ALL HOOKED UP: AN ECOLOGICAL LOOK AT COMPUTERS IN THE CLASSROOM

LEO VAN LIER

Monterey Institute of International Studies
and National Foreign Language Center, Washington, D.C.[1]

1. Introduction

In a radio interview Bob Dylan once said that he wanted to include some hand clapping in a song they were recording in the studio. They were getting ready to clap their hands at the right moment when the recording engineer said: "What do you want to do that for? We have a machine that can do that." This way of thinking can also apply to education. "Why should I learn to multiply? I have a calculator for that. Why should I learn where countries are on the map? I have a CD-ROM for that. Why should I study current affairs? I can get all the news of the world every half hour on TV." Readers may have their own ideas about machines doing things for us, and at what point this becomes either ridiculous or dangerous. Herbert Simon once said that if a resource is to be found everywhere we keep only a small amount of it in our bodies and replenish it often (quoted in Allen – Hoekstra 1992: 30). If this principle applies to mind as well as body, then the entire notion of learning will inevitably be profoundly changed by computers.

There are many writers, from Neil Postman (1995, 1997) to Clifford Stoll (1995) who do not appear to be overly fond of the current explosion of technology, or "technopoly", as Postman calls it (1997). Computer enthusiasts, on the other hand, have at various times made exuberant claims. Symour Papert, inventor of LOGO, predicted that computers would "blow up the school" (Cuban

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1986), and founding father of artificial intelligence Marvin Minsky quipped that thinking machines would become so intelligent that "if we're lucky, they may keep us as pets" (Postman 1997).

Against this backdrop, I want to trace the possibilities, promises, and potential benefits of computers for the classroom teacher and the student, looking at the uses as well as the abuses of the new technology. My thesis will be that the new technology has much to offer, if we put it into the service of a sound pedagogy. It does not improve bad teaching or somehow magically provide sound pedagogy. It does not reduce class sizes or promote equity. It does not take over from the teacher, or make inadequate teaching good.

I will review some of the literature on computers and interaction and include some preliminary information on a longitudinal research project, in which I attempt to develop an ecological research methodology to study the impact of computers on language learning. I will first summarize what I believe a sound pedagogy for diverse populations of students should be. Then I will discuss the role of language and language education, and in the last part of the paper I will discuss various aspects of computer use in language education. I will end with an ecological research framework for investigating the impact of technology on teachers and learners in classrooms.

2. Pedagogy

Computers made their first hesitant entry into schools perhaps fifteen or twenty years ago, but it is only in the last decade that they have become a sizable presence in the educational landscape. It is hard to understand the speed with which the computer revolution has happened and is still happening. Things change so fast that the phrase "up to date" is rapidly becoming meaningless. It is clear that the school cannot avoid being swept up in this torrent of change. Front offices and administrative services have had computers for years, of course, but more recently it has become the classroom teacher's turn. Right now in the US the government and educational authorities are determined to put computers in every classroom, wired and ready to surf the Internet. What to do next is not discussed in any great detail.

Of course, the computer is not the first new invention that has given rise to both enthusiastic and dire predictions about its effects on education. The same has been the case with the invention of the radio, the learning laboratory, "teaching machines", and television, before the computer arrived on the scene (Cuban 1986).

At this point in time no one can be sure if computers will have a greater impact than the earlier technologies. Neil Postman quotes Apple's Alan Kay as saying that "any problems the schools cannot solve without computers, they

cannot solve with them" (Postman 1995: 45). If that is the case, what will be the effect of technology on education?

In their book on talented teenagers, Csikszentmihalyi, Rathunde and Whalen (1993) compare traditional systems of apprenticeship with the role of the teacher in a modern classroom. They argue that the role has shifted from "a practitioner in a domain" to "a transmitter of information". They continue:

> ... the ethos of modern schooling discourages the development of ... extended and transforming relationships [as in apprenticeships]. Instead, modern curricula even in the arts tend to depersonalize even the transmission of information. In the name of diversity and efficiency, relations between teachers and students are kept highly specialized, programmatic, and brief (1993: 178).

Good pedagogy is far more than the transmission of information, or the provision of comprehensible input. The value (and memorability, learnability, etc.) of a certain message depends to a large extent on the emotional, social and cognitive *investment* learners make in that message (Humphrey 1992; Damasio 1994). All messages in social interaction have two aspects: a *transactional* one, which refers to the information it carries, and an *interactional* one, which refers to its social and personal aspects (Brown – Yule 1983). The interactional message is often accomplished through the transactional (informational) message (sometimes it could be the other way around of course). This means that, in everyday social interaction, we pay close attention, not only to the facts conveyed through language, but also to all kinds of other signs that may be available in the environment, including linguistic, prosodic, kinesic, spatial and temporal signs. All these potential signs may give information about the speaker's attitude, the speaker's opinion of his or her audience, various intentions and possible purposes, sociocultural symbols, and much more. The richness of all this meaning material available in a setting might be called the "semiotic budget" of the setting. I will return to this notion later.

It is now widely accepted that socio-cognitive development largely occurs in the context of social interaction. This acceptance leads to such approaches to classroom interaction as *responsive teaching* (Bowers – Flinders 1990), the *instructional conversation* (Tharp – Gallimore 1988), *joinfostering* (Faltis 1993), *exploratory talk* (Wegerif – Scrimshaw 1997) and many others, which all stress the quality of social interaction between teacher and student, and student and student.

Given this importance of social interaction, it may be asked what the role of technology might be. After all, would it not be reasonable to expect that technology would dehumanize and reduce interaction, rather than enhance it? This question will be discussed below. I will try to answer the reasonable sus-

picions of many people in this respect, including the New Luddites who, according to the New York Times, met some time ago to discuss the dire consequences of "technology addiction". According to the report, the New Luddites warned that

> ... the ballyhooed information highway is the road to ruin and that isolation and alienation are increasing in a culture where people do not sit face to face, but instead interface (NYT, April 15, 1996).

And in a rather pessimistic article in the Atlantic Monthly (Oppenheimer 1997), a teacher was quoted as saying:

> Computers are lollipops that rot your teeth. The kids love them. But once they get hooked ... It makes reading a book seem tedious. Books don't have sound effects, and their brains have to do all the work (1997: 61-62).

On the other hand, several researchers argue that computer work, if done right, can stimulate collaboration and exploratory talk (Crook 1994; Ganszauge – Hult – Sajavaara – Konttinen 1994; Wegerif – Scrimshaw 1997). I will return to this discussion later on in the paper. For the moment, let us note that each side of the debate on technology can find plenty of ammunition to bolster its argument.

3. Computers in classrooms and labs

According to Hargreaves we can distinguish five types of school cultures: fragmented individualism, balkanization, contrived collegiality, collaborative culture, and the "moving mosaic" (1994: 238). He comments on the "balkanization" of teachers in schools, i.e., the various ways in which they are compartmentalized and cubbyholed into subgroups, a situation which makes collaboration across subjects almost impossible. This balkanization creates "pedagogical inconsistency, competitive territoriality and lack of opportunities for teachers to learn from and support each other" (1994: 18).

The balkanization of teaching makes it difficult to implement collaborative practices across the curriculum. One such collaborative practice is *language across the curriculum*, in which teachers collaborate to improve all aspects of language education, so that students can comprehend the academic language of subject matter, and can learn and apply language skills in their native, second and foreign language(s) in reading, writing, listening comprehension, self-expression, discussion and debate, and all the other linguistic skills which are essential to academic success. Balkanization can also be a serious handicap in computer use, an area in which collaboration among teachers is crucial, so that scarce expertise and resources can be shared.

Many teachers will remember the language laboratories which became very popular in the 60s and 70s. In these labs students sat in individual booths, working on sequences of listening and speaking exercises, often at their own speed, while being monitored by a teacher at a console. Such setups fitted perfectly the dominant methodology of those days, the audiolingual method, in which pattern practice played a major role. Unfortunately, by the time the technology was well-developed, and affordable installations were available for most schools, the audiolingual method had by and large fallen from grace, and had been replaced by communicative approaches which, in varying degrees, stressed face-to-face interaction and group work. As a result, many a language lab gathered dust without being much used. Others were used, but the time spent in them was often not particularly fondly remembered by students or teachers. In general terms, language labs are not seen now as very cost-effective or communicatively rich environments.

Nowadays computer labs are taking the place of language labs. In fact, many places that have language labs (and still use them) want to add computer functions to their existing audio-lab setups, and some commercial installations exist that do just that. Others go the digital route, that is, use computers to deliver sound and video (and everything else) digitally, without using analog audio tapes and cassettes. This requires a great deal of storage capacity and high-speed access, but no doubt this solution will be readily available any day now, perhaps by the time this paper is in print.

Such technical issues aside, a more basic question is if computer labs are the right way to bring technology into language teaching and learning. Certainly, many schools have computer labs of the traditional type, built along the same lines as the language labs of old: rows of individual work stations, each with their computer and monitor, clearly designed for students to work on their own, and a teacher station at one end of the lab. In addition, since space is generally at a premium, the number of computers that can fit into the room has been carefully calculated, so as to maximize the capacity of the room. As a result there is not much space between the computers, or in general around the computers, and there is not much room to move about. Such a configuration places severe restrictions on the types of work that can be done. While it may be suitable for individual writing, research, or drill work, it is not conducive to collaborative projects or pair work of the types that provide rich, varied and deep learning opportunities.

Another consequence of concentrating computers in large labs is the issue of access: the lab must be booked, and it may be difficult to move one's class for one period, or to book the lab for an entire semester (especially if one is only planning to use computers for part of the time). In addition, competition for lab time may be strong, and language teachers may be relatively low in

the pecking order as compared to science, math, and computer science teachers (there may also be special needs in terms of access to sound, language programs, and different fonts).

There appears to be a trend currently to move away from the traditional rows-and-stations labs to more flexible setups. One solution is to put one or more computers in the regular classroom. This was the approach taken in an interesting study conducted by the University of Jyväskylä (Ganszauge et al. 1994), in which one computer was placed in a small number of secondary English classrooms taught by four different teachers in two schools. Teachers received some minimal training and were basically able to use the computer in any way they saw fit. The results showed that the computer had a positive effect in a context of pair and group work, with pair work being the preferred mode. At the end, students mostly complained about insufficient turns at the computer, or the poor quality of the software available. Interestingly, when individual students were sent to the computer, they were usually either poor performers in English or accomplished computer users (this finding might have some parallel in discussions about equity).

Newsom (1996) also reports about computers in the classroom. He quotes from two teachers. This is what one of them, "Marian", has to say:

> I wrote a proposal for a grant to have two computers in my room and began the process of undoing my classroom structures so that I could take advantage of those two machines. Gradually, I tried new groupings, more interaction, less whole-group direct teaching, and I could sense the students' self-confidence grow as they became more independent (Newsom 1996: 205).

Another teacher, "Chris", comments in a similar way:

> When I brought that first computer into the classroom I was faced with a problem. Since the kids couldn't all work on the computer at once, I realized that this was going to infringe on my whole-class lecture method. The solution was to leave my "sage on the stage" posture, move to a learning centers approach, that had technology in one or two of the centers, and adopt a "guide on the side" philosophy that allowed kids to work more independently and allowed me to move about the room and work with small groups of children (Newsom 1996: 204).

It is hard to predict if adding a few computers to a classroom will make a significant difference in the processes of teaching and learning. Certainly, it seems to have done so for "Marian" and "Chris", as quoted above. In other cases, it seems to have made no difference at all, or it may have made matters worse. As one resource teacher told me, in many cases "computers are used as surrogate teachers". One technology resource person in a large district told me that many teachers are wary of having computers in their classroom, because they know it will mean a significant change in teaching style.

Several researchers report that computers can make unequal access even more unequal (DeVillar – Faltis 1991; Crook 1994; Cummins – Sayers 1995; Schofield 1995), since it is often the brightest and most affluent students, as well as those with most prior experience with computers, who get to use them most. As Crook warns, "we must be wary that their deployment does not serve to *amplify* existing patterns of disadvantage" (1994: 24; emphasis in original).

In addition, the work that is done on the computers can vary a great deal: from "drill and kill" playing around, and aimless browsing, to more focused and creative uses. A software developer at a major university told me that students seem to be excited by the newness of the medium, but he feared that after a while they would get bored and switch off. This would seem to apply especially to materials that are not particularly exciting in the first place. Students may be more interested in clicking to see different messages pop up or to hear funny sounds, but such an interest clearly cannot be sustained for long.

Finally, in some cases, computer use can lead to less interaction between student and teacher, and other students, and in such cases it is debatable whether it is worth having the computers at all. This would be the case if, instead of having a regular class, students would be taken to a computer lab to do individual drills.

To sum up, the physical design is an extremely important part of planning the introduction of technology: once a setup has been decided upon, a number of possibilities and limitations follow, and if the result is undesirable, changing the setup may be impossible or very expensive. Each configuration brings with it a particular range of resources and constraints, possibilities and problems. However, I see it as a positive sign in general that many new installations are moving away from the traditional rows-and-screens computer labs. On solution is to put the monitors below the surface of the desk (visible through a glass viewport), so that students can have face-to-face interaction. This is a solution we successfully implemented in a multimedia classroom at the Monterey Institute of International Studies. Another popular solution is to place the computers facing the walls along the perimeter of the room, with a large table or tables in the center of the room. This is also a very flexible setup, and another advantage is that students can see each other's screens, and this facilitates the opportunities for collaborating and learning from each other.

4. Computers and social interaction

There have been fears that computer use tends to encourage socially isolating experiences, and that computer work is a rather solitary affair, with one student staring at one screen, mesmerized and oblivious to his or her surroundings.

Some movies have computer fanatics being sucked into a virtual world, perhaps never to return. Computer-bright adolescents have been portrayed as hollow-cheeked youths (Crook 1994), and given names implying various levels of prejudice tinged with admiration, such as wizard, techie, geek, nerd.

However, as Crook points out, research has shown that by and large this stereotype is incorrect, and that the computer has often turned out to be a socially congenial instrument. In schools, Crook reports, "when we examine actual classroom practice we find that ... the computer has facilitated socially organized learning rather than inhibited it" (1994: 121). In my own observations I have also noted this, but primarily when students are working with open rather than closed software. Open software refers to general programs that allow for the creative construction of multimedia projects or other open-ended work, whereas closed applications are sequenced language exercises or integrated packages that look a little bit like textbooks on a screen (see also Wegerif – Scrimshaw 1997).

Britain's Colin Harrison notes that, as compared to other countries, educators in the UK have always emphasized the small group work and social interaction side of computer use, partly because of pedagogical opinion (the influence of educational thinkers such as Lawrence Stenhouse and Douglas Barnes, as well as government reports such as Bullock's *A language for Life*, in 1975), and partly because of economic necessity (Harrison 1987: 18). It is certainly noteworthy that, in the US at least, most of the debate and effort currently centers on the economic and technical aspects of computer implementation, and on hardware and software issues. The implied suggestion seems to be that the computer will make a world of instructional and informational resources available, and that this will be all that is required for the new technology to work its magic. In reality, however, without a well-designed curriculum in which the computer is integrated, the effect will be minimal, or is as likely to be detrimental as beneficial.

So far as language education is concerned, it is important to study the ways in which computer use can enhance the quality of social interaction in the classroom. Here, examples such as the ones from Newsom (1996) quoted above, and the results of the Jyväskylä study (Ganszauge et al. 1994) suggest that there may be positive consequences, if implementation is approached in the right way. Here is another example, summarized from a video produced by John Twitchin for the BBC, called *European Awareness*.

> An elementary school class in southern England receives a fax machine from a local business. The teacher sets up contacts with schools in various European countries, including Portugal, Denmark, and Greece. The video shows how, one day, a fax comes in from the school in Greece, containing text and pictures about ancient and modern techniques of weaving in Greece. The text is in Greek, and nobody in the class understands it. After some discussion it turns out that a to one of the families in town is from Greece, and this person is invited to class to come and interpret the fax. She not only does so, but brings her old woven school bag from Greece, tells students about her childhood, teaches them some Greek words, and provides information about Greek culture. The students and their teacher next decide that it is necessary to reciprocate, and embark on a project about spinning and weaving in Wales, involving a field trip to a nearby museum, and much other work. Eventually, a fax about Welsh traditional weaving is sent to Greece.

We can see, in this situation, how the fax machine has succeeded in transforming classroom teaching, at least for a short while, but perhaps, in some fundamental way, forever. The incoming fax presented an unexpected situation to teacher and students alike, and led to a natural experiment in exploratory teaching in which teacher and students all had to decide on a course of action without a prior lesson plan. Furthermore, the Greek fax led to a series of authentic tasks that were directly relevant to the objectives of the course (e.g., cross-cultural understanding).

Examples like the ones quoted here can be multiplied infinitely, to be sure. The exact circumstances of each individual case are not very important, but what is important is the realization that the computer can be an ally of a teacher who has certain changes in pedagogy in mind. However, it can probably not produce changes in an environment in which change is not wanted.

Studies tend to show an increase in interaction and in motivation in many contexts of computer work (except for the solitary drill kind). One student put his preference in no uncertain terms: "You ain't got to listen to the teacher talk" (Schofield 1995: 87). Increased social interaction can be observed even when students work on individual stations, so long as they are allowed to consult with each other, but it becomes especially evident when students work in groups or pairs. Most studies (for summaries, see Edfelt 1989; Crook 1994; DeVillar – Faltis – Cummins 1994) recommend pair work rather than larger groups or individual work. In many cases, an entire class can work on a single large project, such as creating a book of stories (Guthrie – Richardson 1995), though in such cases the project is usually divided into sub-tasks carried out in smaller groups and pairs.

When students work in pairs, they will have to share the keyboard and the mouse, taking turns according to a previously worked-out schedule. In such pairs, it is often noticed that collaboration is richer if the learners are of roughly equal proficiency and knowledge (Gonzalez-Edfelt 1994). The type of software and task is also of crucial importance here. Gonzalez-Edfelt found that two-way tasks, in which each of the participants have knowledge that need to be shared, might lead to the most satisfactory social interaction (Edfelt 1989; Gonzalez-

Edfelt 1994). Further, Yule found that an inequality in terms of language proficiency could be profitably counter-balanced by the linguistically weaker partner having a higher degree of knowledge or expertise in the task domain (Yule 1990).

It is often the case that the computer can be the source of focused attention and social interaction for all or some of the students in a class. Perhaps a new piece of software is being demonstrated or explored, or a student has found something interesting on the Internet, or a group of students have designed a nice little program, and so on.

In a language class talk around the computer can be used for a variety of purposes: learning how to explain or describe actions, how to give instructions, how to ask interested questions, and so on. At a more formal level it may be part of learning how to speak in public (doing presentations).

WITH

At the simplest level, the computer interacts with the learner by saying things like "Wrong, try again". From there on up, the computer can be an interactional partner in a variety of ways: as game player, respondent (in interactive programs), follower of instructions (in programming), and so on.

This sort of interaction has often been feared as having a dehumanizing effect (cf. the quote above about "interfacing" instead of "face-to-face". Yet, if it is successful, such work can provide confidence and motivation to students, in a way similar to creative art or writing. As an example, after producing a simple program one student said:

> "I made this cute little thing and it asked for your name and your boyfriend's name. Then it prints little hearts. I did that ... I did that and I'm so happy about it!" (Schofield 1995: 87).

THROUGH

The computer allows people to communicate with one another over long distances as well as within the same room. E-mail, chat rooms, bulletin boards, and video-conferencing are obvious examples. Special e-mail forums (MUDs and MOOs) are available for ESL students. Within a computer class, integrated writing programs (e.g., the "ENFI" networks – Electronic Networks for Interaction – described in Bruce, Peyton and Batson 1993) allow students to collaboratively construct a piece of writing. This can be of great help for shy students who otherwise do not participate in discussions.

A considerable amount of literature now exists on e-mail, Internet research, and related connectivity systems (e.g., Warschauer 1995a). However, many issues remain to be researched, such as "Netiquette", i.e., appropriate standards

of decency and respect (Warschauer 1995b is a fascinating study on this topic). Also, the written language in e-mail tends to be very informal, and there is considerable tolerance for errors and colloquial language (in a sense, e-mail is a spoken/written hybrid; see some of the contributions in Warschauer 1995a).

5. Teacher education and technology

A Newsweek article a few years ago noted that teachers do not get the training to use computers appropriately. As the article states, "A 1995 federal study found that states put roughly 15 percent of their edutech budgets toward staff development, and recommend [sic] that the percentage be doubled" (1996: 61). In a similar vein, Merrow complains that

> ... schools have kept computers in the administrators' offices and in special "laboratories". That unfortunate policy has kept teachers away from technology, kept them technologically illiterate. Even today, schools provide little in the way of help for teachers who are unfamiliar with computers (1995: 52).

In addition to providing for sufficient staff development, it is necessary to study carefully how this staff development is to be structured, and the period of time over which it is to be provided. Crook notes that, very often, teachers' experiences in computer training courses are disappointing. As he puts it, "the training regimes did not appear well matched to the experience or needs of these teachers" (1994: 5). Part of the reason for this lack of success is that courses focus on problems of using technology and software, at the expense of tackling real educational issues (1994: 5). Schofield reports similarly disappointing experiences of teachers, with most teachers brushing off the brief workshops they received as largely useless, failing to prepare them to use the computers effectively (Schofield 1995). A small informal survey of 40 teachers I did in 1997 revealed a very similar pattern: only five teachers reported having received any training at all, and three of those five explicitly mentioned that the training had not been satisfactory. Most indicated a need for professional development, often mentioning that this should be "hands-on" and "ongoing".

Two major problems emerge when teachers begin to work with computers:
a) problems with the technical management of the equipment and the time required to assist all students while they work.
b) problems with the integration of computer work into a pedagogically solid curriculum.

As regards the first question, if teachers need to spend a lot of time fixing mechanical problems, such as printers that do not work, or cursors that keep freezing, then it is likely that they will not approach the use of computers with great enthusiasm or persistence. But even when the machines work more or

less smoothly a lot of individual helping is required, especially when students work on open rather than closed software, for example constructing multimedia projects, web sites, and so on. During a recent visit to one such classroom in a high school, I spent the entire time going around from computer to computer, even though the class teacher and a resource teacher were both doing the same. Students needed advice on how to create buttons and text fields, how to change fonts, how to insert sounds, etc., as well as – since this was an ESL class – how to spell a particular word, or how to say this or that in English.

On the technical front, Schofield quotes a particularly nightmarish episode in the computer life of one teacher:

> The students ... continue to have a lot of very nitty-gritty problems. Kathy can't get the printer going ... She's scowling and says in an annoyed tone of voice, "Please help me." Mr. East suggests several things, and after they try out four or five different approaches they finally get the paper to print out. Ms. Prentiss has been working with Sharon on word processing ... For the last 10 minutes cries like, "I don't believe it," and "Oh, no. Not again!" have been emanating from both of them ... Finally, Ms. Prentiss calls Mr. East over ... Sharon is clearly getting anxious, pacing around, picking her nails, and the like. She takes her disc and inserts it in another computer hooked up to a different printer. She can't get this printer to work ... Ms. Prentiss rushes over to try to fix it saying, "I just don't believe it!" Ms. Prentiss comes over to me [the observer] and says, "I feel like quitting this ..." At this point Mark calls to Ms. Prentiss, "I need help ..." Ms. Prentiss puts her head down on the desk briefly. She looks at me with what appears to be a mixture of mock and real despair and trudges over to Mark. [Later in the same period] Dan is trying to use a printer that Mr. East thought he had fixed. Dan's essay comes out quadruple spaced. In addition, every single word is underlined. Ms. Prentiss looks at it and breaks into almost hysterical laughter. Dan looks annoyed. Ms. Prentiss says, "I'm sorry, this is just too much – too, too much! ..." Mr. Adams and Mr. East are still working on the second malfunctioning printer. Mr. Adams says, "You know I have a trick. What I do with my Radio Shack computer is just turn it on its side and hit it. Maybe that will work here ..." They turn it on its side and give it a whack as one of them holds the tension on the paper feed. The machine begins to work. (Schofield 1995: 126-127).

Such experiences, and everyone who works with computers can relate to them well enough, do not encourage anyone to leap onto the technology bandwagon with great enthusiasm. It is only when successes compensate sufficiently for such inevitable disasters, that teachers and students are motivated to continue. Since teachers do not usually enjoy the luxury of having one or two technologically trained helpers around, ways need to be found to make the students self-reliant and cooperative. As suggested above, the physical setup of the room can have a big impact on the possibilities for peer assistance.

An additional problem, though related to the one just mentioned, is that teachers feel that computers require them to relinquish control of the classroom. Very often, unpredictable problems come up, and there is no lesson plan that can either prepare for them or solve them. On many occasions teacher and students are in the same boat when things don't work the way they should, and the burden on the teacher who expects to – and is expected to – deal with everything, and solve everything, is disproportionate. This happened to me just a few days ago. I was working with a fourth grade class on a web design program, and a student had a problem erasing a particular graphic. I could not figure it out, but a few seconds after I gave up and stepped back to consult the manual she called me back and said "Don't worry, I figured it out, see, you just click here ..." At such moments one must relinquish the role of the all-knowing teacher and become a learner with a ten-year-old child. Clearly, students often know more about computers than their teachers do, which may be threatening to many teachers who are afraid of their authority being challenged. According to Merrow, the answer is for teachers to change their style of teaching. As one principal advised an anxious teacher: "Relax, let the kids show you." She subsequently reported that the children loved to teach her, and turned out to be good teachers. Weaker students were encouraged that the teacher was learning alongside them, and the whole experience became far less intimidating for everybody involved (Merrow 1995: 38). In our own experience in Monterey, ESL instructors have commented that the computer functioned as a sort of "bonding agent" between students and instructors, as they jointly explored possibilities and solved problems.

Staff development is clearly a crucial piece in the puzzle of creating pedagogically responsible uses of computers in multicultural language education. Brief general workshops do little to help, since they rarely address the specific problems and demands teachers have. Moreover, the best staff development is ongoing, with on-site assistance, peer coaching, team teaching, and various kinds of collaborative experience, where technologically experienced and pedagogically experienced teachers work together as partners. Finally, all technological staff development must address fundamental pedagogical issues of collaboration, social interaction, and autonomous learning, where student input is not only tolerated, but actively sought.

6. A research program

So far I have discussed several of the issues that surround the incorporation of computers in the educational landscape. I will now give a preliminary overview of a study I am currently conducting which aims to address the broad question of what effect computers are having on education, particularly language education. There are quite reasonable doubts among many educators about the

wisdom of pumping vast amounts of money into technology, often at the cost of other programs (Oppenheimer 1997). On the other hand, there is no doubt that computers are here to stay, and wishing them away is not a responsible reaction for any educator. It is therefore crucial to investigate, in as many ways as possible, what it is that computers are doing, what the likely effects are on education, and what it is that educators can do to harness the unstoppable march of technology in ways that are positive for education. The goal of educational policy must be to put educators in charge of technology, and not allow technology (and its marketers) to determine the destiny of education.

It is widely reported that research on the benefits of computers is very mixed and ambiguous. The reasons for this are not very difficult to find. The role of technology in education is changing so fast that, as Mandinach and Cline report, "new and flexible methodologies are needed to capture the effects of [technology-based] learning environments on teaching, learning, and classroom dynamics" (1997). A methodology adapted from cause-effect research in the physical sciences will not be sufficient, since it cannot deal with the multitude of rapidly changing contextual factors involved. Anecdotal reporting, even if scrupulously supported by ethnographic observation and analysis is also insufficient, since, with its focus on here-and-now description, it cannot readily draw on historical antecedents or make plausible predictions and recommendations for the future.

Taking account of these research difficulties, I have been investigating alternative research frameworks that are able to handle complex situations that are in the process of rapid change, and in which many different – and at times conflicting – influences are at work. Here I must emphasize that at this stage I am not looking for "proof" that by using computers in one way or another people can learn language or language-related skills faster or better (such proof is of course likely to remain elusive even in more controllable scenarios), but for ways to understand what is going on, and the kinds of differences human effort is making and may be capable of making. This appears to be an ambitious enough goal.

One way to go about this is to look at systems in other fields that share the same characteristics to some extent. Such systems can readily be found: they range from weather forecasting, economic planning, ecological management and the workings of large corporations, to the rise and fall of entire civilizations. Some of the names given to the study of such complex systems are chaos, complexity and catastrophe theory, the study of non-linear or self-organizing systems, and so on (Gleick 1987; Lewin 1993; Waldrop 1992; see also Larsen-Freeman 1997). It should be emphasized that research based on these and related frameworks from physics and mathematics cannot be seen as replacing the various traditions of qualitative or quantitative research currently in use in applied or educational linguistics. For one thing, the useful results of

these research methods cannot be denied, and it would be foolish to abandon them. For another, there is no adequate research framework available for the human or social sciences that even begins to put into practice the key phenomena signaled in the various complexity-related theories, such as fractals, strange attractors, non-linear processes, and so on.

However, a realization of the limitations of existing research methodologies in the face of fast-changing complex systems makes the search for alternative (but complementary) research frameworks relevant. One such alternative is ecological research, and as Bronfenbrenner recommends (1993), it pays due attention to the *people* in the setting, focuses on the *processes* that are taking place, investigates the *context* in its totality, and takes place over significant *time* period (i.e., longitudinally). These four elements of research lead to Bronfenbrenner's "PPCT" recommendations which are useful as broad guidelines, even though they are too general to provide a practical methodological framework.

Another procedure worth looking at was developed by systems theorist Peter Checkland (1981), and has been recommended for ecological research by Allen and Hoekstra (1992). This procedure is considerably more detailed and practical than other ecological models, contains specific steps for action, and is therefore is a good candidate for adapting to educational technology research. Educational settings are, in the terminology of ecology, "soft systems", that is, they are not determined by linear causal laws. Rather, they are "messy", in that processes are controlled by a number of different, often competing or conflicting agents and events. However, one must assume that there are enough constants and discernible tendencies in the setting to allow for formal research to be possible.

The original model contains eight steps which are intended to be implemented in sequence. These steps alternate between broadening and narrowing perspectives, or between global, macroscopic perspectives and detailed, microscopic perspectives. They also alternate between concrete analysis and abstract conceptualization, and between non-interventive research and intervention in the form of action research. It is clear that such a procedure requires a great deal of time and a clear focus, not to mention patience in gradually putting the many pieces of the puzzle together.

In my adaptation of the Checklandian soft-systems approach I do not see the sequential progress through the eight steps as a particularly viable procedure. This may be because we are not dealing here simply with a management system (such as a multinational corporation), or an ecological task such as an oil spill cleanup or forest management, but with education, specifically language education, and the nature of the inquiry is such that basic questions need to be addressed, such as what we mean by language (and how it relates to context), what our basic learning theory is, and what kinds of goals and expectations we have for the learners in our schools. In other words, a clear epistemological

basis, as well as a scrupulous examination of moral values and goals, are part of the investigation, which therefore cannot be construed as merely technical or engineering work.

The eight steps of the Checklandian framework, here adapted for the technological-educational question at hand, are as follows:

1. What is the overall educational situation in which the change – the introduction of technology – is taking place? This is narrowed down to a specific focus: in this case the role of computers in language learning, or even more narrowly, the impact of the computer on the interaction between teachers and learners. This can be further narrowed down to a particular age or school level, a particular language, a particular range of skills, etc.
2. A rich (or "thick", following Geertz 1973) description of all the things that happen and matter in the setting. Observations, conversations with participants, reports in the media, historical developments, all these and more are sources of information to be tapped.
3. A more abstract phase of defining the essential constructs in the setting. In Checkland's model these are grouped to yield the acronym "CATWOE". Briefly, they can be catalogued as follows:

C Client/Victim: teacher, student.

A Actors: teacher and students; resource persons (the "gurus" or "zealots" as they are sometimes called): technologically savvy teachers or administrators who move and innovate; administrators; trainers; sales people; financial/budget officers; local, state, federal authorities.
NOTE: scale these people according to their scope of influence.[2]

T Transformations: how do computers change the clients' work and life? Money, time, amount of work, knowledge required, motivation, results, etc.

W Worldview: technology as boon or bane.

O Owners: who controls technology? Who wises it up or dumbs it down?

E Environment: what moves or slows it down? E.g., level of expertise, availability of up-to-date machinery, software; budgets, replacement cycle. Here we look at constraints and resources in the environment.

[2] The notion of scaling is a very important one in ecological research. Different clients and actors have different scopes of influence, and interact in different ways with people operating at other scales. I will be using Bronfenbrenner's educational model of nested ecosystems: microsystem, mesosytem, exosystem and macrosystem as a scaling model. Bronfenbrenner's model is a nested hierarchy. However, we may also have to look for non-nested hierarchies (such as in nature the food chain). In addition, there are also non-nested non-hierarchies, heterarchies, holons of several kinds, and so on. The complexity is so enormous that I found it useful to start with a model like Bronfenbrenner's, particularly because it has somewhat of a track record. At the same time, however, I wanted to keep an eye open for other organizational possiblilities that may live within, or cross the boundaries of, the nested ecosystems.

4. Building the research model. This is another abstract step, one that I would argue is particularly crucial in educational technology. Here notions of language in context, what counts as "good" learning, semiotic systems in the environment, including verbal, non-verbal, spatial, and artifactual aspects of meaning making, the role of social interaction, of metalinguistic knowledge and awareness, the nature of complexity, self-regulation and autonomy, and so on. In effect, this is an entire theory of educational linguistics, but without it any meaningful discussion of technological innovation would be spurious.

Steps three and four are the foundations of any solid research effort in our field, and they must be laid broad and wide, to follow the advice of C.S. Peirce. Glossing over the deep issues treated here would merely mean fooling ourselves and creating research of an ephemeral nature.

5. The model is constrained against reality. This step is in a sense a reality check, where the conceptual framework of steps three and four are matched against the thick description of step two, to address what actually happens in representative settings, and to ask which differences make a difference (Bateson 1979). Here detailed ethnographic work, based on video recordings and careful surveying and interviewing come into play. Given a semiotic definition of language, kinesic behavior, and deictic signs, will form a key part in the analysis. The computer, and the contributions to the semiotic budget it affords, is studied in minute detail, not just for the things it does, but also for the things it allows or encourages learners to do – or inhibits them from doing.
6. Here ideal and advisable changes are discussed. This may flow from findings of step five, but also from direct consensual advice noted from teachers, learners, and other participants (clients and agents). It may include particular types of software or task sequences, as well as the physical design of technology-rich learning environments.
7. In this step an actual change is implemented and monitored in an action-research format. Ideal formats are collaborative, longitudinal projects, in which several teachers and their students, as well as perhaps academics, parents and others work together.
8. The final step is an overall evaluation of the research, including a stepping-back and seeing what it all means by placing it in the overall, holistic picture of education painted in step two.

I have suggested that in the present case of technology and language learning an appropriate way to proceed is to advance on several fronts at once. Rather than a linear progression of research steps, I advocate (and am carrying out in practice) the patient assembly of building blocks from several steps (a better word now is "strands") at the same time, in the understanding that information from one strand informs several other strands. An important consideration at

all times is whether there are any prerequisites at given points in the research process, that is, whether certain knowledge and information is necessary at one point before advancement to another point is possible. This needs to be monitored and documented carefully. I would argue, for example, that advancement in strands three and four are necessary to make the thick description in strand two rational and focused. Other connections between strands can readily be assumed, and will no doubt emerge from further work. I would like to see this research framework not as a consecutive implementation of steps, but rather in terms of Wittgenstein's image of a rope, which consists of many strands that are twined together, and which derives its strength not from any one strand, but from the combination of them.

7. Conclusion

In this paper I have addressed the broad phenomenon of the arrival of technology in language education. There are many contradictory aspects to this new development, and there are few people who would venture to predict where it is all headed. Luddites and nerds alike make claims, sometimes quite extravagant ones, about the negative or positive consequences of computers in the schools.

It seems that language teachers, especially foreign language teachers, are late entrants into the technological game. Most other subjects in schools, such as science, math and geography, appear to have had a headstart, and the foreign language teacher may have had trouble gaining access to the technology, even if she or he had an interest in trying it out.

I have argued that researching the impact of technology on language education requires a process and complexity-oriented approach to the issue, one which attempts to note all the ingredients that are contributing to the changes we see taking place. No ready-made methodologies for this type of research exist, but I have suggested an adaptation of an ecological framework, one that takes the complexity of the process and the context into consideration, as a plausible candidate for adaptation via practical implementation. I have chosen a comprehensive and flexible framework from systems theory (Checkland 1981) to provide the basis for this development. Further research will tell us if this approach is indeed one which allows us to gain a better understanding of the changes that are taking place, of the changing needs of teachers and learners, and of the new curricula that manage to incorporate technological tools into a rich and rewarding educational experience for future generations of learners.

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