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From the didactics of computer science towards the didactics of instrumental activities with ICT

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ABSTRACT: *In primary and secondary education in France, there is no real place for computer science as such. What is considered is limited to some general software (like word processors and internet browser) with the vision that practice in itself is sufficient for users to acquire their necessary mastery. ICT (Information and communication technology) has to be used for the learning of classical subject matters in a utilitarian and somehow interdisciplinary context. An analysis of the current situation gives interesting results and reveals new stakes that go largely beyond the strictly utilitarian framework. The real competencies of most users are far weaker than might be expected. Users and computer software have changed. Experimentation, modelisation and so on are possible with computer technologies. That leads to new vision of the place of ICT or computer science and therefore of didactics of informatics in connection with computer instrumented activities.*

Introduction

The field of didactics of informatics relies on contents and modalities of teaching and more generally on the place devoted to informatics in education. To lead research in the field of didactics of informatics suppose that informatics, ICT or computer science are teaching subjects in education. But, in France, if computer science is well established at the university level, it is not the case at primary and secondary levels. ICT is mainly seen as a set of tools that can be used as educational technology in every subject, notably in interdisciplinary activities. A specific school subject called "technologie collège" is in charge of helping students to acquire general ICT competencies during the first years of low secondary education. But all other school subjects are also expected to help students to acquire these competencies. A specific certificate called B2i (*Brevet informatique et internet*) has to be given to student that belong a list of required competencies at the end of primary education (level 1) and at the end of low secondary education (level 2). This certificate as been designed as an incentive to encourage teachers of every subject to include ICT tools in his/her teaching practices (Baron & Bruillard, 2003).

The situation just described seems to show a continuous movement of ICT dissemination. But if the ratio of students by computers is continuously decreasing, many problems remain. First of all, what has to be learned in ICT is not a simple question. It depends on objectives: to master ICT tools, to become a citizen in an information society, to become a creative user, and so on. To fulfil these different objectives, we shall try show that a new vision of ICT is required. We shall begin by questioning the real ICT competencies of users, quoting several studies showing that these are often low. We will then explain that the recent development and spread of computer software have changed their nature and will discuss the example of word processors: what is required to master such a production tool. Finally, we give our point of view concerning what is at stake concerning ICT and education and which can constitute a basis for a didactics of nowadays computer science of information technology.

User ICT competencies: a contrasted situation

Four years ago, I wrote a small provocative text called "*No matter if they understand as far as they are able to use it!*" (Bruillard, 2000). Grounded upon several studies about ICT competencies of students of very different levels and pre-service teachers, the idea was to alert education stakeholders about the situation judged overoptimistic. One can imagine that simplicity of ICT tools is such that usage by itself is sufficient for learners to acquire their necessary mastery. As quoted by Claude Pair, computer scientists tend to be self suppressive: ICT tools become more and more easy to learn and use without the help of specialists. But to say that there is about nothing to learn is certainly hazardous. To judge computer tools mastery only by the success of very simple task really does not appear satisfactory. A deeper look gives more contrasted results: may be the apparent simplicity of use masks incomplete and faulty representations liable to generate learning obstacles. Several studies have tried to reveal such obstacles.

One objective of the Representation European project was to get a better idea of the understanding of young students (10 to 12 age old) concerning computers and Internet. One result obtained, confirmed by other studies in France, was the lot of information known by pupils without framework to organize them. More specifically, the notion of processing was most of the times absent, only the visible part of computers being recognized.

Another study lead by Bernard André (to appear) is devoted to the notion of file. It concerns university students. Many of them are unable to perform simple tasks. For example, they do not understand why by just clicking on a file, whose format is not recognized, the word processor does not open automatically. Furthermore, many of them are not able to save or open a file at a given location.

Normand & Bruillard (2001) have lead a study with pre-service teachers. These teachers were given a specific task: they were taught how to scan a picture and they had to explain other users how to perform the same operation. Their discourse were recorded and then analysed by Sylvie Normand. The results obtained underline the importance of visible interface elements in discourses explaining actions and hesitations. Explanations relies on imitation, and there is a great importance of spatial clues. We noticed the central role of *hic et nunc* in the behaviour of pre-service teachers. What they see is determinant for the choice of what they do. But concerning the language used, it is very poor, no specificity of action (the only verb is *to click* with some complements like *there* or *here*). The flow of visual appearance of the screen characterizes the interaction with the computer. We noticed also a classical confusion between the visual effect of a command or an action and the goal of this action. For example, many users who want to select a set of characters to apply a specific command (to change the format), say they want to underline or set it in grey, quoting a visual effect, not their goal. To conclude, many users are far from being confident in using computers. They do not understand what happen and try to adjust according to what they see, in a continuous process of tries and errors.

To summarize, many users learn by approximation not by understanding, as expressed by Nelson (1990). When they face unexpected results, which is often the case, they have no idea of what happened and what they could do. They try different options offered by icons and menus, hoping that something will fix their problem.

Several reasons can explain this situation. First of all, the teaching and learning processes are often based upon imitation. Books are full of pictures of screens

indicating step to step what you have to reproduce and many hands-on training sessions consist of showing paths you just need to follow. No conceptualisation is required.

Another reason relies upon the choice of nowadays interfaces. WIMP interfaces (Windows, Icons, Menus and Pointing) associated with direct manipulation (Shneiderman 1982, Hutchins, Hollan et Norman, 1985) are certainly easy to use because you just have to operate upon visible objects. The user is engaged in the interaction with the computer and perform directly the actions. But, as with all metaphors, this kind of interaction face strong limitations. It is not possible to operate directly on objects that are not visible and more abstract actions (for example *do again* a series of action) are to complex to perform. Furthermore, users do not acquire a language to speak about their actions. So many users that only know this kind of interaction, do not develop operative representations: they are entirely dependent upon what appears on the screen and have no idea of what they could do. To learn to use a general software is a complex task similar to the acquisition of professional know-how; language plays an important part in it.

Many users think that there is nothing to learn, just some technical things that can easily be mastered or are restricted to computer specialists. In this simplistic vision of computer applications, the magic of the process can be taken as granted. Everything we want can be done if the computer specialists have foreseen the good process, so no worry if it does not work nowadays, it will work perfectly in the near future.

It is always very hard to teach not interested people and the problem is certainly to take the problem by another end: adopt a new vision of ICT.

A new vision of ICT tools: semiotic artefacts

In the process of dissemination followed by computers, in their nowadays important role in a number of human and social activities, the nature itself of informatics has somehow changed.

From a processing chain to an ongoing interactive loop

The old model of computer science is the processing chain with inputs, processing of data and outputs. This kind of model is classically refined with a feedback loop. Though this model is still correct for many computer applications, it does not really take into account the nature of nowadays computer tools with processes of undefined duration interacting with people.

In fact, the execution of a software combines human activity and machine activity in a temporal and situated process. Cognitive and social questions are inherent parts of technical problems. Computer science or information technology is then the science of design and use of semiotic artefacts (Nicolle, 2002), dealing with symbols and their signification for human beings and machines. As the user intervenes in the process, the goal is to set up a significant interaction for human beings and machines, taking into account the dynamics of the process.

A new problem has to be considered: the link with the possible interpretation process of the user. Users choose their actions according to their understanding in a continuous process. For that purpose, they need some knowledge of the treatments the machine can perform and of the objects on which they can act. This knowledge partly belongs to computer science of information technology knowledge and is partly linked with the activity in which the human-computer process takes place.

To illustrate these statements, it can be useful to take the word processor as an example.

The case of word processors: what to know to use them?

The case of word processor software is certainly a good example of hybridising informatics concepts. Word processors are very common software but their mastery is not well established although training sessions are proposed at all levels (from the elementary school to university including adults training).

The link between the computer and the user is characterized by the interface. The question is to better understand the interaction of the two poles: user and internal representation.

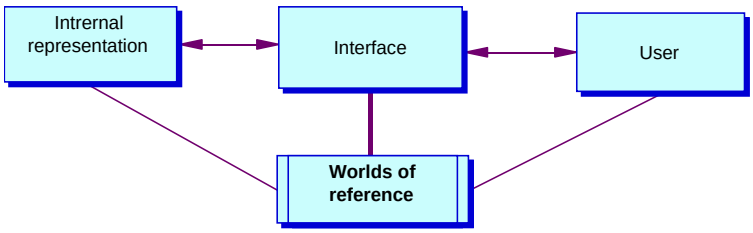

Figure 1. Two poles in interaction

The interface gives to the user the illusion of a real objects like a solid matter or a substance on which he/she can operate, sometimes like a sheet of paper. Several worlds of reference are present: the worlds of reference used by the design team, a sort of trace of these worlds visible through the interface and the worlds of reference for the user from which he or she builds his/her mental model. Standardisation is searched to ease manipulation and transfer of know-how from other software. "Known" instruments are mimicked. Specific professional knowledge is embedded in the software, but the corresponding reference world is not always familiar for users, individually or collectively.

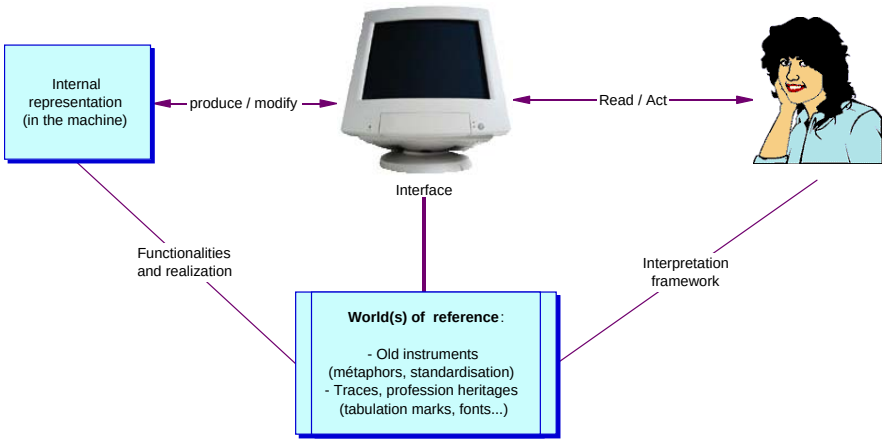

Figure 2. Two poles communicating via an interface with reference worlds not really shared

The locus of control of the interaction used to be in the hands of computer scientists, it has been given to the users. But which training is required and what knowledge has to be master by the user?

A first idea, to answer the previous question, consists in giving information only about the general management of a computer: how to open or save a file, how to print a text and so on. The hypothesis underlying this choice it that the metaphor installed by the interface is sufficient for the user to be efficient. The user is supposed to transfer his/her knowledge of the management of the text to reach his/her goals. In this vision, what is judged important is the activity of the user and the goal of this activity, the user has to focus on that and has not to be disturbed by what is considered to be technical problems.

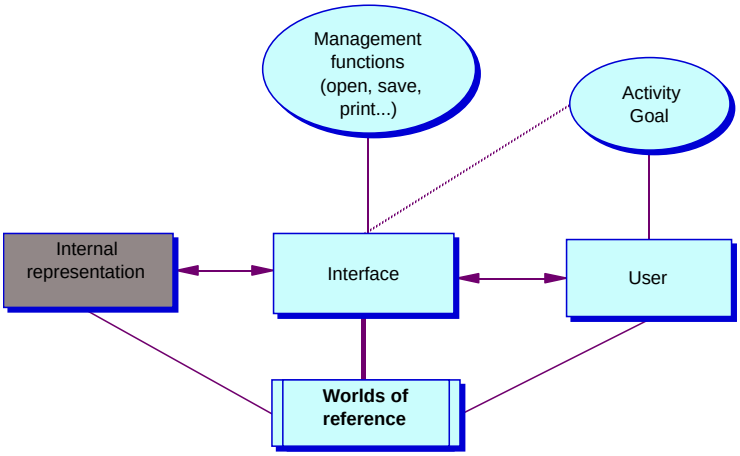

Figure 3. A first vision of what has to be learned

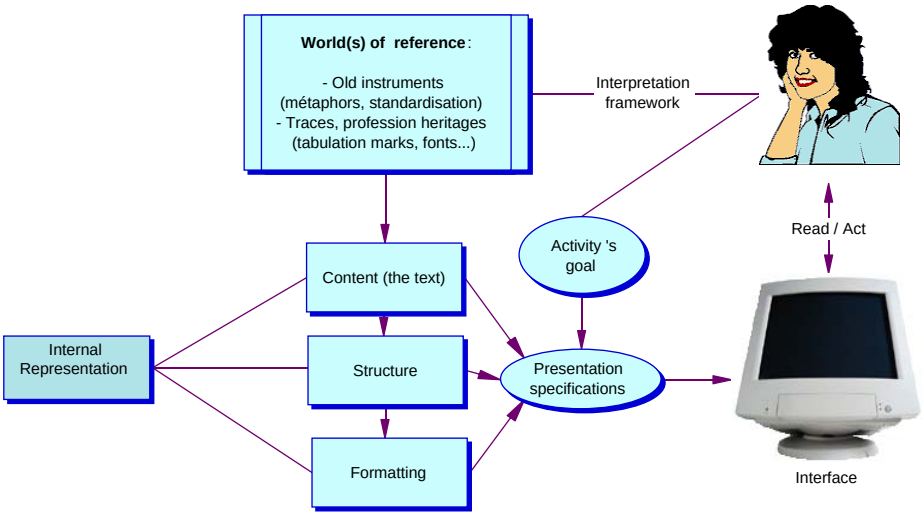

Figure 4. A more complete view of some characteristics of a word processor

However, we can observe that this ideal situation does not quite fit reality. Many users lose a lot of time and their behaviour is often far from efficient. For example, considering a word processor as a typewriter is a classical learning obstacle. Furthermore, studies from Bernard André (2003) reveal many difficulties faced by users with word processors. Then, more knowledge has to be acquired: a better

understanding of some world of reference of activity, notably knowledge from the book printing field (fonts, formatting…) but also some concepts underlying the objects manipulated by the computer. Taking into account recent developments in information technology, it seems nowadays very important for users to understand how a declared structure of a text can facilitate the formatting in different contexts seems, and to have some ideas about style sheets.

According to Sass (2003), the notion of style sheet can be a catalyst for inter-disciplinary works (mother language, arts, information technology). We could multiply examples, but the point is that some understanding of internal representations is really important. As the notion of document is rapidly evolving with electronic documents (see Pedauque, 2003 for a good discussion), what has to be known is also evolving. The border separating technical and conceptual worlds gets more and more narrow, information technology tends to reconfigurate old territories.

Towards a new didactics of informatics?

The preceding point concerning word processor mastery might be deepened, but in this text, we shall just give some concluding remarks about didactic of informatics.

It exists at university level a didactic of informatics or may be several didactics corresponding to different points of view about computer science or information technology. The very fast evolution of concepts and technology explains that there are not many recent works, professors continuously having to adapt their teaching contents and having little time to reflect upon what and how to teach.

The situation is different when we consider primary and secondary education. We observed tensions between performance and understanding in the mastery of activities with computers and advocated the idea of broadening the scope of what has to be considered with the point of view of computers as semiotic artefacts. Baron and Bruillard (2001) gave some indications of specificity of information technology in connection with other school subjects. One important point is that the use of computers and electronic documents can introduce some kinds of experimentation and renew some parts of the teaching and learning of traditional subject matters. The idea is to focus on instrumented activities and on modelisation. That is certainly a fruitful direction of research.

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