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COMPUTERS IN CLASSROOMS

Learners and teachers in new roles

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INTRODUCTION

The computer, during the last three decades, has become a symbol of technological innovation and the source of complex social changes in work and leisure. Information technology has taken a prominent place in industry and in varied sectors of the economy by influencing development and growth, and it has changed dramatically the ways of working and communicating in areas such as research, development, management and financial services, media, communications and publishing. As a result, it has been rightly described that the computer's entry into our lives has constituted a 'second industrial revolution' and a basis for the emergence of a 'postindustrial' or 'information' society (Bell, 1980 cited in Ruthven, 1993, pp.187).

Plomp et al (1996) have also pointed out that the rapid implementation of computers in schools currently plays a paramount role in shaping policies and curricula in the educational systems cross-nationally. However, it has been noted that the effects on teachers and their enacted pedagogies have been largely unaffected (see Ruthven, 1993, Sutton, 1991, Watson, 1993). Balasheff and Kaput (1996) argue that whilst the potential learning gains seem to be many (provided that the learners' engagement with computers in specific subject areas is active), a full integration of computers in school teaching practices has not yet been achieved. The present paper aims to provide an overview of computer use in classrooms by considering the various modes of incorporating computers in the curriculum and by discussing the new roles which potentially teachers and learners undertake.

MODES OF COMPUTER USE IN THE CURRICULUM

Looking back into the varied modes of computer use in classrooms during the last three decades and the associated visions for their integration in the school curriculum, Polydorides-Kontogianopoulou (1996, p.59) cites Anderson who has classified four different models for the computer use in educational practice over the last few decades: a) introductory teaching of programming, b) computer literacy, c) use of the computer as a tool and d) the transparent computer infusion. The first two models represent the main modes of computer use during early 1980s. The *teaching of programming* (e.g. Basic, Logo) was initially regarded as the most appropriate way for introducing students to new technology and had largely replaced drill and practice activities (see Sutton, 1991, p.481), whilst *computer literacy* was regarded as the necessary knowledge about computers and their generic use (e.g. technicalities, file management, software use). The last two models emerged mainly during the 1980s and are related with wider availability of software applications and educational software packages. The use of *computer as a tool* was focusing essentially on the effective use of software (e.g. word processing, graphic tools, databases) in classroom activities and was associated with a trend away from abstract programming and towards an integration of computer use in curriculum activities (McCarthy, 1988). *Transparent computer infusion* emphasises the integration of computer use in specific subject areas. Here, the teaching and learning of basic computer related skills is not entailed in a separate new course in the school timetable, but it becomes part of the pupils experience of using software across a number of curriculum subject areas (see Kontogianopoulou-Polydorides and Makrakis, 1994). One needs to mention that, with flexible curriculum timetables, the above modes can be used simultaneously. For example, Logo, a programming language especially devised for use by young children (Papert, 1980), can be used as a programming language, as a tool for cross curriculum activities and can also be transparently infused in the school timetable for teaching mathematics. It has been identified that children can work in ‘microworlds’ based on the metaphor of ‘turtle’ where by exploring its structural properties can learn to ‘talk’ with computers (i.e. via programming in logo language) and at the same time to learn and more importantly to talk about mathematics.

Recently, the linking of computer technology with telecommunications has resulted into what is often called the ‘information superhighway’ offering a high variety of information, communication channels and services. From this, the term ICT (information communication technology) has emerged embracing the Internet, the World Wide Web, video-conferencing tools, video and digital television. The range of services can be broadly divided into two categories, a) communication (e.g. e-mail, usenet newsgroups, talk and Internet Relay Chat, virtual classrooms and colleges) and b) access to information, resources, materials and databases (see Chronaki and Bourdakis, 1996). ICT or new technologies promise fast access to information and a new way of communicating, networking, teaching, learning and researching (Negroponte, 1995, Windschitl, 1998).

Scrimshaw (1997) has classified different types of software according to their educational characteristics (i.e. view of the learner, suggested group relations and type of knowledge embodied). He refers to a wide range such as; word processors, desktop publishing packages, presentation packages, spreadsheets, graphic packages, composition of music, ideas processors, database packages, modelling packages, programming languages, e-mail, computer conferencing, remote databases, filled read-only tools, text disclosure, simulations, adventure games, instructional hypertexts, encyclopædias, talking books, intelligent tutors, video games, data logging and drill and practice programs. It is interesting to note that learners engaged in data logging and drill and practice programs are characterised merely as ‘receivers’ of information whilst in other categories can potentially be ‘creators’ or ‘explorers’. Further, most software types seem to be oriented around individualised learning (unless otherwise specified by teacher intervention programmes) whilst collaborative or group work is mainly required by types of software that incorporate e-mail and computer conferencing tools.

A different categorisation relates educational software to the intended view of the learner as has been described across the two distinctive traditions of 'objectivism' and 'constructivism'. Alessi and Trollip (1985) explain that an objectivistic approach is consistent with educational software such as programmed instruction, tutorials, and drill and practice programs which view learning as a process of repeated practice and rehearsal. The constructivist tradition emphasises the developing of computer based environments in which the learner is an active organiser of his/her own acquisition of knowledge. Examples of software include hypertext environments, concept mapping environments, simulations, and modelling environments (De Jong and Van Joolingen, 1998).

COMPUTERS AS LEARNING ENVIRONMENTS

The pupils' experience of learning, due to their interaction with computers, cannot be seen merely as a relationship between humans and machines. It needs to be understood as an interactive partnership between humans, machines, available software and the broader educational context in which curriculum activities take place. The new learning strategies embodied in such partnership are often described as active, reflective, mindful, self-organising and socially oriented. The effect of the employment of these strategies is that content learning increases significantly. Davis et al (1997) explain that quality in learning can indeed be enhanced when information technology is approached and utilised as an intellectual 'multi-tool' adaptable to learners needs and supportive of their attempts for conceptual abstracting and for engaging in increasingly decontextualised learning. Somekh (1997) also argues through the experience of the PALM project (Pupil Autonomy in Learning with Microcomputers) about the potential for pupils' active and autonomous learning in computer based learning environments. In short, the learner is not seen anymore as a passive recipient of information (or the consumer of prescriptive guidelines) but has the potential to actively interact with information technology tools and peers and to construct meaning via exploration, discovery, trial and error and social engagement.

Balacheff and Kaput (1996), reviewing seminal projects involved with the development of computer based environments for mathematics learning, coined the terms 'epistemological penetration' and 'computational transposition' to describe the effect of technology on learning. They argue: '*While technology's impact on daily practice has yet to match expectations from two or three decades ago, its epistemological impact is deeper than expected. This impact is based on a reification of mathematical objects and relations that students can use to act more directly on these objects and relations than ever before. This new mathematical realism, when coupled with the fact that the computer becomes a new partner in the didactical contract, forces us to extend the didactical transposition of mathematics to a computational transposition. This new realism also drives ever deeper changes in the curriculum, and it challenges widely held assumptions about what mathematics is learnable by which students and when they may learn it'* (p.469).

Computer based learning environments are often built around conceptual metaphors (e.g. the 'turtle movement' in Logo as a way to think over geometry, the 'speech bubble' in hypercard as a way to think about informal and formal language) which assist to introduce the epistemological features of the learning content. Another integral feature of their construction is the employment of instructional structures (e.g. in the form of tutoring systems) which can be especially engineered to coordinate free exploration, didactic intervention and provision of feedback. Exemplaries of computer based environments that view learning in such powerful ways as argued above (i.e. active, reflective and mindful endeavours) will be discussed below, in order to illustrate the vision for the potential new role of the learner.

Cabri and Logo for constructing mathematical meanings

Cabri-Geometre and Logo are generic software environments (in the sense that the users can construct an unlimited number of activities) which enable pupils to construct mathematical understandings of geometry and algebra in ways significantly different to conventional means (see Laborde, 1993, Papert, 1980, Hoyles and Sutherland, 1989 Hillel and Kieran, 1987). Logo is a programme language based on the metaphor of 'turtle movements', and is especially devised so that young children can learn to construct and talk about mathematical concepts whilst learning to programming with Logo. Geometric and algebraic concepts such as length and angle embodied in turtle displacement and turn, and the algebraic variables and functions embodied in their programming equivalents can be constructed. The mathematical potential (and at the same time the epistemological innovation) of this environment is the explicit relation (in both visual and text forms) of geometrical and algebraic notions. Other conceptual processes involve problem solving strategies such as decomposing a complex problem, instantiated by the use of sub-procedures, and analysing an imperfect solution, instantiated by the process of debugging. A current developments of this work is YoYo; a kid-friendly programming language which can be used by very young children as a way to talk and to command physical objects in a virtual environment. One application of this is the Pet Park; a graphical virtual community where kids can interact with virtual pets and teach them to dance, to greet visitors and talk informally (see http://el. www.media.mit.edu/projects/petpark/).

Cabri-Geometre incorporates a set of primitive objects (e.g. point, segment) offered in the system and on which elementary operations (e.g. construction of parallel lines) can be applied to construct geometrical drawings. These drawings are 'dynamic' in the sense that their position, and metric properties can be altered by dragging the image on the screen. Thus, the learner is enabled to express rules and descriptions about the ways these operations can be performed and associated (Laborte, 1993). Although, both Cabri and Logo integrate visual images of drawings with conceptual understandings of mathematical concepts, the nature of the user's interaction with the drawings is different. In Logo, drawings are 'static' in the sense that one can draw and re-draw them by modifying the Logo programming code that has produced them using a process that involves enumeration and generation with functions defined on numbered segments. Drawings on Cabri consist of a representation of what can be produced by means of ruler and compass and their nature is 'dynamic' in the sense that the user can directly manipulate geometrical objects on the surface of the computer screen (Bellemain and Capponi 1992).

Hypercard and CSILE for constructing understandings for language

McMahon and O'Neill (1989, 1990) have developed a 'hypertext' type of software, called AppleHyperCard, for the construction, categorisation and storing of sets of texts (stacks and cards) which has been especially designed for use in language learning activities in both primary and secondary schools. A specific characteristic of this software is the use of pictorial sequences in the form of cartoons which contain speech bubbles. These 'speech bubbles' can be filled in by the teacher or left empty for the pupils to complete. The bubbles can also be seen as 'thought bubbles' encouraging pupils to suggest what they think a character may be saying and how it relates to another character in the story. The 'bubble dialogue' metaphor is used as a means for helping the learner to explore aspects of language use such as writing and reading skills and building bridges between oral and literary uses of language. Another advantage is that teachers can customise this learning environment by constructing activities based on selected pictorial sequences and texts and can arrange these according to individual needs and rates of progress (e.g. choose between offering ready made sequences with clear stories to which children are asked to add text or ask pupils to generate their original pictures, stories and texts).

Another type of software oriented for language learning and conceptual development is the CSILE (Computer Supported Intentional Learning Environment), which emphasises the network based collaboration of learners and inquiry in local school environments and currently in the Web. The central component of this software is the idea of a community shared database that contains graphics, text and links to other media. The learners are encouraged to develop their skills in questioning, exploring concepts in depth, and learning to manage and to edit information (Scardamalia and Bereiter, 1996). For example, users connected to this network can read from elements called 'notes', they can also use certain rules for editing the notes and finally those notes can be linked to an organisational framework so as to produce an interconnection of notes on a particular topic or issue.

EarthLab as a role play for children as scientists

EarthLab is a computer environment based on the vision of 'children acting as scientists' in their learning of scientific notions. Its central aim is to simulate conditions for children to carry through scientific communication and enable children to take on dialogic roles in the process of scientific reasoning (Newman and Goldman, 1987). It is constructed for use in a local (school based) network in which children can use computers and play the role of scientific researchers. For example the learners can collect data, analyse them individually and collectively, and then communicate publicly their findings. Collaborative structures are built into activities, so that, for example, databases are created by different sets of children in a class providing elements which contribute to the 'jigsaw' picture of the object of enquiry.

The WWW as a forum for collaborative projects

The WWW in particular, has opened up avenues for collaboration in varied styles as compared to more conventional types of computer use or typical classroom resources. Information can be available in Web pages only minutes after the events have taken place (e.g. the Shoemaker-Levy comet's impact on Jupiter; the devastating earthquake in Kobe, Japan), and authentic databases provided by governmental and research agencies can be accessed by students (Windschitl, 1998). Recently, the WWW has become the platform for developing projects and collaborative activities between schools and classrooms cross-nationally. An example of this is the Parade scenario (a team game played within a vehicle-simulation system) where a combination of the Internet and independent software components are used and become operable in game like and role play activities (Kaput, 1993). Children can collaborate and interact at a distance. For example, in this project children in Grenoble, France and in Boston, US operate a simulation of car driving and have to solve specific problems related to the estimation of optimum distances, velocities and positions.

Well documented studies about computer environments that consist of learning activities of the nature described above, have argued that learners can potentially have deep conceptual gains, provided that they undertake specific new learning roles which include becoming more *active*, *reflective*, and *socially oriented*. These new roles entail opportunities for pupils to be involved in more complex and intellectually challenging learning situations (i.e. generalisation or relational thinking, formulating hypotheses and designing experiments in science, drawing inferences from a map, graphical and photographic hypotheses in geography and aspects of content and coherence in pupils' writing of English). Apart from the evidence provided by research focusing in specific computer environments, the above argument has also been supported by empirical studies in projects such as IMPACT[1], INTENT[2] and PALM[3] which have explored effects of computer use on learners in various subject areas and software use. In particular, the IMPACT study (see Watson, 1993) has identified that computers were good motivators for pupils' interest and enjoyment and that they also helped in aiding concentration by focusing pupils' attention on the work at hand. As a result, some pupils and teachers believed that the standard of work produced was of a higher quality than it would have been otherwise. For example, information technology tools assisted in constructing learning environments such as communicating ideas and information, handling information, modelling, as well as measuring and controlling particular situations (see also INTENT,1993).

However, one needs to keep in mind that learning situations for pupils of the quality described above is the outcome of a number of converging factors that envisage aims for this 'quality learning' at their core. Amongst these one needs to mention, the quality of the relevant software and the learners' attitudes for learning. Schofield

[1] The IMPACT (An evaluation of the impact of information technology on children's achievements in primary and secondary schools) project has been funded by DfE and focused in accessing the pupils' achievement when using information technology in the subjects of mathematics, science, geography and english and covered a range of ages (8-10, 12-14, and 14-16).

[2] The INTENT (Initial Teacher Education and New Technology) project, funded mainly by the NCET (now BECTA), had as aims the developing of quality in teaching and learning with IT, providing support to tutors for integrating IT across the curriculum for initial teacher education, developing management strategies and monitoring the process of institutional change.

[3] The PALM (Pupil Autonomy in Learning with Microcomputers) project was also funded by NCET and aimed at working in partnership with teachers and researching the role of IT in developing pupil autonomy in learning.

(1995) agrees with Cole et al (1990) who claim that there is a shortage of educational software that promotes learning in the terms described above and that the majority of this is of the drill and practice type. Means et al (1993) explain that such software presents information in a linear mode with no emphasis on interdisciplinary links. The learner is viewed as receiving and assimilating 'information' and 'knowledge', learning input is based on simple responses, mode of work is often individualised and assessment is based on right and wrong answers. As far as the learner is concerned, Watson (1993) explains that quality learning was prevented by pupils' difficulty in utilising particular software at initial steps, inability to work effectively in a collaborative environment and lack of true engagement in the activity. To these one needs to add issues of the broader educational context such as: pupil access and opportunity in computer use, teacher characteristics and abilities as well as school support. Sutton (1991) reviewing empirical studies of computer use during the last decade, identified a lack of equity in terms of race, gender and class when exploring pupils' access to computer facilities and tools at the school level. She explains that despite the rapid growth of computer infrastructure in schools, the increase in numbers of machines in classrooms is dis-proportioned in terms of equity in access for pupils of minority groups.

In relation to the use of the WWW, Wallace and Kuppeman (1997) identified that pupils' learning can be naïve and superficial when 'surfing' web pages. In a particular Web-Based ecology project, sixth form graders were not found to be reflective or critical but instead they seemed to mainly take on-line information at face value without evaluating the source. Salomon et al (1991) argued that the potential for cognitive processing and intellectual performance depends largely on the *individual's mindful engagement* with the technology at hand. They point out that apart from the product (that is, the effects of technology, in the sense that participants have subsequent cognitive spin-off effects when working away from machines) the process of the learner working with the technology needs to be studied more analytically as it will provide information about the human potential and the kind of mental activities involved. As far as the Web based environments are concerned, Windshitl (1998) argues that apart from a very few exceptions, most evidence about pupils' quality learning is based on gathering 'anectodal information' that views the Web as an extension of existing multimedia and praises uncritically this new learning avenue. The need for exploring critically the nature and effectiveness of the underlying pedagogical structure, the affected human interactions and the true opportunities for the learners in accessing and using search and communicative processes unique for the Web has been identified (see Windshitl, 1998).

COMPUTERS, PEDAGOGY AND TEACHERS

A well supported argument is that the construction of content knowledge in specific subject areas does not emerge spontaneously from interactions between learners and computers. As explained before, it is necessary for the learners to be active, reflective and socially engaged within a complex system that encompasses not only appropriate software but also relevant instructional interventions and a supportive pedagogical context. Alongside, it has been argued that the teachers' influence is paramount for orienting learners towards the new features of their learning role, and as a result, the teacher needs also to adopt new ways in viewing the subject area, learners and pedagogy. For example, Harel (1991), comparing the studying of Logo and fractions arithmetic in a more didactic versus a more constructivist approach, identified that the latter resulted in much deeper mastery and understanding of logo and fractions. As a result, pupils' cognitions were largely affected not only by the software but also by the use of software in a culturally and pedagogically goal setting environment where the teachers' role is a central feature.

Different avenues influencing pedagogy in classroom use of computers

Pedagogy often describes the broader philosophy and visions of a particular educational system in which teaching practices and learning are embedded and embodied (Bruner, 1996). The teachers' new role can be understood in varied dimensions which embrace not only an overall educational vision for using computers in schools and classrooms but also specific teaching strategies employed by teachers whilst interacting with pupils. One then needs to encounter not only the broader educational culture of a system but also the micro-culture of a classroom. Based on the above and considering the potential ways teachers use computers in their classrooms, may be suggested four different 'avenues' which influence the nature of pedagogy when computers are utilised in classrooms: the *'pedagogical orientation'* of the educational system (on a macro-level) in which the computer implementation takes place, the *'pedagogical structure'* embedded within the computer system (i.e the software), the *'pedagogical organisation'* of lessons and lastly the '*pedagogical support'* provided by teachers during their interventions in pupils' activities.

Concerning the '*pedagogical orientation'* of the educational system as a whole, Kontogianopoulou-Polydorides (1996) argues that the 'educational paradigms' of certain educational systems (national cultures, pedagogical philosophies, educational policies and models of practice) not only shape the process of computer implementation in classrooms (in the sense that cross countries pedagogical differences are often attributed to cultural differences on a national level) but also are shaped themselves by policy attempts to implement computer use in the curriculum. This influence can be realised not only in the predominant norms in programmes of teacher training, education and support but also in established teachers' views, levels of their confidence and choices in daily interactions with pupils (see Plomp et al, 1996).

The '*pedagogical structure'* of the software includes the instructional principles built within it, contains the 'didactically central features' of the computer system (to use Bellemain and Capponi (1992) wording) and provides implicit or explicit suggestions for further steps in open or closed ways of interaction and provision of feedback. The nature of the pedagogical structure of the software can be distinguished amongst: *open environments* (see Logo, Cabri) that enable users to explore the content free from guidance, carefully engineered *tutoring systems* (or closed environments) that prescribe certain performances for the user and provide immediate feedback (e.g. the Geometry Tutor, Anderson et al, 1985) and *guided discovery environments* that attempt to balance the previous two (see Elsom-Cook, 1990). Bellemain and Capponi

(1992) argue that teachers need to be aware of the instructional features of the computer based environments and more importantly they need to be aware that pupils themselves do not have the ability to interpret unassisted the didactical content which at most times appears to be hidden within the structure.

The '*pedagogical organisation'* of lessons is another avenue for infusing pedagogy in the learning system and refers to the selection of appropriate software, its customisation into specific learning tasks and activities (e.g. in the form of worksheets) and the structuring of lessons in terms of pupils' mode of work. Examples can be: constructing lessons where learners can use time of activity away from the computer, work collaboratively in groups or setting up inderdisciplinary projects. A classical case of software customisation is the construction of microworlds for exploratory software (Balacheff and Kaput, 1996). Lastly, teachers '*pedagogical support'* can be realised in teacher-pupil classroom interactions and consist of a main avenue for infusing pedagogy since it is based on communicating and intervening with pupils (e.g. in the form of teaching strategies and roles enacted in the classroom). The nature of teacher's pedagogical support will be examined further below.

The nature of teachers' pedagogical support whilst interacting with children

The nature of the support teachers provide to pupils is mainly identified and discussed through observational case studies which often describe varied categories of 'teaching strategies' or 'roles' in which teachers position themselves. The changing (or new) role of the teacher has been broadly described by a proportional shift towards a less didactic and open style of teaching and pedagogical vision and approach. The role model of a teacher as a transmitter of information and controller of knowledge is becoming redundant and is being replaced by a co-worker, co-learner, facilitator or supporter to pupils' learning. Schofield has described the teachers changing role as encompassing four main shifts: '*a) from teacher-directed work to student exploration that builds on students' existing knowledge, b) from didactic teaching to interactive modes of instruction that actively involve students in learning, c) from brief class periods devoted to single subjects to longer blocks of time devoted to multidisciplinary work on tasks that have some obvious connection to the world outside of school and d) from individual work to collaborative work'* (Schofield 1995)

The teacher now is more often found to 'stand back' in order to allow time and space for pupils to develop their own ideas (Somekh, 1997, Fraser et al 1988, Hoyles and Sutherland, 1989). Schofield (1995) also explains that teachers in her study argued that in computer lessons they had more quality time with individual children and groups in terms of providing immediate feedback, co-exploring in tasks and resolving pupils' problems. Descriptions emphasise the increased managerial and organisational features, as well as the new epistemological and pedagogical conceptions that teachers need to develop for their subject area and the human interactions required in classrooms (including virtual classroom interactions).

A classification of teaching strategies has been provided by Hoyles and Sutherland (1989) based on evidence gathered from the LogoMaths project. Concerning, the quality of teachers' interventions, Hoyles and Sutherland have developed three categories named *motivational*, *reflection* and *directional*. Motivational interventions consisted of comments aimed towards reinforcement and encouragement of learners. The category of reflection includes actions related to looking forward (encouraging pupils to reflect on and predict the process as well as the ultimate goal of the activity) and looking back (encouraging pupils to reflect back on problem solving procedures and encouraging pupils to reflect on their goal). The directional intervention aimed to influence or to change the focus of pupils' attention and to include the suggestion or provision of methods, factual information when necessary, introduction of new ideas and enabling pupils to recall past processes or information. De Jong and Van Joolingen (1998) have studied the potential combinations between simulation type of software for science and instructional support. They explain that support is mainly provided for learners to enable direct access to domain information and to facilitate specific discovery processes. These include teachers' support directed for particular learning processes relevant to simulation and experimental situations, such as hypothesis generation, design of experiments, making predictions, and regulating the learning process.

The types of pedagogical support described above consist of very delicate moves and require both epistemological awareness and pedagogical sensitivity from teachers which will then drive them towards making the right interactions at the right moment for the right pupil. The strength of this research line is that it has enabled us to problematise the nature of teacher pupil interactions in a significant depth in which a central (albeit open) question concerning the degree of teachers' intervention for pupils' autonomous learning can be addressed. Some argue in favour of an open and exploratory teaching or a non-interventionist approach where the teacher 'stands back' and pupils are allowed to try their own ideas and 'mess around'. Papert (1988) in particular believes that the use of exploratory software (e.g. logo) needs to be treated not as another subject mastered in a didactic manner but instead it needs to encourage pupils' self-directive learning with as little input from teachers as possible. Somekh (1997) also questions the value of 'structuring' lessons and suggests that an increasingly 'non-interventionist' role of the teacher will assist to promote pupils' autonomy and self-organisation in developing their own learning. She claims that support needs to be offered as and when it is needed. Hoyles and Sutherland (1989), reflecting on their own research study on LogoMaths, explain that although teachers adopted initially a 'non-interventionist', 'standing back' approach allowing pupils to express their own ideas, they had to use a mixture of non-intervention and teacher directed tasks so as to challenge and 'stretch' pupils' cognitive growth.

However, one needs to have in mind that interactions of such quality are often the result of a close relation between researchers and teachers or teachers who take the role of an action researcher (Hoyles and Sutherland, 1989, Somekh, 1993). In these cases, the researcher works closely with teachers and often support is provided in the form of 'mentoring' or 'scaffolding' which creates the 'mental space' for teachers to develop and practice their ideas. Andrews (1997) finds that teachers, in majority, are unprepared to use software in its full potential in subject areas and Johnson (1993) has identified that teachers struggle to understand what is required by them and to come to terms with the increased complexity and responsibility of their role. Furthermore, the under participation of schools in electronic networks has been pointed out by a recent report from the European Union suggesting that we are still short of feasible pedagogical strategies that can be largely espoused by schools and teachers. It explains that although experimental projects indicate fruitful dimensions for using ICT in learning activities and networking (i.e. experimental schools who are networked electronically at regional or local level and produce thematic databases, practical comparitive work and joint projects incorporating text and images), the number of schools who actively participate in existing networks is still small and by mid 1996 less than 5% of European schools were incorporated. The situation varies greatly from one country to the next: For example two thirds of schools are connected in Finland and in Sweden but only 15% of schools in the UK and less than 5% in France and Germany (European Commission Report, 1996).

Fraser et al (1988) studied teachers of varied styles using computers and they described this 'changing role' as comprising a major shift of the 'locus of control' in teachers' managerial and organisational responsibilities. They identified teachers adopting roles such as counsellors and fellow pupils or simply classroom resources for pupils to come and voice particular queries. This is particularly evident in classroom interactions where peer interaction, group work and collaboration (due to the computer presence or the utilisation of particular software based on local or remote networks) between pupils becomes a central feature in structuring lessons (Webb, 1987). Mercer (1996) and Mercer and Edward (1987) examined the quality of pupils' discussions in group settings whilst working in computer based activities and argued that at most times 'collaboration' fails because pupils do not share similar views (or ground rules) about the expected behaviours of participants in groups. Chronaki (1998) has also reported that rarely do teachers themselves posses coherent understandings about pupils' collaboration or viable strategies that could enable pupils to work in groups. As a result they rely mainly on personal 'survival' strategies which focus more on disciplining pupils rather than fostering a true collaborative pattern of group work. Thus, the increased need for pupils' group work and collaboration in certain computer environments, raises new challenges for teacher roles in classrooms since they need to change their patterns of interaction with pupils. Computer use seems to require more active interaction of teachers with individuals and groups in which teachers are more often faced with facilitating pupils' working relationships and remedying possible false understandings.

Moreover, it is anticipated that the rapid development and provision of environments such as virtual classrooms or customised teacher intervention at a distance will create conditions where pedagogical support (of the type described above) and human interactions geared towards high order conceptual understandings need to be re-discussed. For example, *TeleCabri* is a new software medium that represents real time teaching at a distance. The whole idea is that the teacher interacts with individual students in real time, often supported by a video channel allowing tele-presence. The pupils are working on a geometrical task with Cabri and when the communication is established between the student and the teacher, the latter sees the current screen of Cabri-geometre and must make sense of what the student has constructed and why. S/he then must decide what action to take and what adequate feedback to provide for the user pupils. A two-way messaging text window may provide more information about the drawing and its construction and perhaps some aspects of what the student has previously tried (see Balacheff and Kaput, 1996). In this type of situation, compared to traditional classrooms, the teacher needs to sustain a substantial dialogue with the pupils. As a result, certain negotiations about pupils' current understandings, the content in curriculum areas and the provision of feedback cannot be avoided and must be articulated in different forms and discources.

CONCLUSION

The availability of computers in classrooms has resulted in restructuring classroom contexts, not only in terms of physical rearrangements, but mainly in social terms closely associated with an envisaged 'new role' for both learners and teachers. This vision is shared with educationists who believe that computer use and development of innovative software entails a central goal for transforming experiences of learning and pedagogy (Salomon, 1991, Simon, 1993, Schofield, 1995, Leach and Moon, 1999). These new roles are being characterised by a major shift away from the traditional pattern of the learner as passive recipient of knowledge and the teacher as transmitter of information to the adoption of an active, reflective, mindful and socially aware role. Learning and teaching then becomes contextualised in environments which represent and simulate real life phenomena, authentic situations and subject related content on the computer screen. In such environments, learners are asked to perform by taking an active part in problem solving and exploring novel situations. The teachers' role is seen as 'orchestrating' learners activity by selecting tasks, monitoring, facilitating and supporting their learning. Overall, an increasingly interactive role between teachers, learners, machines and information is being envisaged.

Although the 'new' roles of learners and teachers are described in very attractive terms, it has been identified that schools, classrooms and teachers in the vast majority, resist changing traditional patterns of working. Obstacles to learning and teaching in the terms described above can be a lack of equity in access to computer use (Sutton, 1991) and the non availability of educational software that encourages learning environments of the above type (Cole et al, 1990). Schofield (1995) argues that another potential obstacle is that teachers (and schools systems) may not espouse the same educational purposes and pedagogical visions for the 'transformative roles' that computer use brings along and are therefore unable to put them into practice. In a similar vein, Leach and Moon (1999) discussing current concerns about learning in multiple contexts and arenas (i.e. classrooms, homes, workshops, electronic forums, institutions) address the need for reconceptualising 'pedagogy' in ways that would inform the rapid global and local changes of our teaching and learning habits. They argue: *'New forms of pedagogy will be in a constant process of renewal taking evidence and ideas from all available sources, driven inevitably with controversy but always forward looking. A more intellectualised pedagogy should provide the cornerstone to legitimating teaching as a professional activity drawing on a wide variety of perspectives'* (p. 462). In other words, the survival and fostering of these new learning and teaching roles seems to depend on a complex systemic frame. In this, it is necessary to encounter provision not only for adequate infrastructure in terms of computer machines and relevant educational software but also for channels that would enable communication and the sharing of pedagogical visions which embrace and promote these new roles.

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