workshop entitled "Information Technology Implementation in Schools" was organized to inform school administrators, computer coordinators, and ministry officers in Turkey about issues in information technology implementation in schools.

The content of the summer schools and workshops as well as results of the evaluation conducted are discussed in (Orhun & Kommers, 2002).

## 4.    Applied Research in the Projects

Several questions had to be addressed in the projects concerning the selection and use of computer-based cognitive tools for the summer school and the measures for enhancing the projects' impact and sustainability. The initial research aimed at addressing the following questions:

1. What are cognitive tools and which factors affect their effectiveness?
2. Which computer-based cognitive tools should be included in teacher training?
3. How usable are some of the computer-based cognitive tools for teaching and learning?

Some of these questions have been addressed in (Orhun, 1995). The summer schools and follow-up workshops addressed the issue of "pedagogical uses of  information technologies" identified in the IEA study of 21 countries (Pelgrum and Plomp, 1993). However, such in-service training offered outside of the school setting is ineffective if not embedded in a continuous development context with sufficient support (Fullan, 1991). In response to research findings that indicated low use of information technology in teaching, even in countries where most schools do have access to computers, the focus of research studies aimed at improving the use and integration of computers in education have shifted since the 1970s from the technical characteristics of the proposed innovation to "how the proposed innovation fits with the teachers' working conditions and value systems" (Grunberg and Summers, 1992). The strategies used to develop ICT in teacher education that have had a strong higher-education perspective are now evolving, in accord with shifts in the view of innovation, into strategies directed to the culture of the school. Such strategies assume that the process of implementation is essentially a learning process and acknowledge that learning for work is most effectively achieved in the context of the work itself. Also, people are most likely to apply new competencies when they have been acquired alongside colleagues, rather than in a detached setting. Huberman and Miles (1984) have shown the importance of the amount and quality of assistance that the users of innovations receive during this process.

We can thus view teachers facing the ICT implementation as a community of learners who  might benefit from the support given by universities. Actually, knowledge about how computers can enhance teaching and learning is only slowly being developed at the classroom level by teachers who are acting as researchers (OECD 1992). One of the conclusions reached in the OECD report on Education and New Information Technologies: Teacher Training and Research is:

> . . . in-service and continuous training cannot be isolated from classroom reality, i.e. the level of education, subject matters, individual teaching strategies, student learning objectives, the students' styles and *this training should be closely linked to research and development activities in the learning processes involving inter alia information and communication technologies*. (p.10; italics original)

The OECD report recommends the development of cooperative action research projects between universities and schools in which "teachers will be . . . trained in their own classrooms while university researchers will increase their research effectiveness and produce more relevant findings."

ICT innovation efforts in most Mediterranean countries are characterised by a lack of research into the options for policies and strategies and the impact of the actions taken. Very little is known about the extent of computer use in teaching and learning, the factors affecting the use of computers, the quality or inadequacies of the courseware developed, or the effectiveness of the in-service programs. This situation appears to be typical of most developing countries, as noted by Hawkridge et al. (1990).

The Med-Campus projects included an applied research component aimed at contributing to our understanding of the factors that affect ICT implementation in Turkey. The study focused on ICT innovation from the perspective of teachers and attempted to address the following questions:

- What factors have been reported as affecting ICT implementation by teachers?

- What are the main attributes of the process of ICT innovation in education in Turkey and what is its current state (as viewed by teachers, principals, district directors, and the ministry)?
- What are the main characteristics of the teachers at schools involved in ICT innovation?
- What is the extent of ICT implementation at the schools involved in ICT innovation?
- What are the main factors affecting the extent of ICT implementation by teachers?
- How can we explain the extent of ICT implementation?
- To what extent are the results of the study compatible with the results of studies reported for other countries?

The study investigated ICT implementation in a sample of 12 secondary schools in İzmir, Turkey, employing both quantitative and qualitative approaches to address the questions defined. The research instruments included questionnaires and interviews. An understanding of the factors affecting ICT implementation was sought by attempting to construct interpretative categories and hypotheses that explained the descriptive data. Results of this study are available in (Orhun, 2000; Orhun & Kommers, 2002).

## 5. Conclusions

The COG-TECH projects aimed at allowing teacher educators and practicing teachers to use ICTs as effective teaching and learning tools. It was expected that this would be accompanied by changes in the roles of teachers, who would act more as facilitators and managers of learning who encourage self-directed learning and cooperation and less as transmitters of knowledge. In the long run, students interacting with such teachers will be more autonomous learners who can take more responsibility for directing their own learning and will use ICT in the pursuit of learning with the guidance of teachers. Such lifelong learners working in collaboration with others will not only meet the requirements of a flexible and continually learning workforce but will also foster the development of learning societies.

The described projects have made progress toward that aim. A body of knowledge needed for using ICTs as effective teaching and learning tools were defined and materials based on this knowledge were developed and disseminated as part of the projects. The training activities exposed more than 200 teacher educators and practicing teachers from several Mediterranean countries to the ways that ICTs can be used as effective teaching and learning tools. It is hoped that a sufficient number of those trained will be pioneers in their institutions in creating a community of practitioners that will achieve successful integration of ICT into teaching. Several participants of the summer schools conducted successful workshops for their local communities--a significant indicator for the achievement of some of the expected results. The evaluation of the projects' impact (Orhun & Kommers, 2002) has indicated that the knowledge and skills acquired during the training activities have already led to some successful integration of ICT into teaching in Turkey. The results indicate that a significant proportion of the participants have used at least one of the tools that were presented in the training in their teaching or practice. Almost all participants have started using the tool(s) as a result of their participation in the training activity. Participation in the training activities have also led to changes in most of the participants' practice. Changes in viewing technology in the teaching and learning process have been most significant. It can be said that the training activities have had a significant impact on the teaching and practice of many educators by exposing them to new approaches and helping them acquire knowledge and skills needed for using ICTs as teaching and learning tools. The feedback received indicates that educators highly value such activities and request their continuation.

Other expected results, including changes in the roles of teachers from transmitters of knowledge to facilitators and managers of learning, and students' use of ICTs in the pursuit of learning as autonomous and lifelong learners, are overarching long-term results. The projects have provided a model that can be further tried, improved, and scaled up toward the achievement of these long-term results. The further realization of the expected impact and its sustainability will depend on continuing efforts for enhanced partnerships between schools and universities and other factors, some of which may be identified through research and reflecting upon our collaborative activities.

The COG-TECH initiative has attempted to utilize some of the knowledge we have accumulated during the last thirty years about how people learn to improve education. It has been disappointing to witness the proliferation of the use of ICT in education, especially in the Mediterranean countries targeted by the projects, in the form of knowledge transmission media--computer-assisted instruction, multimedia, and Internet--rather than as cognitive tools.

As Piet Kommers has noted in the final report of the INCO project, "Technological assets themselves cannot be brought into the classroom without a rather in-depth restructuring of the curricular, instructional and even ideological facets at the teacher and the school management levels" (Orhun et al., 2001). Precisely this cluster of variables has been carefully considered in these projects. Yet reality is still more complex, so complex that it is almost impossible to determine and evaluate the complete impact of ICT innovation in education. Kommers points to the processes concurrent with the ICT innovation, including "globalisation that enlarges curricula to international awareness, but also ongoing pluralism in societies with an ever more demanding flexibility, multi-culturalism and

life-long learning". In this broader spectrum, the question becomes "whether ICT–enriched didactics is a means or an end". The initial projects have focused on the second answer.

Kommers argues that "the ongoing globalisation has also made the information society a potential trigger for multicultural confrontations and reconciliation at the same time". In accord, we may expect that "schools will have an ever growing responsibility to accommodate this immense task of ideology and every-day practice in helping and understanding the other cultures that were remote and 'alien' for ages up till now". From this perspective it seems quite natural that we should plan following projects with a method similar to this project, but targeted at precisely this point: Using and rebuilding media facilities and curricular content that facilitate the barely needed transformation from national/regional education into world citizens, eager to learn from other cultures and willing to assimilate those concepts in our mentality and behavior. We believe that viewing ICTs as cognitive tools will be still productive for this stage, but the focus will shift to the "ends".

In this broader spectrum, we cannot claim that our comprehension of the complex dynamics of educational change is deep enough. Fullan (1999, p. ix) notes that our understanding of the "change forces" has gone beyond key concepts such as vision, strategic planning, and strong leadership, which have "contributed to superficial thinking". New ways of thinking provided by complexity and evolutionary theories are offering "liberating and inspiring possibilities for individuals at all levels of the system to understand better and to act much effectively" in this era of "chaos and disillusionment" (Fullan, 1999, p.12). The capability of learning is crucial to coping with the changing world. In order to survive as an institution, the school must become a learning organization and a member in a community of learners, which includes state and local authorities as well as parents (Fullan, 1999, p.61). As Egan (1997, p.32), points out, "The problem is not with the school necessarily but with the way we conceive what the school is supposed to do." ICT innovation offers us an opportunity to reconsider what education is supposed to do.

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