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Abstract.

This report presents a multi-perspective framework from which to view the rising density of communication between the worlds of art, technology, and science. Designating the site of this hybrid activity as the studio-laboratory, the first section traces the development of such organizations historically, compares their dynamics to that of “transdisciplinary” knowledge production in science and technology, and argues that they foster incremental, radical and systemic innovation. The second section examines this framework through the prism of five discussion themes: Instruments of the imagination, Creative users, Access, Reflexivity, Public awareness. A brief conclusion identifies five issues and questions for further investigation.

Introduction.

This report presents a framework for thinking about the artist as an actor in the innovation process in information and communication technologies. The framework differs from most approaches to the interactions between the creative arts and techno-science in two ways. First, it attempts to identify and characterize the range of innovative outcomes and the factors that shape them along multiple dimensions - aesthetic, technological, scientific, economic - and time frames, both long and short. Second, the framework stresses the importance of a new class of hybrid innovative institution, the *studio laboratory*, where new media technologies are designed and developed in co-evolution with their creative application.

The research is informed by an overview of contemporary studio-laboratories, a historical case study tracing the build-up of a strong digital media capability in Canada, and a review of literatures bearing on the sociology and economics of innovation. Numerous individual artists, researchers, theoreticians and policy-makers have been consulted. The framework presented widens the way contemporary artistic practices are understood by placing them in the context of innovation studies; and in turn, it broadens the way in which the literature on innovation has up till now addressed the contribution of the creative artist in the digital media design and diffusion process.

The report is organized in a series of short thematic chapters, each treating in a different way the common thesis unifying them: that in the emerging digitally networked society, the creative arts and cultural institutions in general are mutating by forming a constellation of productive relationships with the science and technology research system, industry, humanistic and social science scholarship,

and with emerging new structures of civil society. This apparently rising density of communication suggests the need to begin rethinking some aspects of the relationship between cultural support policy, innovation and research policy, and the still nascent but interconnected set of concerns about the requirements for widespread creative participation in a "techno-sphere" increasingly shaped by fast-changing digital media technologies. The concluding section identifies a set of possible interventions and topics for further study, though the phase of research does not permit the preparation of detailed designs or proposals for specific measures.

Cultural theorists will no doubt recognize the shifts briefly alluded to as continuous with a progressive reduction throughout the 20th century of the so-called autonomy of the artist as an alienated or estranged figure existing on the margins of society. Particularly among groups who have defined their 'art' more or less in terms of technological innovation, this turn away from the Enlightenment notion of the aesthetic as the 'disinterested play of the senses' can sometimes provide the material basis for establishing sustainable linkages with highly charged sectors of the global economy -- the entertainment and information industries -- and their associated scientific and technological bases. But it would be a mistake to consider the breadth of these shifts only as a widening of the well-established role of creators in industrial design to include such relatively new, trendy factors as 'interaction design' or 'relationship technologies'. As art historians have pointed out, the movement of the machine into the studio is a progressive one which can be variously traced to the early 20th century avant-gardes, but in particular, a marked tendency since the 1960s to engage critically with the technological sublime as both material and subject-matter.[1] This critical orientation, at least among some of emerging media-art and technology community, is part of what makes the phenomena difficult to describe from a singular disciplinary perspective. Works conceived to make a conceptual or critical point by re-appropriating simple or older techniques can be misread when only evaluated in terms of technological novelty; just as, conversely, the point of *speculative* technological invention may at times be missed by developers seeking only incremental innovation understandable in terms of existing markets and users.

Similarly, the sites of innovation with which we will be concerned in this report, studio-laboratories, need to be understood as emergent formations fed by, and flowing into artistic, techno-scientific, economic and discursive sources. This anti-reductionist approach is unavoidable, given the complexity of interests in and about digital media today. While we aim to characterize a wide range of linkages between art, science, technology and society through digital media, the emphasis will be on identifying those pathways to innovation with the greatest potential benefit to the widest number of actors. Somewhat differently conceived, pathways are perhaps better understood as configurations, since multi-finality is taken for granted in the phenomena being discussed. As such, the approach will contrast sharply with other current stances towards the *unity of knowledge* question that continues to be widely debated on both sides of the postmodern divide. For instance, the socio-biological project of Wilson proposes to bring the arts and their interpretation safely within the purview of contemporary neuro-science, explicitly aiming to demystify the truth and beauty of the arts in terms of epigenetic regularities yet undiscovered. Notably, Wilson's *consilience*, a term for trans-disciplinary coherence, dismisses the messy

hybridity of today's "unpleasantly self-conscious form[s] of scientific art or artistic science" [2 p211]. Self-conscious or not, it is precisely towards these intermediary zones - open to the logic of both/and, rather than the categorical closures of either/or[3] - that we must turn to make sense of the otherwise baffling multiplicity of today's creative practices and institutional forms.

In 1974, pioneering electronic artist Nam June Paik assumed the role of technological forecaster and submitted a report to the Rockefeller Foundation urging the construction of a global broadband telecommunications infrastructure.[4] While critical of mandarin intellectual disdain for mass media, surprisingly Paik did not even bother to advocate spending on the avant-garde arts, or on the promotion of the work of his fellow video-artists. Rather, he envisioned a two-way, high-capacity video and data network - the electronic superhighway - that would augur a profound cultural shift. In the framework of this now familiar wired world, artists and intellectuals would have the opportunity to make a broader social contribution, what he called 'output capacity', beyond the convention-bound production of luxury cultural goods for limited circulation.

This broader role was to *humanise technology*, according to Paik, a more complex social implication that follows his consideration of the artist or intellectual in the context of then-current notions of the 'post-industrial society'. Paik drew on Daniel Bell for his understanding of art as information, and John Kenneth Galbraith to underwrite an increasingly central role for the arts as a factor in economic growth. He conceived an amalgam of media, information, knowledge and communication, serving as "a lubricant and impresario to facilitate the relationships and cybernetic interaction of the society of the future".

Now, twenty-five years later, much of the infrastructure aspect of Paik's vision seems to be in place, owing in large measure to the incredibly rapid uptake of the internet for multimedia as well as transactional communication. The kinds of immediate benefits Paik foresaw an electronic superhighway providing, easily distributed educational programming and greater connectivity for work and pleasure, are becoming commonplace for the growing members of the *virtual class*. The falling costs of hardware, coupled with relatively cheap or free software, make the barriers to entry for creators lower than they were in Paik's day, when he was one of the earliest to adopt portable video equipment and to devise his own techniques for electronically processing images. And today digital media are widely understood to be facilitating, as Paik predicted, new and varied kinds of relationships and not only between buyers and sellers, teachers and learners, creators and audiences. Further, they have attracted the participation of a significant number of the very cultural elites whose disdain for the public television of the 1970s Paik took pains to criticize in his report.

Yet from the vantage of the late millennium, it is no longer possible to share Nam June Paik's optimism about the wonders of global connectivity, nor, from an analytical standpoint, his deterministic belief in the sufficiency of technological infrastructure for stimulating a widespread culture of active producers of new creative expression. The internet repeats aspects of the early history of radio broadcasting [5] with the growing consolidation of corporate interests at the high end of broadband and advanced applications; cultural applications of interactivity have bunched up

around a relatively narrow group of heavily promoted large-market entertainment products (even if, in some cases, they are played online in technologically innovative multi-player configurations); and thirty year-old visions of new kinds of computer-enabled literacy, extending sensory acuity and augmenting intellectual capacity, seem to be more stalled than spurred by the current market frenzy around media technology. Most crucially, in the 1970s, Paik was not yet in a position to address the key issue of how to bridge the new skill-sets associated with digital technologies with existing, often age-old capabilities grounded in embodied, locally specific practices.

Software indeed has a dual nature, as both medium and tool; practices cannot transcend the limitations of the constraints built into software tools, unless these are *reflexively* designed to permit extensible, evolving development in the process of use. This is not just the familiar problem of market power exerted by the dominant position of a few large software companies, whose application packages define a de facto standard that, for better or worse, tends to be accepted as the benchmark of digital literacy. In the arts community, too, disquiet rises among the more reflective, like Carnegie Mellon professor of both art and robotics, Simon Penny [6]:

> …every day we come to new reconciliations between our artistic goals and methods and the requirements and restrictions of the machines we work with. With a little critical distance, we can see that we are reshaping artistic practice to suit a new set of tools.

Yet these concerns, which have circulated uneasily among the electronic art, music, and graphics communities since the 1980s, are rarely considered in relation to those of the apparently opposite end of the technological spectrum (and world) - the digitally disenfranchised, to whom, typically, technological capability is presented as nothing else but the adoption of a set of pre-set, externally-defined solutions. Yet the same questioning can illuminate both sides of the spectrum: how can local, contextually-relevant capacities be developed, which at once build on but also provide the potential to transcend the existing media ecology? Manuel Castells, addressing the culture of the network society, insists on the need to look for and understand the 'specificity of new cultural expressions, their ideological and technological freedom to scan the planet and the whole of humankind, and to integrate, and mix, in the supertext any sign from anywhere' [7]. This cultural specificity, or capacity to adapt material means to self-defined expressive uses, is by no means a given result of technological deployment, on the one hand, nor of the transmission of pre-existing messages through digital channels, on the other. If the image of digital expression as a *dynamic, moldable medium* dates back to the early years of the computer era [8], its reality is not a lot more widespread now than it was then.

This report on Pathways to Innovation in Digital Culture will concentrate, as Paik put it in 1974, on those configurations with the greatest potential for *humanizing* technology. But it will also take careful heed of the various sceptical voices who over the ensuing decades have developed a paradoxically post-humanist stance towards the liberating potential of human-machine communication and expression. After Donna Haraway's celebrated feminist 'manifesto for cyborgs', or more recently Katherine Hayles tale of how since cybernetics we became post-human [9], there is no need anymore to rehearse familiar myths of empowerment in terms of the liberal unified humanist subject. The vision of human expression seamlessly articulated with intelligent machines, pleasing to few adherents of art's proudly transcendent claims

to Truth and Beauty, nonetheless provides a basis for building fruitful understandings between the diverse social actors with interests in the shaping of digital media - researchers, technology developers, artists, and theorists. Increasingly, it appears that these meetings are taking place within innovative institutional structures - spanning organizations, research networks, and projects. And it is to these sites - the studio-laboratory for combined art production and technological research - that we now turn.

Transdisciplinary Knowledge Production and the Arts

The concentration of scientific research in structurally distinct industrial or institutional laboratories dates only from the later 19th century. Current scholars describing what are now termed *systems of innovation* have pointed out common trends, as well as national differences, in the transition from pre-industrial to the more familiar industrial and now post-industrial organization of research and development. During the first of these phases, it is sometimes overlooked how strong was the artisanal component - mechanical skills, like spatial imagination, dexterity, and fluency with materials - in enabling early industrial innovation. With the spread of advanced professional university training, as well as the formation of scientific and engineering societies, the specialized research and development laboratory became increasingly common in the early 20th century, bringing disciplined scientific knowledge to bear on industrial problems. With important national differences, the role of the state was always crucial, particularly in steering priorities towards the military, health, and particular industrial sectors.[10]

After World War II, and the decisive impact of the mission-oriented Manhattan project in the U.S., the distinctions between *pure* scientific knowledge from its *applied* technological development began to erode. Not just the close interaction of multiple branches of science was at work here, but also the importance of new developments in technology, and especially instrumentation, in setting the very research agendas for science. A compelling, if somewhat stylized interpretation of these complex shifts distinguishes between two concurrent modes of knowledge production.[11] Gibbons, a former director of the Sussex University Science Policy Research Unit (SPRU), along with an international team of social scientists, calls traditional discipline-bound R and D Mode 1 knowledge production. He summarizes the emergent second mode in terms of a set of key trends:

- *Transdisciplinary.* Further than inter-disciplinary work, in which different fields address separate problems inside a common framework, transdisciplinary research involves a stronger “interpenetration of disciplinary epistemologies”. Effectively, this means new fused horizons become possible, beyond or transcending paradigms existing within single disciplines. Consciously pursued, transdisciplinarity is an approach to problem-solving suited to settings where disciplinary modes prove inadequate.

- *Multi-site.* More numerous organizations become involved as partners or collaborators in research, making the process more socially distributed as well as heterogeneous. Scientific discovery becomes more collective, as

evidenced by publication authorship, and it becomes more organizationally diverse: hospitals, institutes, user-groups, consortia, networks, etc.

- *Applied*. Gibbons *et al* classify much transdisciplinary research as "essentially a temporary configuration and thus highly mutable. It takes its particular shape and generates the content of the theoretical and methodological core in response to problem-formulations that occur in highly specific and local contexts of application".

- *Reflexive* . Social accountability becomes more important in determining research agendas; furthermore, greater inter-communication between fields tends to foster a higher degree of self-awareness in defining and explaining disciplinary frameworks.

In the arts and humanities, transdisciplinarity has had a different career since 1850. Nineteenth-century sensibility was decisively rocked by the Wagnerian notion of the total work of art - the Gesamtkunstwerke - which, in an abstract sense, can be understood as initiating a movement towards more expansive and deliberate synchronization of the separate disciplines of the arts into new synthetic combinations. The legacy of this creative and conceptual innovation was a radical way of thinking about art forms or media in terms of the inter-relatedness of their codes or constituent parts. By the second decade of the 20th century, and alongside the rapid growth of mass industrialization, the conceptual scope of some artists and cultural theorists extended still further, to embrace 'art and technology [as] a new unity'. This 1922 slogan of Walter Gropius, from the Weimar Bauhaus, underlined a strongly applied socio-technical project to shape the quality of mass reproduced designs with all the imaginative resources of the contemporary creative spectrum - not excluding abstract art, modernist music, architecture, and theatre. Its *technological* realization, with the diffusion after 1945 of electronic and telematic media, provides an often neglected connecting thread between today's virtual worlds of interactivity, and those of the early 20th century avant-gardes.

These basic shifts in culture, touched upon all too briefly here, are rarely seen as pertinent, even conceptually, to the changes in knowledge production previously summarized. Gibbons' treatment of the arts and humanities identified some aspects of Mode 2 processes, like the increased role of instrumentation in the humanities (e.g. the use of the computer to produce theoretical models) and what is called the re-shaping of aesthetic response.[11] But overall, he remains ambivalent about the way in which artists and humanists fit into the new mode of knowledge production. They are described as:

> …standing aside as quizzical commentators who offer doom-laden prophecies or playful critiques, and as performers who provide pastiche entertainment or heritage culture as a diversion from threatening complexity and volatility. In other senses, they are even more deeply implicated: through the culture industry, they fashion powerful, even hegemonic images, and through higher education they play a direct part in the new social stratification. (110)

This report will demonstrate a set of closer affinities, by looking at the growth of what we have designated the studio-laboratory, as a site within or through which artists, scientists, technologists and theorists commingle. In a study commissioned by the

French Ministry of Culture, Norman [13] has previously profiled a dozen current European cultural laboratory and media centres where transdisciplinarity contributes to the creation of new aesthetic forms grounded in development of new technologies. Besides transdisciplinarity, this study confirms a marked tendency towards multi-site co-operation and, among several cases, a strong vocation to serve as a bridge between social needs (often expressed as “the culture of the network society”) and the technology development process.

A 1996 conference Art@Science, sponsored by the Japanese research consortium ATR, has produced a collection of papers which, among other things, reinforces what Gibbons might call the interpenetration of applied (artistic) and theoretical (scientific) components in the Mode 2 research context.[14] The conceptual framework for this contribution, at least at the editorial level, tends however to stress a putative “convergence” between art and science, rather than the more contingent, evolutionary models implied in Gibbons’ notion of Mode 2 knowledge production.

The rest of this chapter considers the studio-laboratory phenomenon in relation to the wider dynamics of contemporary research. The first part interprets the growth of studio-laboratory settings since the 1960s; second, their historical emergence in relation to a common classification of types of innovation; and third, an introduction and brief description of a diverse illustrative range of studio-laboratories and related structures.

Studio Labs since 1960.

In recent years, scholars have begun to unpack some of the persistent habits of thought which have tended to construe art and science as dichotomous. Caroline Jones and Peter Galison, respectively historians of art and of science, summarize the aim of a recent collection as moving beyond the focus on ‘art’ and ‘science’ as discrete *products*, to look at commonalties in the *practices* that produce them.[15] Still, little attention has yet been given to the institutional development of the contemporary studio-laboratory. Three overlapping phases may be distinguished.

In the first phase, dating from the 1960s and 1970s, artist centres, networks, university-based institutes and public sector labs were established to support open-ended exploration of new and emerging technologies by artists. Among the most celebrated examples was Experiments in Art and Technology (EAT) founded by artist Robert Rauschenberg and Bell Labs physicist Billy Klüver in New York in 1966. The goal of EAT was to establish an international network of experimental services and activities designed to catalyze the physical, economic and social conditions necessary for cooperation between artists, engineers and scientists. The research role of the contemporary artist was understood by EAT as providing ‘a unique source of experimentation and exploration for developing human environments of the future.’[16] At the same time, other Bell Labs scientists were also engaged in collaborative research, in computer graphics and vision, music and acoustics.[17, 18]

Also during the late 1960s, at MIT, the Hungarian artist and Bauhaus affiliate Gyorgy Kepes founded the Centre for Advanced Visual Studies, providing a stable location for collaboration between artists-in-residence and university-based scientists and

engineers. In the 1970s, composer Pierre Boulez launched the IRCAM (Institut de Recherche et Coordination en Acoustique et Musique) in Paris, based on a dialectical conception of research/invention as the central activity of contemporary musical creation; not incidentally, Boulez invoked the 'model of the Bauhaus' as interdisciplinary inspiration for what he considered the inevitable collaboration of musicians and scientists.[19]

The relative autonomy of these new centres - in the case of IRCAM., established with a fiercely guarded aesthetic independence setting it apart as a modernist citadel - distinguish them from the more publicly oriented type of media centre that began to appear in the 1980s and 1990s. Typically incorporating festivals, exhibitions, commissions and competitions of electronic art, this second phase saw the increased commitment of both public administrations and private corporations towards exposing the most radical media-based creativity to a wider public. As festivals such as Ars Electronica or SIGGRAPH's non-commercial art exhibition became global in scope during the 1980s, so plans were drawn up in most advanced industrial countries to establish permanent centres able to incorporate a dual research/development and public education mandate. To mention only a few of the most conspicuous of these institutions, the Zentrum fur Kunst und Medien (ZKM) and the NTT InterCommunication Centre were active in commissioning and publishing throughout the 1990s even before their physical centres were opened in 1997. The German philosopher and critic Florian Roetzer analyzed the 'media centre' bandwagon of the late 1980s, when he commented sardonically that "everywhere there are plans to inaugurate media centres, in order not to lose the technological 'connection'…This new attention is supported by the diffuse intention to get on with 'it' now, the contents remaining rather arbitrary, so long as art, technology and science are somehow joined in some more or less apparent affiliation with business and commerce." [20] Roetzer was then not alone among critical intellectuals in harbouring a deep ambivalence about these institutional developments, fearing that they would serve only to accelerate the public acceptance of automation in everyday life, on the one hand, and to co-opt artists - "with their purported creativity" - into becoming commercial application designers, on the other.

As it has turned out, explicitly designed linkages between art, research and innovation have developed a good deal beyond Roetzer's cynical prognostications, and now form the basis for the third phase of the contemporary studio-laboratory. Many observers would probably count the MIT Media Laboratory as the main propagandist, if not initiator, of this phase, in spite of the secondary importance of artistic practice or input in its research activities. Xerox PARC since the early 1990s has prominently supported an in-house artist-in-residence program (though whose modest scale perhaps belies the extensive attention it has received). In the words of its manager John Seeley Brown, the program serves as "one of the ways that PARC seeks to maintain itself as an innovator, to keep its ground fertile and to stay relevant to the needs to Xerox"[21]. Other Silicon Valley, Japanese and some European private firms have followed suit, in differing flavors, though more or less in agreement with PARC's position that the traditional model of "corporate support for the arts" - hands-off, patrician, and marketing-driven - overlooks basic potentials for core innovation. Among cultural organizations, the Banff Centre for the Arts in Canada was early in initiating a major-scale investigation of virtual environments as a partnership with university researchers and industry sponsors.[22] Since 1995,

research networks have begun to appear with the express aim of linking multimedia art with technological development and the social sciences. In short, the deliberate involvement of artists as collaborative researchers in innovation programs now takes place in a wide variety of social and economic settings, with a corresponding diversity of approach and program design.

The increasing pace of establishment of studio-laboratory sites in the 20th century, clearly shows a grouping of activity in or bordering the 1960s, and again, the 1990s. This pace has now reached a point where it is no longer conceivable to keep accurate track, particularly with the proliferation of all manner of new media centres at various degrees of sophistication and scope on university and college campuses, within corporations, as regional industrial development efforts, and as catalysts for public access and digital literacy efforts. Rather than even attempting a comprehensive listing of such sites, we will focus below on characterizing the range and styles of their approaches to innovation.

Before turning to this, however it will be useful to briefly consider the widening scope of the Research and Development process in the context of recent critiques of the so-called 'linear' model of innovation. This critique, undertaken since the 1960s by sociologists, historians, and economists of science and technology, makes explicit what Gibbons' Mode 2 concept of knowledge production accepts implicitly: the inadequacy of the simple model of a one-way flow of ideas from basic science through applied research to development and commercial innovation. In the place of the traditional mechanistic model, evolutionary, interactive models emphasize the linking of inventions to markets, with significant stress on user innovation and the role of embodied skill - tacit knowledge - as determinants of innovation.

Innovation types.

Economist Christopher Freeman distinguishes between four categories of innovation and their diffusion: incremental innovations, radical innovations, new technological systems, and changes in techno-economic paradigm.[23]

1. *Incremental* innovation involves small-step improvement of existing technologies or processes; as such it covers the vast majority of patents that are taken out in the world, as well as typical changes in product design or styling within industry. It is worth adding, in this particular context, that it also includes the bulk of contributions to scientific research. Indeed Thomas Kuhn, the philosopher of science whose book on the structure of scientific revolution brought the concept of paradigm change into common use, defined normal science as puzzle solving. Whereas within the arts, innovation is a primary value, in science it arises only as a response to *crises* in established paradigms.[24]

2. *Radical* innovations are discontinuous events, going beyond variational creativity. In the oft-told explanation, no combination of horse-driven coaches could have produced the railway; so, for many artists interested in working with information technologies, the aim is often to explore or invent new media forms, as the 'unit' of innovative work, as opposed to working within

established techno-cultural genres. It is worth noting how artists' ideas about radical innovation since the 1960s have been in part shaped by the way in which Marshall McLuhan's widely diffused discourses about media as art forms characterized experimental artists as prophetic. Although McLuhan was himself thinking mainly about the modernist writers and painters whose radical innovations (Eco's open work) actually anticipated aesthetic structures now embodied in electronic media, the very notion of new media artworks as 'perceptual training' for yet-to-be-invented new media environments now has taken hold widely. This makes it possible, today, to consider the proliferation of user interface creations in aesthetic terms - much as McLuhan spoke of the content of new media in terms of the features of previous ones.

3. *New technological systems* involve constellations of interrelated innovations, both radical and incremental; as systems, they entail economic and social as well as technological changes. Examples include plastics and synthetic materials, in the 30s and 40s, consumer electronics in the 1960s, and digital networks in our time. Taking the latter case as illustration, changes are underway in how knowledge is technically produced and distributed, in models of education and life-long learning, in the globalization of finance, and the rise of electronic commerce. These interrelated technologies and organizational changes combine to produce 'trajectories', along which new innovations that would have been radical become incremental as the system matures. The idea of technological trajectory is closely associated with that of 'path-dependency', the familiar effect of 'lock-in' which takes place when new technologies and associated human skills are widely diffused.[25] Another standpoint on the reversibility of technological trajectories, perhaps more suited to the complex patterns of interaction between art and technology, is provided by the French sociologists of innovation associated with the so-called actor-network theory. These scholars speak of socio-technical *dispositifs* - a set-up, or dynamic apparatus - which combine objects, both human and non-human, the conditions under which they are used, plus the means through which new entities or agencies in networks emerge.[26] From this anti-reductionist angle, constraints are in both things and people, and are both limiting and generative. Technological systems grow out of the co-evolution of actors and techniques during the conception and adoption of innovations [27]. Crucially, for the digital *dispositifs* under consideration here, it would appear that artistic conventions, craft routines, and related embodied practices can play an important role in the growth of *new* networks (or trajectories).

4. Changes in *techno-economic paradigm* refer to the so-called 'long-waves' of economic and social change which, according to some evolutionary economists, have articulated the history of the industrialized world in 50-60 year periods since the mid-18th century. Techno-economic paradigms are pervasive shifts, based on the arrival of new material inputs that are cheap, widely available, and revolutionary in impact. The current Information Technology paradigm, by this account, was in preparation since the 1940s and 50s, but only began in the 1980s with the widespread and cheap availability of micro-electronics. (The previous mass-production paradigm began in the 1930s and 40s, organized around the cheap availability of energy supplies including oil.)

As interpreted by social scientists such as Manuel Castells, the information technology paradigm provides the basis for producing a vast synthesis of current political, social, economic and cultural tendencies;[28] however, so far little attention has been given to what sectors may now be forming in preparation for the next techno-economic paradigm. It seems apparent from the vantage of the late 1990s that some combination of bio-technology and cheap bandwidth will likely form the basis in coming decades of the next techno-economic paradigm, distinct from but building on information technology. What philosopher Vilem Flusser already identified as an emerging *ars vivendi* in the late 1980s clearly signalled what is turning into a central issue for creators in the arts and techno-science, as we begin to imagine what it means to move beyond mere biological analogies to the practical construction of post-organic life.

Sampling of Studio-Laboratory Institutions and Structures.

By juxtaposing the starting dates of studio labs against the five innovation waves, it can be shown that they cluster around the rising portions of the waves. No rules or strong theories are meant to be implied by this observation. It is surely suggestive to think of the Bauhaus as catalytic in relation to the broader flow of innovation within the Fordist mass-production regime. Many of the studio-labs that appeared between 1950-65 dealt broadly with a range of material technologies, light, electronics, and kinetic or cybernetic systems. However from the standpoint of the *aesthetic* paradigms which they explored and defined, they could be understood as preparing the terrain for the new material possibilities afforded only by very powerful networked micro-processors, which only became a reality toward the mid-1990s. As will be seen in the following survey, the current studio-laboratories are active in all four of the categories of innovation previously introduced. Some, a distinct minority but noteworthy nonetheless, are oriented toward the issues and challenges associated with what may be a new emerging bio-techno-economic paradigm. For the most part, however, description here centers on the still far from exhausted potential of digital media (some would say, recalling the perennial software crisis, barely tapped).

The studio-laboratory as a class is by no means homogenous. Some are privately funded by corporations, seeking to understand the properties of radically new media technologies via aesthetic R & D programs; others are public funded and linked to traditional mandates for public education; others are industrially sponsored pre-competitive laboratories based in universities; still other models are network-based and more or less explicitly tied to long-term state or regional industrial development objectives. The studio-laboratory can be understood as providing a site for an ongoing and progressive series of negotiations between artist-users and technology designers, which simultaneously shaped the technology, its use, and users.

Instruments and the Imagination.

One fruitful way to think historically about the kind of techno-cultural creativity manifest in studio labs is to recall the role that instruments have long played on the margins between science, art, magic, entertainment, and philosophy. Citing science

historian Thomas Hankins: “To understand actual scientific practice, we have to understand instruments, not only how they are constructed, but also how they are used, and more important, how they are regarded”. Hankins does just this in a book about curious, mostly forgotten instruments from the 18th and 19th centuries - ocular harpsichords, animal automata, stereoscopes and magic lanterns - which oscillate between demonstration, entertainment, magic, and measurement. The crucial point that Hankins makes is that even such objective devices as the telescope, microscope or air pump were the subjects of controversy in their time; just as the photograph later was in the 19th century, and today, digital processing of images makes the veracity of any picture questionable. “We *choose*”, Hankins writes, “how to represent the natural world to ourselves”.[44] Instruments are a way of questioning nature, a language of inquiry; and the historical examples retold with verve in Hankins’ book suggest a way of considering today’s investigators -- artists and scientists - in the spirit of those natural philosophers, whose instruments move easily between natural science and other human activity.

Media technology as boundary object.

A striking set of examples where today’s investigators specifically designate technology as a shared medium of joint exploration is available from the Xerox artist-scientist pairings. Each case indicates the medium taken as point of departure, and the contrasting way in which they were regarded and employed by scientist and artist respectively:

- Scanning tunneling microscopes (STM): as a sub-atomic recording device; used by musicians to convert atomic bumps into sound patterns
- Images as glyphs in which technical data is embedded; images as iconography carrying metaphorical and linguistic layers
- Web-site for social-action art project with mental patients; web-site for corporate communications.

The PARC commentators refer to the medium (or experimental document in their corporate jargon) as a common language, but a more apt metaphor is perhaps that of the boundary object. This is a term introduced by sociologist of science S. Leigh Star, describing scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements for both of them.[45] Through a radically opposed dialogue about the STM, one PARC researcher recounts, a new line of questioning grew about how the senses are extended through instruments: Are there untapped sensory channels for interacting with the unseeable which enable powerful conceptualization?[31]

Similar conceptualizations of the sensorium characterized the collaborations during the 1960s between AT&T Bell Labs researchers in vision and perception, and the varied artists - musicians and filmmakers, mainly - who worked with them. In the words of vision researcher Bela Julesz: “Visual perception is historically a common area for both the artist and scientist, a common intersection where there is no gap or artificial bridge. The same kinds of things can be artistic or scientific; the only difference is the motivation. The artist is searching for an artistic truth, an intimate truth he wants to convey, and I am searching for scientific truth, which is testable and

very defined."[17] The activities of these teams tended to focus around the digital computer, which was constructed as a tool for understanding human perception, and at the same time, as a potential new medium for artistic expression. Bell researchers tended, in the main, to locate the artistic added value in the unique ways in which artists could train themselves to perceive, and thereby, shape, images or sounds. John Pierce, director of the Communication Sciences Division, acknowledged that in seeking to program computers to produce intelligible speech, one of the most important human faculties is that of being able to judge qualities even when we cannot measure them. Here the ear of the trained musician may be as valuable as the digital computer.

Today, similar cases abound; entire labs, like the Chicago Electronic Visualization Laboratory, operate on the basis of the heterogeneous shaping of a common medium which can prod new disciplinary insights. In some cases, the uncertainty of the object's identity has declined over time, becoming, much as Hankins described some of the pre-scientific instruments of natural magic, more or less stabilized at one or another of its poles of attraction. Such, it could be argued, is the case of scientific visualization at the EVL: to the extent that the aesthetic shaping of the immersive simulations developed there is confined to the usual non-essential parameters of colour, form, or texture, the object has settled at the scientific side of the margin.

As we have previously seen, one area where the boundaries today are notably blurred is the field of artificial life, attracting artists with interests and background in biology and computation to create evolutionary digital systems. Broadly speaking, ideas from genetics have begun to shape the way many computational artists conceive the inter-relationships between their formal materials. In the simplest manner, style can be characterized in terms of traits, and as objects - drawings, or melodies, for example - replicate, they change form according to programmed rules of reproduction and mutation. Artificial life extends evolutionary metaphors even further, in the work of the team Christa Sommerer and Laurent Mignonneau, who develop artificial-life installation works as researchers at ATR corporation in Tokyo. They build imaginary eco-systems which evolve and mutate as artificial virtual worlds, but are able also to react to observers' gestures when provided.

A scientific colleague at the same lab, computational biologist Tom Ray, illustrates well the instability of borders between artificial-life artists and scientists, when he calls for a new aesthetics, based on free evolution in the digital medium. Interestingly, he argues this evolution need not be "inherently visual or auditory in nature … and would not be recognized as conventional artistic creations". He seems to be describing a kind of computational beauty inherent to the digital medium, with "richness comparable to what [evolution] has expressed in the organic medium".[46]

The Musical Instrument as Interface Metaphor.

There is one special case of the projection of human imagination through skilled instrumental performance: musical instruments have long served as metaphor and analytical model for philosophers (think of Heraclitus or Confucius), mathematicians (Pythagoras or Galileo), and in our own time, computer scientists and interface designers.

From the earliest years of personal computing, a controversy has simmered about the trade-offs in designing systems that are easy-to-use but quite general in their scope, or more challenging to master, but with greater depth and power. Alan Kay, credited with conceiving the personal computer as a portable *Dynabook* (and later helping Xerox to implement one of the first personal workstations), was also influential in promoting the notion of computer use as a medium for creative thought. In their 1977 paper on personal dynamic media, Kay and Goldberg [47] explained their design goals as wanting to combine *both* the broad, standard-model usability of inflexibly mass-produced items like cars and TV sets, with the plastic, moldable, open-endedness of tangible media like paper or clay. The key, Kay argued in 1977, is learning to use a high-level programming language, inspired by Seymour Papert's artistic approach towards teaching children to program.

In the meantime, the trajectory that actually became locked-in once personal computing took off in the 1980s is based not a style of programming, but rather a graphical means of manipulating and selecting surface icons - the ubiquitous graphical user interface. Far from Kay's subtle, even dialectical conception of fluency within a dynamic medium, most computer use could be characterized as brittle, fault-intolerant, and closely coupled with proprietary software solutions - packaged applications - that offer only minimal room for user-programmed extensions or variation.

In a forthcoming book about Douglas Engelbart and his Palo Alto research group, Bardini sharply pinpoints the actual losses entailed in the "lock-in" of the PC in its present form. [48] Early researchers, like Engelbart during the 1960s, thought of the user as acquiring progressively more powerful kinesthetic and motor skills; in effect, operating interfaces with greater instrumental virtuosity to keep pace with the mental scope and expressive boundaries set by the user's intellect. The idea of learning to play a piano-like key-set, in order to navigate conceptually through information space, may seem like science fiction; but this is what Engelbart himself built and mastered, and arguably, its originality is such that it deserves to be considered a more profound interaction paradigm than the "mouse" with which he is actually credited.

Alan Kay, meanwhile, who is himself a skilled musician, has tended to be ambivalent about how literally to base human computer interaction on a metaphor of musicianship. Younger theorists already describe interface as the characteristic art form of the 21st century, with much the same kind of historical determinism driving their arguments that pertained during Henri Bergson's time when cinema was widely welcomed as the 20th century's defining art form.[49] To have a glimpse today at what this prediction might look like in 10 to 20 years, it is likely more suggestive to extrapolate from the more speculative, 3D or installation-based creation of current artists and design engineers, than to look at the incremental variations coming from software vendors. Much of this work begins with something like a musical notion of the machine interface, using bodily motions, breathing, movement, gesture to shape the art-work's responses in a way that is, at least in principle, amenable to personal nuance.

Turning back towards what might be dubbed the more cognitive pole of the mind-body continuum, it is still worth recalling how Kay and Goldberg had envisaged the system design of a "dynamic personal medium" two decades ago:

> Our design strategy, then, divides the problem. The burden of system design and specification is transferred to the user. This approach will only work if we do a very careful and comprehensive job of providing a general medium of communication which will allow ordinary users to casually and easily describe their desires for a specific tool. We must also provide enough already-written general tools so that a user need not start from scratch for most things she or he may wish to do.[47]

Creative Users in IT Design and Diffusion.

User innovation has become a commonplace term of late, indicating the importance of the user (customer, client) as a partner in the innovation process. Von Hippel explains the benefits of turning users into designers as faster and better and cheaper learning by using.[50] Advanced firms, he argues, are changing the very economics of design, by investing in software-based application-specific toolkits that transfer a capability to design truly novel customized products and services to users. His examples come from manufacturing (custom-designed circuits and software), and he stresses that the design tool-kit reduces the iterations and flow back and forth between users and designers.

Consider these points in a non-manufacturing case now, the software used by artists to make movies, music, or multimedia - all dynamic, time-based expressions which technically challenge the computer's capacity to synchronize and co-ordinate various kinds of audio-visual representations. Software applications have been widely available for some 15-20 years that permit artists to create more-or-less independently from the system programmers on whom they formerly depended if they wanted to use computers without learning to program. As a class, software for animation or music *abstracts* [51] some aspects of the craft of movie-making or composition, mechanizing them into modules much like the already-written generic tools Alan Kay thought all users would likely call on in his SmallTalk system. But what about support for individual expressiveness, corresponding to the distinctive traits of an artists' style or signature? Recalling Simon Penny's present-day concern about artists' practices being re-shaped to conform to the restrictions of their computer-based tools, it is evident that the ability to design novel capacities beyond the base mechanisms embedded in common applications remains elusive.

As has been shown by the successive diffusion of desktop publishing, image processing, music composing, and now multimedia/animation software, the distinctive appeal of such programs lies in the way they facilitate for new classes of users a degree of creativity that formerly required a specialists' craft training. The issue of boosting the general user's media fluency is of less interest to this discussion, however, than to look in greater depth at the way in which *new* types of creative possibilities get embedded in software in the first place.

To do this, we will here present a précis of the results of part of a full case study about the emergence of the creative user of computer animation. In the mid-1960s, when computers were completely intractable to all but engineers, the very idea of

applying digital calculation to the intensely artisanal production of animated film was by no means obvious. A host of contrasting, often conflicting interests existed from the start of computer graphics, and the earliest encounters between artists, system designers and programmers reveal a fascinating, and in some ways instructive story about the conditions under which creative users enter into productive relationships with designers. Another way of saying this is that between the 1960s and mid-1980s, the computer itself was *constructed* as a medium for making movies, within a wide and sometimes contested zone of interpretive flexibility, to use the phrase of Dutch sociologist of technology W. Bijker.[52]

Artists as Lead Users of Early Computer Animation Systems.

The base technologies for interactive computer graphics were largely developed in U.S. military research programs, often closely aligned with key universities like MIT, and supported by the Pentagon's aggressive funding of fundamental information processing research. By the mid-1960s, development of civilian applications was underway as well, notably in aviation, architecture, scientific communication. Many of the same organizations also experimented with artists as lead users of early mainframe animation systems. Broadly speaking, two design approaches towards computer animation were pursued: picture-driven, and language-based. The latter specified visual images and their continuity using traditional textual computer programming languages; they depended on the ability to describe visual phenomena mathematically. Picture-driven approaches aimed to assist aspects of the hand-crafted art of animation, permitting the non-specialist artist to draw and ink the cells serving as key-frames, using the computer to coordinate the images and calculate the transitions between them (in-between) images.[53]

The study looks at similarities and differences between the way in which this field developed in various parts of North America; in particular, close attention is being given to the conditions of innovation which led to an unusually dense concentration of firms, researchers, and electronic media artists in Canada. Beginning in the mid-1960s, researchers at the National Research Council (NRC) and the National Film Board (NFB) - both federally-funded agencies - began to investigate the potential for using computers in film-making. The approaches taken, in each case, differ markedly from those of the American research sites. In both cases, the Canadian investigators were scientific and technical followers, not leaders, and they had very restricted budgets for equipment and personnel. They began their research by intensively studying everything the Americans had done to date.

To start with, the NRC researchers chose film-making as an application domain through which to study the problems of the man-machine interface. Besides computer animation, they also began an equally important program in computer-assisted music composition. Their goal was general understanding, ultimately to better support the use of interactive computing in science and engineering. But it was by no means irrelevant to their choice that the NRC was already a kind of studio-laboratory, supporting in the same Radio and Electrical Engineering department the groundbreaking research of a physicist-cum-composer on electronic musical instruments. By modelling the user as a *creative* artist, an original outlook

resulted which at the time of its formulation in 1969 was notably different from the U.S. corporate or university labs [54]:

> …Up to this point, it has been assumed that the best possible way to design the computer would be to make it transparent. That is to make it look to the user as though it were not even present, so whatever idea occurred to him, it could be rapidly formed into a final creation. This is not necessarily true

Constraints, argued researcher Ken Pulfer, are crucial to the creative process, giving examples such as conventions for drawing in architecture, or scales and notational conventions in music. By supporting the use of such conventions, the user is given a more meaningful starting point than the abstract 'blank slate' of total generality.

> …Most computer languages now available ...are unsatisfactory either because they are mathematically oriented, or because they result in cumbersome and slow programs. As a result we are usually left with the situation where an artist-programmer team is formed, the artist uses the system without having intimate control over the functions of the blocks he uses, and the programmer builds blocks without fully appreciating the needs of the artists.

Pulfer and his team chose therefore to develop a system in which:

> at no time [was] it necessary for the user to learn how to program the computer, or in fact even to know how to operate it other than through making some choices from names presented to him on the screen... he can proceed to learn the 'language' by trial and error.

Crucial to the implementation of this design was the just-published research of the first graphical user interface published in 1968 by Douglas Engelbart [55] - interestingly, as a system for augmenting the human intellect. The NRC team considered the results produced by the U.S. artist-programmer teams to lack validity for their purposes; for this reason, they chose to work only with professional filmmakers (or composers) who could teach them something about movie-making (or music composition).

Beyond the Access Paradigm.

The preceding section demonstrated how creative users linked to the innovation process over a several decade period contributed not only to cultural enrichment in the uses of technology, but also to the growth of an important sector of a regional information economy. From the standpoint of the worsening inequities between the information haves and have-nots, showing how a strong cultural informatics capacity grew up at the figurative doorstep of Hollywood might not at first glance seem all that pertinent. However, there is also a long tradition of analyzing Canada as a borderline case - the hidden *ground* for the big powers , as McLuhan characteristically quipped[62], with elements of both first and third world countries.

Recasting the Canadian case slightly, it can be seen as one pathway to the building of local cultural distinctiveness in a situated set of informational practices. Situated in this context, leads us to consider the challenge of cultural diversity in the age of globalization. Much culturalist thought on this topic is still stuck in a mass-media mindset, like post-colonial theorist Edward Said who has railed:

> The threat to independence in the late twentieth century from the new electronics could be greater than was colonialism. The new media have the power to penetrate more deeply into a 'receiving' culture than any previous manifestation of Western technology. (quoted in [63])

To be sure, corporate concentration in the media and entertainment fields continues its rampant increase. As the Economist magazine observed tartly: "What will the digital revolution do to the entertainment industry's emerging global oligopoly? Probably boost it."[64]

Said obviously overlooks the myriad ways new media have been used by opposition groups, NGOs, identity-formations of all sorts; it is striking indeed that he appears to grant no power to the backchannels available through digital media. This movement goes alongside the fusion of internet, multimedia and computer games with the entertainment economy, and so far, it is anyone's guess the degree to which pessimistic Frankfurt-School type predictions of imperialist cultural hegemony will prevail.

Cultural policy makers have not, for the most part, helped matters much by their willingness to concede a limited role for culture as compensation against the loss of national identity through economic globalization. This lack of vision and advocacy often gets translated into a heritage-based conception of identity, grounded in the irreproachable values of restoration, preservation, and conservation. For those approaching cultural development from a more active technological perspective, policies emphasizing heritage priorities channel inordinate resources towards information projects concerned with inventory management, data retrieval, and classification standards. Unquestionably, the librarian's, curator's, or conservator's professional skills are crucial to delivering effective *access* to cultural heritage. But these objectives need not be in conflict with broader issues of creativity and innovation in the cultural *use* of digital media. As Stuart Hall has said, "identity is not in the past to be *found*, but in the future to be *constructed"* (quoted in [65]).

In a recent book about information technology for sustainable development, Robin Mansell stresses the role of information cultures in shaping people's ideas about how they should be concerned with media, technologies, the advantages/or not of information access, tele-learning, telework [66]. Drawing on the work of Ursula Mier-Rabler, an Austrian scholar, she lists four such cultures, each followed here by a sketch of the values implied by each label:

1. Protestant-enlightened information culture (U.S.A) - competitiveness, transparency, ICT's a basic instrument of economic action
2. Social democratic-liberal information culture (Scandinavia) - enhanced knowledge about civil society is beneficial to individuals, and ICT central to political emancipation
3. Catholic-feudal information culture - information is hierarchically organized, and transmitted from the 'info-rich' to others; no consensus on individual information rights
4. Centralist-socialist information culture (former Eastern bloc) - precise information gathered and fed from the periphery to central organizations

As Mansell notes, none of these is a pure form. How they are configured is a factor in determining whether there will be a demand for access to information via advanced Information and Communication Technologies.

As we have been developing in different ways throughout this report, another important information culture might be identified, defined less in terms of political or ideological alignments, than its tactical grasp of the pragmatics of media. We will call this, partly tongue-in-cheek, the art-hacker information culture. This culture rejects any rigid separation of form and content; communication is never passive reception, but invariably entails some more or less actively expressed response. Response is not confined, furthermore, to the pre-figured options that might shape a system. If the occasion demands it, new extensions can always be added to make it possible to think *outside the box* or *jam the channels*. A certain parodist reflexivity prevails in this ethos, as the adbusters or culture jammers play with and undermine the communication flows of their opponents.

On a more theoretical level, this information culture has a deep suspicion of what Berkeley linguist George Lakoff identifies as the conduit metaphor, a deeply engrained linguistic habit in which "ideas are taken as objects and thought is taken as the manipulation of objects [and] that memory is storage…Ideas are objects that you can put into words, so that language is a container for ideas, and you send ideas in words over a conduit, a channel of communication to someone else who extracts the ideas from the words".[67] The conduit metaphor for communication, like the "linear model" of innovation previously critiqued, is deficient because of its inability to cope with complex systems. The metaphor is widespread and pervasive, contributing to the common way in which content or content services are seen to be made of separate stuff from software and hardware, to which people are given access or not, through more or less transparent or affordable interfaces or channels.

The art-hacker culture pervades the practices of the various studio-laboratories already discussed; here we wish to consider the way it drives a particular approach to socio-technical development. Two main aspects typify this approach: first, a preference for the open source philosophy of development. This ethos, which stems in part from the earliest hacker culture of the 1960s, has now acquired serious corporate respectability as a credible alternative to proprietary, hierarchically managed development of software and hardware systems. In place of hierarchy, many artisans contribute components within open, standards-defined frameworks, freely sharing improvements and benefiting jointly from the collective rising tide. The second aspect of this culture is a style of heterogeneous teamwork, typically assembled around temporary, socially-specific projects or campaigns. Geert Lovink, the Dutch media theorist and co-organizer of Hybrid Workspace at Dokumenta, formulates a framework for cooperative action as:

> … a radical pragmatic coalition of intellectual and artistic forces-- forces that, so far, have been working in different directions. It is time for dialogue and confrontation between media activists, electronic artists, cultural studies scholars, designers and programmers, media theorists, journalists, those who work in fashion, pop culture, visual arts, theatre and architecture.[63]

The tactical media orientation uses all modes of media, old and new, and in particular looks for ways of combining the virtual world of digital media with

community based media practices. Lovink and colleagues have been closely aligned as technical and creative advisors to the Soros foundation, in setting up internet access centres, media art research labs, and training in the former Eastern bloc. They now are turning their attention to Asia, developing links in China, India, Indonesia.

An apparent spin-off of these developing links between the Euro-socialist-art-hacker information culture and the developing world is the recently announced Sarai - the first independent media culture centre in India. Sarai is a joint initiative of the Centre for the Study of Developing Societies, Delhi, Raqs Media Collective, Delhi, in collaboration with The Society for Old & New Media, the Waag, Amsterdam. Sarai is conceived:

1. As a public access driven, de-centralized constellation of a variety of research, creative practice and education initiatives in all aspects of the new and old media landscape.
2. As an alive and integral part of the new urban culture and emerging civic consciousness of the city of Delhi/New Delhi. As a major player in the shaping of the urban culture and political imagination of the city of Delhi/New Delhi in the future.
3. As a place where young and old people, academics, scholars, activists, technicians and artists can interact amongst themselves and with others through old and new media, through a variety of programs that are designed primarily to be low -cost or no-cost. This includes, terminals for free public Internet access, ISP services, offline/dial up connectivity for those who cannot afford personal internet accounts, publication, outreach and education programs and a variety of open public events.
4. As a hub of networking amongst new/old media activists, a centre for creating and exhibiting original work and as a clearing house for innovative ideas in the South Asian/Asian region.
5. As an equal partner of new media initiatives at an international level, and as a contributor to the content of emerging/new media cultures across the world.[68]

Sarai is still in the earliest stages of establishment. As a model, it suggests a possible structural approach towards wider development of active media and information capabilities. The stress on local self-direction, combined with globally sophisticated cultural partnerships, bodes well for its future. Some possible pitfalls can be anticipated: too heavy reliance, for example, on what worked well for the European partner. It is likely, for instance, that training programmers to think about creative users, or artists how to program, may require a completely different approach in the Indian context, than has worked in Western or Eastern Europe.

Cultural Critique, Reflexivity and Innovation.

In the main, humanists have had considerably less to do with the kind of co-operative development of technologies undertaken between artists, engineers and scientists. One thoughtful commentator has summed up the usual interests of humanists in information technology as follows:

- Computation becomes the object of humanities research: the history of computation, the sociology of computer use, cultural criticism of Artificial Life
- Computational tools are used for humanistic projects. Humanists compose with word processors, send each other email, read the latest articles over the Web.
- Computational artifacts become essential research tools; automatic text analysis is used to support literary criticism, scholarly papers appear in hypertext, collaborative writing environments are used to co-write texts.
- In conjunction with the adoption of computational tools, computational concepts are borrowed and adapted to humanist projects: chaos theory as a method of literary analysis, the cyborg as a model of subjectivity, the robot historian as first-person perspective.[69]

The author of this passage, Phoebe Sengers, is a rare case of a computer scientist with equal background in cultural theory [70]. Her own original contribution is a widened conception of what she terms cultural informatics

> … a practice of technical development that includes a deep understanding of the relationship between computer science research and broader culture. This means understanding computing as a historical, cultural phenomenon, including, for example, analysis of metaphors that shape technical approaches, discovering prejudices in the Heideggerian sense that cause us to look at problems in one way to the exclusion of others, finding unconsciously held philosophical difficulties that leak their way into technical problems. These insights are used as a basis to change underlying metaphors, prejudices, philosophy, resulting in changes in technology. Cultural informatics integrates a broad humanist perspective with concrete interventions in technology and technical practices.

As a term in English, informatics is preferred by some scholars to designate the disciplines usually called computer science or engineering. The preference is not incidental. Nor is it without adherents from the computer science community too, and for similar reasons. Yale professor David Gelernter has called for a complete re-thinking of the training of computer people, though not emphasizing cultural theory but an in-depth knowledge of history of art, design and aesthetics. “Software programming should be taught in studios, like art”, Gelernter writes [71]. Far less stress should be placed on correctness, and more on elegance.

What Gelernter is pleading for is a higher standard of design in digital media, a balance of form and function that goes far beyond the usual requirements-based conception of user-centred design. To convey that extra measure of aptness, of conviviality past mere usability, elegance accounts only for what might be seen as the surface design elements. Taking seriously Sengers’ proposal to consider computing as a humanist discipline actually pushes at the intersections between deep system-level design, philosophy, and social science. It is hardly surprising that this agenda is, so far, little understood in the academy.

At the Banff Centre’s Art and Virtual Environments project (1991-94), a deliberate plan was made to precede a period of active technology-art development with a formative symposium organized to critically examine the concept of virtuality. This was carried out in a 10 week residency, involving not only artists and technology developers, but philosophers, cultural theorists, art historians. Virtuality here is understood:

> ... as an expression of social discourses that are already in place. One of the intentions of the residency is to address the broader context of socio-cultural shifts that are both the cause and symptom of technological changes.[72]

The goal was to develop a set of alternative conceptions - metaphors, scenarios, speculative designs - that could inform the development team through the actual implementation phase. In fact, few linkages were made at so functional a level. The actual experience revealed the very wide gaps separating the world-views of critical theorists and those of engineers and programmers (much less so, most of the artists). As noted by one of the participants self identified as theorist:

> While the majority of artists appear to have been theoretically and practically ill-equipped to deal with this new technology at the level of its technical organization, those involved in developing its hardware and software are equally ill-equipped to deal with its social and cultural dimensions as well as its political implications.

Yet, as was proved in the subsequent implementation phase, the artist-developer teams *were* eminently capable of developing, at a project level, cooperative strategies sufficient to produce what one commentator has since termed projects that would permanently extend the tools we have for seeing and hearing.[73] But what remained under-realized in this project was precisely the kind of conscious integration of what Sengers called 'humanist perspective' in an ongoing technical practice. The Banff technical group disbanded after the project, and the cumulated expertise and software capability dispersed among the participating artists and researchers.

Within the context of the European Union research networks, several ethnographers, sociologists and anthropologists have been carrying out field studies of contemporary technological art installations, aiming thereby to inform subsequent system and design practice. In an ethnography of visitors to the ZKM Media Museum, investigators chose to analyze media art works sociologically as *breaching experiments*. With a technical goal to devise protocols for interoperability between different virtual environments, they studied the sense of presence experienced by museum visitors, to better understand their intersubjective organization.[74] These early results do not indicate whether or how findings would lead into the design phase.

Also in the past year, interdisciplinary humanities seminars have been held on Computing science as a human science at the University of Chicago, and on Virtual reality, past and present, at Cornell. These seminars are intended to engage with the technical community, but do so still within the usual framework of critique.

Applied research combined with critical perspectives has been termed critical technical practice.[75] Still, very little of this community seems to be connected to or even aware of the potential resources and talents of the electronic art community.

Broadening Public Awareness of Techno-Science.

In an informal evaluation of the Wellcome Trust's Sci-Art program, Cohen noted the deep sense of urgency expressed by many of the applicants, that they felt the need

to look outside the limitations built into their careers and institutions. “It may be too strong to say that they felt some kind of moral imperative…it is rather that they appeared to feel that the boundaries of their discipline were (and indeed are) weakening at the edges, that people from outside were doing work similar to their own, and that by moving outside the discipline, they may be rewarded by a new perspective and new ways of thinking about their subject”.[76]

If this type of program has indeed struck a nerve, it would be worth considering how it might be made more accessible beyond the U.K. While the outcomes of such collaborations can clearly be very broad, here it is worth underlining the potential contribution to public discourse about scientific and technological issues.

Two final points to close this discussion: As we have seen previously, artists are increasingly attracted to the horizons of bio-medical and evolutionary computation. The ethical quandaries arising from these fields may perhaps be as well articulated and illustrated through the kinds of expressive collaborations with scientists that are nurtured through schemes like the Wellcome Trust’s Sci-Art. Second, providing a more variegated sense of the so-called *hard* professions of science and technology, might influence young people to conceive of these professions in new, more nuanced ways than tends to be the case. To close with an anecdote: one of the most gifted female computer graphics systems programmers began her higher education at art school in Canada. After seeing the early computer animated film Hunger, she decided to train in computer science, in order to create better tools for artists.

Conclusion.

This report has attempted to present a multi-perspective framework from which to view the rising density of communication between the worlds of art, technology, and science. Designating the site of this hybrid activity as the studio-laboratory, the first section traced the development of such organizations historically, compared their dynamics to that of *cross-disciplinary* knowledge production in science and technology, and argued that they foster incremental, radical and systemic innovation. By its boundary-spanning nature, a good deal of this activity stretches the limits of established paradigms, whether these are considered from the techno-economic, social or aesthetic standpoint.

The survey of current studio-labs revealed a number of commonalties with Gibbons’ description of ‘mode 2’ knowledge production. The assembly of scientist-artist-engineer teams usually takes place in a specific context of application, which can range widely from art commission to teams of more or less equal artist-scientist researchers. In many cases, the crucial collaborative communication still takes place in face-to-face encounters, as a rule laboratory or production rather than seminar/theoretical settings. Where distant teams work on common projects, periods of intensive residential development are interspersed with tasks still often divided by discipline. This makes particular sense for cyclical, iterative projects, like system design and development, where the learning by using can only go on so long before major overhauls are needed. The temporary media lab notion is the most lightweight version of the contingent manner of organizing the conjuncture of artists,

programmers, and theorists; it contrasts with the high-overhead, large-permanent staffing of the centres like the ZKM or IRCAM.

With the price to performance ration of commodity hardware continuing to decline, specialized equipment is becoming less critical to the studio-lab than the range of collaborative dynamics they can accommodate. Individual artists are, more and more, acquiring effective home-based studios which even five years ago were rare outside high end labs or commercial facilities. What we have learned through our survey, however, is that much of the innovation emerging from both the older and more recently founded structures takes place in the flesh, within particular settings, whether these be temporary special events, industrial labs, cultural centres, or universities.

How the specificities of particular studio-labs relate to the system of innovation in which they function is a rich subject for further study. As we have seen, a dialogue is already occurring in the E.U. between the arts/cultural sector, industry, and university researchers, and new mechanisms are being devised to turn that dialogue to action. In North America, there are no large scale public-oriented studio-labs operating with the kind of ongoing government sponsorship found in Europe, or corporate sponsorship as in Japan. But the tremendous dynamism of the U.S. information/media sectors generates lots of studio-lab activity which could not be addressed in this report; for instance, Intel's support for artists working in a variety of university labs, or Disney Corporation's now very substantial scientific research department. In the specific U.S. setting the difficulty seems to be less about attracting corporations to finance educational facilities with hardware/software; the more important dilemmas arise over the strings attached to such sponsorship. For this reason, the key question in the North American context will turn on how *independent* media labs can be sustained, whether on campuses, through 'enlightened' corporate programs like Xerox, or, what has been less attempted on this continent, building onto existing cultural infrastructures like museums or theatres. Clearly, this particular discussion will need to be framed broadly enough to bring industry, artist/designers, technology researchers and social/cultural theorists around the same table.

In our look at the studio-lab phenomenon, we have stressed that place still matters, perhaps even more now that communication is so deceptively ubiquitous. We have also made clear that the range of innovations coming from these sites falls into all four of the classes described by Freeman. What is less clear, from a policy standpoint, is whether all should be equally supported, or greater efforts be concentrated towards a few. This question will, naturally, be answered differently in the developing world, where the incremental integration of digital with older, locally-specific forms of media may be the soundest way to start building up a broadly based innovative capacity.

Also, from a policy perspective, it is important to think of the cultural shape of future digital media in terms of the accumulation of expressive traditions: ancient and modern, individual and collective, purely informational and materially embodied. Support for projects, valuable as they will invariably be, should nonetheless be understood in these larger terms. From this assumption, though, arises yet further questions: what models of studio labs fit best into which national innovation context?

We examined this framework through the prism of five discussion themes. Using the figure of *Instruments of the imagination,* the cybernetic art work was likened to previous representational *dispositifs* - mediating devices or boundary objects between the sensorium and a "natural" world ever more saturated by artifice. *Creative users* extends the much-studied user-producer relationship to consider the artist as a kind of user-to-come, a necessary extension where the field of innovation is a fast-evolving symbolic environment. Seeing the artist as a cognitive pioneer only, we suggest, weighs too heavily on the side of theory; learning through using is how artists have always fashioned their poised balance between form and content, technique and idea.

Access, it was suggested, has become a leaky portmanteau term - carrying all freight but delivering little. Besides measures based on hardware, price, and intellectual coherence, access entails a new kind of fluency with the medium-specific traits of the computer; the build-up of such fluency may be less an individual trait, and more a function of networks (programmer, designer, artist, user). Reflexivity thematizes technical practice as socially situated. The distance between the worldviews of cultural and social theory, and those of the designer-engineer-artist, remains large but there are promising indications that insights between them are growing. Finally public awareness about techno-science may be enriched through more extensive art-science collaborations. Benefits include improved conceptual articulations and re-shaping of the image of professional practices.

Necessarily, a report of this nature leads more to openings than to prescriptions. More knowledge is needed about a host of issues and questions, a partial list of which includes:

- The structural viability and likely longevity of the new large-scale stand-alone centres for art and technology.
- The potential value of tactical and temporary media lab interventions in the developing world: in particular, what infrastructure and resources would be needed to encourage greater linkage between studio-laboratories in the developed and developing worlds.
- Widening awareness in the corporate world of the potential value of an engaged style of cultural support, modelled more on innovation than traditional notions of patronage.
- Whether networks of innovators, here characterized separately in terms of research, civil society, and art-production, can become more integrally connected.
- How best to advance a common pragmatic agenda for cultural informatics, joining the concerns of social and cultural theory with the fields of computer engineering and software design.

Art historian Erwin Panofsky, writing about the Renaissance, attributed the flowering of the arts and the birth of observation-based science to new transmission belts that re-connected theory and practice, art and science, instrumentation and sense-perception.[77] At least as much may be at stake, five hundred years later, as we face the challenge of continually re-humanizing our technological world.

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