TOOL, INSTRUMENT, ARTIFACT? THE COGNITIVE COMPUTER*

by
Jacob L. Mey

Motto:
'Toiling to live, that we may live to toil'
(Wm. Morris, 19th century Utopian thinker,
quoted Ehn 1988:371)

In this article, I discuss the tool vs. instrument character of the cognitive artifacts often referred to as 'instruments of mind'. Having established a basic distinction between tool and instrument, I then go on to review the notion of artifact itself, and discuss the potential for mind change that is inherent in the use of 'mental' instruments such as the computer. It is pointed out that the relationship between the mind and its instruments is a dialectic one, and that this constitutes the very nature of our interaction with cognitive instruments, such as it is studied in Cognitive Technology (CT).

1. The computer: Tool or instrument?

1.1. Phenomenology of terminology

I will start out by looking at our common use of the terms 'tool' and 'instrument'. (The notion of 'artifact', as well as questions about their use and design, will be taken up in section 4).

We talk about instruments for making music; we have surgical instruments; we are familiar with the instruments on the dashboard of a car or in the cockpit of a plane, and so on.

Compare that we talk of a tool box, carpenter's tools, bicycle tools, gardening tools, etc. In addition we have: (cooking) utensils and implements (of destruction), but they need not concern us here.

One clear (but maybe superficial) difference between tools and instruments emerges when we compare the two kinds of artifacts as they are both found in the car: the instruments are on the dashboard, the tools are in the trunk. (Is a cigarette lighter a tool? An instrument? Or a gadget?)

1.2. So what's the real difference?

Take a hammer. A hammer as such is just a hammer; following Marx; we can say that it only becomes a *tool* by getting 'socialized', that is, by entering the production process.[1]

This *socializing* aspect is of the essence. The emphasis here is on the user and her/his skills, not on the tool as a physical entity. Consider that the same hammer, in the hands of the physician, becomes an *instrument* rather than a tool (for instance, when s/he tests out your knee-jerk reflexes).

To take another example: A surgeon uses a scalpel to perform operations. In emergencies, surgeons may use kitchen tables and kitchen knives to do an operation; the kitchen knife then becomes a surgical instrument, a kind of oversized scalpel.

1.3. Emphasis on the user and his skills

Pelle Ehn has remarked that 'the tool perspective takes the labor process as its origin rather than data or information flow' (1988:375). This is even more so the case when we consider instruments as a kind of highly specialized tools, designed to help the worker perform the operation in a skilled way, or vice versa, when instruments are 'created' out of tools thanks to the skills of the operator. It is the skill of the surgeon that converts the humble kitchen tool into a surgical instrument.

Still, it is not the amount of technical sophistication that makes the tool into an instrument; tools can be highly sophisticated, but still not qualify as instruments. For instance, even if I upgrade the common goad-stick (a long rod with a nail attached to its end) to an electric or electronic device for goading on my cattle, I am still using a tool, even if I employ high technology. But if I govern the animals by remote control, allowing me to finely steer their movements from a distance, in the fashion of a boy flying his miniature airplane, then I'm using an instrument. Here, my skills in manipulating the device are what constitutes the *instrument* as such.

1.4. Emphasis on the nature of the operation

A further difference between tools and instruments is in the operations they perform. Tools are essentially for constructing or repairing, instruments are for 'instructing', 'guiding a process' (in accordance with the term's etymology: Latin *instruere* plus the suffix *-mentum*, as in *tegu-mentum* 'that by which I cover' (e.g. a blanket, a roof), *indu-mentum* 'that which I put on' (a garment[2]). When my car breaks down, I don't start banging on the instruments on the dashboard; I get out my wrench and jack and other tools and try to fix the problem.

Thus, whereas a tool is for running or 'debugging' an operation, the instrument 'instructs', 'in-forms' it. While the tool is a direct extension of my skills, the instrument helps me govern my skills. Both tool and instrument have to do with performing an operation and using one's skills; however, in the case of the tool, the emphasis is more on the operation, and on the kind of work that is performed, while in the case of the instrument, the emphasis is on the user's skills and the way s/he does the work.

The computer is the 'instrument of mind' *par excellence*. Hence, the distinction between 'tool' and 'instrument' is of importance for the design of computers and for the way we interact with them. This will be discussed in section 4, below. But before we do that, let's turn to another question, viz.: whose instruments and whose minds are we talking about when we discuss 'instruments of mind'?

2. Whose instruments, whose mind?

2.1. The computer worker and his/her tools

Normally, we consider the worker as the one who is in control of his or her tools. Other people are kindly but strongly reminded to stay out of the work place and not touch the tools unless allowed to do so. Here is a warning that appeared on the door of the main computer room at Yale University's Department of Computer Science in the early eighties:

ACHTUNG!!!

Alles touristen and Non-technischen Lookens Peepers!

Das Machine control is nicht fur Gerfingerpoken und Mittengrabben. Oderwise is easy Schnappen der Spriggenwerk, Blownfuse, und Poppencorken mit Spitzensparken. Der Machine is Diggen by Experten only. Is nicht fur Gerverken by das Dumnkopfen. Das Rubberneken Sightseenen Keepen das Cottenpicken Hands in das Pockets.
So Relaxen und Watchen das Blinkenlight.

The message is clear, despite (or maybe even thanks to?) its baroque Germanesque 'command language': 'Hands Off, All Non-Expert Users'! The persons behind the message, the experts themselves, did not want any interference with their instruments from people who didn't know how to use them. In other words, the experts exercised propriety rights over the computer: the computer was properly theirs.

In yet another sense, the computer was the experts': the design that was prevalent in the early years centered around the people who knew. Thus, the whole operation of the computer room had something of the arcane atmosphere to it that normally is associated with secret societies and exotic priesthoods. The computers were designed to be manipulated by experts only, not by common users; the operations that these experts performed had mostly to do with maintenance and repair: the mainframe computer was a massive, central unit that served a whole community of 'end-users' (notice the term 'server', which seems appropriate in this context).

All of this changed with the advent of work stations and later, personal computers. Gradually, design, too, shifted: from being oriented towards 'experts only' to a concern for the 'dummies'; cf. the name of a family of very successful computer instruction books, whose general heading reads 'X For Dummies' (where 'X' could be 'UNIX', 'MS Word', 'Mac OS' or any other computer-related subject). End-users (the ones using the computer in their daily work) were now the focus of design, and the word 'user-friendly' became a shibboleth for the implementation of programs that could assist the

user in his or her daily work at the terminal. What earlier had been a tool for performing specific operations (scientific calculation, 'number crushing', strict 'word processing', or at most some primitive computer game such as 'Adventure') now started to live a life of its own as an instrument of the mind. Users started to be creative with their texts in ways that had not been possible before and as a result, the instrument not only facilitated the workings of the mind, but in addition, and more importantly, influenced the very way the mind functioned. I will come back to this in section 3.

2.2. Who owns our minds?

The question could be raised whether, as a matter of principle, minds can be owned, period. Hasn't Schiller told us that 'Thoughts are free' (*Die Gedanken sind frei*)? Even if we speak of a 'captive mind', or a 'captive audience', or of being 'captivated' by some presentation, we are using metaphoric terminology; we don't really envision our minds or our thoughts as belonging to someone else than ourselves.

Yet, there may be more to the metaphor than meets the eye (or the mind, for that matter). If we think of the mind in a modular way, as suggested by Marvin Minsky (1986) in his famous model of 'the society of mind', where several semi-independent 'operators' join to produce what we see as a unitary operation, then we can also take the next step, in which we reproduce the modules of the brain on an artificial basis.

To turn to a more recent development, given that, in the terminology of Artificial Life (AL), we can define (biological) life itself as a function (Helmreich 1998), we certainly can define certain parts of the human 'wetware' as programmable units, to be incorporated in physically independent, replaceable parts that can operate in the fashion of a computer component.[3] And once we have taken that step, it is easy to imagine that a market for such replaceable 'wetware' spare parts comes into being, where electronic brain simulation components are bought and sold. If you can't afford to have your brain (partially) replaced, you can lease an artificial brain, or part of it; that part then essentially belongs to, and is under the control of, the company or person who purchased it initially. It can be remote programmed and steered, and people will truly 'be like machines' (Mey 1982).

As we see, the viewpoints commonly advocated by Cognitive Technology in these matters, especially with regard to the way the computer impacts on our minds, imply a number of grave consequences that we ought to consider carefully in the light of our assumptions about the mind as an instrument. Is it the case that the instrument will become the main player in this game? How can we vouchsafe for the freedom and independence of the individual, while keeping the beneficial effects of 'computerizing' the mind? Without giving up our view of CT as 'mind-boggling', we still don't want to end up in what one could call the extreme and perverse end of CT, where everything's just computational (as in the illustrious 'computational tar-pit', to use Alan Perlis' immortal expression; cf. Mey 2001:178), and where the 'soul of language' (Gorayska 1994), the mind itself, is forever gone.

In the next section, I will consider what it means to have the mind impact on the computer and vice versa, what are the implications of the computer impacting on the mind.

3. Mind changes instrument, instrument changes mind

Don Norman has remarked that 'artifacts [including such things as tools and instruments, JM] change the tasks we do' (1993:78; but it is equally true that they change our minds, such that the tasks we seem to be performing not only are no longer the same tasks; in addition, we consider ourselves as changed in relation to the tasks.

A housewife owning a vacuum cleaner is changed by this fact of ownership, as many have remarked when this household gadget (supposed to relieve the lives of countless women around the world) turned out to be a mighty tyrant in its own right, adjusting and raising the standards for housework that had been prevalent until then. Another example is that of the leaf-blower, discussed elsewhere (Mey 1996).

Among the things that are said to distinguish tools from instruments is the amount of 'guidance' that the artifact allows, respectively expects us to exert. Instruments provide feedback on a process; tools usually just make the process happen, and do not adjust themselves to change the product as it emerges. A glass blower's pipe is a tool that permits the blower to shape the product at the end of the pipe, and currently adjust its form until the desired shape has

been obtained. But if we want to do the same, using a mechanized artifact such as an 'automatic glass-blowing machine', we will need to have controls steering the blowing process: instruments that allow us to keep track of the ongoing process, and adjust it so that the machine continues to operate satisfactorily. But at the same time, the instruments act on our minds; they are an intermediate between mind and tool, more 'reflexive' than tools and coming closer to what Norman calls a 'compositional medium', where 'compositionality' is understood as the quality of mind that 'allows [affords] adding new representations, modifying and manipulating old ones, and then performing comparisons' (1993:247).

There is, of course, always some reflexive activity involved in even the simplest mechanical tools and their operation. I hear the difference in sound when my saw is half way through the log, as against when it approaches the bottom side of the log; should I be so unfortunate as to graze a hidden nail that someone has hammered into the tree many years ago, again, the sound will stop me from sawing on. But there is a considerable distance from, and difference between, the reflexivity that is happening in the mind, when I think and compare the process with its outcome, all the time adjusting and evaluating, then adjusting again, along different dimensions, and the reflexivity involved in tool use, where the reflexive cycle is unidimensional and short-lived (as in the saw example).

I want to suggest that we can project the various artifacts that join mind and nature along a scale of lesser to greater distance, and that this scale is matched by another one, going in the opposite direction, that of feedback. Feedback is inversely proportionate to distance, such that the artifacts closest to the human mind have the most extensive and most 'compositional' feedback (i.e. they feed information back into the mind along different dimensions, and allow for comparisons between the various effects of the process), while at the bottom of the scale, we find the world, as it presents its raw materials to us, offering itself for development by the means of human tools.

The case of the *prosthesis* provides an interesting example. As discussed elsewhere in the literature (cf. Janney 1999; Gorayska & Marsh 1999), prostheses take over part of the tasks that the human no longer can, or is interested in, performing. Prostheses may be purely mechanical, and resemble tools: like the hook that the pirate captain brandishes in lieu of a hand (but still, we don't consider this gadget a tool or an instrument). Other prostheses are more sophisti-

cated, and sometimes even programmable, so that they can cooperate forever better with the human in exercising some of the erstwhile purely human functions. This is especially the case with those prostheses that we strictly speaking may call 'instruments of mind', as in science fiction's computerized and replaceable body parts: take the built-in eye wear, 'invented' by William Gibson, that will give you a readout on time and date, but in addition can be wired directly into your home computer or other people's 'sensoria' (1984).

Graphically represented, the 'hierarchy' looks like this:

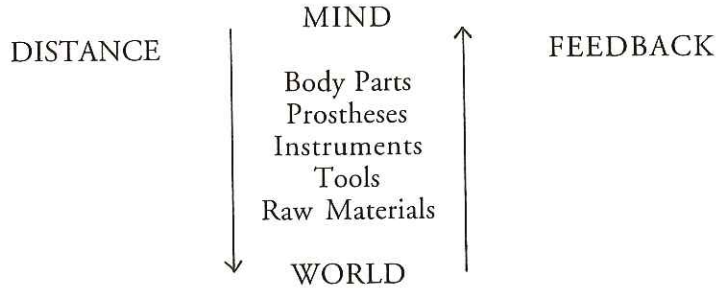

Figure 1. The Mind-World Hierarchy of Artifacts

As far as the distinction between tools and instruments is concerned, a couple of conclusions remain to be drawn:

1. We use tools to work on instruments in order to adjust or repair them. This is why a tuning key is a musical tool, while the piano key is (part of) an instrument. A tuning fork is likewise primarily a musical tool (in extreme cases, one could imagine it being used as a musical instrument, e.g. when electronically amplified as part of an orchestra).

2. The closer an artifact comes to the top of the scale, the more it resembles an instrument, and conversely: the more it approaches the bottom end, the more tool-like it becomes. The same artifact can function either as a tool or as an instrument; above, we saw how the kitchen knife could function as a scalpel (an instrument).

Or consider the painter's brush. A house painter's brush is a tool, whereas the landscape painter uses what, abstractly speaking, could be the same physical item as the painter's brush, as an instrument; the difference is in the distance and the feedback. The house painter executes a mechanical operation with standardized routines aimed at facilitating and speeding up the process. You have to think of the paint brush as a pump, says Schön (in a too little quoted article; 1993:139ff); in practice, this means that you have to listen for a typical 'feedback' sound from your brush. If it says 'swish, swish', you're OK with regard to the quantity of paint that you're transferring on to the wall you're painting ('pumping paint'); if it says 'scrape, scrape', you're cheap on the paint ('your pump is dry') and the result will be an unequal layer of paint. In contrast, the landscape or portrait painter is listening with his mind: the feedback s/he perceives is of a different, 'mental' character ('Is this the color or the nuance I want? Do these lines correspond to the image I've got in my mind?'; and so on).

3. Both tools and instruments are intermediaries between the world and the mind; if we want a generic name for them, we may call them, with Norman, 'artifacts'. The computer then, being 'reflexive' and programmable (and maybe partly 'compositional'), clearly is an artifact that is placed rather highly in the hierarchy. It is a mental instrument, and in many cases could even be called a mental prosthesis (see Janney 1999).

4. The feedback that happens from artifacts (and here I'm not even excluding the unadulterated raw materials, such as natural resources – God's artifacts, one could call them) to the human mind changes the mind. Minds are altered, based on the feedback they receive. Then again, the altered mind naturally expects a different type of feedback, and this in turn creates the need for new instruments (or artifacts). So, depending on feedback, an instrument may move up the ladder to eventually become a prosthesis or body-part (see Figure 1, above). The artifacts that we call 'instruments of mind' are not a fixed, rigid, immutable category: thanks to the dialectical nature of the feedback cycle, they keep changing all the time, and do this, hopefully, and under our guidance, in the direction of the more humane, towards what is often called a 'human' design.

The next sections will deal with design and use in human artifacts.

4. Artifacts, design, and use

What are principles of good design? In particular, what principles should guide us in designing artifacts that embody the principles of Cognitive Technology? I will consider these questions first from the point of the artifact, then from that of the user, and third, from that of the designer. Finally, I will try to bring these points of view together in what I call the 'dialectics of artifact design and use'.

4.1. On artifacts, cognitive and others

The notion of artifact was originally coined in physical anthropology and archaeology. It is used to indicate the presence of a human agent in a piece of nature, as for example a fetish or a tool. If I find such an 'artificial' object in nature, my first thought is that there has been somebody out there who made it, or put it there. By extension, the artifact can be used in various other ways: e.g., to prove the existence of God.[4]

In a further extension of the notion, one could consider the fact of finding to be an act by an agent that transforms the object or piece of nature into an artifact by the mere fact of its being found. This is the case of the so-called *objet trouvé*, the odd item (possibly itself already an artifact) that enters the artist's conception of nature, as expressed in the work of art.

As the name indicates, cognitive artifacts are of a different, special kind: they have something to do with cognition, with the way humans cognizingly enter and represent the world. A good example is the artifact commonly known as the book. Norman gives the following description:

> Cognitive artifacts are tools, cognitive tools. But how they interact with the mind and what results they deliver depend [*sic*] upon how they are used. A book is a cognitive tool only for those who know how to read, but even then, what kind of tool it is depends upon how the reader employs it. (1993:47)

Considering the tool as an artifact of cognition means that we somehow must be able to use it in our cognitive operations. At the low end of 'toolness' we find such devices as the cairn or other stone artifacts, possibly used in measuring the time or seasons, or a system of arrows designed to point the way to food, or the primitive stone cutter's chisel, used to produce an inscription. In the case of the book, the feedback that the reader gets from the book may be quite different, depending on his or her world orientation and cognitive stance. If I throw the book at someone (in the non-metaphoric, extra-judiciary sense), I use the book as a weapon. Small children use books to tear them apart. (That's why children's books are printed on heavy canvas or cardboard). Older children look at pictures. Adults (and younger proficient readers) spurn pictures and want to go directly to the text itself. Mature readers take in all these 'bookish aspects' and synthesize them into one smooth, well-adapted reader behavior.

The complexity of the tool is one factor to consider (as we have seen above, section 3). But complexity in itself is not the only thing to worry about. A tool can be extremely complex, yet not transcend its 'toolness'. This is where representation enters the picture.

Cognitive artifacts represent the world to us. Charles S. Peirce distinguished between three ways of representing: by indexes (an arrow pointing to some location), by icons (the artifact having a certain resemblance to the object represented, such as the common pictogram for 'No Smoking': a cigarette (or a pipe, or a cigar) in a circle outlined in red, with a line drawn across it from top left to bottom right), and by symbols (tools such as words, that represent through a mental operation of recognition that has nothing to do with their shape).

But representing is not just a state: it is an activity. Humans are representing animals: whatever they do, there is some meaning attached to it, a meaning that most often is pretty far removed from what the activity itself represents. For instance, walking as such is pure locomotion; but if a member of the Roman Senate picks up his toga and walks from one end of the Senate Chamber to the other, in order to take up his place there along with his colleagues making a similar movement, he performs an act of voting: 'going with your feet to a decision', *pedibus eundo in sententiam.* The movement becomes a 'motion', as we nowadays call it, seconded and approved by the body, the feet. (Ernst Cassirer called humans

'symbolic animals', which is of course the same idea, but applied more narrowly to language as the symbolic representation par excellence).

To go back to the cognitive artifacts and their characteristics: As Norman points out, to understand cognitive artifacts we must begin with an understanding of representation (1993:49). But this is not enough. Far from it: the best representation only comes alive on the condition that we have a representer who actively interprets the represented. In other words, the artifact (of whatever kind) must be such that it one, exhibits enough complexity to offer a complete (or at least passable) representation; two, represents in such a way that the people using it will have no trouble identifying what is represented and how it works, given the representation.

Moreover, whenever an artifact represents, it does so only on the condition that its way of representing is adapted to, and adaptable, to the represented and the representer. This adaptation, however, shouldn't be seen as a quality given once and for all; adaptation is a process of give and take, of mutual conditioning, in short a dialectical process. The next sections will discuss how this affects our view of the user and of the design of the mental artifact that this article is about.

4.2. The use(r)

In questions of design, the user is traditionally thought of as an 'end-user', that is the people at the keyboard of the PC or the Mac, not the persons dealing with software or hardware at higher levels of use (such as software support managers, systems analysts and programmers, and so on).

These users are the ones that have to 'live' with the software, not 'off it'; hence the demand that instruments of mind must be such that the user is able to live with them. This claim for 'convivial' tools (originally formulated by Ivan Illich, 1973) centers around the notion of a dynamic, changing context, in which a living organism adapts itself to constantly new environments, new challenges, new instruments, in short, a new life. With the reservations I have formulated elsewhere (Mey 1998), the user, in order 'to survive as a skillful tool-user of computer artifacts, [has] to adapt to changes, not just get more experienced with the tools [he/she] already knows'

(Ehn 1988:394; I will return to the idea of 'adaptability' in section 4.4, below).

4.3. The design(er)

The first and most important question to raise in the context of CT design is: Who is the designer working for? (A variation on the theme of: 'Whose minds, whose instruments?'). The designer is a Janus-like figure, who at the same time must keep an eye on the market and his or her employer (and more indirectly, on his or her own status in the market place or the company), and on the user, as the final arbiter in matters of what sells and what doesn't.

As Don Norman once has remarked, even the very notion of 'user-friendliness' can be read in different ways, and not all of them are to the benefit of the user. What the designer thinks the user needs, and consequently incorporates into his or her idea of 'being friendly', may well turn out to be a highly irritating feature of an overblown information content (often repeated to infinity) or a set of instructions that, once internalized, are not 'helpful' any longer (a good example is the 'Help' function on many personal computers: one has to wade through oceans of 'friendly' advice before one gets to the 'meat'; shortcuts are possible, but only practical if you know how to formulate your request for help in the exactly right manner). 'Start with the needs of the user' (Norman 1986:59-61) is a good, general recipe for design, but it has to be made more concrete to be useful.

Anticipating the needs and wants of a user can be a tricky business. The traditional profile of a user as one who just wants to have a tool to assist him or her in a particular activity (e.g., replacing the typewriter in the production of written texts) is no longer valid. Users want *instruments*, not just tools – and they want instruments of the mind, that is to say, devices that can help them change their mind behavior, literally 'blow their minds'.

Such a new attitude to computer technology has of course both its positive and its negative sides. On the positive count, we notice a new degree of freedom in the written word: the extreme finality of the text in 'black on white' has been replaced by the finer tonalities of black on grey (or green or magenta or any other color that I might prefer), thereby reducing the anguish of the writing process and relieving one of 'mind-blocks' of the kind that writers used to be

plagued by. (Remember Jack Nicholson as the frustrated writer in *The Shining*?).

On the negative side, one has the impression that for some, the option of re-using (or 'recycling') one's words has become a veritable instrument of the mind, maybe even a writer's 'mind-set' (and not a particularly good set at that). As editor of three journals, I have come across authors who brazenly submit the same article as 'revised', when the only thing they have done is changing the font and the type size. A Japanese friend once told me about a university colleague of his, whose productivity had increased remarkably after he got himself a laptop. While this person never used to write more than a single article every two or three years, he now had produced already five in the course of a mere 9 months – but, as my spokesman said, 'they're all the same'.

Between replication and expansion of the mind, we have to steer a precarious course. It is all right to opt for a 'user-centered design', in Norman and Draper's (1986) felicitous phraseology; but the users' minds and their instruments should not be centered solely on their personal goals, or on the limited goals set by the producer. As we have seen above, in section 3, the mind should change in the direction of greater flexibility and true adaptation, not mindless repetition and mechanistic adaptivity (Mey 1998).

4.4. Use to design, design to use

Ehn has drawn our attention to the fact that there is an apparent contradiction built into the very notion of design. Just as 'the division of labor is not only social but also technical, [the] design and use of artifacts [read: instruments, JM] is not only technical but also social' (1988:101). What this means is that the technical aspects of shaping an instrument to the specifications of a user inevitably will have an effect on the user him-/herself; and conversely, the influence that the user exerts in choosing between diverse instruments (say, computer software or applications) will have its influence on the way design is carried out.

But not only that: the relationship is one of true *dialectics*, as best illustrated by the general case of tool-use. Improving my tools will not only enhance the quality of my product; as a result, my relationship to the work process will change, and so will my mental

attitude, my understanding of what I am doing. Changing the tool thus eventually changes the worker, who then in turn will change the use of the tool and the work process, and eventually the product itself.

In all this, we recognize the fundamental processes that are seen as characteristic for CT. The mind creates its instrument (in our case subsumed under the general label of 'computer technology', as we saw in section 3); but using the instrument does not leave the users (and their minds) untouched. The dialectics of mind and instrument has to reflect itself in the design process, designers and users interacting in the creation of mental instruments. Only in this way can the 'hidden dimensions' of design be brought out into the open: to wit, the social relations that are encapsulated in the design, as well as the social labor that is 'congealed' in it, to use Marx' expression. The computer as an instrument of mind is 'neither natural nor given' (Ehn 1988:100); the same goes for its use, which has to be negotiated in a context of social responsibility and human adaptability.

5. Conclusion

When talking about instruments of mind, we have to be clear as to what our terms are. In the preceding, I have mostly talked about the various interpretations of the term 'instrument', and how they fit our 'mental' picture of the world and ourselves, including our relationship to the work we are doing. The question of what is meant by 'the mind' is a much more vast and tricky one.

As Lindsay has remarked, talking of minds and possible 'mind-changes' as a result of using the computer, '[t]he model of mind which has been most influential in western thought is that associated with Cartesian dualism' (1999:50). In this view, the mind is considered some kind of unit separate from the body, but in contrast to the latter, immaterial and dimensionless. Compare that in our days, after the behaviorists' 'mindless dreams' of the late nineteenth and twentieth centuries, the mind seems to have had some kind of revival, a 'ghost' reappearing in the 'machine', to borrow Ryle's expression (quoted by Lindsay, *ibid.*).

But rather than go into the debates around the existence or status of this elusive 'thing', the mind (see Lindsay 1999 for a fruitful

exposition-cum-discussion as regards the possibilities of 'mind-changes'), I would rather, in the guise of a conclusion, specify the ways in which the mind operates in relation to its instrument, the computer. Or maybe it would be better to start at the other end, looking at the computer with our mental eyes, and ask ourselves: What kind of instrument do we want this 'mental artifact' to be?

The answer, of course, depends on the way we look at it. To vary the poet's saying, just as the beauty of a thing, the usefulness of an instrument 'is in the eyes of the beholder'. Briefly: the instrument is only as good as the mind that is beholding it, or that it is beholden to. And this has some serious repercussions on the way we see the future of our mind-computer cooperation and interaction.

In the early days of the computer's entry on the mental scene, it was thought of as a practical device for calculating and numbering. It evolved into a tool for replacing drudgery (in mental operations such as dictionary look-up and making concordances). A little bit later (this was in the early sixties), some smart educators found that the computer could be programmed to take over certain tasks that they did not feel motivated to perform, such as the drilling of students in grammar, or the grading of exam papers. The outcomes of such thoughts are well-known: we got the phenomenon called CAI (computer assisted instruction), in which the laboratory drills that used to be performed individually by the students using a tape recorder and a microphone, or just pencil and paper, now were introduced in the form of programmed functions on the screen, where instant feedback (and a possible symbolic remuneration) became the propelling force in the learning process.

In this case, we see how the computer, reproducing a mindless program, became mindless itself. The computer as instrument of learning was no better than the lackluster routines that it replaced; but while the latter always could be repaired by the presence of a live teacher, computer-aided instruction had no such options and as a result, this use of the computer instrument quickly faded into the background.

Grading exam questions in computerized mode led to another atrocity: the 'multiple choice' text. The early computers operated with a programming input derived from the original Hollerith punched cards (Hollerith's patent was acquired by IBM in the late eighteen-nineties, and laid the foundations for the firm's subsequent prosperity and expansion). The thought then naturally arose: If one

can feed information about programming into the computer in this way, to be executed purely mechanically, then why not try and feed information about students' learning progress into the machine in the same way, and have it 'executed' (read: tested) in a similar fashion?

In order to realize this project, one had to have something that was analogous to the Hollerith system: a punched card with a certain number of options. The five part multiple choice question is therefore a direct derivate of the original 32-slot IBM punch card (I have no idea where the number five came from); limiting the options for answers in this way, to be executed by punching holes in a card (or by blackening a box on a form), became the standard for both questionnaires and examinations. (I refrain from commenting on recent catastrophic consequences of this punching technique in a much commented-on national election).

Rather than checking on understanding and learning, the multiple choice test was a check on the presence or absence of certain elements of knowledge, to be separated out and identified as discrete amounts of factual 'stuff'. The only right answer of the five revealed the presence of this knowledge, whereas all the other options, no matter how ingenious, and perhaps more interesting as answers, were discarded as 'wrong'. Again, a mindless procedure incorporating itself in a mindless instrument.

The conclusion is that our instruments, the computers, never will be better than our minds. Rather than worrying too much about the facilities and enhancements (of a mere technical nature) that one may want to introduce into one's computer programming or software 'packages', we should ask ourselves what the mental options are that we want the computer to 'instrumentalize', or help us carry out. To stay in our educational example: the whole difference between grading a paper in the classical way and testing a student's knowledge with the aid of the computer is in the mind and in the mental operations it presupposes.

When the two young students in Roger Schank's recent book, a futuristic fable about the decay of education (2001), finally get to talk to Old Joe, the only remaining teacher of the 'old school', they are astonished to learn from him that in his time, he used to give grades for class and home work, rather than merely reporting test results.

> 'You mean there used to be grades for courses instead of test scores?' asked the girl. 'Yes, there were', replied Joe. 'There was once a time when what the teacher taught was different from what the Testing authorities tested. ... Once [the Testing authorities] started to pay the teachers according to the test scores their teaching pro-duced, all pretense of education was gone. Now it was just tests, tests, and more tests. Soon there was no instruction, only tests'. (Schank 2001:96)

In the story, Scrooge (reincarnated as the director of a mega-testing company) finally repents, and reverts to the teachings of his old professor John Dewey, vowing to put an end to the mindless instrumentalization of learning, abandoning all his test equipment and mindless testing operations, in order to go back to an old fashioned 'sharing of the minds'.

As we put the horse before the cart, so, too, we must put the instrument before the mind. In order to improve the quality of our instrument of mind, the computer, we have to learn how to instruct and improve, not just test and check, the mind itself. And to the extent that the computer tool can help us in this task, it is going to be a useful mental instrument, rather than a mindless artifact.

Institute of Language and Communication
University of Southern Denmark
Campusvej 55
DK-5230 Odense M

Notes

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1. In the capitalist mode of production, the tool furthermore becomes capital. Cf.: 'A negro is a negro. Only under certain conditions [that is, in a slave economy, JM] does he becomes a slave' (Marx 1971:155; quoted Ehn 1988:97).

2. This term being itself a further example of the same derivation: 'that with which one adorns oneself' (cf. 'to garnish'). Cf. also other English Latinate expressions such as 'govern-ment' = 'that by which one governs, or that which governs'; 'statement' = 'that by which I state, or: that which I state', etc.
3. The idea, originally due to researchers like Christopher Langton and his associates (see the articles in Langton 1989, 1992, 1994), that AL is all about essentially programmable functions replicating 'the logical form of life', is expressed as follows by Stefan Helmreich: 'formal and material properties of entities can be usefully separated, and what really matters is form' (1998:211). For some fascinating visionary illustrations from the sci-fi literature, compare the works of William Gibson, e.g. *Neuromancer* (1984).
4. This is the first of the four 'canonical' proofs, often called 'the watch in the desert proof'; among the remaining three, the best known is the so-called 'ontological' one, of dubious fame.

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