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Dinosaurs and White Elephants: the Science Centre in the 21st Century[1]

JAMES M. BRADBURNE

Introduction

First of all, I would like to thank the Fondazione Agnelli for having invited me to contribute to its conference in Turin (March 1998), at which this material was first presented, and for its support of an open discussion about the future of the science centre in particular, and of informal learning systems in general. Second, I would like to make it clear that what I am about to express is my personal opinion, based on many years working in the field of informal education, and not the official policy of the institution I represented there, newMetropolis in Amsterdam. Readers will understand my caution better when I summarise the theses I am about to present—that science centres as they are presently constituted are dinosaurs threatened with extinction in the not too distant future, and that science centres as major capital projects are white elephants which can only saddle governments with unrecoverable debts. I have therefore entitled this paper, *Dinosaurs and White Elephants: The Science Centre in the 21st Century*.

After spending nearly fifteen years working on new approaches to creating public informal learning environments, including museums, art galleries, World's Fair pavilions, and of course, science centres, I have come, by the hard way, to the reluctant conclusion that the science centre is doomed. Almost ten years ago, in a paper written in 1989 subtitled *Truth telling and the Doing of Science*[2], I attempted to sketch a provisional history of the science museum as an expression of changes in the history of ideas, notably in the history of science. I argued that the seventeenth century emphasis on peer-reviewed empirical observation, an emphasis which largely defined the modern period, had profoundly shaped the development of all our institutions of informal learning, as the paradigm of the natural sciences was appropriated in every field of human activity. I argued that the resurgence of idealism in the twentieth century, in both philosophy and the sciences, had prompted a parallel transformation in the science museum, and that we were witnessing the birth of a 'third generation' of science museums, based on the active practices of doing science, rather than on the passive receiving of science as a canon of accepted truths. It was clear to me that we needed a new model for our institutions, based on the fully engaged activity of the visitor. I closed by saying "Third generation science is an attempt to unhook the cart of absolute truth from the horse of enquiry, so visitors can leave not saying 'I know', but rather 'I know *how* to know'"[3].

Since 1989, I have been one of a growing number of planners who have championed the idea that our institutions of informal learning must undergo dramatic change if they are to survive and remain relevant in the next century. Over the course of the past nine years, often in collaboration with the Canadian anthropologist and museum planner, Drew Ann Wake, I have been involved in a number of new approaches to the creation of informal learning environments. All of these approaches have stressed two key factors—'bottom-up', or user-driven learning[4], and flexibility. The first means that the user must be considered the starting point for all effective learning—most science centres argue that interaction is enough—however, hands-on interactive displays rarely allow visitors to shape actively the nature of their enquiry[5]. The second, that our strategies, installations and institutions must be able to respond quickly and effectively to change. Most science centres recognise the need to change rapidly, but, by focussing on their installations, they cannot respond quickly or effectively. Many of the experimental projects developed during this period may be familiar to readers. *The Body in the Library*[6], for instance, in which forensic science was presented in the form of a murder mystery, is now to be found in various forms in science centres from Sudbury, Ontario to Copenhagen. *Beyond the Naked Eye*[7], an installation about medical imaging technologies, based on case studies and medical challenges, has been widely copied. *Mine Games*[8], an installation where the subject of earth sciences was transformed into a forum for debate on the future of the mining industry, was for over two years the focal point for social and political discussion about resource use in British Columbia. Finally, newMetropolis in Amsterdam has opened in 1998[9] as a challenge to the view that science centres should have science as their central concern[10].

Despite the success of these experiments, few science centres seem to have been prepared to subject their practices to critical scrutiny. New science centres continue to be planned based on the traditional pattern of clusters of hands-on displays about science and scientific principles (the most popular display topic is physics)[11], and existing science centres still develop installations based on the assumption that physical interaction is a good thing, in and of itself. These traditional approaches to interactive displays share three signal weaknesses. They focus almost exclusively on principles and phenomena rather than processes, they misrepresent the nature of scientific activity, and they show science out of context—science defined 'top-down' by scientists, rather than as experienced by visitors[12]. Even when an institution tries to put science and technology into a social context, it is science and technology that is the point—not the society[13]. The dominant model in which science centres 'vulgarise' knowledge to make it palatable to the masses, or sugar-coat science with gratuitous hands-on interaction to arouse visitor curiosity[14], is rarely if ever questioned[15]. However, as a consequence of its inability or unwillingness to change, I would argue that the science centre as a social and educational institution is now under attack, an attack signalled by falling visitor numbers and the recent closure of institutions such as Baltimore's Hall of Exploration[16]. Its mission no longer meets the needs of society, its relevance to the public is diminishing, and it is being made superfluous by new communication technology.

These threats to the science centre cannot be lightly shrugged off, and it is clear that a real transformation of the institution is required. If science centres cannot rise to these challenges, they risk becoming, like the planetarium before

them, the '8-track cassette' of late twentieth century institutions—a transitional moment, fundamentally flawed, and soon replaced by new technologies. After nearly ten years of trying to create a 'third generation' science centre, I can only conclude that the science centre, both as an institution and as a building project, is doomed to extinction, as a consequence of two factors—ecology and economy.

The Ecology of Dinosaurs

Let us start with the proposition that the science centre is a dinosaur. Certainly the current building boom in America and Europe, notably in the United Kingdom, would suggest that the science centre is alive and kicking[17]. The number of science centres world-wide is growing[18], and there appears to be no end in sight. How can I possibly suggest that the institution is facing extinction? My metaphor is chosen deliberately. Dinosaurs became extinct for three fundamental reasons—rapid change in the climate, insufficient food to sustain their bulk, and increased competition from smaller, more flexible forms of life. In the same way, the life and death of the science centre as an institution is a question of ecology, and its demise just a matter of time.

Let me review these three points in detail:

The Traditional Science Centre Mission is No Longer Relevant

In its modern form, the science centre is a creature of Second-World-War American society. Spurred by the Soviet Union's conquest of space with Sputnik, stimulated by the race to put a man on the moon, and alarmed by increasing public scepticism about the benefits of such scientific blessings as pesticides, nuclear power and genetically altered food, government and industry have supported the science centre as a means of informing the public about science and technology. Like the dinosaur, the science centre fitted into an ecological niche—fed by government and industry in the lush tropical climate of the Cold War. Of course it was assumed that, once understood, science and technology, and the interests that directed them, would be seen in a favourable light. Thus science centre literature included statements like the following: "Still, all too often do the negative aspects of science and technology get attention, and not their positive effects on society. In order for society to fully benefit from science and technology, accepting them is an absolute necessity. The applications in our daily life are often experienced as threatening and lead to the feeling of lacking knowledge. One tends to ignore science unnecessarily. NINT can play an important role in informing the normal citizen"[19].

Or, to fulfil its role, "The objective is to excite interest in the basic principles of the natural sciences and the technological applications"[20]. The mission of the science centre was to inform and convert, and learning about science and technology was seen as a prerequisite for good citizenship. One of the leaders of the crusade, Jon Miller of the Public Opinion Laboratory at Northern Illinois University, commented: "I doubt that anyone would argue that a citizen who failed the minimal set of items included in this measure [of scientific literacy] would be very effective in following major issues in science and technology"[21]. Implicit in the enterprise was that the public was ignorant, and that the new

science centres, with their emphasis of hands-on, interactive experiences, would cajole and delight the public into understanding, and thus accepting, the social programme of those directing the scientific enterprises[22].

Now at the threshold of the 21st century, with the Soviet threat collapsed and the Cold War behind us, the traditional mission of the science centre is no longer relevant. New challenges face society, and understanding science and technology, in and of itself, does not seem to hold out the key to meeting these challenges. As Jean-Marc Levy Leblond noted, being an engineer is no more necessary to taking a position on the use of nuclear power than being a lawyer is necessary to vote. The issues facing the public are almost all social issues, in which economics, ethics and politics play as important a role as science and technology. The globalisation of the economy has now shifted the emphasis from political to economic survival[23]. In order to remain competitive in a period when the 'high-volume' production is increasingly being done in countries with lower labour costs, 'First World' societies must constantly create a new 'high-value' economy if they are to survive[24]. Such an economy means a dramatically new approach to education, an approach in which informal education and a commitment to lifelong learning plays an essential part[25]. If Europe, for example, is to survive economically, it must become a learning society, and its institutions must turn their attention to the challenges of enhancing skills, rather than merely dispensing information and arousing curiosity. This change in economic climate has been understood by national governments and industry, and has been clearly signalled in the European Union's 5th programme framework, which outlines the research and economic development strategy for Europe for the next four years, and stresses the importance of adapting to rapid change[26]. The traditional science centre focus on scientific information is simply no longer tenable if the next generation is to keep up with the speed at which society is being transformed. Knowing how a telephone works is not going to help us, knowing how to use one is.

The Institutional Model is No Longer Appropriate

In several key respects, the science centre has grown out of the museum tradition. Broadly speaking, institutions of informal learning follow one of two models—the library and the collection of objects. The library is a resource, and it puts the accent on use, especially directed by the user himself. The organisation of a library is a function of its use. The collection, on the other hand, is meant to be displayed, and its identity is bound to the collector, or more recently, the curator. The organisation of a collection is a function of the messages its organiser wishes to communicate. The prime consideration of the library is the user, and of the collection, the visitor. The science centre has largely followed the model of the collection, despite the fact that one of the distinguishing features of these new institutions—hands-on science centres—is that effectively they have no collections. The first of them, the so-called 'second-generation' science centres, were basically 'collections' of physical principles and phenomena. The science centre was in the words of Frank Oppenheimer, 'a forest of phenomena', places where the public could experience at first hand real phenomena—spectra, electricity, inertia and illusions which allowed the visitor to reflect on his own perception—phenomena increasingly being squeezed out of the class-

room and out of daily life as well. Nevertheless, like museums with collections, the public function of these institutions was to show, to display and to illustrate[27].

But following the model of the collection increasingly comes at a high price—that of dependence on visitors. A collection is visited, and once visited, the visitor's task is fulfilled. The objects in a collection are exhibited—displayed to a public which is often unable to engage with it due to lack of interest, inclination or information. With their phenomena and principles enshrined in hands-on displays, and their outcome repeatable and predictable[28], the science centre's collections too are often exhausted by the visit[29]. Notwithstanding the importance of the 'affective' or emotional impact of the museum visit[30], several museum visitor studies suggest that most museum visitors come three times in a lifetime[31]—as a child (often in a school class), as a young parent, and as a grandparent[32]. This general pattern is of course mitigated to some extent by what the tourist industry calls VFF—Visiting Family and Friends—so when your sister-in-law drops in with the kids, or your school chums passes through town for the weekend, a trip to the museum might be the perfect way to spend a Sunday afternoon. While it is true that schoolchildren often come more frequently, depending on the museum's outreach programmes, these visits are generally compulsory and cannot be credited to the museum's attraction as an informal setting. However, notwithstanding VFF, and school visits, this three-visit pattern tends to force the museum or science centre to create programmes of temporary exhibitions as a means of generating repeat visits. In fact, the modern temporary exhibition is a creature born out of a desire to increase the number of visitors. In the 1970s, the first great 'blockbuster' exhibitions such as 'King Tut', proved that the temporary exhibition could be a major money-earner as well as a sure generator of extra visitors. Without change to generate repeat visits, or a constant influx of new visitors, the number of visits inevitably declines. Attempting to rely increasingly on transient tourist visits only compounds the problem by marginalising the local audience. Paradoxically, however, increased visitor numbers impair the ability to deliver the high quality engagement that is at the heart of the museum, and science centre, experience. Large numbers of visitors shorten and degrade every individual's ability to engage with the exhibits and interactive displays, and, when international tourists make up the bulk of the visitors, the local community can be squeezed out almost entirely[33]. And, if the science centre expands to meet the increased demand, it incurs increased operating costs which only make the problem worse. Indeed, the dinosaur ends up being unable to feed its increasingly heavy bulk.

This is the crisis many museums and most science centres are now facing. The recent data published by the Association of Science and Technology Centres (ASTC) paints a picture of growing science centre attendance[34]. This is certainly true when one includes the new centres and their visitors. But a closer look at the figures tells a different story[35]. If the attendance to new centres is discounted, many science centres are seeing their visitor numbers fall annually—often dramatically in the case of 'middle-aged' institutions[36]—and if these figures are then adjusted to eliminate the temporary effect of temporary exhibitions, the picture is even bleaker[37]. This suggests that the science centre is becoming a victim of the institutional model it has chosen to follow. By defining its success

in terms of visits, not use, the science centre slowly exhausts its pool of potential visitors. On the other hand, the library model is, at least in theory in a far better position. A library is both rooted within its community of users and global in terms of the resources it makes available. As a resource centre, it can service its users in a wide variety of ways. Furthermore, a library is not exhausted by a visit, it is on the contrary, refreshed by it. A library is used, and as long as it provides resources and experiences—real or virtual—which are needed by its users, its health is guaranteed. The model of the collection—particularly with regard to an institution without one—cannot be remedied by throwing money at it. The problem can only be remedied by change.

The Institution Cannot Compete

An institution can only survive if it provides, at a competitive price, a product or service unavailable elsewhere. The traditional science centre has provided an environment in which visitors can manipulate simple interactive displays illustrating/exploiting the phenomena and principles of science. These experiences have been largely unavailable in the classroom, and were novel and exciting to use. However, they were also very easy to imitate, desirable in a pre-Internet period, and, like a kind of educational MacDonalds, we have witnessed an explosion of science centre building which has still not ended. Today there are over 800 science centres world-wide, and nearly every major city has a science centre. In these science centres there are 'experiences'—for example the opportunity to study an artefact, or a demonstration, or making a dam in running water—which cannot be replaced by new media. The power of a live demonstration cannot be replaced by a talking head on a 17″ screen, whatever the inherent interest of the subject. However, hands-on interaction is not always enough to sustain engagement[38], and the science centre is no longer the only mechanism to offer informal learning opportunities. It must now compete for the attention of its visitors with other informal learning resources—notably CD-ROMs, video games and television—which are often far less expensive, and better still, available at home on the Internet[39].

When many science centres were founded, the computer revolution had not yet begun. I remember as a young student going to the Ontario Science Centre in Toronto to see their computers—computers for which they had paid a great deal of money. Some of these computers—the IBM 360 for instance—filled an entire climate-controlled room. No-one imagined that within relatively few years the personal computer would invade the household. Certainly no-one imagined the revolution which would be brought about by the use of the Internet, and again within a matter of a few years, broadband communication over the Internet promises to turn the home into a resource centre for interactive activities, with video-on-demand, networked games, discussion groups, forums, debates, etc. The science centre, lacking a unique collection to begin with, is now extremely vulnerable to the increasing ability of new technologies to bring to the home what was heretofore only available at the science centre[40]. The competitive pressure is enormous. Why go to a science centre at all? And at prices which go as high as US$50.00 for a family of four, why pay for the privilege?

Nor is the science centre the only institution offering informal learning. Increasingly other institutions are providing high-quality learning opportunities

outside the formal system, and research labs, community centres and libraries all provide workshops, lectures and seminars. The entertainment giants like Disney and Spielberg have also begun to move into the field of informal learning, newly baptised 'edu-tainment', and Disney claims to crease "an imagination-powered playsite where children and their parents can build important bonds through interactive and creative play"[41]. The science centre must now compete to deliver a unique and irreplaceable experience to all its potential users. And, as long as science centres remain wedded to their narrowly defined historic mission, they miss out on the opportunities to reach audiences not interested in science and technology as such, but in society as a whole) including issues such as enviromental protection, genetic manipulation, euthanasia, urban development and crime. As long as science centres continue to define themselves apart from culture as a whole they risk losing out to other institutions and other interests. Like the dinosaur, the heavy and slow-moving science centre is now threatened by smaller, lighter, more agile opportunities, which threaten to take its place in the ecology of informal learning.

The Economics of White Elephants

The argument outlined above suggests that the science centre—as an institution—is no longer able to meet the challenges which will face us in the next century, and will thus become extinct in due course. But what about the science centre as a building project—a civic monument? If the life or death of the institution was a question of ecology, the decision of whether to build or not is a question of economics. In recent decades we have experienced an explosion of new museum—and new science centre-building. With the state and other bodies supplying the cash, and the clock ticking down to the year 2000 providing a symbolic deadline, there seems to be no slowing down in sight, as a rash of new projects in Britain, America and the Far East near completion. The economic cost of overbuilding in the museum community is already beginning to be seen, and cautious critics are worried about the prospects for today's new science centres in ten years time[42]. The case against trapping the institution in a new, expensive and inflexible building can be summed up as follows:

High Capital Costs

The costs of any new building are high, and with erratic interest rates the cost of financing makes it imperative to build quickly and efficiently. A science centre is a special kind of building, with specific needs in terms of services and facilities, and particular challenges to overcome in order to accommodate interactive displays. Often costly special media are called for—IMAX, OMNIMAX, Showscan, virtual reality CAVEs—all of which involve a large initial investment and a high degree of involvement on the part of architects, designers and planners. The architectural fees for designing science centres are high, and with the shortened building schedule, the risks are also high. The chances of a major science centre project staying on time and on budget—however well managed the project is—are very slim. Added to this are the costs of exhibition development, which are a function of how much new design is desired. The greater the amount of prototyping, the greater the cost, the greater the risk, and the longer

it takes. These capital costs are not normally recovered by the revenues generated by the project after opening.

High Operating Costs

Once it is built and opened, the science centre must be operated. Depending on the size of the centre, this means a substantial investment in floor staff, workshop staff, administrative personnel and maintenance workers, not to mention the costs of keeping a public building going—light, heat, water, power. The larger the institution the greater the investment in operations, and the greater investment in personnel. But the greater investment in personnel, the less flexibility the institution has when it comes to responding to fluctuations in demand and revenue. The tail soon begins to wag the dog—programmes are modified to keep staff in work, rather than to serve visitor needs. Furthermore, attendance at a traditional science centre is closely related to the weather—when it is raining visitors come in droves, but when it is sunny they go to the beach. Unfortunately, the weather is not among the factors over which the science centre can exercise much control.

High Maintenance and Renewal Costs

Finally, due to the highly interactive nature of their displays, science centres must devote a substantial percentage of their operating revenue to constant maintenance and renewal. More importantly, due to the nature of their interactive displays and the premium placed on novelty, renewal plays an important part in a science centre's ability to generate new revenue. Science centre interactive displays, particularly when they are high profile, are generally expensive and require specialised staff to design them. Few science centres generate enough revenue to renew their displays as often as they would wish, and fewer still can afford to employ in-house the specialised staff required to design and build them. As a consequence, special displays and temporary exhibitions are brought in from other sources, or designed by outside firms, with a corresponding impact on the institution's budget.

Given the above, it is possible to argue that society should still fund new institutions of informal learning, albeit not necessarily science centres in the historic sense. Funding an institution, however, does not necessarily mean funding a building project, and the arguments in favour of building must be carefully considered. Institutions do not necessarily need new buildings. Successful projects around the world have shown that an institution can flourish in makeshift or borrowed surroundings, and take advantage of rehabilitated and adapted facilities to mount its installations, temporary exhibitions, workshops. and other programmes. Thus instead of spending a huge amount on 'bricks and mortar', scarce resources can be applied directly to projects and people[43]. Why lock up 60% or more of the investment capital available in the building when a higher proportion of it could be going into programmes? It could be argued that the capital costs are amortised over the life of the building, but it can equally be argued that investing, say $3 million/year in programmes and temporary events for ten years could be just as wise an investment as spending $30 million to get the doors of a purpose-built structure open once.

A typical interactive science centre display costs US$2500/m^2 [44], since it must be built to withstand hundreds of thousands of visitors and be expected to last two, three, or even more years. On the other hand, high-quality temporary displays can be developed and built for as little as US$500/m^2 [45], and can be readily transported, repaired and replaced. Even less costly are programmes intended for the Internet. Forums, discussions. and debates can all be prepared quickly and effectively with a relatively low investment of staff time. Creating interactive resources for the electronic networks—particularly broadband—holds out great promise for the future as our institutions move away from the straitjackets imposed by physical building.

We know from the research of Marilyn Hood[46] and others that for the majority of our visitors, the public physical space is currently one of the central motivations for visiting. Although it tries to, the Internet cannot replace real public space (not to be confused with the social space of dialogue, which can be very effectively supported by Internet). The extraordinary variety of a two-hour visit passed in a public space, wherein one can read a paper, play a computer game, make a bridge out of blocks, have a coffee, kiss your sweetheart or chat with friends, can never be rivalled by an experience circumscribed by a visual display unit. A public space is one which has other real, flesh-and-blood creatures in it, creatures demonstrably different from their e-mail addresses, opinions or self-representations. However these may overlap in the virtual space of the Internet, the human body only exists in space, and the public human exists in a public space. Nevertheless, a public space need not be a permanent space, as Ciencia Viva in Rio de Janeiro[47], Science Alberta, and the Palace of Miracles in Budapest have demonstrated. Once freed from the burden of running a large and complex building, projects and programmes can be developed which make the fullest use of human resources. A relatively small core staff can manage a large number of initiatives. Temporary projects can rely on appropriate temporary staff, and longer term projects can be structured in such a way as to give the institution the greatest degree of flexibility. Why set out to create an unwieldy and inflexible management structure when a high degree of flexibility is the only way to respond quickly to changing needs?

The reasons which could justify building a permanent home for a new institution vary widely, and are closely tied to local circumstances. In countries or cities where public space has been eroded by commercialisation, road building and changing demography, the establishment of the new institution may provide an opportunity to create new urban social space. newMetropolis in Amsterdam is a good example, and the building's roof has created a piazza where people can stroll, look at the city and listen to concerts. In other locations, a showcase may be called for—a place where informal learning practices can be seen, engaged in and discussed—for example the Anacostia Neighbourhood Museum[48], or the new Ars Electronica Centrum in Linz[49]. In others, a new building might be justified as providing a research centre, a place where communities of learners can work together to generate new knowledge or, in some cases, real jobs, such as at IDIS in Naples. In all cases it is essential to separate the challenges of building an institution, from those of making a building. Each has important, and sometimes sufficient reasons, but, the one does not justify the other. In fact, I would argue that the reasons to build new institutions far outnumber those to erect a building to house an institution. Some important initiat-

ives taken in recent years, CAST's children's science centre in Beijing, for instance, or the Science Alberta Foundation, have no permanent buildings and instead take advantage of existing networks and other buildings for their activities, such as research labs, daycare centres, libraries and hospitals. This in no way diminishes their effectiveness as institutions of informal learning.

To conclude, the White Elephant crisis can be summed up as follows: institutions such as science centres are expensive to create as capital projects, expensive to maintain with a professional staff, and, given the high costs of exhibit development, expensive to change. Lacking a permanent collection of unique artefacts with which to attract repeat visitors, the science centre is at risk when it cannot change quickly enough to meet the demands of its users. In the past, temporary exhibitions have been used as a means of creating more frequent change. Now, however, given the exponential increase of the availability of new electronic media, such as home computers, CD-ROMs, and, soon, interactive television, coupled with their massive interconnection via the Internet, the informal learning which once was the preserve of the science centre can now be enjoyed at home or in other sites, thus rendering the science centre increasingly unwieldy, expensive, irrelevant and obsolete. In short, the science centre is faltering because, on the one hand, unlike the museum, it offers little that is truly local (nearly everything which can be found in one science centre can be found in almost every other one, or on the Internet) and on the other, the historic mission of the science centre no longer addresses the needs of the world we are in the process of creating.

Towards a New Institution

I do not want to end on a note of despair, however. When I wrote about the three generations of science centres in 1989, I described the need for a new kind of institution. The subsequent years have not proven me wrong. In fact, over the course of the past ten years we have seen the launching of an increasing number of institutions, some of them housed in new facilities, which point to the emergence of a new kind of institution for informal learning. Moreover, government, cities and industry are all signalling that they are in desperate need of such an institution, both as an informal learning platform, and as a centre for research. Now, at the threshold of the twenty-first century, I argue the emphasis is fully on creating a learning society, and how the learning process can be supported. A learning society needs new institutions dedicated to informal learning, and institutions like Science North in Sudbury, Ontario, the Science Alberta Foundation, the Ars Electronica centrum in Linz, the ZKM in Karlsruhe, and newMetropolis in Amsterdam all represent a new approach to the challenge of creating public informal learning environments.

Where I was mistaken was to see this new kind of institution as developing from the traditional science centre. We can easily imagine a world bereft of science centres, but it is difficult to imagine a world without informal learning institutions. Instead, I would now argue that a new—and independent—form of institution is evolving from a wide range of existing institutions, an institution in which the emphasis is on supporting self-initiated, self-directed. and self-sustained learning in an informal setting. Not a science centre, not a museum, not a library, this is a new hybrid institution—a new learning platform. However,

before I continue, let me first define more clearly what I mean by informal, as opposed to formal, learning in this context. The key feature which distinguishes the museum from the school, or more broadly, the informal setting from the formal one, can be summarised succinctly in the words of Frank Oppenheimer, founder of the San Francisco Exploratorium, one of the first, and still one of the world's most innovative science centres. He said 'nobody ever failed a museum'. In a school, the student must be carefully modelled, in terms of prerequisite knowledge and abilities, and carefully evaluated, in order to ensure the coherent and standardised acquisition of knowledge. In a museum, the visitor is defined by the act of visiting, and there are no pre-visit qualifications or post-visit tests. Our visitors are unknown, and, perhaps more importantly, unknowable. In the formal system, the student is responsible for learning. In the informal system, the institution is responsible for creating learning opportunities. A student can fail a school, but only the museum can fail its visitors.

The two systems, although complementary, are like oil and water: they do not mix. The formality we speak of in the learning environment is not just a question of style—dusty classrooms and boring lectures versus interactive experiences and jolly good fun. An interactive programme set in the science centre, on whose success or failure a student passes or fails, remains a formal experience, even if it is not conducted in the classroom. On the other hand, an evening lecture series in a classroom, voluntarily entered into and unrelated to passing or failing, is informal, wherever it happens to take place. Even though they often work in consort, and are both concerned with education, the formal and informal systems are distinct, independent, and parallel. The formal system thinks in terms of students, and the informal system in terms of learners.

Why do these differences matter? What can the informal system offer that the formal system cannot? After all, it is often argued that in order to achieve its goals, all that is needed is more education, more hardware in the classroom and more software to run on it. Following this logic European and other governments should pour more money into the formal educational system, not the informal one. What makes the informal sector worth the investment? The informal environment is a prime site for learning about learning, and learning to learn, and I would argue that new learning platforms offer two key features—research and reach.

First of all, research—our informal learning institutions are potentially powerhouses of learning about learning. Only the informal environment can provide governments with proof of the effectiveness of new strategies to stimulate learning. On the one hand, if thousands of students go to classes every day, this does not demonstrate either the attractiveness or the effectiveness of the learning environment provided by the schools. Students go to school because they have to go to school. On the other hand, thousands of users daily 'vote with their feet' and pay to engage in unforced learning, and so long as we can ensure that learning occurs in the centre, then learning it is, even it it is perceived by the visitor to be fun. When our learning environments attract users it is evidence of their ability to stimulate and structure self-initiated, self-directed and self-sustained learning. When they don't, our failure is public and painful. Success in attracting users is not enough, however. Michael Shortland's famous question of 1988 still obtains: 'but are they learning?'[50]. Although there remains a substantial debate, there is now good evidence that certain interpretive strategies can pro-

mote learning[51]. If users voluntarily come to our programmes (thereby proving their attractiveness), and they can be shown to learn (proving their effectiveness), then we can argue that we can have knowledge about motivation and effectiveness which can be transferred into the formal setting. If the knowledge we create in the informal setting can be transferred to the formal environment, then we have not only proven the value of the informal environment, but have enriched the formal environment as well.

Second, reach—the informal system potentially provides a means to catch the increasing number of people outside of the formal system—dropouts, the unemployed, the elderly and ethnic minorities. Because the informal system is by definition not restrictive, a broader spectrum of the public can find an opportunity to learn in the museum than in the school. Because it is concerned with learners not students, the museum can create a wide range of different learning opportunities for a broad number of people. This reach will be of enormous importance to the world economy in the coming decades. As global finance and new technologies change the face of the working world, and people have to adjust rapidly to changes in the workplace, the informal learning environment becomes an increasingly important place in which to learn new skills, not only those skills immediately involved in the new technologies, but skills of communication, collaboration and discussion. This socialisation has often been associated narrowly with the formal environment[52], but it is increasingly a feature of the informal learning environment as the museum takes on the forum function in modern society. Whereas the formal system sees its success in terms of more students, the informal system succeeds in terms of more learners. To compete in the next century, we need more learners, not just more students.

So what about newMetropolis, Europe's newest science centre? Given the arguments above, is it also a dinosaur as an institution, and a white elephant as a building project? Or does it hold out the promise of some new directions for the development of our institutions of informal learning? As an institution, newMetropolis is not a science centre in the 'traditional' sense. It is not *about* science and technology, and it does have as its prime goal the transmission of information about science and technology. It is an informal learning environment in which the emphasis is explicitly on developing new skills, such as abstraction, experimentation, collaboration and systems thinking, which allow users to deal better with the rapid changes being brought about in large measure by advances in science and technology. It is a place where the human being, in the fullest senses, is at the centre. It is a learner-driven environment in which the user can develop new skills to allow him to deal with the challenges of contemporary society better. But how then can newMetropolis avoid the pitfalls which afflict most other science centres which are indeed losing audience, revenue and relevance worldwide (much as the planetarium lost its role in the 1970s and 1980s)? I would argue that the answer lies in the way it has been conceived, developed and implemented, and how it envisages its missions: newMetropolis thinks in terms of users not visitors. In focusing its development on groups which can readily come to newMetropolis, and creating experiences which can be returned to, it is less dependent on capricious, expensive to attract, tourist revenue (a repeat visitor costs four times less to attract than a first-time visitor). In this way we are consciously moving the institution away from the museum model, towards the library model.

newMetropolis is actively committed to change. Our institutions must change, and more importantly, be seen to change, in order to attract new visitors and retain existing users. Traditionally, change has meant large-scale and expensive projects—new displays, new technologies, new installations, new wings. From the outset newMetropolis has placed an emphasis on easy and inexpensive change. Texts can be changed in three days at little cost (and over 60% of the instruction texts have been changed during the first few weeks of operation). Pop-up actors can change their acts in response to the news, i.e. daily. And of course the "Actua" information system is updated daily as well. Our new institutions are sites for research into learning. newMetropolis was explicitly built as an experiment, and as a means of testing specific questions about interactive learning. The commitment to ongoing research is fundamental to the development of new products and programmes (to meet the needs of new users), and to financial independence and stability (to ensure structural funding). At newMetropolis the real commitment to research, excluding floor staff who play an active role in new programme development, represents nearly 30% of the total budget of the institution.

As a building project, it is certainly subject to the critique formulated above. newMetropolis cost a substantial amount to build, and costs a substantial amount to operate. It could readily be argued that newMetropolis could have equally well found a home in an adapted old warehouse, or an abandoned building in the city centre. This is perfectly true, and in other circumstances lower cost and lower profile housing might have been the appropriate framework for the new institution. However, as a building project newMetropolis can be justified as an experiment in urbanistic terms. Its goal is to create new social space, to enlarge the city of Amsterdam. In creating a new social space—the new '*piazza*'—Renzo Piano gave newMetropolis the means to integrate itself into the social life of the city, and by exploiting this 'forum function', through events, concerts, debates, discussions, etc., newMetropolis can integrate itself into a much broader spectrum of free-time activity than the traditional science centre.

Financially, newMetropolis is fortunate to have been developed with multiple funding sources. No science centre can survive if it is solely dependent on visitor revenue, and newMetropolis does not intend to be 'self-sufficient' if that means 100% reliance on gate revenue. Excessive dependence upon an unpredictable and unstable source of income of necessity means compromising the long-term goals of the institution so as to ensure short-term survival—not a desirable option for an innovative institution of informal learning. One of newMetropolis's strengths lies its strong links to three key sectors of Dutch society—the State, the City and Industry—links based in part on its past as the Museum van de Arbeid. These triple links mean that the institution can to a limited extent be buffered financially, and supported in pursuit of its research and development goals. But what about the 'S' curve you might ask? Of course attendance can be expected to fall off in the medium term, and the challenge is to flatten the slope of the 'S', strategies for which form part of the mission of the institution. There is no guarantee of success, but, unlike many new centres, confronting that issue from the outset is part of the core mission. Although it calls itself a science centre for a variety of reasons, newMetropolis is really the paradigm for a new kind of institution, but only the next ten years experience will show whether it succeeds or fails.

Conclusions

So what characterises this new institutional form we see emerging? Our museums and science centres must change if they are to meet the challenges of the next century, and the key to that change is the embracing of new technologies which make many-to-many communication easier and more effective. Consequently I want to conclude with some possible strategies which will help guide our institutions in the next century.

The next generation of new learning platforms are not defined by their physical setting. They do not even need to have their own buildings. Our new institutions of informal learning, whatever their roots, will I believe be characterised by the following features:

- **skills not information**—the new learning platforms must stress the acquisition of new skills, not just information. These skills are largely shared by art, science and technology alike—creativity, collaboration, abstraction, thinking in terms of systems. The common ground provided by putting the accent on skills has the effect of making less important the distinctions formerly made according to content—science, ethnology, history, fine arts. Of course information is still indispensable, but it must be linked to the skills of finding, using and appropriating that information. The new learning platforms recall the humanist education of the Renaissance, and prepare the learner for all fields of endeavour. As Jonathan Miller once said, they "prepare us for a world in which the life of the mind is a pleasure".
- **turn visitors into users**—the value of the new learning platform is created by use. Our institutions of informal learning must not be satisfied with the casual visit, nor driven by the single-minded goal to increase the numbers of visitors passing through the turnstiles. The new learning platforms must draw lessons from the library, not only the theme park, and thereby provide experiences which satisfy the full range of interests and expectations. After all, a library is not judged by the numbers of tourists who visit, nor by the blockbuster appeal of its presentations. The new learning platform must establish its base in the community, work with its local community to expand that base, and encourage repeat visits, real or virtual.
- **high value, not high volume**—our institutions must focus on creating a high value informal learning environment in all respects, and for all its users. This means exploiting the specific strengths of all the media—real things for their immediacy and specificity, public space for its conviviality, computers for their ability to engage the player, the Internet for its access to global resources of both information and interaction. Installations such as *Mine Games* have shown that computer games can be an effective way to create what Cziksenmihalyi calls the 'flow experience'[53]. Institutions like the Laboratorio dell'Immaginario Scientifico have demonstrated the tremendous potential for creating linked group learning activities via the Internet, while those like ArsLab have shown the effectiveness of temporary manifestations. It is not the medium which matters most. What matters is that the quality and duration of the user's engagement is maximised[54].
- **research and knowledge transfer**—a fundamental part of a new institution's mission is to generate new information about informal learning, digest it and turn it into effective new tools for teacher training. This is an integrated

role which only a new kind of institution can undertake. By definition, informal learning is learning sought for its own sake, and it has to be self-initiated, self-directed and, above all, self-sustaining. Traditional, school-based educational research is unable to investigate these questions, since those researchers have little or no access to a public environment in which learning is unforced. Publishers, on the other hand, are not geared to take the financial risks involved in creating new educational tools, and they lack the means of adequately testing their products prior to release. Only a public informal learning enviromment, with a stream of uncoerced users, can provide the research setting necessary to create the tools and the training so desperately needed by the schools, and by society[55].

- **think global, act local**—a new learning platform must place its emphasis on what is unique to its specific locality, and on what cannot be found or done somewhere else. It must set a premium on local culture, local practices, local experience. It must be firmly rooted in its local conditions, and use them to build a community commitment to the institution. In past decades, displays could not effectively be shared, so they had to be duplicated. However, the new media and the Internet now allow our institutions to place the emphasis on local circumstances and local culture for the physical site[56], and global culture and global circumstances for the virtual site. Global information networks allow for the first time the creation of real, virtual institutions, open to visits from around the world, and to real-time participation. This participation need not be limited to the Web site itself. Displays can be designed so that they can be actively enjoyed by international virtual participants, as well as by local users, and the participation of the virtual community can actively change the state of the local activity, much as an earthquake in Tokyo can shake the financial market in New York. By exploiting the new media, the physical scale of the institution can be tailored to local circumstances. The institution does not have to be a major capital project, unless circumstances demand it. Ineed. it can be a rented storefront, a community hall, a borrowed lab—any space which can be adapted to house the kind of institution needed by the community.

To conclude, it is important to emphasise the fact that the key to the survival of our institutions of informal learning, both as institutions and as real places, lies in their having the flexibility to respond to the needs of a wide variety of users.

An exhibit in the newly opened Ars Electronica Centre in Linz is a perfect example of the direction I believe our institutions must take if they are to survive. It is not the virtual reality cave, nor the myriad of interactive computer-based displays. It is the virtual garden. In Linz there is a real garden, with real earth and real plants which grow in the real, local, Austrian sunshine, but this is a garden with a difference. It is 'planted, 'watered' and 'tended' by a growing number of virtual gardeners via the Internet. They not only 'tend' their own plants, but of course now communicate with each other, forming a virtual community. However, unlike most virtual communities on the Internet, such as newsgroups, this community's common object is both real and local. The garden is, in a sense, the real consequence of a virtual world; a reality shaped and tended by a real group of caring gardeners. It is not difficult to extrapolate from

this to the possibility of exhibit experiences being created in local environments but shaped by global communities of learners, each contributing, and each being rewarded for its contribution. This kind of exhibit holds out the promise of realising many of the approaches described above—it is both local and global, it is user-driven, it transforms visitors into users, and it is profoundly social and open to change. By turning our efforts to this kind of approach, the science centre itself becomes a kind of virtual garden, wherein we all can play the part of gardeners.

Consequently our institutions should seize the initiative in developing new products and programmes by exploiting the media. As specialists in the informal learning environment, certain of us are well positioned to take a leading role in creating new approaches to informal learning, and generate greater knowledge about how to support such learning processes. newMetropolis may not be alone in the field, nor should it be, but the new institution's future is guaranteed so long as it continues to take the initiative in creating rich learning opportunities, inside and outside, with and without its walls.

Footnotes

1. This article has been written in the framework of a research project of the Fondazione Giovanni Agnelli, Turin, on the international experience of Science Centres. Copyright Fondazione Giovanni Agnelli, 1998. An English translation of the original article has also been published in The Public Understanding of Science, Vol 7, No 3, July 1998 and is reproduced here with permission from IOP Publishing Ltd.
2. Bradburne, J. *Truth-telling and the Doing of Science.* Amsterdam: 1993.
3. op. cit.
4. A critique of the prevailing 'deficit model' of the public's understanding of science can be found in Wake, D. A. and Bradburne, J. Fields of Knowledge. *AMCSTI*/Infos Spring 1993.
5. Many science centre professionals might argue that hands-on displays are, by definition, 'bottom-up' and user-driven. This contention is explicitly challenged in Wake, D. A. and Bradburne, J. Paradox Lost: Rediscovering Scientific Creativity, *Alliage* No. 6, 1991.
6. Described in Wake, D. A. and Bradburne, J. Priming the Pump: Building a Science Network in Alberta, in *La science en scène*. Paris: Palais de la Découverte; 1993.
7. Described in Wake, D. A. and Bradburne, J. Au-dela de l'oueil nu. *Alliage* No. 15.
8. Described in Bradburne, J., Mine Games, *La Revue des Arts et Métiers* No. 10, Spring.
9. A complete account can be found in Tracing our routes/Chemins à faire in Vers les musées du XXIe siècle—*La Révolution de la Muséologie des Sciences: Nouvelles perspectives américaines, européennes et australiennes* ed. Bernard Schiele PUL; 1997.
10. The planners of newMetropolis would have great difficulty accepting the statement made by Beetlestone et al. that "Most visitors are intimidated by science. That's why science centers exist. Yet everything in a science center is, by definition, scientific." (Beetlestone, J.G. et al., The Science Center Movement, Public Understanding of Science Vol. 7, No. 1 January 1998, p. 8).
11. ASTC Yearbook of Science Center Statistics 1997.
12. *The Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'*, conducted by the Centre for Research in Primary Science and Technology at the University of Liverpool in April 1988, was critical of the project on several grounds, particularly for fragmenting and decontextualising scientific subject matter, but provided some advice: "It might well be the case the developers will wish to be more selective of content in the future, as the public's response and the effectiveness of various types of experience are better understood…For example, under the umbrella of science and technology are included experiences involving obvious scientific principles, less obvious technological applications, examples of measuring techniques, visual illusions, spatial probems, etc. All these experiences might well be fascinating and capable of arousing curiosity. Their effectiveness in supporting the exhibition objectives is not always self-evident. One of the difficulties of presenting a range of experiences

to the public in a context such as Techniquest is that there is no obvious linking concept to help people make sense of their experiences. Without such a strong background context, there is a danger of the experience becoming fragmentary, and consequently trivialised."

13. For a thorough and detailed discussion of the relationship of science studies to the science centre, and of the science centre's relationship to science, see Regeer, B. *Two Paradoxes and a Triangle: the public understanding of science exhibited,* unpublished Master's Thesis, Amsterdam, 1996.
14. The effectiveness of hands-on displays in terms of learning, and the response that they are intended to trigger, rather than communicate, is made clear in the *Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'* (op cit): "As might well have been predicted, the sample visitor responses also indicate that in one or two 'exhibits', including some of the more popular ones—'Bernouilli Table', for example—there was little understanding of the scientific principle which explains the phenomenon presented. This is not to suggest that there should or could have been understanding…For example, in some cases, visitors were provided with useful intuitive experiences which they could not be expected to describe or understand, but which might provide under-pinning experiences supporting later understanding."
15. The increasing importance of constructivism in the science centre debate in recent years, championed by planners such as George Hein, has called many of these approaches into question. Moreover, debate in the related fields of the public understanding of science, science dynamics, and the sociology of science, have focussed on the inadequacy of the traditional institutional approaches. Despite these critiques, many institutions remain committed to the traditional hands-on approach pioneered in the late 1960s, based on an implicit reception theory and an unreflectively realist position tomorrow. See in particular *Visitor Behavior* Volume XII Nos. 3& 4 Fall/Winter 1997.
16. A report on the closure of the Columbus Center's Hall of Exploration due to inadequate visitor numbers (it attracted only 70,000 instead of the projected 280,000) can be found in the *ASTC Newsletter* Volume 26 Number 1, Jan/Feb 1998.
17. This phenomenon is shown graphically in Beetlestone, J. G. et al., The Science Center Movement, *Public Understanding of Science* Vol. 7, No. 1, January 1998, p. 6.
18. ASTC reports that during 1990–1996, 86 new science centres had opened, more than in the entire previous decade.
19. NINT annual report 1984.
20. NINT Mission Statement 1979.
21. Statement made in a lecture at the conference on The Public Understanding of Science, The Science Museum, London, April 11, 1990.
22. The mission of the science centre to "beguile" the visitor into engaging with science (in the words of former Techniquest director John Beetlestone) can be seen in their mission statement, where the goal of the exhibitions is "to engage, to amuse, and to engender a sense of fun in the exploration and understanding of the world around us", from the Evaluation of the Pilot Phase, op cit.
23. See the Dutch Government's white paper *Scanning the future: a long-term scenario study of the world economy 1900–2015,* SDU; Den Haag: 1992.
24. This argument is made at length in Douma, J. *Prototyping for the 21st Century*. Amsterdam; 1994.
25. op cit, "The reason for writing [the Discourse] has been primarily to develop a vision to guide our development. For we truly believe that we cannot simply build a Science Centre without having reflected as thoroughly as possible on what role this new centre should and could play in our present and future society. Science centres and museums alike have always been children of their time and this infant of ours should be able to participate in societal life for as long as possible."
26. The draft framework document was presented in Fall 1997, and has been published in Spring 1998.
27. See Hudson, K. *A Social History of Museums.* Atlantic Highlands: Humanities Press; 1975 and Hudson, K. *Museums of Influence*. Cambridge: Cambridge University Press; 1987.
28. In the Evaluation of the Pilot Phase of Techniquest, cited above, data show that the average mean time spent with the 'exhibits' was 50 seconds, with mean interaction times at individual 'exhibits' ranging from 14 seconds to 182 seconds. op cit.

29. This is of course not true for all science centre displays, and much of the work of the past three decades has been to create displays which allow real interaction, leave room for the visitor to ask and answer their own questions, and truly engage with the material. Sadly, many, if not most, science centre displays are still just devices which allow the visitor to set into motion principles or phenomena which someone finds interesting, and the so-called hands-on interaction merely turns the user into an extension of the display, a soft hand to conjur up the phenomenon the designer or educator intended. This tendency for exhibits to become vehicles for the designer's, rather than the visitor's questioning was noted by science centre pioneer Frank Oppenheimer, founder of the San Francisco Exploratorium, who said "I don't want anyone to leave a science center thinking: 'Gee, isn't someone else clever'."
30. Many studies bear out the importance of the emotional, or 'hearts-on' character of the museum visit, which stems in large part from its social nature, undertaken with family and friends.
31. This is of course a broad generalisation, and discounts the confounding effect of temporary exhibitions, special programmes, multiple school visits (which are formal, rather than informal), and VFF, all which serving to mask the three peaks.
32. It could be argued that the fact that the museum visit is most often an emotionally-charged, social occasion in the company of family and friends accounts in large measure for the observed frequency, and that even repeat visits based on this affective charge merely re-inforce the pattern of visits.
33. As an example, in 1997, over 85% of the visitors to the Van Gogh Museum in Amsterdam were foreign tourists.
34. *Yearbook of science center statistics* 1997 ASTC; Washington; 1998.
35. See R. Russell, Attendance Projections: Real and Imagined, *The Informal Science Review,* No. 25, July/August 1997.
36. In the same issue of *The Informal Science Review* is the report that the Pacific Northwest Museum of Natural History, declared to be one of America's best new museums by the Smithsonian Institution, was closing in 1997 (after only opening in 1994!). Issue No. 27 of the same Journal reports the closing of the Columbus Centre Hall of Exploration in Baltimore due to inadequate visitor numbers.
37. Evidence of this phenomenon can be found in a privately commissioned feasibility study conducted for Erlebnis Wien by Ravest Associates in conjunction with Drew Ann Wake and the author.
38. The inability of conventional hands-on physics displays to hold visitor attention has been discussed for the past ten years; see Wake, D.A. and Mitchell, J. *An informal study of visitor behaviour at two exhibits,* Unpublished research paper, Toronto: Ontario Science Centre; 1987.
39. See Drew Ann Wake's contribution to the debate in *The Informal Science Revue* No. 20 under the heading 'Are Science Centres Doomed?' which sets out many of the arguments made in this paper.
40. This message has not yet penetrated to many in the field, and the science centre is still thought to be the vehicle for launching and demonstrating new technologies. Nora Lee, editor of the 'edutainment' trendspotting magazine the *E-Zone*, writes "Science centers have always been on the cutting edge, particularly in presenting new technology to the public." This statement betrays a certain confusion between the role of World's Fairs, temporary events that have traditionally been the launchpad for new technology, and science centres, which by the fact of their permanence, cannot keep up with the pace of replacing new technologies with ever newer ones.
41. *ASTC Newsletter* Volume 26 Number 1 Jan/Feb 1998, p. 2.
42. Museums built in the 1980s, such as the Frankfurt Museum für Kunsthandwerk, housed in a striking Richard Meier building, are already undergoing difficulties due to low attendance, and the Lottery-funded Bristol 2000 project has forced the closure of Britain's oldest hands-on science centre, the Bristol Exploratory, causing speculation about the negative impact on smaller, community centres by large new-build projects.
43. Unfortunately, the opposite strategy—to fund 'bricks and mortar' at the expense of programmes—seems to be the norm, even in countries where investment in people would seem to demand the higher priority. Bruce Lewenstein recently visited the Far East, and his report highlights a common finding that many Third World governments prefer to build monuments than to create new institutions of informal learning. "After a small start several years ago, the Indonesian Science and Technology Center opened in November 1995. It occupies a brand-new 24,000 sq-meter, 3-story facility in the Taman Mini Indonesia Indah…reputedly Indonesia's

most popular attraction. The science museum is open, but still only partially full. It has about 200+ exhibits. Some were built by the LIPI's institute on instrumentation and standards, relying on the 'cookbooks' produced by the Exploratorium. Some were bought from science museums in Australia. Some are donations from companies; a few of these appear to be designed for interactive science museums, but many appear to be last year's trade show booths, ranging from a BMW exhibit touting its new aluminum drive shaft to a British defense contractor's exhibit on the lethality of its missiles. Although the museum staff had hoped to group exhibits into four areas (transport, life sciences, telecommunications, and energy), the exigencies of which exhibits they could produce, fund, or borrow have led to something of a mish-mash. Dr. Jenny R. E. Kiligis, the director of exhibits and education, said they are now in the process of trying to regroup the exhibits to create some coherence. Nothing she said implied that the museum has a clear long-range plan of how to build its collection of exhibits systematically. She knows that many of the exhibits provided by companies are inappropriate both in tone and design for the science museum, but accepts that for the near term she will have to work with what she can get." unpublished report, August 1996. See also Bradburne, J. *Informal Science in the Jordan,* Paris: internal UNESCO Technical Report; 1993.

44. Based on the author's experience on numerous science centre projects.
45. Our target—successfully met—for the exhibition *The Body in the Library*, opened in Calgary, Alberta, in 1993, was CD$50/ft^2 (@$385/m^2).
46. Hood, M. *Leisure Preferences are the key to science centre audience research.* Unpublished paper, Vantaa: World Science Centre Congress; 1996.
47. See Bazin, M. Ciencia viva à Rio in *Alliage* No. 3 Spring 1990.
48. The Anacostia Museum was developed by American psychologist Dr. Caryl Marsh for the Smithsonian Institution in 1967, and was the first such museum to be established in a predominantly black neighbourhood.
49. See Stocker, G. et al. *Ars Electronica Center: Museum of the Future,* Linz: 1996.
50. Shortland, M. No business like show business, *Nature* Vol. 328, 1987.
51. Since it opened in June 1997, newMetropolis has been conducting active research into the effectiveness of its exhibition strategies. This research is to be published, beginning in late 1998.
52. Notably in Bourdieu, P. and Darbel, A. *L'amour de l'art.* Paris: Editions de minuit; 1969.
53. See especially Cziksentmihalyi, M. *Flow*. New York: Harpers; 1990 and Cziksentmihalyi, M., *Talented Teens,* New York: Harpers; 1990.
54. Preliminary data indicate that newMetropolis visitors spend substantially greater amounts of time engaging in the interactive displays than at any other institution for which we have data. The average visit to newMetropolis is nearly five hours—a substantial investment in time for only 5000 m^2 of interactive exhibitions. Moreover, data also suggest that despite the emphasis on games and game playing, users do make the connection between the game activity and related social and technological issues.
55. In a recent project sponsored by a government ministry, Dutch citizens were asked to 'vote' on their choice of planning strategy for the future of the country in 2030. After substantial publicity, over 1600 written ballots were sent in from throughout the country. To co-incide with this event, newMetropolis designed an interactive video debate on four of its 'Actua' computers. In this debate, users could listen to short video clips promoting different positions, and having heard at least four opposing positions, could vote. In the two months of the national poll, over 2700 'votes' were cast at newMetropolis—more than half of the entire poll! The complete data from this experiment will be published in late 1998.
56. The 18 'Actua' computers at newMetropolis provide both open access to selected Internet information providers, and an extensive collection of sites linked specifically to each of newMetropolis's 150+ interactive displays. During an average week (@6000–7000 visitors), approximately 55,000 pages of information are consulted.