ONTARIO COLLEGE OF ART & DESIGN

Address to City University of Hong Kong at the launch of the Applied Laboratory for Interactive Visualization and Embodiment (ALiVE) at Hong Kong Science Park

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It is with great thanks that I address you today — thank you Jeffrey Shaw and President Way Kuo for this opportunity. I wish you well with your spectacular new building and with the ambitious ALiVE research centre. I will share some thoughts on the value of art, and science, technology, design and engineering collaboration and its relevance to the university. I will then speak about the importance of one of your fields of focus, one that I share, data visualization.

In earlier tribal cultures (such as the Inuit of Canada) art, science and technology invention were interlaced, even united. And before the twentieth century, art and artists from many cultures were inspired by disciplines as proximate as the humanities — literature, philosophy, history such as mathematics, physics, earth sciences, biology. But the post-war era in the West rigidified specialization, creating barriers between even proximate disciplines and, with this, a separation of the arts and sciences. Yet artists in the late 20th century and this century have rigorously insisted on their right to engage across structures of knowledge, including more recently the social sciences. It is clearly a time when the sciences and the arts are joining forces again. “ArtSci”or “SciArt” in the USA[i] are terms that emerged in the 1990s in the United Kingdom to designate collaborations between artists and scientists. There is a philosophical and a pragmatic urgency to such collaboration because the world’s great challenges can be seen and approached through different lenses. When we bring together different relevant knowledge and methodologies we can trigger insights. Collaboration is a fundamental requirement of many large-scale new media projects where new tools are as needed as new artistic expressions. Transdisciplinary experiments push the boundaries of aesthetic practices, emerge new techniques and actual tools and reshape world views.

Artists and scientists derive their approaches from different training and ways of working, with much differentiation within their own disciplines. Yet, more than other fields — each is driven by curiosity and imagination. Artists work in relatively speculative ways — asking questions and not predefining a result or through empirical investigations, drawing from technical and experiential, process-based methods as well as on philosophically driven questioning and the self-reflexive studio critique. Many scientists and social scientists also work speculatively and then add experimental tests of proof, mixing quantitative iteration with qualitative assessment. Contemporary engineering and design use relatively applied methods where concrete outcomes are imagined, prototyped, tested, and revised, yet have increasingly crossed into complexity and social engagement. In the digital and biotechnical eras, the combined power of these ways of understanding the world, of critical questioning, of practicing, representing, embodying, making, and theorizing are critical if art and design institutions wish to play a role in shaping our future as a species and our survival as a planet.

Despite the segregation that I have named, there is an ongoing but often unrecognized history of collaboration between artists, designers, and scientists that has resulted in past and present innovations. Artists and engineers collaborated in the exciting early wave of early digital discovery: the 1960s.[ii] Scientist Billy Kluver, at Bell Labs opened the door for artists to work with scientists. Kluver and Robert Rauschenberg co-founded EAT (Experiments in Art and Technology), an institution that also exhibited art and technology works, often to a mystified audience who lacked a critical language to understand the results. Rauschenberg and Kluver created *9 Evenings (performances), Oracle* (1963-1965) and *Soundings* (1968), art that anticipated the power of digital media and encouraged "a participatory role for the audience"[iii] and resulted in *The Machine As Seen at the End of the Mechanical Age,* an exhibition held in 1968 at the Museum of Modern Art (New York, U.S.). There were also international collaborations, such as Anand with the Nehru Foundation, artist Robert Whitman and engineers, creating a rural television network in India.

Kluver did not expect that art and technology projects would immediately produce new technologies. Rather, he hoped to inspire each field towards relevant creation in its own domain, demystify the workings of technologies and, in time discover new expressions: "What I am suggesting is that the use of the engineer by the artist will stimulate new ways of looking at technology and dealing with life in the future."[iv] He argued for a willingness to accept failure in order to find ultimate success: "The artist's work is like that of a scientist. It is an investigation which may or may not yield meaningful results; in many cases we only know many years later."[v] This view does challenge the art world's requirement for successful new works, while negation of assumptions and past discoveries is fundamental to discovery in science. Kluver's refreshingly optimistic modernist view has been tempered by science and technology studies and decades of critical postmodernism, yet the experimentalist tone and sense of emergent potential still offers an exciting opening for cross-disciplinary pedagogy and research.

At the same time, in the current economy, and given the fast paced nature of discovery and change in digital media (such as the emergence of social media, beginning in labs in the late 90s to the current regime), Kluver's patient anticipation of outcomes and a tolerance for failure is in part eclipsed by a more instrumental set of expectations of art and technology collaboration as research becomes more focused on commercialization and application development. A key lesson today in creating collaborative research is the need to combine methods, time lines and expectations — programs can span open-ended investigation and more instrumental engagement in order to satisfy the needs of all collaborators.

Canada has built an historical model of mixing pure research and instrumentality. Beginning in the mid-1960s, researchers at the National Research Council (NRC) and the National Film Board (NFB) — renowned for animation and documentary and both federally-funded agencies — began investigated the use of computers in animated film-making and computer music. NRC was already a miniature studio-laboratory, supporting in its Radio and Electrical Engineering department the groundbreaking research of a physicist-composer on electronic musical instruments — Bill Buxton. Peter Foldes developed *Hunger*, a film released in 1973, using digital key frame animation, which was recognized immediately as an artistically convincing character animation; it was nominated for an Academy Award and won numerous festival prizes. At the NFB during the mid-1960s, another team of filmmakers and technicians developed a unique multi-screen projection and camera system for the Montreal world EXPO which was thereafter transformed and commercialized as IMAX wide-screen format.

The NFB treated the end-user as a creative artist, influenced by Norman McLaren's philosophy that tools should be invisible, allowing the artist to "handle personally the mechanisms that do remain," using constraint as opportunity and facilitating improvisation. Michael Century describes this as a "heuristic" approach to technology invention, learning and inventing through practice-based research, through the necessity of making.[vi] Graphics research was later taken up at The Banff Centre through the Art and Virtual Environments Research Project led by Douglas MacLeod — a sister project to Professor Jeffrey Shaw's world renowned work at ZKM. Nearly all the successful producers of animation software, whose products are used around the world in the animation, multimedia, and CAD industries, were descended from or assisted by the people, ideas, systems jointly formed at NFB and NRC. The outcome of the early and consistent Canadian scenes of innovation in computer graphics and animation — Alias/Wavefront and SoftImage, proved to be economically significant.

In the decades to follow corporations such as Phillips UK, the NTT (Nippon Telegraph and Telephone Corp), HP Bristol Labs, created studio-laboratories. Experiments of art, science and technology collaboration occurred within such labs (for example, Xerox PARC — where iPads and intelligent books were developed — or Peter Allen's Interval Research — where touch tables, 3D video with head tracking, subcutaneous intelligent jewellery, intelligent text, social gaming were created) — falling away after the crash of 2000. Experimentation continued through independent artists' projects and in a raft of specialized institutions such as ZKM that Jeffrey Shaw led in Karlsruhe, Ars Electronica in Austria, or the Banff New Media Institute that I founded and led. In the last decade this wave of collaboration between art, science and design and technology has now moved into university curriculum and research institutes such as Hexagram in Canadam SmartLab UK, or the California Institute of Telecommunications and Information Technology (Calit^2) that build on historic experiments such as those at the University of Illinois National Centre for Supercomputer Applications where Donna Cox a leading visualization artist has worked for many years. We have also seen the success of large scale networks such as the GRAND National Centre of Excellence in Canada ($23 million in funding for five years), the Mobile Digital Commons Network (two years exploring and inventing deep location-based experiences and related engineering), or Am-I-Able (two years exploring ambient intelligence in architecture and fashion) or the Centre for Information Visualization and Data Driven Design (CIV/DDD) — a $11.5 million project that I have recently secured in Canada.

There is a major cultural shift as science begins to move towards art and design, a notable change from the 1990s when artists were chasing science. Paola Antonelli, Curator of Design at the Museum of Modern Art in New York City, and creator of the *Design and the Elastic Mind Exhibit* proposes that the earlier twentieth-century conversation between design and science in the 1960s has returned to the foreground in this century and has become focused. She argues that this is, in great part, a result of technologies that offer scientists the freedom to use their imaginations, particularly in the realm of biosciences, biotechnologies, green and clean technology and nanotechnologies, opening their minds to the views of artists and designers. Design thinkers such as Anthony Dunne argue that such a convergence of design and science allows design to engage with science as a research-methods discipline (brainstorming, sketching, scenario building, etc.) and to take up a critical and ethical position in relation to science, technology and invention.[vii]

Without question artists in particular and now designers have posed important ethical concerns that critique technologies as well as use them, and insist on a culturally diverse approach to the use and even the design of technology. The pragmatic role of artists in proposing new applications that are inclusive is of significant importance. Examples include Mongrel's Black cultural tool set and the dynamic practice in digital media by Canada's many Aboriginal artists. Some artists and designers such as Lisa Jevbratt or Natalie Jeremejenko also offer a post-human ethics (in which the world is understood from an ecological and network perspective outside human control) which are being taken up more vigorously by science.

Not only ethics are at stake. Contemporary sociologists such as Wendy Kellogg, and Thomas Erickson of IBM Labs who observe collaborations have discovered that complex multidisciplinary systems foster results that are “different” than the sum of their parts, not simply greater. These differences can lead to breakthrough discoveries and new forms of knowledge,[viii] tendering thresholds that result in new attitudes, expressions and roles. 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" (Michael Century, 1999). Effectively, this means new fused horizons become possible — such as the fields of data visualization, social media, mobile experience design, wearable computing/design — beyond or transcending paradigms existing within single disciplines. And, collaborative practices have moved beyond a single laboratory as talent must cross institutional and national boundaries in order to address challenging fundamental research questions, requiring the management of differences that are not only disciplinary but cultural.

Collaboration is challenging. Gerhard Fischer, (echoing Kluver a century later) designs tools for interdisciplinary teams, and stresses the need for a complex and open contexts where collaborators can learn from their mistakes.[ix] Lily Diaz-Kommonen notes some of the ingredients she has found successful in the researcher and student experience at the Media Lab, LUME in Helsinki. The environment favours “the acceptance of openness and indeterminacy to acknowledge others’ agency.”[x] Diaz-Kommonen returns to the role of artists and designers in locating technology into a larger social context. She comments that finding common research goals requires a process of critique in which tangible art, design, science, or engineering research is placed into a social and cultural understanding that focuses on the “contexts in which these objects exist and the communities and practices within which they acquire meaning.”[xi] Collaborations arrive at “boundary objects” — these are intermediary representations, whether a drawing, or a tangible prototype that captures the shared understanding between disciplines. Artists’ and designers’ collaborations represent a strong vocation to serve as a bridge between social needs (such as "the culture of the network society") and the technology development process. Such an exercise requires not only social and cultural theory but empathy and imagination, skills that are part of the repertoire of trained artists and designers. This underlines the valuable experience that students will gain in intensive collaborations with other disciplinary areas.

Role hybridity can be a direct result of long-term transdisciplinarity, eventually requiring a redefinition or expansion of “artist” or “designer”, “technologist” or “scientist” or “engineer”. The National Research Council of the National Academies notes that effective collaboration appears to create cohesion or “intersubjectivity”[xii] that transcends “traditional role boundaries to exploit different perspectives and skills and create new ideas and products”.[xiii] Students need to be formed as “pie shaped” individuals — with several areas of deep specialization that allow them to contribute to the dialogue, with the capacity to work effectively and openly across boundaries and as future project leaders and inventors in this complex world.

Artists’ tools, at times, address problems that require solutions but that science has not prioritized.[xiv] Forays into technology creation by artists can therefore have significant impact.[xv] A virtual reality software product provides an example. The MANDALA® Virtual Reality System (now the Vivid Group of technologies) used camera tracking of gesture, placing the performer into an animated stage set. It was first created by performance artist Vincent John Vincent in 1984 who sought an unencumbered, gestural full body interface at a time when research was centered on helmets, gloves and goggles. Vincent used the tool to collaborate with live musicians in many places around the world. He played music, danced and juggled.”[xvi] Vincent provided a different artist-friendly design perspective on a set of mass market emerging technologies.[xvii] His tools are now embedded within mobile telephones (in Japan and China) to enable gesture-based interactions for gaming, navigation, and communication, as well as stage technologies and tools for the disabled, moving human and technology interaction away from text-based interfaces to full-body engagement.

We have focused on the relationship of art to science, yet at the same time, science has something to say about art-making and design. Scientists and mathematicians may look to art or design as a means of understanding difficult questions or representing the invisible, such as n-dimensionality. They may see artists and designers as grappling with similar philosophical challenges to theirs. They may be curious about approaches to beauty or aesthetics that are parallel to or divergent from their own view. They may share a critique of our technology dominated culture, of surveillance, or globalization. During his appointment in 2002 as scientist in residence at the Institute of Contemporary Art (ICA) London, UK, neuroscientist Daniel Glaser worked closely with artists in order to understand how perception transpires. He is the senior research fellow in imaging neuroscience at the University College of London's prestigious Institute of Cognitive Science. Glaser was so inspired by this experience that he created the ongoing Café Scientique, an opportunity for scientists and artists to share their research, and he continues to research with artists on visual cognition.[xviii]

Science research is increasingly interested in working with artists on cognitive studies, and the brain physiology connected to creativity, or the ways that colour perception and visual culture studies and applications of colour-theory bridge science and art. Cognitive scientists and visual artists collaborate because of a shared interest in memory and emotion, for example at Baycrest, a centre for the aged and an institute for advanced brain research in Toronto, Canada. Judith Doyle and Martha Ladly, OCAD University researchers and their students collaborate with the Memory Link project there, led by Dr. Guy Proulx. Artists already make significant contributions to medical imaging, scientific and data visualization, with the creation of abstract and experimental as well as instrumental imagery.

There are many sciences (the various fields of theoretical physics, biology, psychology, genetics, for example) that offer theory, methods, and materials to art and equally many approaches to art. Hybridity or dialogues across differences and within differences are even more powerful than those within, according to Mark Muller, a preeminent HCI scientist, when these occur between, not within groups.[xix] The visual arts and the sciences contain many rich but often contradictory philosophical threads. The value of art and science to each other are in the realm of instrumentalism, assisting with related discovery, illustration or tools. It is also beyond this with the differences and parallels in methods revitalizing theory-bound and language congested art making, updating stale scientific methods that hit an impasse on discovery and producing art, design, technology and science pedagogy and research in a way that is appropriate for contemporary times. This requires a basic knowledge and comfort with each others' territories, not a small demand for researchers and students. Hence OCADU's undergraduate and graduate Digital Futures programs include four pillars: critical studies, business methods, computation and creative skills.

Collaboration has an impact on aesthetics in art and science. Art and science, and art and technology creative projects have often fallen outside of the common discourse of the visual arts, requiring a fundamental attention to critical dialogue in our learning institutions. Discourses about interactivity, monumentality, immersion, the role of the subject, emergent or social aesthetics are vivid and present through publication and pedagogy, but often unresolved. The archiving of art works, their collection and critical appraisal is of fundamental necessity in building centres such as ALiVE.

The shift from individual experience to hybrid group experiences and expressions is precisely the challenge that Warren Sack, (a designer of collaborative spaces for large-scale online conversations) makes to artificial intelligence research and cognitive science in his recent article in *Database Aesthetics*.[xx] He argues that contemporary technology systems require an aesthetic that allows the emergence of new common and collectively constructed shared experiences and identities rather than a focus on individual cognition.

To reposition our relevance my own institution developed a strategic plan, ***Leading in the Age of Imagination*** that defined our goal as contributing to "the fields of art and design, local and global cultural initiatives, and knowledge and invention across a wide range of disciplines." It defined its culture as "a learning environment that integrates studio-based education with historical, critical, and scientific inquiry. OCADU values accessibility, cultural diversity, equitable global citizenship, art and design advocacy, aesthetic and formal excellence, sustainability and entrepreneurship." In designing the learning environment we stress collaborative as well as individual creativity and research and the use of tools in everyday activities in fully integrated ways. We foster undergraduate as well as graduate research skills — believing that inquiry and critique must start at a young age. And we recognize that the digitization of contemporary life has a tremendous impact on incoming student capacity and the design of learning for generations who are technology literate and highly collaborative in their practices.

There are many emerging fields that illustrate the requirement of mixing art, science, technology innovation and design. Of these data visualization, which is of information and scientific data (one of the core strands of research at ALiVE) bears tremendous currency. Data comprise a set of organized measurements created by instruments that calibrate quantifiable qualities of an original source (natural, artificial or recombinant). 'Data' are both an abstraction and mediation of actual phenomena. We can understand data only when it is placed in context and interpreted. This requires building algorithms that allow for selection, extraction, organization, analysis and presentation. Given that sensory expression — most often visual, sometimes sonic or tactile — is the only means to perceive many contemporary data sets aesthetics are fundamental, not additive to the emerging field of Data Visualization. Aesthetics structure experiences in formal perceptual ways and provide interpretive tools, at times constructing meaning. The field of Data Visualisation contains aesthetic practices that draw from art, design, computer and information science and the sciences.

The growth of cloud computing, visual search engines, penetration of fast broadband and wireless networks have all created an ideal environment for an explosion of capacity in data visualization. Data visualization is growing exponentially in scientific, social science and even humanities research, as well as in commercial applications such as social media. [iv] Our expectations of the intelligibility and accessibility of data have shifted with the growth of databases and search technologies. This situation creates an expanding demand for tools and expressions that facilitate finding information and analysis. Entire new practices that cross the boundaries of information and science, such as genomics and bioinformatics have come on stream. These fields rely on data visualization to excavate structures in large-scale data sets. They have no photo realist technologies to fall back on. Secondly, as Lev Manovich has remarked, data visualization allows representations to be mapped onto each other, to compare and overlay vastly different data sets, permitting the representation of infinite permutations and complexity. [v]

The field of Data Visualization is compelling because it carries the traces of the empirical world and its instruments of measurement and representation. Case studies of visualizations — some with the same data set — underscore how data sets are shaped by prior decisions, such as the instruments chosen to collect the data, the structure of the database, source and sampling methods and software choices. [xxii] After all, a visualization of Internet packets is many degrees of separation away from the conditions of production of that packet and of its producers. Data visualizations carry with them the aesthetics and assumptions of their contributing technologies. They are discoveries in their own right, creating new kinds of experiences. Data visualization technologies absorb aesthetics of 2D and 3D graphics and animation systems, with their formal styles and malleability.

There are raging debates about whether beauty in data visualization compels or dispels discovery. Andrew Vande Moere argues for the need to aggregate beauty and utility in the creation of lush images, ‘The best works are those where the aesthetics help people understand the data, where they’re almost telling a story.’ [xlvi] Beautiful visualizations compel not only experts, but also the public. He has observed that consumers, shown an effective visualization of energy wastage data, begin to adopt energy-efficient practices.[xlvii] Legibility, instrumentality and beauty need not be discordant.

Studies such as those of HCI (human computer interaction) scholars Noam Tractinsky, A. S. Katz and D. Ikar demonstrate that users pay greater attention to beautiful images and that usability and beauty are viable companions. [liv] For example, Jane Prophet’s 2002 work *Cell* [lv] was created with mathematician Mark d’Inverno, adult stem-cell geneticist Neil Theise; computer scientist Rob Saunders and curator Peter Ride. It is visually arresting software built to facilitate Theise’s breakthrough research, demonstrating relationships between previously invisible phenomena, test a series of mathematical and programming challenges and result in an art work. [lvi] Prophet notes the ways that collaboration was premised on the notion, ‘that artists can ‘imagine’ scientific and mathematical theories and thereby influence the development of scientific, mathematical, and computer science research and their associated aesthetics.’ [lvii] Theise’s results ‘revised understandings of human liver microanatomy which, in turn, led directly to identification of possible liver stem cell niches and the marrow-to-liver regeneration pathway.’ His collaboration with Prophet, and her revealing visualizations led Theise to a new interest in theoretical biology and complexity theory.[lviii] At the same time Prophet, who is a visual artist, continually reminded the team and her audiences of the value that beauty brought to this discovery process.

Data visualization requires both the awareness of cognitive aspects of human visual apprehension, such as colour theory and the need to make the visualization meaningful to a user’s context. In a much-quoted statement, Edward Tufte describes graphical excellence as ‘that which gives the viewer the greatest numbers of ideas in the shortest time with the least ink in the smallest space.’ [lxvii] Colin Ware proposes that Data Visualization is the scientific study of ‘distributed cognition’ [lxviii] between pattern mechanisms in the human brain and the algorithms that map data to the computer [lxix] connecting human cognition, computer memory and its related algorithms, and the physical actions of the user.[lxx] Indeed successful design requires attention to the physiology of brain, hand and eye. However, these formulae describe a mechanism at work in the perception of visualizations but are bereft of understanding the ways that human experience differs from machine, encompassing the non-linear, cultural and aesthetic, as well as inductive processes at work. Much cognitive science research -in the field studies techniques of performance enhancement, that is legibility and speed, rather than breakthrough discovery or the play of poetics or insight. [lxxi]

Projects such as ALiVE or our CIV/DDD can enrich cognitive science research with artistic knowledge. At the same time, valuable lessons from cognitive science can help designers and artists to understand the differences between reading and viewing, and the ways that visuals can allow pattern recognition and text can act to lock down meaning and context in visualizations. These lie in parallel to current theories about the image that reside within visual culture studies, locating aspects of cognition outside of conscious grasp. For example, digital media create opportunities for humans to experience time and space in ways that stretch and extend their existing physical apparatus.[lxxxiv] Data visualizations of large and multi-dimensional data files occur on 3D screens and at times in 3D CAVE environments. These are full body experiences, where the user is navigating data in real time, performing discovery simultaneously or with retrospective thought. Aesthetics is mediated between the body and its object in a continual flow or 'becoming.' [lxxxv]

One of the most dynamic growth areas of data visualization is text visualization, where semantic and social networking relationships are discovered through visual and textual patterns. This field applies to the massive quantities of scientific texts, social media output, chat, or descriptive Meta data. Artists with an interest in linguistics and conceptualism now turn to Data Visualization as a digital trajectory to linguistic intervention, semiotics and conceptualism of the last decades. Visual artists began to treat language and text as material in the twentieth century, continuing nineteenth-century artists' fascination with literature.[cv] In the 1980s, artists applied structural semiotic tools to the visual image, a set of practices that are mirrored in data mining text analysis tools.

We Feel Fine by Jonathan Harris and Sep Kamvar bears an interest in affective expression and uses the measurement of text data to find it.[cviii] *We Feel Fine* builds emotional portraits of specific online populations by extracting expressions of feelings from Weblogs. The project provides six movements (like a symphony), driven by statistical analysis and data aggregation, and then reshaped by users' paths through the data. Feelings accumulate in mounds on the screen, quivering when the mouse-cursor passes over. The site is poignant and amusing.

Text-based information visualization provides tools that enable collaboration, requiring an aesthetic that allows the emergence of common and collectively constructed experiences and identities. It is logical that designs with high degree of interactivity would facilitate the creation of new identities. Figure 13 provides two prototypes from *CodeZebraOS*, an interactive conversation visualization tool. A neural network extracts and averages behaviours within and between texts.[lxxx] Graphics show relationships between topical chat postings, using graphics to assign an emotional tone to each thread and topic.

Data visualization approaches deriving from the art world are of value in their own right, producing compelling works of art, and valuable as a means to raise new questions and approaches to data. For example, the formalism of abstraction can result in breath-taking beauty or be applied to discovery. Structuralism can tell us about the nature of the source data. Despite the emergence of common structures and metaphors this is an emerging practice. Art's deconstructive tendencies are helpful in unfolding assumptions that are built into data collection and structure. There is a need for tools that provoke new insights in the fields where data visualizations are applied. Experimental, abstract, multi-dimensional, highly interactive works can be immersive and provocative; perhaps more so than simplified visualizations that illustrative pre-figured assumptions. Aesthetics that can evoke and provoke other- disciplines yet draw from the formal and critical values of art are the most promising, and the most difficult to attain. This is a field where art and design practices can be engaged in multiple layers of discovery — of new forms of expression and of new realizations in the fields that are aligned with the source data, be these genomics, physics, economics, or information theory.

There is a significant responsibility in undertaking a turn to art and science collaboration. Anne Cauquelin, a French sociologist of culture, argues against a cold technological aesthetic-, and a set of practices that could obliterate the aesthetic history and variability of art and its embodied références in favour of science and technologies. She argues for a science and art engagement that is "*kinesthésiques, tactiles ou polysensorielles that can 'permettant d'éprouver le sentiment de la presence de l'autre, et de contrebalancer ainsi la dureté des temps*" and that does not reproduce the separation of nature and culture.[xxi] We can achieve this — there is no question that we are contributing to an acceleration of collaborative practices of "big art" with "big science" away from the margins and into an important place at the core of art and design teaching and research institutions and programs.

Thank-you and good luck with ALiVE! I look forward to our ongoing collaboration.

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[i] SciArt is used in some contexts as an alternative. We use the term with correct alphabetical order.

[ii] See Randolph Packer and Ken Jordan, *Multimedia: From Wagner to Virtual Reality* (New York: Norton, 2001).

[iii] Packer and Jordan xix.

[iv] Kluver in Packer and Jordon 33.

[v] Kluver 33.

[vi] See Michael Century's valuable paper *Pathways to Innovation in Digital Culture* (Centre for Research in Canadian Culture and Institutions, 1999) Available at < http://www.nextcentury.ca/PI/PI.html>.

[vii] See Anthony Dunne & Fiona Raby's *Design Noir: the Secret Life of Objects*. (Basil, Boston, Berlin: August/Birkhauser, 2001) and the citation of their work in Peter Hall's essay "Critical Visualisation" in Paola Antonelli's *Design and the Elastic Mind* (New York: Museum of Modern Art, 2008) 120-131.

[viii] See Thomas Erickson and Wendy Kellogg, "Knowledge Communities: Online Environments for Supporting Knowledge Management and Its Social Context," in Ackerman, M., Volkman, R., & Volker, W., eds. *Sharing Expertise: Beyond Knowledge Management*, (Cambridge: MIT P, 2003) 299-326; and Kate Mason, Jon Denzinger and Sheelagh Carpendale, (2004) "Negotiating Gestalt: Artistic expression and coalition formation in multi-agent systems", in the *Proceedings of AAAMA, July 2004.* New York: ACM, 2004 1350-1351.

[ix]Gerhard Fischer, "Social Creativity: Turning Barriers into Opportunities for Collaborative Design," *Proceedings: Participatory Design Conference, 2004, Toronto* (New York: ACM, 2004) 152-161.

[x] Lily Diaz-Kommonen. "Design, Knowledge and Multidisciplinary Collaboration," *Media Lab Helsinki: 10 Years*, eds. Marjo Mawnpaa, Jon Nykanen, and Philip Dean, trans. Susanna Heiskanen (Helsinki: Media Lab, University of Art and Design, 2005) 92-104.

[xi] Diaz-Kommonen 96.

[xii] Vilém Flusser, *Writings*, ed. Andreas Ströhl (Minneapolis: U of Minnesota P, 2004).

[xiii] See William J. Mitchell, Alan S. Inouye, and Marjory S. Blumenthal, M., eds. *Beyond Productivity: Information Technology, Innovation and Creativity*, a document of the Committee on Information, Technology and Creativity, Computer Science and Telecommunications Board Division on Engineering and Physical Sciences, National Research Council of the National Academies (Washington, DC: National Academies Press, 2003). 56

[xiv] Michael Century, "Collaboratories," *Proceedings of Banff Bridges II: October 4 - 6, 2002, Banff Centre for the Arts* (The paper is on deposit at Banff: Banff New Media Institute Archives, 2006) Information about this event and an abstract of Century's keynote and other papers is available online at *Banff Bridges Conference Two Proceedings* <http://www.banffcentre.ca/bnmi/bridges/speakerabstract.html> See also Mitchell, Inouye and Blumenthal.

[xv] In the 1970s artists such as Dan Sandin (2007), undertook artistic research that had a tremendous impact on computer graphics and the emergence of virtual reality (BNMI, Smart, Sexy, Healthy, 2001) Sandin created early graphics works and then, working with computer scientists, built simple related tools that were expressive of undiscovered capacities of the technologies that he was exploring.

[xvi] For more information on Vincent's work, see "Vincent John Vincent: Virtual Reality Pioneer," *Vincent John Vincent*, n.d., Web 31 Jan. 2009, <http://www.vjvincent.com/>.

[xvii] In addition, Ted Druckery and Hatje Cantz indicate the ways that Ars Electronica's commissions and exhibitions added new features to technologies. Finally, Maenpaa, Nyakaneen and Dean provide case studies of such projects at the Helsinki Media Lab. See Maenpaa, Nykaneen, and Dean; Ted Druckery, *Ars Electronica Facing the Future: A Survey of Ten Decades*,(Cambridge: MIT Press, 1999) print; and Hatje Cantz, *International Compendium : Ars Electronica CyberArts* (Linz: ORF, 2003).

[xviii] For an overview of Glaser's initiatives see Daniel Glaser, home page, n.d., Web, 31 Jan. 2009, <http://www.danielglaser.org/index.html>.

[xix] See Muller.

[xx] Warren Sack, "Network Aesthetics," *Database Aesthetics: Art in the Age of Information Overload*, ed. Victor Vesna (Minneapolis: U of Minnesota P, 2007) 183-210.

[xxi] Anne Cauquelin, *L'Art du Lieu Commun: Du bon usage de la DOXA* (Paris: Editions du Seuil, 1999).