Metaphors, Computers and Architectural Education

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In this paper we present the case for employing metaphor to explain the impact of technology. This contrasts with the empirical-theoretical method of inquiry. We also contrast two widely held metaphors of architectural education (the EPISTEMOLOGICAL and the COMMUNITY metaphors) and of the role of the computer (the MAINFRAME and the URIQUITOUS COMPUTING metaphors). We show how in each case both metaphors result in different kinds of decision making in relation to resourcing an architecture school.

1. Understanding Technology

It is difficult to plan for computer technology. The technology is changing rapidly and unpredictably. Technologies also change work practices, so it is difficult to identify need independently of the technology that is presented to address that need.

Unfortunately, there is no empirical-theoretical method to assist in decision making in this area. According to the theoretical method, we make observations about the practices of a group of people (such as designers). Then there is an attempt to identify variables, to find correlations between variables, and to form generalisations. In so doing there is an attempt to uncover the underlying structure of the practices under study. We then move into a new experimental context where the generalisations serve as tools for prediction. So we apply our findings to new situations, such as designers working with Computers. We would know from our generalisations about designers that they require large drawing surfaces, they need somewhere to display their work, they work with models, and they sketch. We could also plan for emerging technologies, such as computer-mediated collaborative design. We would know that designers need common drawing surfaces, a means of exchanging information, audit trails, and they need face-to-face contact with groups of people. Such generalisations would thereby guide our research programs, curriculum development, and decision making about computer resources.

However, the invention, design and integration of computer technologies is far more fluid than this. The process is more usually one of prototyping and informal testing in use. It is obvious that the practice of design is influenced by the technologies to hand. In tacit recognition of this influence, computer-aided design research is usually conducted around case studies. In a similar manner, teaching programs and resource decisionmaking are usually worked out by pooling experiences. Underlying principles are elusive. Does this mean that CAD research programs, curriculum development, and
decision making about computer resources are chaotic? In this article we show that this is not the case. The way we invent, design and integrate computer technologies can be accounted for in terms of metaphor. By recognising the role of metaphor it is possible to abandon the idea that there are underlying principles governing practices. A recognition of the role of metaphor involves a recognition of how effective decision-making actually occurs. It opens up the possibility of better decision making.

2. The study of metaphor

There is a growing body of work that asserts the primacy of metaphor in understanding (Schön, 1963; Ricoeur, 1977; Black, 1979; Lakoff and Johnson, 1980; Johnson, 1987; Lakoff, 1987; Sternberg, 1990). To speak metaphorically is simply to relate two entities through the verb "to be- (is) or the preposition "as"-the mind is a machine, I see the drawing as a square and a triangle, that person is a dynamo, design is searching a problem space, I see the floor plan as a flow diagram, a building is forms in light, she is an architect. The importance of metaphor in understanding the operations of language cannot be over stressed. Writers such as Ricoeur (1977) argue that the operations of metaphor permeate our very being. All statements in language are metaphorical, from the "primitive" act of pointing to an object to profound utterances in science or poetry.

A summary of how metaphor operates is provided by Snodgrass and Coyne (1992). Only the main points are summarised here.

d) Metaphor is not something that is to be explained in terms of substitution-that is, a substitution of the exotic for the prosaic ("celestial dome" instead of "sky," sceptred isle" instead of "England"); stating something figuratively that could just as readily have been said literally. (In fact the whole idea of a "literal statement" is under question.)

e) Metaphor is not merely a case of seeing the unfamiliar in terms of the familiar. For example, terms such as "mind" and "machine" often appear interchangeably as the terms of a metaphor: the mind as a computer, a computer as a mind.

f) Neither is the relationship between the terms of a metaphor (such as "mind" and "machine") established through lists of commonalities-what features does a mind have in common with a machine?-as though we could list these features and tick off the common ones. Definitive feature lists are elusive. The power of the particular metaphor lies in its use in a particular context of understanding.

g) Neither is metaphor able to be explained in terms of the operations of logic. To presume the reduction of metaphor to logic is in turn to generate contradictions. To assert that one thing is another is also to assert that the thing is not the other. To assert that design is search is also to assert that it is not search. Every such assertion entails the counter assertion that the thing is something more, or less, or different (Snodgrass and Coyne, 1992). As will be explained subsequently, a recognition of this negating role of metaphor is extremely valuable in the analysis of a technology. However, seen in terms of logic, metaphor seems to trade in contradiction.
The terms of a metaphor reflect back on each other. Computer as mind informs our view of both computer and mind.

It follows that metaphors are not to be considered merely as linguistic ornamentation, but imbue the entire working of language. Juxtaposing "design" and "search" (as in "design is search") is as much a metaphor as juxtaposing person" and "dynamo." Scientific models are metaphors, and metaphor is in play as scientists make observations (Eisenberg, 1992).

3. The entailments of metaphors

What is the advantage of studying the metaphors we use? Metaphors carry entailments. In so doing they reveal and conceal. Seeing one thing as another reveals something about the thing: a problem to be solved, an action to be undertaken, a scenario to be acted out. To see design as search may entail setting goals, defining the design space, establishing decision points, ordering actions. (The precise nature of the entailments will depend on context and understanding.) So metaphors are implicated in an understanding of actions and consequences. Metaphors also conceal. As long as we are articulating goals we may momentarily leave to one side understandings wrought through other metaphors: the fluidity of design, the role of social interaction, caprice. Metaphors also entail privilege. Not all metaphors are equal for a particular situation. For example, it is acceptable for the metaphor of design as search to prevail in the context of certain kinds of design research, but less so in most architectural design studios. Clearly the metaphor of mind as machine has enjoyed privileged status in some quarters.

The greatest privileging is where certain metaphors are so taken for granted that they are not generally seen as metaphors. This is the realm of "literal language:" the entities that make their appearance as the terms of a metaphor-mind, machine, person, dynamo, design, search, analysis, situation. Objective, analytical talk is simply an appeal to certain highly privileged metaphors. To say "let's analyse the problem" is to see design as problem solving. There are entailments: there is a problem to be overcome, it can be broken into parts. If a grasp of metaphor is slippery then the quest for literal language is totally elusive (Lakoff, 1987). A study of the metaphors we use is informative as a means of revealing "hidden entailments." It exposes that which is taken for granted.

Of course, to study metaphor is never to break out of the system. All statements about metaphor are metaphorical. That a metaphor is the juxtaposition of two ideas is a metaphor. The efficacy of this kind of study lies in whether it progresses our understanding.

It can be shown that an understanding of metaphor in turn provides an understanding technology. There are several arguments by which the link between metaphors and technology can be forged.

4. Technology and metaphor

Technology is commonly understood through particular metaphors and itself provides a metaphor for other phenomena. For example, technologies are sometimes described in terms of biology (the evolution of computers, a species of inventions [Basalla, 1988]), and biology is sometimes understood in terms of technology (the inputs and outputs of
biological systems). A similar reciprocity is observed in the case of computers and mind.

But technology as a source of metaphor can also operate in far more subtle and powerful ways. Technology can furnish us with metaphors through which intellectual movements are set in train and gain impetus. Writers such as Ong (1982), Havelock (1986), Illicit and Saunders (1988) and Heim (1987) assert that the developments of literacy and print have contributed substantially to the primacy of method, individualism and notions of objectivity, leading the way for the Enlightenment and modern science.

It is in this climate of dominant metaphors that problems emerge. The view that technology and metaphors interact puts to one side any suggestion that technologies arise as a response to some abstract need or problem. Technologies, metaphors and problems are interrelated in a set of changing associations. According to Schön (1979) different metaphors promote different problems. Technologies are commonly advanced as the solutions to particular problems, yet it is apparent that the technologies have brought about the metaphor shifts that define and even create the problems. Thought is shaped by the technologies in such a way that the technologies are readily accommodated. One example is the powerful metaphor of design as information processing. Communications technologies have prompted us to see design in terms of passing around information. The problems set by this metaphor include how to best convey information from the designer to the contractor, how to formulate accurate databases, and how to minimise ambiguity through formalised drawing conventions.

Metaphor also features in an understanding of important dependencies between technologies. We understand and develop new technologies and new designs in the light of our experience of existing technologies and designs. This can be seen as a metaphorical phenomenon. The early technology sheds light on the new technology: stone construction is seen as carpentry (in masonry Greek temples); plastic is seen as sheet metal (the early plastic bucket). Certain computer-aided drafting systems make extensive use of metaphors wrought through a consideration of manual drafting tools: the screen cursor is seen as a pencil or a paint brush (Mitchell and McCullough, 1992; Radford and Stevens, 1987).

The relationship between technologies is not a static phenomenon. New technology also sheds light on old methods of working. Construction in stone tells us something new about construction and structure. For example, an understanding of the resistance to compression and susceptibility to shear of stone informs us about the unique behaviours of timber. The metaphor prompts us to look at timber construction in a new light. In a similar manner CAD drawing systems inform us about the unique properties of manual drawing.

A study of metaphor also provides a means of understanding the development of the computer. First, understanding human thought as driven by metaphor challenges the privileged view that there is such a thing as "pure reason," and that the computer is a transcendent reasoning device with access to the "pure reason" of number and logic. The study of metaphor teaches us that these very concepts (of pure reason, number and logic) are based in metaphor (Johnson, 1987). Second, metaphor imbues the theories that drive our understanding of electronics and the various theories of computer organisation—the binary system, logic, set theory, formal languages, Turing machines and hierarchical organisation.

Metaphors are also implicated in an understanding of the power of particular technologies, through an appreciation of difference. According to metaphor theory, in asserting that a technology is one thing we are also at the same time denying it is that thing. When researchers of "hard" AI (Artificial Intelligence) asserted that the computer can (or could) think, it was clearly not the "thinking" qualities of the computer that
were of primary interest. The attempt was to make machines that do not get tired, become emotional or succumb to extraneous influences. The AI systems would not reside in bodies but live on desks, course through networks, and control complex manufacturing processes. The AI idea was marketed on a whole range of attributes that thinking clearly does not exhibit.

In a similar manner, VR (Virtual Reality) is promoted on the basis of how the experience of wearing "eye phones" to visualise stereoscopic views of computer models is unlike reality. Through VR it is possible to fly through buildings, break through walls, and reach out and move building components-facilities that "reality" does not provide. In a similar manner, the capability of video conferencing to bring people closer so that we see the screen image as the other person, is clearly also a negation-the image is not the person. So we behave differently than if they were physically present, we can make the person disappear with the touch of a switch, we can easily direct their attention by moving the camera, we can hide from their view, make them speak louder or softer, and communicate even though they are on the other side of the world.

So an exploration of the metaphors through which we understand technologies is also a study of what is denied by those metaphors. This strange phenomenon can be extremely enabling. Seeing technologies as something other than that which we take for granted opens up possibilities for new understanding and new invention.

5. Metaphors in practice

A recognition of the role of metaphor also enables us to recognise what is actually taking place as we invent, design and integrate technologies. Effective decision making involves identifying: dominant metaphors; metaphorical relationships; entailments (especially the problems set by the metaphors we use); and differences. According to this view decision making about technologies is case specific. It involves judgment based on experience, and dialogue based on shared and different experiences. The metaphorical view replaces talk of principles and plans with talk of scenarios: imagining a future based on our experience; projecting past experience with existing technologies as new technologies in new situations; and seeing new situations as past situations. Scenarios are contingent. A scenario is a best guess to be worked out and revised in the actual situation. (The empirical-theoretical method also trades on metaphors and is contingent, though its metaphorical and contingent nature is hidden behind the language of objectivity [Lakoff, 1987].) The metaphorical view also enables us to make explicit the fact that every prediction is an interpretive act, a matter of judgment. Judgement is primarily based on experience, rather than the application of principles about the underlying structures of some phenomenon (Gadamer, 1976; Fish, 1989). (More specifically, principles have to be applied, and their application is a matter of judgment.) The metaphorical view also encourages talk of precedent, similarity and difference-an enabling and liberating mode of discussion in the context of design.

What uses can an "analysis through metaphor" be put to? This kind of analysis provides insights into the practices of an organisation. Certain prevalent metaphors guide the organisation of work practices and decision making in organisations. These metaphors relate to how we see the organisation, its constituents, including personnel, clients, customers, users, managers, and equipment. Metaphors emerge through the practices of the organisation, its relationships to the wider world, the ideologies of related professions, trades and institutions, and pervasive technologies. The metaphors set the problems of the organisation, and define its successes and failures. Reflecting on the
prevailing metaphors within organisations can bring about change and provide pointers to future practice. This theme is developed at length by Lakoff and Johnson (1980).

More specifically, metaphor provides a valuable understanding of architectural education. For example, there are at least two prevalent metaphors that guide the teaching practices of an architecture school: (i) architectural education as the acquisition of architectural skills and knowledge (the EPISTEMOLOGICAL metaphor); and (ii) architectural education as initiation into a critical community (the COMMUNITY metaphor). These oppositions have been highlighted by radical educationalists such as Freire (1972) and Illich (1971), (also see Coyne and Snodgrass [1992]). Of course, these metaphors can be described with different terms, they are not mutually exclusive, neither are they the only metaphors through which we define architectural education. However, they are each prominent and each privileged to varying degrees in different circles, schools of thought, and architectural teaching establishments. An "analysis though metaphor" provides insights into two widely different modes of education.

What is the web of metaphorical relationships within which each of these metaphors is defined? The EPISTEMOLOGICAL metaphor trades in metaphors of knowledge as being built up, knowledge is foundational. The metaphor trades in the technologies of writing and print—the idea of the permanent record, accuracy, and repeatability. It can also be related to certain kinds of organisational practice: hierarchical organisation; the transfer of information through chains of command. On the other hand the COMMUNITY metaphor trades largely in metaphors of ecology, complexity within the whole, networks, dynamism, cycles, and conversation.

What problem setting entailments of the EPISTEMOLOGICAL metaphor include: how to establish rigour, define the knowledge base, ascertain the competency of graduates, transmit knowledge, and maintain standards. The COMMUNITY metaphor entails problems of maintaining a diversity of skills, encouraging collaboration, facilitating continued learning, and reforming accepted practice.

What differences and negations do each of these metaphors bring to light? As for any system within which the definition of a norm is rigorously pursued, the EPISTEMOLOGICAL metaphor brings to light a strong sense of "the other." The theoretical basis of understanding is set in opposition to practice—that essential but non-conforming range of activities institutionalised in the design studio teaching method. Strangely, the EPISTEMOLOGICAL metaphor also exposes a strong sense of the eccentric, the diverse—a point explored at length by Foucault in the context of military organisation and rigorously defined social practices. Where there is a strong sense of the norm there is also a recognition of deviation—the power of the norm "individualises by making it possible to measure gaps, to determine levels, to fix specialties, and to render the differences useful by fitting them one to another" (Foucault, 1984, p.197). The COMMUNITY metaphor also carries its own negation. The community that sustains itself also destroys itself, or rather changes its definition and its boundaries. The skills of a professional group that sees design as participatory is changing its boundaries to include users and clients. Teachers who see students as co-investigators and co-learners eventually "do themselves out of a job," or rather their jobs change. Were it not for change, the self critical community would eventually have no norm to criticise, and would cease to be a critical community.

What are the scenarios offered by these metaphors in relation to the use of computers? According to the EPISTEMOLOGICAL metaphor the agenda is to develop knowledge and skills in computer use pertaining to the practice of architecture. An obvious scenario is to focus teaching on the use of a particular CAD system likely to be encountered in practice. According to the EPISTEMOLOGICAL metaphor the teaching of computer use also proceeds from theory to practice. So the teaching of CAD should
begin with that which is certain: the rules, the principles, and the theories. On the other hand, the COMMUNITY metaphor opens up the pursuit of shared learning, and learning through involvement-application rather than theory. It also suggests that the technology be presented in a critical light. Students will be agents of change and influence the course the technology is taking.

6. Metaphors of computer facilities

A similar style of analysis can be conducted for deciding on the computer equipment needs of an architecture school. There is the metaphor of (i) the computer as a precious centralised facility (the MAINFRAME metaphor), and (ii) the metaphor of the computer as a shared, distributed resource (the UBIQUITOUS COMPUTING metaphor) (Winograd and Flores, 1986; Weiser, 1991). These metaphors are not mutually exclusive, but each has privilege in certain contexts, particularly in relation to the EPISTEMOLOGICAL and COMMUNITY metaphors of architectural education. There are other metaphors, and there are variations around these two. However, these two metaphors highlight significant differences in approaches to integrating and managing computer resources.

What is the web of metaphorical relationships within which each of these metaphors is defined? The MAINFRAME metaphor trades in metaphors of centralisation and control. It relies on the early technology of the large, powerful, expensive mainframe computer from which emanated peripherals and terminals. This metaphor readily conspires with the EPISTEMOLOGICAL metaphor of architectural education-centralised computing power and a centralised professional knowledge-base. The metaphor is also readily accommodated by centralised organisational structures. The MAINFRAME metaphor reveals not only a particular configuration of computer equipment (a centralised processor and file server) but an attitude and a style of management.

On the other hand the UBIQUITOUS COMPUTING metaphor trades in metaphors promoted through recent developments in computerisation that devolve power to the computer user: personal computers, local area networks, international networks, electronic communications, file sharing, miniaturisation, portable computers, high level software tools, and iconic interfaces. But it also trades on metaphors of the every-day--those things we take for granted. Weiser (1991) appeals to the metaphor of books, magazines, toffy wrappers and street signs: the "constant background of these products of 'literacy technology' does not require active attention" (Weiser, 1991, p.66). He cites the example of the "vanishing" of electric motors at the turn of the century. The average automobile now contains many motors and solenoids, but the driver is largely unaware of them. Electric motors have become inconspicuous and ubiquitous, as will computers. The UBIQUITOUS COMPUTING metaphor readily conspires with the COMMUNITY Metaphor of architectural education. Both suggest decentralisation, a devolution of power, inconspicuous organisational infrastructures, and a focus on the work task and interactions between people.

The problem setting entailments of the MAINFRAME metaphor include: a concern with controlling access to the facility, and maintaining integrity, consistency and security. The acquisition of the right equipment and its effective maintenance are essential, particularly the main file server or main processor, as the rest of the system depends upon them. Design issues focus on computational power. The facility has to be powerful and general to accommodate a wide range of unspecified work tasks, and to harness the benefits of economies of scale. On the other hand the UBIQUITOUS COMPUTING metaphor presents
problems of providing a flexible physical infrastructure through which computer equipment can be connected, and brought to the work task. It also entails the problem of providing an open ended organisational infrastructure through which equipment can be purchased, leased, and managed. The focus is on the work task and the way people interrelate. So the design focus begins with the people and their tasks: how can computers facilitate what they do? The solutions to these problem formulations of the UBQUITOUS COMPUTING metaphor may be other than technological.

What differences and negations do each of these metaphors bring to light? As with any centralised system, the MAINFRAME metaphor brings to light a subversive counter culture. The centralised facility breeds satellites of discontent for those whose needs cannot be met by the main facility. The system fragments, or rival systems are established. Those who do not agree with the policies of the centralised management seek to work around the system, to manipulate it, or to set up rival management systems. On the other hand the UBQUITOUS COMPUTING metaphor contains its own contradictions. Effective collaborators can agree to pool their resources and harness the economies of scale of a centralised facility. Also, a facility that is ubiquitous can be exploited by cynical suppliers. When the goods are taken for granted then the controlling suppliers can increase their prices (as with charges for the use of the ubiquitous credit card)-a "mainframe" type of control. Further, when computing becomes ubiquitous it may cease to be identified as computing. This carries its own contradictions. The companies providing the innovations referred to by Weiser may increasingly find that they are merely the suppliers of a small range of generalised products, such as powerful microchips. These components are then assembled by companies with specialised expertise in the work task-a similar process to that occurring with software development. Computing may simply be absorbed within a range of task-related products and services. As with electrical motor, ubiquity leads to a small number of highly specialised suppliers of components-a centralised, "mainframe" system of dependence. This is not a direct return to centralisation however. As with the COMMUNITY metaphor of architectural education these contradictions demonstrate how the UBQUITOUS COMPUTING metaphor is implicated in a dynamic redefinition of industries, markets, technologies and work tasks.

What are the scenarios offered by these metaphors for the resourcing of an architecture school? The MAINFRAME metaphor suggests the familiar scenario of centralised computer facilities, special laboratories, security access and the use of passwords. There are rules for the use of the facility, time restrictions, and the granting of permissions. The acquisition of resources fits within the conventional hierarchical model of organisations. Establish the needs of the users, formulate plans to meet those needs, then require the users of the system to work within the constraints of the facility provided. The facility is visually conspicuous. In some quarters this provides leverage for the acquisition of further equipment. There is also a strong demarcation between computer-oriented tasks (such as CAD modelling) and other tasks (such as manual drawing). This demarcation serves to define the facilities and the scope of the teachers and support personnel who use them. The advent of extensive local area networking and file sharing (as provided by the Macintosh System 7 operating system for example) does not automatically guard against the "mainframe mentality." The computers can still be kept in one room, it is possible to subvert the idea of an open system with a central file server and passwords, and the resources can still be controlled centrally. Computing appeared well served by this metaphor when the resources were expensive, difficult to use and their use was marginal to the main stream of architecture.

The UBQUITOUS COMPUTING metaphor suggests a different future however: it allows the metaphors provided by the emerging technologies of extensive networking and
portability to inform the acquisition, management and use of the resources. It is too early to provide confident predictions and guidelines. However, several scenarios are suggested here. They are already being acted out in some areas.

6.1 Focus on infrastructure

There is substantial precedent for the provision of ubiquitous goods and services, such as electrical power, published materials, and office supplies. The usual course is to focus resource management on infrastructure, such as the provision of a grid system in the case of electrical power, libraries in the case of published materials, and a distribution system in the case of office supplies. The focus is away from the actual item (kilowatts of power, books or paper clips) and onto the overall facility that enables the goods and services to be delivered, connected and rendered effective. In the case of computers this primarily means providing the network- to the design studios, library, offices, common rooms, work areas and lecture rooms. It also means providing telephone lines for remote access, and providing the expensive but essential peripherals, such as colour printers, scanners and file servers (though these need not be centralised). With the infrastructure in place the procurement and use of computing equipment can be flexible and devolved.

6.2 Flexible procurement arrangements

With a flexible infrastructure in place there are several options for the procurement and use of equipment. With the lowering of cost and increasing portability it is becoming feasible to hire and lease equipment to students and staff. The obvious precedents are borrowing books from a library, borrowing AV equipment, and the use of car pools. In time it will also be feasible for students to buy their own computers that they can carry around and connect to the network when needed. Whereas the design and cost of infrastructure is clearly a major management concern, the purchase of computers can be a matter for individual staff, students and interest groups.

6.3 Computers in learning

Where networked computers are ubiquitous then there is the possibility of new forms of communication, providing new dimensions to distance learning, and new kinds of collaboration among staff, students and researchers. There are many educational experiments under way with the text-based communication medium of Internet (the international academic and research network), which is soon to be extended to multimedia communication. Explorations in the Department of Architectural and Design Science at the University of Sydney and elsewhere reveal the potential of "e-communication." Students see themselves as participants in an international learning community, with access to other students, researchers, news services, lists and other e-communication Services.

6.4 Learning about computers

As computer technology is changing, any teaching syllabus that makes use of the technology has to be flexible. More significantly, the UBIQUITOUS COMPUTING metaphor places emphasis on the work task: designing, documenting, problem solving, composing reports, computer programming, and so on. At the same time it suggests the need for
critical reflection on what is taking place. The metaphor therefore suggests replacing the *theory to practice* mode of education with one in which there is an emphasis on learning by doing, accompanied by critical reflection.

6.5 Computer as a design tool

The UBIQUITOUS COMPUTING metaphor puts the spotlight onto designers and how they can work together better. The emerging field of computer-mediated collaborative design (CMCD) can be seen as a response to this. CMCD facilities are computer environments in which the four technologies of local area networks, e-communications, CAD and multimedia technologies are brought together at the work place to enable designers to model, visualise, evaluate and document their designs—and to do so collaboratively. Designers can work on the same task while located at different work stations, different cities and even different countries.

6.6 Computers at the work task

The UBIQUITOUS COMPUTING metaphor suggests that the computer can be brought to the work task. There is a recognition that computers will not necessarily supplant books, manual drawing and hand writing. The computer will be one of several resources to hand to assist in a task. This militates against the possibility of the complete, fully integrated electronic work environment. It also suggests that computers will appear wherever the professional happens to be. The use of mobile phones, tape recorders and other portable equipment provide ample precedent for this. The computer can be taken onto the construction site, and into meetings with clients at their homes. Students can use wordprocessing and CAD in the library, in the common room, at home, in the coffee shop and in the design studio. There are at least two interesting scenarios provided by the ubiquity of computing in the case of office practice. One emerges through the metaphor of the office as club (Duffy, 1992). Professionals join general purpose business establishments that provide infrastructure, a pleasant working environment, and the opportunity for strategic face-to-face contact. The environment is nonspecific. The specific work related support is provided through the computer. Obvious examples of organisations well suited to this kind of arrangement are those related to finance—where specific needs are met by communication and access to databases. A second (and not unrelated) scenario is where the professional is either itinerant, works from home or works in a very task-specific environment such as a studio. In this case the computer provides support for the more general business activities, such as communications.

7. The clash of metaphors

The scenarios are not the only ones suggested by these metaphors. Nor is it the case that the above scenarios (6.1 to 6.6) are only available if we embrace the UBIQUITOUS COMPUTING metaphor. However, seen through the MAINFRAME metaphor the scenarios can take on a different complexion: to focus on infrastructure can mean dependence on an essential facility to control, exploit and withhold; devolved funding and leasing arrangements can be turned into centralised accounting and control; e-communication can be recast in terms of placing people in touch with central databases and automated expert systems, monitoring computer usage, the use of punitive memos, and avoiding face-to-face contact; research into collaborative design environments can focus on
capturing "knowledge representations," user models, and other entailments of the metaphor of mind as machine; the computer at the work task can be cast in terms of designing more megalithic, multi-purpose office buildings with complex infrastructures. However, there is clearly an asymmetry between these two metaphors. There are problems and conflicts brought about the "clash of metaphors" of managing a distributed system with a "mainframe mentality." There are parallels between the two metaphors of education (the EPISTEMOLOGICAL metaphor and the COMMUNITY metaphor) and the two metaphors of computing (the MAINFRAME metaphor and the UBQUITOUS COMPUTING metaphor). There are also parallels with the oppositions with which this article began. The empirical-theoretical method of inquiry into technology is by definition epistemological, and is arguably a "mainframe," centralist view of understanding. On the other hand the view that understanding is driven by metaphor asserts the communal, dynamic, distributed and contingent nature of understanding.

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