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Workshop Report

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with input from the participants

Establishing a Network of Excellence for Art + Science + Technology Research: Infrastructural and Intellectual Foundations

March 16–18, 2011

The Curtis R. Priem Experimental Media and Performing Arts Center
EMPAC

Rensselaer Polytechnic Institute
Troy, New York

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1. Context and Goals of the Workshop

This workshop was the third in the series initiated by the joint workshop of the National Science Foundation and the National Endowment for the Arts. The first workshop, entitled *RE/search: Art, Science, and Information Technology*, was held in September 2010*;* it continued in January 2011 at the Rhode Island School of Design with a workshop on *Bridging STEM to STEAM*.

The third workshop, whose outcomes are reported here, focused on the intellectual, infrastructural, and managerial requirements to create a network of institutions, researchers, engineers, and artists that is aiming at realizing concrete projects at the intersections of arts, science, and technology. Transdisciplinary projects, at least those that actually leave the silos of current disciplines behind, are still rare and remain a challenge. Inter-institutional efforts to build and conduct joint projects require a constant exchange on the basis of individual projects to maximize potential collaborations. The area of *Art + Science + Technology* is as diverse as it is a non-standardized academic research area. A "network of excellence" may provide a platform to allow proposals, support, and exchange for larger scale projects to emerge in this area.

The goal of this workshop was to attempt to define in concrete terms a platform that sustains cross-disciplinary and trans-disciplinary research, collaboration, and exchange in the integration of quantifiable and qualitatively defined paradigms at the intersection of creativity, technology, research, and innovation. This area of research can be subsumed under the heading of "creativity-based technology research and technology-based creativity research."

There are a few larger centers or funding initiatives in the United States and internationally that are working across boundaries in the described areas. Examples include the Graphics, Animation, and New Media (GRAND) network, which seeks to mobilize Canadian centers of excellence into collaboration across disciplinary, geographic, and private-public sector boundaries[1]; the United States', Humanities, Arts, Science and Technology Advanced Collaboratory (HASTAC), which is a network of individuals and institutions committed to new forms of collaboration across communities and disciplines fostered by creative uses of technology; and Britain's National Endowment for Science, Technology and the Arts (NESTA), which is an independent body that fosters innovation through partnerships with policymakers, community organizations, educators, and other investors. Additionally, there are individuals and smaller groups in academia tackling specific issues in this area. In contrast to established research fields in science and technology, there are few supported platforms—such as symposia, conferences, publications or Internet-based resources—that are dedicated to establish communication and continuity in creativity-based technology research in the United States.

[1] See http://grand-nce.ca/ (last accessed Sept 17, 2011)

Interdisciplinary distributed organizations and virtual collaborative organizations in the US—such as Virtual Centers of Excellence (VCOEs), which are used by industry and academia to bridge geographical, organizational, and disciplinal boundaries—can serve as models to define the infrastructure for a distributed network infrastructure for the sustained support of the field. Possible future support for a creativity-based technology research VCOE could come from NSF via the Virtual Organizations as Sociotechnical Systems (VOSS) program or the Division of Information and Intelligent Systems; from the National Endowment for the Humanities' Office of Digital Humanities; and (particularly as it relates to inclusion of the arts into STEM education) from foundation initiatives such as the MacArthur Foundation's Digital Media and Learning program.

Objectives for this workshop were defined as:

- Identify key issues in infrastructure needs to support creativity-based technology research;
- Develop concrete plans toward the development, management, and constituent involvement in a distributed network infrastructure for the sustained support of the field; and
- Identify leading institutions that will move forward on proposals to possible supporting agencies and foundations.

Based on these objectives, the following actions were developed during the workshop:

- Initial definition of a network structure of key institutions that can develop a proposal to the NSF and/or other funding entities to support the network structure;
- Collaborative research proposals as an extension of existing research projects, which currently are limited to one center or to one sub-field where other centers may have complementary research expertise and capacity; and
- Commitment, timeline, and structure of future tasks required to consolidate the initiatives coming out of this workshop with the goal of developing a network of centers, researchers, and creative practitioners.

Most of these objectives were worked out in five breakout groups, and the reports for these groups can be found in Sections 5.3.1-5.3.5 of this report. The breakout group reports state which concrete terms were reached and how they grew out of this workshop.

2. Strategy and Structure of Workshop

A major emphasis in the preparation for the workshop was put on the development of a structure and sequence of plenary sessions, work sessions, and keynotes (the full program is listed in Appendix B). The goal was to master the common challenges of such workshops, which on the one hand engage participants from many different disciplines, and on the other hand include participants working in such a specialized area that the main players know each other very well. The main objectives (and challenges) with regard to workshop structure were:

- To attract participants who are not yet part of an inner circle of experts;
- To infuse knowledge and experience from a position not yet known to most of the participants;
- To give enough time to individual positions and experiences to be presented outside of the immediacy of back-and-forth discussions;
- To move beyond statements of personal positions;
- To enable continuity of discussions within a very limited timeframe; and
- To balance social networking, open discussions, and the desire to reach "actionable results."

As this workshop was the third and last in a series of three workshops supported by the NSF CreativeIT program, the goal was to create a platform that the research community of arts, science, and technology, which had experienced a major boost through the CreativeIT program, could continue, which could intensify their work and critical dialogue.

As it was the last workshop in this series, this was the ideal opportunity to investigate what the *Infrastructural and Intellectual Foundations* will have to be for *Establishing a Network of Excellence for Art + Science + Technology Research* once the CreativeIT program has been "archived."

The strategy and structure of the workshop was to optimize the potential to reach concrete results in the form of commitment from mostly academic units to establish such network of excellence. The biggest constraint was the limitation of the workshop to not quite two full days of work, while enabling individual travel to and from the conference without "eating" into the time of the workshop through late arrivals and early departures. The biggest challenge was how to enable a lively and controversial discussion while having to establish common ground and trying to reach concrete "action items."

It is obvious that this is like trying to fit a square peg into a round hole—be it under scientific, artistic or pragmatic aspirations. Nevertheless, the following developed structure came as close as possible to the unsolvable:

- Participation was by invitation only; this allowed balancing among those who had participated in the previous workshops for continuity, those who were leaders in the field, those who could make commitments, and those who had not yet been part of the exchange. – *There were no negative responses to the by-invitation-only even though the previous two workshops had been based on open calls.*
- The number of participants was limited to 30. – *This allowed plenary sessions where each participant could actually see and hear everyone who spoke.*
- A questionnaire allowed fielding the diverse backgrounds and interests of the participants; the responses to the questionnaire were sent to the participants several days before the workshop commenced. – *The return of 17 out of 22 questionnaires was very good.*
- The workshop extended from one evening through a full day to half a day at the end, which allowed participants to still reach home that final day. – *The number of those coming late and leaving early was minimized.*
- The first evening started with dinner and then laid common ground for the next full workshop day through a report on the previous workshops and a keynote. – *Starting with a keynote that promised new perspectives, which engaged everyone, worked out well.*
- There was only one main keynote; four mini-keynotes on the second evening gave selected participants the opportunity to present different aspects. – *Having more major keynotes to broaden the horizon for discussions was contemplated, but this was dismissed as being too disruptive in the overall evolution of the workshop. The selection of the four participants to be invited to give a strictly limited mini-keynote created an uneasy political situation—why her, not him, what were the criteria for the selection?*
- The four workgroups met on two days; the participants were self-selected based on topics developed in plenary sessions; the participants remained with the same group for both meetings. – *The model of random grouping of workgroups or of changing participants in workgroups did not seem to be appropriate under the condition that actual results emanating from the exchange were hoped for.*
- The plenary and workgroup meetings were ending at the given end-times so that the meals and “dessert and wine” after the evening sessions gave enough time for informal exchanges. – *It turned out that the certain rigidity with which sessions were ended were preferable to slipping schedules and social time getting squeezed.*
- The seating for the plenary sessions was planned in advance and seats were assigned in order to avoid clustering of pre-existing groups.

3. Pre-Workshop Questionnaire

In preparation for the workshop, a questionnaire was sent to the participants coming to Rensselaer. Twenty-two (22) of the 31 total participants came from off campus. Seventeen (17) of these 22 returned the questionnaire.

The purpose for the questionnaire was to gain an overview of the backgrounds of the participants specific to the topic of the workshop and to learn what they saw as major topics for the workshop itself.

The questions were geared specifically toward engaging the participants in thinking about the workshop in more concrete terms before they arrived. The replies were evaluated to facilitate the discussion in the first workshop meeting, which was to define the specific topics for the workgroups (see Section 2: *Strategy and Structure of Workshop*).

An anonymous overview was sent to all participants five days before the workshop, and replies to the following 11 topics were requested:

1. Main research areas
2. Areas of interest that currently are not part of your research but with which you would like to collaborate or reach out to in order to investigate potential projects
3. Possible reasons for not having been able to engage in collaborations you would like to pursue
4. Current interdisciplinary project(s)
5. Interdisciplinary dream project
6. What difficulties do you see in cross-disciplinary research projects?
7. What advantages would you see in inter-institutional research projects?
8. What advantages (or barriers) do you see in collaborative intra-institutional research projects?
9. How can your interdisciplinary research be integrated into education? What are academic or administrative barriers? How does your institution support such approaches in concrete terms?
10. Topic ideas (research areas, strategic, political) for a network of excellence
11. What conditions would need to be met by a networked center of excellence so you would engage and contribute to its program?

The complete individual responses are listed in Appendix X.

The wide-ranging backgrounds, research areas, and interests of the participants do not justify providing a condensed overview of the responses. The full range of replies can be seen as a historic document of and view into the thoughts and strategies, which

at this point in time are at the forefront of those working—mostly in the academic environment—at the intersection of arts, science, and technology. The workshop itself, its discussions and outcomes actually can be seen as a focal point in which the highly diverse comments to the questionnaire gathered and then expanded again into different directions.

The questionnaire was not only sent out to direct the attention of the participants to the subject of the workshop before they arrived, but to also serve as a basis for the direction the workshop should take and which areas should be addressed. The principal investigators (PIs) organized the responses of the returned questionnaires into four main areas, each with alternative perspectives that could be discussed during the workshop. The first full workshop session was dedicated to determining the concrete topics that were to be discussed in the workshop. The following evocative questions, based on the responses to the questionnaire, were handed out at the beginning of the first session. Each main question was discussed for 25 minutes:

1. What is the proposed *"network of excellence*?"
    - A coalition
    - A community platform (from blog to conferences)
    - An organization facilitating funding and project coordination
    - An organization of centers that exist at the intersection of arts, science, and technology to facilitate
    - An organization for academic institutions
    - An organization for individuals, academic institutions, and public/private partnership
2. What is the specific goal of this particular workshop?
    - Creating a concrete basis that allows at the end of the workshop to define commitment needed and steps of action to be taken
    - Creating a collective presence to demonstrate the importance of continued funding efforts by federal agencies that support research in the arts, science, and technology field and to discuss how NSF and NEA can be brought together for concrete projects
    - Continuing the exchange of ideas about how the wide-ranging areas of expertise and interests coming together under the umbrella of arts, science, and technology can create enough momentum to be seen as a field of its own
3. How would the focus on "arts, science, and technology" in such a network reflect on the definition of projects and thus concrete steps?

- Every project bridging arts on the one side and science and technology on the other
- Any project that involves media and arts or science or engineering
- Bridging methodologies of humanities and the arts with methodologies in science and engineering

4. Inter/Transdisciplinarity – which factors work the strongest against it…
   - "Time" and "funding" as the personally limiting factors
   - The academic gap between arts/humanities and the sciences/engineering; "academic inhibitors" from curriculum restrictions to the academic evaluation/tenure process; and the diverging criteria between the sciences and engineering vs. the humanities and the arts.… and which realistically are the most effective approaches to overcoming them?
   - Bottom-up vs. top-down / personal vs. institutional change
   - Experience from existing programs: why did attempts fail; which strategies and conditions allowed success; and which modifications to the original mission had to be made to be successful?

The outcome of a highly disciplined discourse, where the discussion of each question was stopped after 25 minutes, laid the foundation for all subsequent workshop activities.

4. Background of Participants

The goal of the workshop was to determine if and how a network of excellence could or should be established that would embrace arts, science, and technology. An interdisciplinary topic such as this can only come to fruition if all relevant and affected areas of expertise are gathered and if a meaningful exchange can be established.

The selection of the participants to be invited was directed by several criteria:

- Representation of areas of expertise needed to come together for arts, science, and engineering
- Representation of universities, departments or centers, which are engaged and active at the forefront of arts, science, and engineering
- Continuity with the two previous workshops in September 2010 and January 2011 (see Section 1: *Context and Goals of the Workshop*)

Based on the returned questionnaires and additional information from those who did not return the questionnaire, the background of the participants and what they brought to the table for the workshop discussions can be described as "exhaustive," "extremely wide-ranging," and "highly diverse."

A few characteristics of the group that participated in this workshop should be highlighted:

- Expertise in image and audio was present with equal weight
- Theory and practice in arts, science, and technology were both represented in the group of participants
- Artists, scientists, and engineers were represented, with a large number of attendees spanning at least two of these fields
- Representatives of both NSF and NEA attended

To complement the scope, a freelance artist who worked outside of institutions participated, as well.

It is rare for such conferences that audio and image are represented with equal weight and depth. Usually, audio is seen as enhancement to visuals, and not as area of its own. Since audio and image coming from the artistic realm as music and moving image (interactive, immersive) with their respective set of properties, also were represented, this reflected the engineering and scientific presence of experts in those fields. Additionally, the field of architecture complemented the presence of "inhabited spaces" as major contributor to the topic of the workshop.

In science and engineering, areas from signal processing to psychophysiology and from education sciences to artificial intelligence were represented.

The group brought together expertise from almost all relevant areas that are involved in arts, science, and technology.

The presence of NEA and NSF was of major importance as it offered the rare opportunity to evaluate and confront the perspectives, opportunities, and restrictions of the programs and the funding coming from the agencies with the goals and visions coming from the community of research and production at the intersection of arts, science, and technology.

5. Meeting Protocol

5.1 First Workshop Day (Wednesday, March 16, 2011)

5.1.1 Welcome Address

Johannes Goebel's general introduction was a summary of the material presented in Sections 1–4 of this report. The second part of the welcome address, which is summarized below, was given by Pamela Jennings from NSF with the title *Storymap of the NSF/NEA Workshop "RE/search: Art, Science, and Information Technology."*

Theme: The presentations focused on the outcome of the first NSF/NEA-related workshop. Based on the outcome of this workshop, its organizers created a "storymap," a strategic graphical document that outlines a strategy to move from the current interdisciplinary way of approaching arts, science, and technology related projects to a transformative approach that goes beyond current disciplinary silos.

Description: The talk started with a summary of past efforts to foster research among arts, science, and technology, which Jennings considers as its own field. The NSF CreativeIT program (2007–2010), which was managed by Jennings during its last year, helped to pass the first phase of exploring this field or work practice. Although the CreativeIT program has come to an end, interest for this field remains within NSF (e.g., in the social behavioral and engineering directorates). There were different field orientations represented in the CreativeIT community, and the participants of the workshop at EMPAC represent a subset of this community.

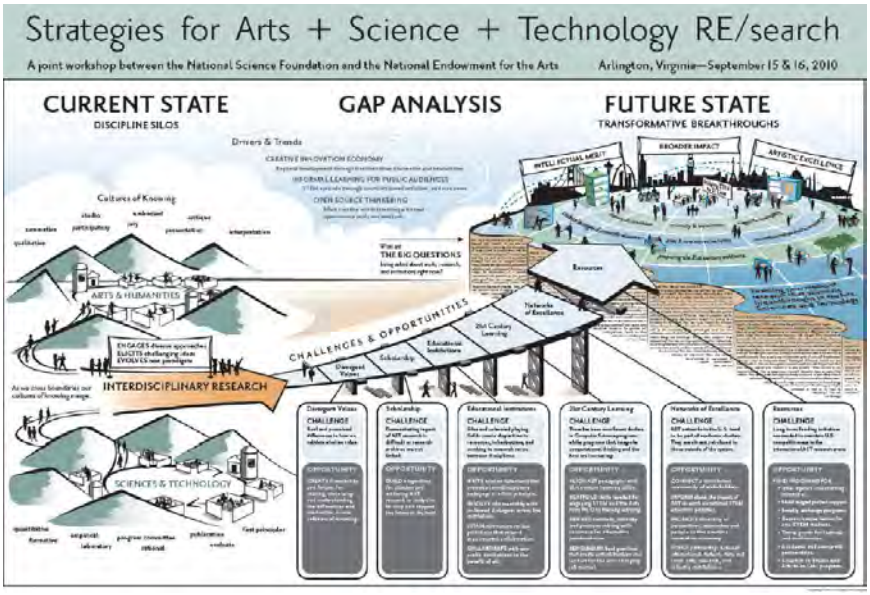

Fig. 1 Pamela Jennings' storymap, which resulted from the NSF/NEA workshop "RE/search: Art, Science, and Information Technology."

The first workshop of the series of three was held in 2010 with 60 participants from NSF and NEA. During this interactive workshop, present and future states were discussed, as presented in the storymap (see Fig. 1) and an executive summary.

The second workshop was held at RISD in January 2011 and focused on strategies to move from the current science, technology, engineering, and mathematics (STEM) paradigm to one that involves art as the fifth discipline (science + technology + engineering + arts + mathematics = STEAM). The workshop was hosted by John Meada, Chris Rose, and Ben Smith, and brought in a lot of people from the professional design community who were not part of the original NSF CreativeIT group.

The goal of the workshop series is to bring together two separate worlds (arts and sciences/technology), each having their own set of methods. Jennings categorized some of the different practices as follows:

ARTS	**SCIENCES/TECHNOLOGY**
Lone maverick	Individual entrepreneur
Practice	Research
Vertical management	Horizontal management
Studio	Lab
Situated learning	Situated learning
Exploratory	Applied
Free agent	Managed practice
Solo (or small groups)	Sustained collaboration

A gap-analysis exercise was conducted during the first workshop to investigate the implications of having such different sets of methods in intersecting projects with arts, science, and technology. In addition, the big questions that exist in each field were discussed to see where overlaps existed and where gaps could be filled. The gap analysis also looked at current drivers and trends, for example, the practice of *Open Source Thinkering*. One outcome of the analysis was that the current foci are too often on institutional work, which often is characterized by silos of different disciplines. A number of challenges were identified in the storymap:

- Divergent values
- Scholarship
- Educational institutions
- 21st century learning
- Networks of excellence
- Resources

As a future state, we are looking for more *transformative breakthroughs* in the field of arts, science, and technology. The transition process is not homogenous, and some of us represent the desired state already, although the structural frameworks do not yet exist in most academic institutions.

The workshop at EMPAC focused on *Establishing a Network of Excellence for Art + Science + Technology Research* to identify key issues in infrastructure needs to support creativity-based technology research. The creation of such a network is essential to move along the lines of the storymap in order to demonstrate international leadership in the field of arts, science, and technology. In concrete terms, the following issues need to be addressed:

- Develop plans toward the development, management and constituent involvement in a distributed network infrastructure for the sustained support of the field;
- Identify leading institutions that will move forward on proposals to possible supporting agencies and foundations; and
- Establish a *Network of Excellence for Art + Science + Technology Research* based on infrastructural and intellectual foundations.

5.1.2 Keynote: Abby Goodrum

Synopsis: The goal of the first keynote lecture was to learn firsthand from the experiences other research teams had when establishing networks of excellence. While the workshop's intention was to discuss strategies and approaches to form a US network of excellence covering the intersections of arts, science, and technology, similar approaches have been accomplished successfully in other parts of the world (Canada, Europe). To learn more about these existing projects, we invited Abby Goodrum, one of the initiators of the Canadian GRAND network, who is currently serving as director for social sciences and humanities research and is a board member for this network, to speak.

Summary: The GRAND network is a federally funded network of centres of excellence[2] to foster research in digital media and bring computer scientists and engineers together with artists, designers, and social scientists. GRAND focuses on five different themes:

1. New media challenges and opportunities (nMedia)
2. Games and interactive simulation (GamSim)
3. Animation, graphics, and imaging (AnImage)
4. Social, legal, economic, and cultural perspectives (SocLeg)
5. Enabling technologies and methodologies (TechMeth)

[2] The URL for the Canadian Network of Centres of Excellence program is: http://www.nce-rce.gc.ca/index_eng.asp (last accessed Sept 17, 2011)

The network involves 34 research projects across 24 Canadian institutions and lists 30 industry, government, and nonprofit partners. The GRAND network is funded by the following three Canadian organizations: Canadian Institutes of Health Research (CIHR),[3] the Natural Sciences and Engineering Research Council of Canada (NSERC),[4] and the Social Sciences and Humanities Research Council (SSHRC).[5] Since the Canada Council for the Art's[6] policy is to only fund individual artists, there was no possibility to integrate this institution into the GRAND core funding concept, although the GRAND concept also covers the scope of this funding institution.

The GRAND network was announced in December 2009 with a budget of CAD $25M for five years of operation. It is part of the Canadian Network of Centres of Excellence program, which was founded 20 years ago with a traditional focus on science and engineering. Network of Centres of Excellence grants are funded for up to 15 years total, with the expectation that industrial applications are a result of the network. Given the traditional framework of the Network of Centres of Excellence program, a number of challenges had to be met to bring a project to success that had a much bigger interdisciplinary character than the typical networks that had been funded before.

Abby Goodrum credits GRAND's success to a number of initiatives. One was to form a board of 13–17 members before the actual proposal was written. The board was able to come up with internal rules that addressed the particular interdisciplinary needs of the anticipated project:

1. Every project has to have a lead and co-lead from different disciplines, universities, and if possible, provinces;
2. Every team needs to have at least one artist/designer on the team;
3. Every project needs a project champion (NGO), someone who can connect with communities (receptors); and
4. Everyone has to be at least on two projects (cross-geographic, cross-disciplinary).

The rules were then announced on an open list (call for participation), and the board members selected the most promising project suggestions. The proposals had to address the requirements of the solicitation's innovation and social impact merits to be competitive. One of the core GRAND ideas to make Canada a front-runner in the field was to go beyond the technical innovations in digital media and combine this type of research with ideas from researchers and artists interested in the aesthetic and design aspects of digital media.

[3] http://www.cihr-irsc.gc.ca/ (last accessed Sept 17, 2011)
[4] http://www.nserc-crsng.gc.ca/ (last accessed Sept 17, 2011)
[5] http://www.sshrc-crsh.gc.ca/ (last accessed Sept 17, 2011)
[6] http://www.canadacouncil.ca/ (last accessed Sept 17, 2011)

GRAND currently supports its members by funding travel, students, and equipment. On average, each faculty member receives about CAD $50-$60K per year per.[7] GRAND currently supports highly qualified personnel (HQP) training for 12 postdocs, 55 PhD students, 75 master's students, 10 undergraduate students, and 5 research technicians. GRAND also provides money for lab visits, and access to CFI-funded labs.[8] The network has partnered with 15 national and international companies, including the National Film Board of Canada, the Canadian Film Centre, BC Hydro Power, Smart, Autodesk, Pixar, and Intel.

Like all networks of centres of excellence, the GRAND network is evaluated annually based on these categories:

1. Research
2. HQP (students)
3. Networking and partnership
4. Knowledge and technology
5. Dissemination

Every GRAND member has to fill out an annual, web-based report, which is evaluated by a research management committee. A graduate student advisory committee exists and students write their own reports. To encourage student work, a GRAND challenge competition exists where students from different labs and different projects can compete based on student poster sessions. Most students have a cross-disciplinary background with a deep focus in what they want to get their degree in.

Based the experience with the GRAND network, Abby Goodrum had a number of recommendations for the workshop group:

1. Avoid themes that don't do anything for your project team. Projects need to provide bottom-up insights
2. Don't fund projects, but network investigators
3. Combine high-level of expertise in different fields
4. It is important to find good, dedicated project champions who understand the goals of the network and are able to advocate for the network from an entrepreneurial viewpoint
5. One challenge is to define "What is research?" and "What is excellence?" in an interdisciplinary environment. Program evaluators like countable things like papers, patents, and the importance of exhibitions has to be advocated for
6. Question bottom-up vs. top-down structures. How can one connect with colleagues who are not yet in the interdisciplinary pool?

[7] It should be noted that the Canadian grant funding system differs fundamentally from the US system, with lower tuition and overheard rates and no summer salary funding. The operating costs of Canadian universities are funded to a larger extent directly by the federal and local governments.

[8] Canada Foundation for Innovation (CFI): http://www.innovation.ca/en (last accessed Sept. 17, 2011).

Conclusion: Although, the Canadian funding landscape is significantly different from the one in the US, a lot of lessons can be learned from the GRAND network, in particular the approach to setting up a board ahead of the proposal writing, the mechanism to encourage collaborative and interdisciplinary research team work, and the active programming involvement of students.

5.2 Second Workshop Day (Thursday, March 17, 2011)

5.2.1 Full Workshop Meeting

The objective of the first full panel discussion session, moderated by Goebel, was to refine the goal of this workshop to develop a strategy that will lead to the formation of a *network of excellence*. Based on the returned questionnaires, a number of items were discussed on given topics in strict 20-minute time slots. Based on the discussion, the group later decided on individual topics for five breakout groups of six members each (see Section 5.2.3). Before describing the selected topics, the discussion around each topic item was summarized:

Topic 1: What is the proposed "network of excellence?"

- *A coalition*
- *A community platform (from blogs to conferences)*
- *An organization facilitating funding and project coordination*
- *An organization of centers that exist at the intersection of arts, science, and technology to facilitate*
- *An organization for academic institutions*
- *An organization for individuals, academic institutions, and public/private partnership*

Part of the main discussion focused on understanding the distinction between *networks* and *centers of excellence*. The participants agreed that a center or network of centers would imply actual dedicated physical locations where the work of the center could be carried out. In contrast, a *network of excellence* does not necessarily have physical research space available other than the spaces that the individual members of the network already own or have access to. Both models, though, would establish a network across institutions, and it was further discussed to what extent such a network should be a loose network or a distinguished club. It was suggested that the membership has to be well defined and controlled for a center model that provides access to physical spaces. However, in the case of a virtual network of excellence that is organized, for example, through a website, membership can be more open, and current trends, such as the transition from formal networks to crowd sourcing, can be considered.

Participants expressed strong interest in a network that provides physical facilities, where people can meet face to face. Further interest was expressed in a model that would serve various disciplines with different evaluation/publication systems. Currently,

it is often difficult to conduct joint research between arts and science/engineering, because the different work models for each side do not fit the concept of existing discipline-based centers.

Another important aspect was to find a goal for the network that goes beyond the sole interests of the founders to ensure a broad impact on society. The network should have a good graduate student support model and a solid base that is willing to commit time and money to the network. The latter can be driven by the ideal that the whole group can achieve something greater than the summed output of the individuals. During the discussion, a hybrid model was proposed that could contain elements of networks and centers and be derived from an iterative model. If successful, this model could then be exported to other disciplines. It was concluded that the group first needs to know the goals it wants to accomplish through the center/network, before the ideal infrastructure that best serves these goals can be agreed upon. The comment led to the next discussion topic:

Topic 2: What is the specific goal of this particular workshop?

- *Creating a concrete basis that allows at the end of the workshop to define the commitment needed and steps of action to be taken*
- *Creating a collective presence to demonstrate the importance of continued funding efforts by federal agencies that support research in the arts, science, and technology field and to discuss how NSF and NEA can be brought together for concrete projects*
- *Continuing the exchange of ideas about how the wide-ranging areas of expertise and interests coming together under the umbrella of arts, science, and technology can create enough momentum to be seen as a field of its own*

An intense debate arose around the idea of establishing a new field spanning *arts, science, and technology*. A number of participants thought such a move would be desirable to receive more recognition and to find formal ways to support this field. Others were opposed to the concept of well-defined fields, and instead expressed their wish to find better (and especially more accepted) ways for research that bridges traditional fields and disciplines. A third group seemed indifferent to the discussion, emphasizing that we should focus on actual content and projects and not so much on a framework.

A significant part of the discussion expressed the obstacles of current disciplinary thinking. It was pointed out that in many cases students acquired new ways of hybrid thinking, but the current disciplinary curriculum structure does not allow these students to develop their hybrid skills in an optimal way. In this context, it was suggested that we could move from current models of practice to a model of interest.

A reference was made to the historic Macy Conferences that later led to the birth of cybernetics—as a highly interdisciplinary field that inspired many other fields. It was questioned whether the NSF workgroup would be able to spark something entirely new, or rather build on an existing idea that just needs to be carved out.

The second part of the discussion focused on research topic selection, after it was pointed out that we need to understand trends outside of academics. The NSF CreativeIT program was given as an example, where the program has a high reputation across academic circles, but its relationship to the entertainment industry is still unclear.

Further, it was pointed out that NSF has difficulty documenting how their funding of science has a big impact on society, but documenting this is really important. A good model of arts, science, and technology-related research could support NSF's effort in a creative and powerful way, but new models to disseminate the outcome of this research need to be found beyond academic circles. A good model will provide measures for the impact that the group has made. The evaluation process needs to acknowledge and respect methods of artists, scientists, and engineers.

With regard to bullet points 1 and 2 of the topic 2 agenda, it was pointed out from the side of the funding agencies' participants that addressing these bullet points will be crucial. It was advised that the group should find firm ground on which to stand, and then look what the different funding agencies can offer. Based on this comment, it was reemphasized that the group needs to find concrete topics before its members can write actual funding proposals. This led to the third topic:

Topic 3: How would the focus on arts, science, and technology in such a network reflect on the definition of projects, and thus concrete steps?

- *Every project bridging arts on the one side and science and technology on the other*
- *Any project that involves media and arts or science or engineering*
- *Bridging methodologies of humanities and the arts with methodologies in science and engineering*

The discussions on the third topic started with the clarification of some of the terms. A number of participants saw science as the *creation of reproducible knowledge* and arts as the *value of asking questions*. Interdisciplinarity was thought to be often the "tension" between these fields, which led to a discussion on how one could use this model to become more productive and achieve things that cannot be achieved by one of the disciplines by itself. The strict distinction between science and technology was also not obvious to all participants, but the group was informed that NSF traditionally distinguishes between technology and natural sciences. It was then highlighted that technology is not a time-invariant term; computer science is a technology like reading and writing was thousands of years ago. The latter, however, is no longer a technology. In addition, people have different opinions about technology. In the research areas the group was interested in, technology is often used to bridge science and art. For example, a number of NSF projects within the CreativeIT program are dedicated to develop tools for artists based on scientific models.

The second half of the discussion centered around concrete ideas, after someone asked what the group would do if it had $50M. It was then debated how arts, science,

and technology-related research can help to solve the imminent problems of the world. Health and sustainability and were named as examples. With a focus on the latter, it was suggested that the group could explore AST research topics that could help people to understand how they consume electricity. Can we establish an eco-art/eco-representation with artists that represents an energy bill with better (more meaningful) feedback instead of simply stating the kWhs? It was suggested that we could try to document the outcome to prove that such an approach could make the difference through success stories. Further topic suggestions centered around women's education, STEM to STEAM models, and broadening the understanding of research methods and education. These discussions were followed by the last topic in the workshop schedule:

Topic 4: Inter/Transdisciplinarity – which factors work the strongest against it:

"Time" and "funding" as the personally limiting factors

- *The academic gap between arts/humanities and the sciences/engineering; "academic inhibitors" from curriculum restrictions to the academic evaluation/tenure process; and the diverging criteria between the sciences and engineering vs. the humanities and the arts*

… and which realistically are the most effective approaches to overcome them:

- *Bottom-up vs. top-down / personal vs. institutional change*
- *Experience from existing programs: why did attempts fail; which strategies and conditions allowed success: and which modifications to the original mission had to be made to be successful?*

Based on the participants' questionnaires, time, funding, and academic gaps are often the reason why inter/transdisciplinary research collaborations fall through. Hence, most of our current problems are related to the academic world. While some participants emphasized that the lack of understanding of the methods and goals of outside disciplines was a problem, others thought that the problem was deeper than this, because the goals and practices are so different among arts, science, and technology. It was also articulated that it is often the way we categorize disciplines that makes arts and science look so different from each other. Seen from the standpoint of creating something new, artists and engineers have something important in common; colleagues in natural sciences and humanities often try to understand processes without creating something physically new (although, of course, these fields create new knowledge). As a final thought, C.P. Snow's (1960) *The Two Cultures* was brought up with a question regarding whether the situation today is different from what Snow described in 1960. Unfortunately, the question had to be left unanswered because the workshop needed to move along with the next topic.

5.2.2 Panel: NSF and NEA Opportunities

Pamela Jennings (NSF), Bill O'Brien (NEA), Alice Mygatt (NEA)

Theme: The purpose of this session was to inform the workshop participants from a program director perspective what opportunities their agencies provide for AST-related research projects.

Description: Pamela Jennings mentioned in her presentation that academic standards of publish or perish are often at odds with interesting work that crosses boundaries, and collisions between individual and collective approaches are often caused by different development and assessment methods, different incentives and reward structures, and different interpretations of the same terms. She pointed out that although no program at NSF currently directly targets AST-related projects and their special academic standards requirements as the CreativeIT program used to, numerous NSF opportunities still exist to compete for funding in the field, including:

- Science and Technology Centers (STC): Integrative Partnerships NSF CISE
- Integrative Graduate Education and Research Traineeship Program (IGERT)
- Expeditions in Computing
- Research Coordination Networks (RCN)
- Virtual Organizations as Sociotechnical Systems (VOSS)
- Digging into Data Challenge[9]

Further, it was discussed that a number of goals of these programs are in line with the objectives of the program highlighted above. The STC program, for example, "supports innovative, potentially transformative, complex research and education projects that require large-scale, long-term awards," while the IGERT program "meet[s] the challenges of educating US PhD scientists and engineers with interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional, and personal skills." The Expeditions in Computing program addresses the CISE community "to pursue ambitious, fundamental research agendas that promise to define the future of computing and information." The RCN program provides an interesting opportunity, as its goal is "to advance a field or create new directions in research or education." The program specifically addresses "training and educational activities across disciplinary, organizational, geographic, and international boundaries." The Digging into Data Challenge was an international competition held in 2009 and 2011 with a number of participating grant agencies (in addition to NSF, the Social Sciences and Humanities Research Council of Canada (SSHRC), the Netherlands Organisation for Scientific Research (NWO), the UK Joint Information Systems Committee (JISC), the UK Arts and Humanities Research Council (AHRC), the UK Economic and Social Research Council (ESRC), the US Institute of Museum and Library Services (IMLS), and the US National Endowment for the Humanities (NEH)). The competition promoted large-scale, international, and interdisciplinary analysis of large data sets

[9] http://www.diggingintodata.org/

within the humanities and social sciences, and it remains to be seen if future competitions will be held.

Mechanisms for seed funding also exist through the NSF EAGER funding mechanism, and the Center for Innovative Learning Technologies (CILT),[10] which was founded through an NSF grant in 1997, also funds seed grants and provided support services in the areas of visualization and modeling, ubiquitous computing, community tools, and assessments for learning.

Bill O'Brien and Alice Myatt noted in their presentation that the National Endowment for the Arts envisions: "A nation in which the arts enrich the lives of all Americans and enhance the livability of communities." The organization has the mission: "to advance artistic excellence, creativity, and innovation for the benefit of individuals and communities," based on these goals:

1. The creation of art that meets the highest standards of excellence.
2. To engage the public with diverse and excellent art.
3. To promote public knowledge and understanding about the contributions of the arts.
4. To enable the NEA mission through organizational excellence.

O'Brien pointed out that the renewed vision of NEA now focuses on the livability of communities, an aspect that was not important in the old strategic plan. With respect to this, goals 3 and 4 include new changes. While the NEA is not allowed to lobby, it can advocate for *art and public knowledge.* Unlike the Canada Council for the Arts (as was highlighted in Abby Goodrum's talk the night before), NEA has the ability to fund organizations and swarm other funds around the projects.

As a practical example, O'Brien discussed the NEA Innovation/Consortium Grants.[11] In today's language, *innovation* is an overloaded word and often used in the context in global economy. NEA, however, uses this term more in the context of transformative meaningful changes to society.

Typically, successful grant applications to this program demonstrate strength with regard to the following issues:

- They are likely to prove *transformative with the potential for meaningful change, whether in the development or enhancement of new or existing art forms, new approaches to the creation or presentation of art, or new ways of engaging the public with art.*
- They are distinctive, offering *fresh insights and new value for their fields and/or the public through unconventional solutions.*
- They have the *potential to be shared and/or emulated, or are likely to lead to other innovations.*

[10] http://cilt.concord.org/

[11] More information can be found here: http://www.nea.gov/grants/apply/ (last accessed Oct. 06, 2011).

Alice Myatt pointed out that under her new leadership as program director for new media, she anticipates a number of strategic changes. First, she wants to cover new media in its totality to include games and online projects, and asked to have the guidelines rewritten, which will be enforced in 2012. Secondly, she plans to make NEA more visible, for example by supporting *Indigames* and *South by Southwest*. For these initiatives, affirmation is often more important than cash. Myatt also encouraged the participants to submit media-related projects to solicitations that do not focus directly on it, reminding the audience that media is ubiquitous.

5.2.3 Full Workshop Meetings / Work Groups Meetings

Later in the workshop, the members were divided into five groups to develop strategic plans to create networks in the intersecting fields of arts, science and technology. Each of the groups addressed this initiative from a different angle, based on the full workshop meeting (Section 5.2.1):

- Group #1, the **Clearinghouse** group, proposed a multi-layer platform to publish and disseminate multimedia material.
- Group #2, the **Network Opportunity** group, planned an open network for opportunity, sustainability, and regeneration, which supports intellectual exchange between communities and academic circles and promotes good ideas through small startup grants.
- Group #3, the **Open Network I** group, proposed to set up national laboratories for interdisciplinary research in the intersecting fields of science, engineering, arts, and design through a three-stage plan starting with 1) connecting existing facilities in the field; 2) designing a prototype national laboratory, which then can be used as a model for; 3) a network of such institutions.
- Group #4, the **Open Network II** group, also worked on a facility-support model, but their model focused on the integration of existing facilities, rather than on erecting new infrastructure.
- Group #5, the **Curriculum** group, examined models to support education aspects of a network of excellence in the fields of science, engineering, arts and design.

The breakout groups met and discussed their topics during the day and presented their work on the third workshop day. The outcome of the group meetings are summarized in Sections 5.3.1–5.3.5.

5.2.4 Mini-Keynotes (Donna Cox, Gunalan Nadarajan, Thanassis Rikakis, Sheldon Brown)

The purpose of the evening mini-keynotes was to share perspectives about collaborative practices that will be needed for a network of excellence. Since such an inter-school network does not yet exist for art, science, and technology spanning

projects, leaders from successful in-school models were invited to give a 15 minute presentation each to complement the keynote about the Canadian GRAND network.

In the first mini-keynote, Donna Cox drew conclusions from her own career as a digital artist working on numerous visualization projects of scientific data, including her work on the IMAX feature film, *Hubble 3D*. Cox sees computational science as the "third pillar of science," complementary to observational and experimental methods. According to Cox, "Visualization is the telescope into 21st century digital laboratory," using portals such as digital domes, CAVEs, which can provide large format embodied experiences into the virtual universe. As the director of the Emerging Digital Research and Education in Digital Arts Media (eDream) Institute, she fosters collaboration across the disciplines of art, humanities, sciences, and education. Her work focuses on global renaissance team projects, where visual artists and designers, including herself, bring skills to the challenges of large data visualization. In her scheme, the artists and designers have an intellectual cultural function to encode billions of numbers into evolving digital visual metaphors, the so-called *visaphors*.

Thanassis Rikakis, director of ASU's Arts, Music and Engineering School (which emerged from an NSF IGERT grant he spearheaded) presented on "structuring successful interdisciplinary collaborations based on their targeted outcome," with an attempt to classify various forms of collaborations. Rikakis pointed out that there are various forms of collaborations across arts, sciences, and engineering. He viewed a standardized model as not useful, but instead called for goal-based structures, e.g., collaborative frameworks that are optimized to reach the given goals according to specified evaluation metrics. At one end of the possible solutions stands the hierarchical "disciplinary outcome model," where the outcome belongs to a single discipline and other disciplines are asked to support the realization of this outcome. Then there are various forms of "interdisciplinary outcome models" ranging from those where one discipline has a clear lead function (hierarchical) to those where several disciplines equally share leadership (flat collaboration). Both models require the development of new knowledge in one or more contributing disciplines as well as a multifaceted outcome model that addresses each participating discipline. At the other end of the spectrum, we find the "transdisciplinary outcome model," where the collaboration of a diverse team transcends existing disciplines. Such a model requires the development of new knowledge that specifically addresses the transdisciplinary goal(s). The difficulty in this approach is that the outcome might not fit the standardized expectation of the participating disciplines, the challenging and interesting part that the outcome "is understood and controlled through collective intelligence."

Sheldon Brown addressed the audience based on an introspective view of his answers to the questionnaire that was sent to the workshop participants in advance. He sees finding and keeping the artistic vision as one of the major difficulties in cross-disciplinary research projects, and believes that one of the advantages of inter-institutional research projects is that participants can collaborate with their best intentions and behavior, because these projects often circumnavigate intra-institutional

politics. However, collaborative intra-institutional research projects often have the advantage that researchers have local access to diverse expertise.

Based on his long-term experience as visual artist and director of the Center for Research in Computing and the Arts (CRCA), Brown believes that sustained collaborations should have both strategic and tactical outcomes; strategic in a sense that the outcomes improve the climate for the field and enrich the discourse, while tactical aspects provide complementary capabilities to complete tasks to increase viability of inputs and outputs (funding and exhibitions/publications). His talk concluded with a number of interesting topic ideas for a network of excellence including a journal of interdisciplinarity. He also suggested that the group should take on multiple projects that can simultaneously work across the network to bring different aspects into play. The network should cultivate external partners such as museums, publishers, industry, government agencies, and also international partners. When forming the network, the group should consider under which conditions the members would engage and contribute to its program and how it will be able to support the work taking place to provide the means for distributing/exhibiting outcomes.

5.3 Third Workshop Day (Friday, March 18, 2011)

In the following section, the results for each breakout group are summarized. The descriptions are based on material provided by each group (ranging from bullet notes to written-out documents) and notes taken from the oral presentations given at the last workshop day.

5.3.1 Group 1: Clearinghouse[12]

Group Members: Jonas Braasch, Donna Cox, Gerhard Fischer, Adriene Jenik, Thanassis Rikakis

Problem: In the current academic landscape, several publication formats exist. While for paper-style publications a vast number of publishers release papers at various levels for peer and post review, fewer opportunities exist to disseminate multimedia content. In the latter case, unsupervised platforms like Flickr, YouTube, Vimeo, and other services dominate the field. Due to a lack of quality control, these are not adequate to document the qualitative standing of a project, which is necessary for project, student, and faculty evaluation.

Core Idea: To provide a platform with three different layers of review with a mechanism to promote contributions to the next-higher level. The proposed platform is more flexible in allowable multimedia formats than current multimedia supplements of journals and conference proceedings.

[12] This project idea was funded through NSF in June 2011: *"Collaborative Projects: EAGER: A virtual eXchange to support networks of creativity and innovation amongst Science, Engineering, Arts and Design (XSEAD),"* Award #1141631.

Description: After 40+ years of art, science, and technology collaborations, we have reached a place of maturity in the field. Nevertheless, many long-term practitioners in the field have had the experience of re-presenting and re-arguing for the basic validity of this exchange. Though we know that these arguments will need to continue to be articulated, a dynamic portal, repository/archive of important projects, papers, and exemplars in the field is a crucial infrastructural underpinning for the next stages of growth. Having multiple entrance points (top-level art/science/technology Wikipedia entry, links from active researcher/artists/institutions), the portal seeks to serve diverse audiences including but not limited to: teachers and informal learning communities seeking exemplars for curricular development, young artists/scientists/researchers looking for inspiration and prior work in their field, active practitioners looking for further institutional opportunities to present and support their ongoing work, and academics seeking to support program initiatives across disciplines and promotion cases. Distinct from present sites that are primarily comprised of papers, the portal will host rich, unusual media forms revealing the full range of activity in this broad field; the portal will also host and point to important archives and conference proceedings and house papers and articles that examine and analyze art/science/technology collaborations.

The proposed structure of the portal will feature 3 “layers:”

1. Layer edited by editorial board
2. Layer based on invited contributions from key people using the TED talk form, will include reference page with notes, key events, and key institutions
3. Layers provides open access to a broad community

A well designed and publicly accessible/inviting/entrancing first layer will enable the person entering to easily navigate to the resources they are most interested in accessing. The second layer will feature rotating invited practitioners (artists, scientists, designers, industry leaders, etc.) who provide short “stories” or statements with select pointers to resources on the site as a unique and deeply engaged inroad to the vast repository. Finally, to keep the portal dynamic and reflective of the growing field, the third layer will enable artists/scientists/students, etc., to upload their projects and papers, tag and categorize them to “place them” in the overall field content mesh, and offer for linking from the first and second layer editorial content.

Proposed Schedule:

0–6 months

- Appoint preparatory coordinator of effort and editorial board (temporary editor, Donna Cox and Thanassis Rikakis co-volunteered)
- Appoint first editorial board of 15 people across academia, industry, and practitioners (willing to be involved in brainstorming sessions, promoting clearinghouse and proposing names and content for layers 1 and 2)
- Conference call among early board members
- Find temporary name, invite more board members, find academic institution to host and provide storage space. Strategy for seed funds from agencies and

foundations. Ask academic institution to host website and provide storage space (1 terabyte for the first year). Provide a statement back to the community. Collect more names for layer 2

- By 3-6 months find total seed funds: $100,000
- After 3 months
  - Hire for two years: editor/senior writer ($25K per year, part-time), needs to know the field, translator type (understands both arts and sciences), good writer, good organizer, mid-career person proposed (credibility in the field important)
  - Editor starts research on what is out there and who we need to connect with (reports to board)
- After 6 months, editor hired for two years
  - web designer ($25K per year, part-time), good track record in multimedia websites, needs to understand both design and computing issues, knows content-based management (can deal with large databases online). We expect that contributions will need to meet formatting requirements

6–12 months

- Establish copyright policy
- Do first invites for second layer
- Establish content policy for third layer
- Begin design of first layer

12–18 months

- Senior editor/editorial board/web designer needs to implement all three layers and populate layer 1 and 2
- Develop technical proposal to NSF on content issues
- Develop sustainability proposal for staff to funding agencies and foundations

Discussion Notes: A Wikipedia entry page was suggested to promote the system, which should go beyond addressing a pure academic interest group. Another suggested promotional tool was to establish and finance a TV documentary. Further, it was noted that copyright issues have to be addressed, but models from other sites, such as Flickr, could serve as role model.

5.3.2 Group 2: Network Opportunity: Open network for opportunity; sustainability, and regeneration[13]

Group Members: Chris Chafe, Carol LaFayette, Alyce Myatt, Brian Smith, Carol Strohecker

[13] This project idea was also funded through NSF in July 2011: *"Collaborative Research: EAGER: Network for Science, Engineering, Arts and Design (NSEAD),"* Award #1142510.

Problem: Existing academic structures are not working economically, students must make connections in new ways; organizations are slow to change and people are not waiting for academy to catch up.

Core Idea: To learn from historic time parallels, for example, the industrial revolution requiring reorganization of labor, education, to create a community-based involvement, open platform.

Description: The project goal is to create a forum where everyone can participate, and which allows people to move in different paces. Another goal is to overcome current limitations of academic structures that are often slow in adapting. This step is necessary as we continue to move into knowledge-based industries. The industrial revolution can serve as a role model for such a drastic societal change. Other sources of inspiration are the Maker Faire, [14] TED talk's inspirations focusing on curiosity, and the aims of DorkBot, FabLabs to endorse learning and "thinkering." The network will consist of people and ideas and physical and virtual components. It will be in service of growth of the arts and sciences. The forum should be based on an open architecture as a junction to signalize communication from all sources as opposed to going a one-way route.

Content-wise, the forum is based on the STEAM model, but includes another discipline, humanities (to be inclusive to learning) to form the acronym THEMAS. The conversations of the forum will be situated around the shared making of projects. The group assumes that we are moving into a time where there are no boundaries, literal or figurative (i.e., remix culture—a cultural shift). Consequently, we will need a cooperative model with mixed sectors, generations, cultures, etc. The forum should appeal to the open source community, which is building engines but has no time to publish research papers. Unlike the research community, the latter group also has no real interest in peer-reviewed publications. Role models are grassroots events like the Maker Faire, which helped to create a different kind of environment. The forum should not be about inclusivity or exclusivity, per se, and it remains to be seen where the boundaries are. The network should build on knowledge brokers, which exist on other networks like the "Brainpickings" site.[15] These brokers are trusted sources that can guide an individual to what is sought. They can wade through inventory and suggest resources. The forum should have a great interest in the emerging interdisciplinary process oriented approaches, including design processes and learning processes. The idea is to connect existing fields and disciplines to create new fruitful opportunities and define a transformative network that can be sustained.

With regard to structure, the physical components of the network should include immediate community spaces for shared doing/making, dialogue, and events for showing/retreats. The network should establish a virtual gallery for project

[14] http://makerfaire.com/ (last accessed Oct. 13, 2011).
[15] http://www.brainpickings.org/ (last accessed Oct. 13, 2011).

presentations. A number of questions should be addressed to come up with an optimal structure for the network:

1. Who can use this (a given output)?
2. Does this privilege surprise and wonder? (i.e., viral work)
3. How else might the idea be represented (modality; medium)?
4. What dissemination modes does each imply?

Incentives and output

One of the main incentives for participation should be the expectation that that the ideas go viral, where the audience numbers are exponential relative to in-person experiences. The network could operate on a "fee free" paradigm, assuming the more you give away, the better the income you will receive. Role models for such an approach exist, e.g., the Prelinger Archives,[16] where everything is free but licenses cost. The "capital" is viral public appreciation, the source of income. To achieve this goal, participants must have a demonstrable component of outreach/inclusiveness/accessibility. The "Earth and Sky"[17] site with online space for contributions is another site that is frequently picked up by other media.

Regeneration

Regeneration is a major component of the network. Part of the regenerative process will be a kick-starter model where ideas are funded rather than people (project proposals rather than fellowships, e.g., Rtmark.com). The selection process could be based on design competitions with the hope that communities kick in with microfunding and matching grants from NSF, NEA, could be obtained if enough money is raised from public.

Sustainability

To sustain the network, the group could bootstrap ideas to raise funding. Support needs to come through co-ops, foundations, cooperate funding. Operating expenses could come from co-owned interest, where a core group commits to support. Earned income can come from sales (entrepreneurial), and members can commit their service/expertise that someone can buy, which will be a way to get the art and science community to buy in (example: timebanks.com).

Student Support

The network should support the creation and fostering of ideas for new student career opportunities, by art/science/technology entering into traditionally analog arenas (i.e., theater, opera, museums). Student support should include stipends, mentorship, as well as class/project/internship opportunities.

[16] http://www.archive.org/details/prelinger (last accessed Oct. 30, 2011).
[17] http://earthsky.org/ (last accessed Oct. 30, 2011).

5.3.3 Group 3: Support Network I: National Laboratory, standalone physical space, sustainable research sharing, exportable ideas

Group Members: Shawn Brixey, Michael Century, Abby Goodrum, Kathy High, Paul Kaiser, Gunalan Nadarajan

Problem: Several universities run laboratories at the intersection of STEAM disciplines, but none of these centers reach the size of big research centers in traditional fields of science.

Core Idea: The core idea is to develop a road map that leads to the creation of a national laboratory or a network of national laboratories. These would allow us to work on projects at a larger scale than currently possible. They also would stand out from academic constraints such as promotion and tenure.

Description: In the first phase, which is expected to take a year, the project starts with an incubating-themes burst conference on health care and sustainability, to which people can apply. The group would try to get a sponsor for this conference. In the second phase, the project would elevate to a boot camp that could be held at DxArts, EMPAC, or another similar venue. The financial plan would seek to cover the costs with a funding model where external funds, government funds, and institutional funds each carry a third of the share. The group would try to involve NEA, NSF, and NIH in the funding scheme. The group would like to avoid a work-for-hire model, like that currently practiced at the MIT Media Lab, for example.

In phase two, the group expects to accomplish the final artistic work that can go out in the public sphere. Additionally, e-papers and patents may be filed (although the group is committed to an open source model). The ultimate goal is to develop a national laboratory (or a series of three national laboratories) in STEAM-related areas. The group anticipates building the first facility within the first five years of the project, but notes that the group can use an existing agnostic space in the interim.

5.3.4 Group 4: Support Network II

Group Members: Chris Bregler, Sheldon Brown, Winslow Burleson, Pamela Jennings, Lou Tassinary, Matt Wright

Purpose: Create a distributed national art and technology laboratory to advance the development, production, dissemination, and presentation of transformative projects.

Description: STEAM-related research centers like the Allosphere provide unique opportunities and would do so even more if they were linked together. Since the US is front-runner in media technology and art-related fields, the group has move the whole field forward to maintain its leadership role. The goal of the network is to advance new art forms and to facilitate large-scale creative transdisciplinary projects. The network

will promote emerging art forms that can bring unique insights into the human condition. The latter have the potential to improve the human condition (quality of life, livability). Further, the network will foster/enable/advance research and the production of ambitious, field-expanding, large-scale, cutting-edge technologized projects. Presenting these projects in an adequate way is also part of the network. The network will be development rather than research driven and it will link diverse but like-minded environments. In addition, it will invite/engage/inspire the public to engage as active full participants in the creation and experience of these culture-related projects as citizen artists and citizen scientists.

The group will allow flexibility for each specific project to define its own development path from ideation through production according to the group's own needs. It will also help to amortize development and production, with the goal that developments can be carried out at lower cost. The network will also support intellectual exchange, for example, in the form of shared algorithms and short-term boot camps to train scientists and artists in related fields.

The idea will need a big investment to take off, which could be covered through research funds, patronage, and an MIT-media-lab model of consortium. The national laboratory network might not pay by itself but attract more funding, and then the outcomes of the network can be monetized (e.g., patents, spin-offs).

Action Items (3-6 months)

- Identify low-hanging fruit (e.g., ongoing projects that can be assimilated)
- Identify leading institutions that would help coalesce this by hosting various stages of this effort
- Fine-tune and consolidate these ideas
- Pick a project to push through this system as a design driver
- Look at promising projects that were not afforded the paths they could have had and test cases of what might have been

5.3.5 Group 5: Curriculum

Group Members: Fred Belmont, Ben Chang, Barbara Cutler, Ted Krueger, Bryan Pardo

Problem: The network of excellence needs a strategy to involve graduate students and meet the future generation's needs in terms of curriculum and research opportunities.

Core Idea: Brief Statement on the Purpose of the Topic

The "network of excellence" should be pursued at multiple levels, including graduate and undergraduate arts and technology education and graduate student networking and research. Specifically, the group believes it is important to empower graduate-

student network development, graduate and undergraduate interdisciplinary education, and cross-disciplinary teaching resources for professors.

Description: Strategies to Develop

Project Idea 1: *Cross-disciplinary educational incentives for students*

Motivation: To support real innovation that combines art and technology, we must empower the next generation of leaders with the basic tools needed to succeed in multiple disciplines. These are typically provided in the coursework designed to educate students for this purpose.

Challenges: Arts and technology undergraduate majors (e.g., fine arts and computer science) typically have curricula that are packed full with courses in the major (i.e.., 75% of coursework is within the major). This contrasts with liberal arts degrees that often have significantly lower within-major demands. Therefore, those students who wish to work in two areas have to take significant course overloads and pay additional money. Graduate students wishing to pursue cross-disciplinary study to shore up knowledge and experience in a second area face similar constraints: undergraduate courses not allowed for credit, graduate advisors not interested in paying for out-of-discipline coursework, heavy workloads, and time-to-degree requirements.

Solutions: Small fellowships (on the order of $6K per student) to support taking summer coursework outside the degree area and to offset advisor grant expenses for supporting out-of-discipline basic education.

Metric for Success: Measure the percent of student grant recipients receiving degrees in multiple areas (extra minors, certifications, double majors) and compare that to the general population of students. At the graduate level, measure outcomes in terms of the broadness of publication records of the graduate students (e.g., measure whether they are publishing/exhibiting in multiple areas).

Project Idea 2: *Support for medium term (on the order of a 1 to 3 months) interdisciplinary, cross-institute lab and studio visits for graduate students*

Motivation: To create truly transdisciplinary leaders, graduate students must have the opportunity to interact with researchers beyond their home institutions in a meaningful way. Europe, Korea, and China all have programs that fund graduate student lab visits to other institutions for 3 to 6 months. This support promotes the building of professional networks, cross-pollination of ideas, cross cultural understanding and closer ties among researchers at disparate institutions. To remain competitive with Europe and China, transdisciplinary research in the United States should support similar initiatives.

Challenges: In the sciences and technology disciplines, students are typically funded by professor grants. The requirements of funding from grants with deliverables and limited timeframes, combined with the realities of leases and travel costs, make it

impractical to fund a graduate student to spend a few months in a lab or studio at another institution. In the arts, there is simply no funding for this kind of thing. Therefore, the chance that an artist's studio could fund a multi-month visit is low.

Solutions:

1. REU-sized grants[18] (on the order of $5-10K) to support lab/studio visits by graduate students to go spend time at another institution in another discipline, learning their ways.
2. In addition, make a long-term symposium (e.g., one month) for a small number of students instead of a short symposium for a large number of students. This would be similar to the workshops that happen at Johns Hopkins for speech technologies every summer.[19]

Metric for Success: We need to measure knowledge, skills, behaviors and attitudes. While we do not have all the answers just yet, we can measure outcomes in terms of the broadness of publication records of the graduate students (e.g., measure whether they are publishing/exhibiting in multiple areas). Another measure would be the number of joint grants/papers/exhibits produced subsequent to the visit.

Project Idea 3: *A network/clearinghouse of teaching resources to support development of combined arts and technology education*

Motivation: If we wish to build up transdisciplinary leaders in the next generation, the education they receive must be transdisciplinary. Therefore, we must revamp a number of courses so that they are informed by multiple disciplines.

Challenges: Typical undergraduate courses of study in each field frequently impose barriers to interdisciplinary studies. Educators are steeped in a single discipline and the motivating example course materials available are drawn from individual disciplines. The educators themselves are under significant time pressure and may not have the resources to tailor the course materials to incorporate other disciplines in a meaningful way.

Solution: An online clearinghouse where educators who develop transdisciplinary teaching materials can share them in a cross-institution way. There are many social networking and crowd sourcing tools that can be adapted for this purpose. It is important that the materials be vetted, labeled, and documented. Wikipedia provides a social control model for crowd-sourced information that we can use as a first step.

Metric: Multiple metrics are possible. These include the number of participating professors/lecturers/institutions, the quantity of resources being shared, and the number of cross-disciplinary courses that use the materials. Another metric could be

[18] REU= Research opportunities for Research Experience (NSF program).
[19] URL: http://www.clsp.jhu.edu/workshops/ws11/internship.php.

the level of activity of conversation through the clearinghouse of news information related to it (tweets, blogs, etc.)

Action Items for the Next 6 Months

For all three topics, we need to gather a group of institutions interested in participation.

- Project Idea 1: Cross-disciplinary educational incentives for students:
  Engage host institutions (e.g., Northwestern University), private foundations (e.g., Mellon Foundation) and the national granting agencies (e.g., NEA, NSF) to determine what would be the best model for funding this project.
- Project Idea 2: Support for a medium term (1 to 3 months) interdisciplinary, cross-institute lab, and studio visits for graduate students:
  Study how such programs are organized and supported in the places (e.g., Europe) where such programs are common. Contact Johns Hopkins to determine how their six-week workshop in speech technology works. Determine best-in-class practices. Develop a proposal for grant support and governance.
- Project Idea 3: A network/clearinghouse of teaching resources to support development of combined arts and technology education:
  Study how similar networks/clearinghouses work in different domains. Examples include Rhizome.org (a website run by the New Museum and is a central clearinghouse for Internet art); the New Media Caucus (a group of new media academics, part of the college art association; the Independent Games Development Association (a curriculum template resource for game-design courses); Wikipedia; Github (to have a history of changes of a shared resources); iBetaTest (for feedback from interested users).

Minimal requirements for success for the next 12 months and following two years depend on the outcome of the short-term (six month) action items.

Appendix A

Replies to the questionnaire.

In preparation for the workshop, a questionnaire was sent to the participants coming to Rensselaer. Altogether, 22 of the total number of participants (31) came from off-campus. 17 of these 22 returned the questionnaire.
The replies are not edited. They cannot be matched, so that for instance the fifth reply to one question would come from the same person as the fifth reply to another question.
Information that allows to identify the responder has not been modified or removed.
This overview was sent to the participants in advance of the workshop. Furthermore it served as basis for the definition of four major areas, which initialized the discussion of the workshop.
These replies can be regarded as a source or almost historical document of what at this point in time is being thought about the issues at the intersection of arts, science and technology from a mostly academic perspective.

Main research areas

- Computational learning environments, interaction design
- Experimental media, hybrid environmental art and interactive electronic public spaces inspired by and synthesized with physics, astronomy, cosmology, and biology. Research by further sub-discipline; custom electronics and photonics, holography, spatial imaging, machine vision, telepresence, nano-technology, biotechnology, mixed and augmented reality.
- Experiential Media (hybrid physical-digital systems), Mixed Reality Rehabilitation, Interdisciplinary Education, Sound Perception, Music Composition.
- Cultures of participation, meta-design, social creativity, human-centered computing, transdisciplinary collaboration
- Perception of Attractiveness, Affect-laden information processing and psychophysiological measurement.
- Regenerative uses/applications of technology; interactive installation; immersive system content and interface design; remote sensing; physical computing; new technologies for museums and galleries; projects relating to environment and ecosystems
- interactive cinema, telematic performance, digital storytelling, telecommunications media art
- artistic research into the expressive qualities of stereoscopic 3D; abstracted movement of dance and ordinary movement; interactive drawing
- Media Arts
- The objective of my research is to develop theoretical advances in artificial intelligence, signal processing and interface design, that enable the key

technologies required to automatically find, label and manipulate important structures in audio, with a focus on music as a problem domain.
- Music composition, performance, research (synthesis, signal processing, perception)
- media art history and theory (late 20th century primarily); innovation studies; musical creation and performance.
- New forms of digital media, virtual reality, computer games, cinema, machinima, interactive installation, public art. New computing methods and systems designs to support the former with parallel computing and client server systems design.
- Motion Capture, Graphics, Animation, Visualization, Computer Vision, Artificial Intelligence, HCI, Crowd Sourcing, Gaming, Machine Learning,
- Interactive immersive audiovisual environments. Spatial sound. Scientific data sonification and visualization. Interactive realtime systems. Human perception and production of rhythm. Expressive timing. Live performance and improvisation. Artificial listeners. Representation of musical material with high-level models. Human/Computer Interaction. Design of potentially expressive computer-based musical instruments. Cybernetics. Human motion in skilled performance. Mapping of physical gesture to musical control. Traditional musics of Brazil, North Africa, the Middle East,, the Arab world, Iran, Afghanistan, and India. Computational ethnomusicology. Analysis/synthesis of musical sound via mutable representations. Machine learning.
- Human Perception, Extreme Environments, Human-Environment Interaction

Areas of interest, which are currently not part of your research but which you would like to collaborate with or reach out to in order to investigate potential projects:

- Earth science, space science, computer science, AI, large scale data-mining and visualization, synthetic biology, plant-neurobiology, gaming and simulation, cognitive science, neuro-aesthetics, etc.
- Besides my own research interests, and the interests of my direct collaborators, as director of our School (AME) I also represent the research and education interests of the School. Other colleagues at our School work on: mediated K-12 education, enactive arts, participatory culture, reflective living, social network analysis, informal learning, and memory and perception in mediated environments.
- eco-arts, eco-visualization, technologies supporting the change of human behavior, intrinsic motivation, boundary objects
- Aesthetics, impedance tomography, source-localization techniques, wearable sensors
- Mobile computing; data visualization; augmented reality; technology for rural areas

- Data extrapolation, high bandwidth distance learning, international arts learning exchange
- text analysis on levels more advanced than simple word concordances; exploration of different display and projection technologies, perhaps more tightly integrated into a given architectural space
- As a government funding organization we are interested in fostering collaborations. This can include grantmaking and Cooperative Agreements as well as sponsoring convenings.
- Interactive multi-modal art installations
- Artificial Intelligence
- multimodal representation of information for purposes of meaning-discovery and retrieval through improvisational expressive gesture.
- Augmented reality with distributed social networks.
- Multicore computing. Collaborations on infrastructure and content.
- Human perception of space from an embodied perspective in scales ranging from the haptic to the metropolitan

Possible reasons for not having been able to engage in collaborations you would like to pursue:

- Time.
- Ongoing administrative, professional and academic commitments and requirements of hybrid research fields I am already expert in don't provide enough extra time to hybridize further. Not enough large scale speculative research funding available to support the wider migration of artists and scientists into shared radical research projects.
- Financial constrains, lack of time, lack of aligned research interests, lacked of aligned infrastructure, misalignment of desired outcomes amongst potential collaborators.
- Lack of resources (time and money)
- Lack of time, disciplinary barriers, lack of funding.
- Cross-disciplinary collaboration is harder to characterize to stakeholders and not well understood in general. Funding for the arts is scarce and small, relative to that for science and technology; arts exhibition and funding opportunities sometimes focus only on traditional mediums. Archival issues with digital works (digital = ephemeral) therefore viewed as less "collectable" thus less valuable. Some art forms created with new media--for example, physical and ubiquitous computing--have opened up different sharing and distribution paths, away from exhibition-based and toward entrepreneurial-based methods, without a corresponding rise in forms of support for such work. Sometimes project supporters balk at the overhead percentage expected by college and department—overhead is not well understood in the art funding world.

- #1 = Lack of time, #2 = money, specialized researchers, #3 lack of global infrastructure
- Lack of funds. 2. Both interdisciplinary and collaborative work are poorly understood in the art world, and many projects we pursue don't fall within the surprisingly narrow categories imposed by museum curators and, for that matter, art critics. Thus, some projects fail to find the commissions upon which our work largely depends.
- Lack of money, time, collaborators with complementary skills and interest.
- Time. The time scale of progress in much of science necessitates patience and finding venues and teams which persist over the long haul. Quick-turn funding and presenter projects are fine for early results being translated into art but miss out on what might be achieved with longer, greater science scope. And nothing in research comes with guarantees, so accepting risk is part of the agreement.
- time, money, imprecision of goals
- Funding restrictions and particular expertise needed in new API's.
- Funding
- Too busy building the instrument.
- Proximity/contact with researchers with similar interests. Administrative responsibilities.

Current Interdisciplinary Project(s):

- STEAM…how art/design + science/engineering might co-exist to create new pedagogical frameworks for creativity and innovation.
- us Augurum | The Museum of the North and the Geophysics Institute at the University of Alaska. Using an innovative combination of crystal physics and nanotechnology methods similar to "doping" in solar-cell and semi-conductor fabrication I have developed in my research, I have been commissioned to create a new large-scale ice-art installation designed to clone tiny fragments of rare "ice" core samples taken from ancient North American glaciers that are rapidly disappearing due to the impact of global climate change. Integrated with the physical installation will be innovative smart-phone and tablet applications. The exhibition will tour throughout numerous arts and research institutions in the circumpolar north.
- Mixed Reality Rehabilitation for Stroke Survivors
  (http://ame2.asu.edu/projects/mrrehab/)
  Interactive tools for outcome based, user driven education
  (http://digitalculture.asu.edu/map)
- Transformative Models of Learning and Discovery in Cultures of Participation
- Energy Sustainability and Smart Grids: Fostering and Supporting Cultures of Participation in the Energy Landscape of the Future
- A Meta-Design Framework for Participative Software Systems

- Increasing Participation and Sustaining a Research Community in Creativity and IT
- Neuroaesthetics "journal club," Event-related brain activity during rapid decision making and natural scene processing.
- Immersive experiences for museums: interactive 3D environments
  Rural ecosystem investigated through remote sensing to discover interconnections
  Virtual scuba dive in partnership with NOAA Southeast Region
- Open_Borders Lounge (telematic performance, arts, performance, performance studies, humanities, languages)
- Interactive 3D drawing, in collaboration with Georgia Tech. Visualization of large data-sets, with EMPAC and the Tetherless World team of RPI.
- Cognitive modeling of human learning of sounds (collaboration with researchers in auditory psychology).
- Building adaptive interfaces for music production that work in terms of the user's conceptual map instead of the tool-builder's (music, HCI research, signal processing, machine learning)
- Synthetic Aesthetics (with synthetic biology), EcoG music of brain signals, environmental "musifications"
- none. I managed an interdisciplinary network of new media research centers in Canada for 3 years (1993-1996): 6 centers, approx. 25 projects, annual budget approx 5,000,000 USD. I coordinated and edited proposal to Canadian national program for "networks of centers of excellence" in 1997-1998, to establish a new network "Technology, Media, and Creativity" (not funded;). Previous projects include dozens of new media art works involving aesthetic and technical co-development in which I served as producer/executive producer. I also authored a policy study for Rockefeller Foundation (1999) on art, science and technology "Pathways to Innovation in Digital Culture".
- The Scalable City - soon to be a massive multiplayer online enviornment. The Center for Hybrid Multicore Productivity Research - and NSF I/UCRC which I direct the UCSD branch of.
- Squidball.net : Crowd based motion capture gaming – with producers, artists, musicians, game designers, interactive artists, and computer scientists.
- GreenDot: Body Language analytics with Linguists, Psychologist, Dancers, Choreographers, Animators, Computer Scientists
- Laban Capture: With Dancers, Choreographers
- Sports Viz: With Medical Experts, Athlets, Biomechanics, Neurologists, Computer Scientist
- Several collaborations with scientific domain experts to represent their data content multimodally in the AlloSphere. We typically partner with scientists who supply models, data, and questions; our role is to present data in a new way that is both insightful and beautiful. We are agnostic to content and loosely categorize our work in three divisions: (1) biomedical/biogenerative, (2)

quantum information processing and structural materials research, and (3) arts and entertainment.

A project with Prof. Jamey Marth and the UCSB/Sanford-Burnham Center for Nanomedicine navigates through an anatomically correct 3D model of the human body while simulating malignant tumor growth and the fluid dynamics of cancer-killing nanoparticles in the bloodstream. The AlloBrain reconstructs an interactive 3D model of a human brain from fMRI data, with "intelligent" agents interactively mining the data set for blood density levels, and deliver the information to the researchers sonically.

Two quantum mechanics demonstrations interactively visualize and sonifiy the wavefunction of a single hydrogen electron using solutions to the time-dependent Schrödinger equation, with and without spin. Superposition of electron orbitals produces dynamic behaviors such as photon emission and absorption. The interactive component allows one to fly through the atom with a probe that emits "stream particles" that follow along the largest changes in the probability current and gradient of the electron.

A collaboration with cosmologists displays and sonifies both the measured cosmic microwave background (CMB) and the simulated CMB that would arise in universes with different physical parameters.

- Collaboration on design of multi-sensory interfaces.

Your interdisciplinary dream project:

- A long-term study of the ways that people develop interests and proficiencies in art and design disciplines. This could involve psychologists, computer / information scientists, domain experts in art/design,…
- A series of teleportation projects
- A truly integrated arts and science education model across many institutions
- Understanding, Fostering, and Supporting Cultures of Participation
- Exploring the effects of the macro-environment on real-time decision making using unobtrusive and non-invasive psychophysiological measurements
- One in which art and science are perfectly blended and balanced, creating something entirely new.
- In terms of technology, finding ways to see and experience phenomena that is impossible to achieve through other means.
- Would involve global partners working with large datasets compiled from environmental, census, economic and social data to extrapolate possible futures that could be further developed into stories and games.
- Combines drawing and writing as interactive performance, with AI that can parse sentences as well as gestures.
- Hmm…I'm mostly doing them.
- New life forms which are intrinsically musical or artistic (no kidding).
- "Dream" -- Magister Ludi: The Glass Bead Game (Hesse, 1943). Seriously, fiction has a powerful role in envisioning human intellectual potentiality. Hesse

conceived an abstract synthesis of all arts and sciences. This is a valuable vision still.

- I have a film project which involves the generation of real time cinema with previously recorded and edited pieces.
- Hmm, I don't want to sound snobbish, but I am pretty much doing what I want. Of course it would be great to get more funding for it.
- We are "agnostic to the data." From our point of view good projects involve top-notch researchers who see the need to display their data and models multimodally in an immersive interactive environment in order to support discovery, not just education and outreach. Good projects require ongoing collaboration including lots of discussions, in-person exploratory sessions, and ongoing iterative refinement. Stable funding is of course essential.
- Understanding the perception, conceptualization, and use of space in its cultural and cognitive dimensions.

Which difficulties do you see in cross-disciplinary research projects?

- It's hard to be cross-disciplinary without some disciplinary focus. It takes time and effort to gain that sort of expertise in new areas, integrate with existing knowledge. But doing it well seems to require more than just a surface skim of literature in other fields. So time. - Oh yeah. If you happen to be a junior faculty member at a research institution, you're might not be encouraged to do cross-disciplinary work. The academic standards of publish or perish are often at odds with interesting work that crosses boundaries (and hence established publication venues).
- After 25 years as a pioneer in the field I have seen every level of difficulty surrounding collaborative hybrid research, the remaining issues are pervasive and manifold. There are cultural barriers, institutional barriers, structural barriers, funding barriers, disciplinary barriers, assessment barriers, etc. A major shift in these collective problems could be addressed by the creation of a revolutionary new model of hybrid research, creative practice, knowledge and discovery at the frontier of the arts, sciences and technology running as a longitudinal line from K-°©- 12 through higher education.
- Lack of clear agreement on project outcomes; collision between individual and collective approaches; different development and assessment methodologies; different incentive and reward structures; different understandings of same terms; different cultures;
- Fighting against the academic establishment (deeply engaged and protective of their respective research disciplines
- Lack of shared vocabulary and understanding of extant literatures. For example, what appears as a new discovery in HCI may have already investigated in psychology decades earlier. Put differently, it's hard to avoid reinventing the wheel.
- Due to differing language, thought structures, and conceptual approaches from those in different knowledge domains, project vision and goals can become

vague or skewed.
A cultural focus on empirical knowledge can devalue artistic exploration and experimentation.
Funding streams are usually customized for specific knowledge/discipline domains.

- Languages and cultures that surround and encase disciplines – the funding structures and basic research values and questions are often not able to find common ground or deeply shared commitments in order to sustain themselves.
- My experience has been that clear communications and mutual respect are the two key components to a positive cross-disciplinary project and when either is missing, the project suffers.
- 1) Making sure that people in all disciplines understand and value the goals and skills of the other discipline.
  2) Institutional support and understanding of interdisciplinary work
    a. Supporting pre-tenure faculty in doing interdisciplinary work
    b. Providing resources to projects that may bring glory to another department
    c. Allowing teaching of subjects that fall across disciplinary boundaries
- Venues for presentation. This is really basic – I work in sound and I almost always have to truck over loudspeakers to be able to present to groups in other disciplines. No matter whether conference, class, etc. it's always a problem.
- The most basic problem is failure to understand that there are multiple "logics" of interdisciplinarity, and also multiple "modes" or methods of pursuing collaboration. For reference to academic article providing such an analysis, see Barry, A., Born, G., and G. Weszkalnys (2008). "Logics of Interdisciplinarity." Economy and Society 37(1)
- Finding and keeping the artistic vision.
- Funding. There is also cross disciplinary communication, but with enough time that's actually fun, and part of the discovery project
- Different cultures, jargon, languages. Artists "not being taken seriously" by scientists, particularly scientists who are entrenched in their current working methods.
- Disciplinary-specific value structures, terminology, epistemologies and temporal rhythms often conflict. These take time, trust and respect to overcome. Many very successful in their own discipline do not understand that they hold but one approach to a problem; they may not see the whole problem.

What advantages would you see in *inter*-institutional research projects?

- Learning with like-minded others that have fresh insights.
- Dynamic synergy, accelerated innovation and problem solving • Rapid introduction of new research horizons with greater global impact • Stronger organization, diversity, and collective lobbying power for national shared research funding • Shift of institutional priorities and values to include inter- institutional collaboration • Encourage critically needed hybrid

collaboration with scientists, engineers, artists, and humanists • Create and sustain important online inter- institutional research portals, research societies and peer reviewed periodical literature with higher potential long- term existence • Reduce redundancy, manage finite resources better more responsibly, privilege sustainable resource sharing • Share internal organizational strategies and policy information • Provide functioning and experience based cost</>benefit models to new research partners • Increase sustainable products, ideas, and exportable methods emerging from co- investment/co- development • Enable shared peer- review models, including equitable assessment for tenure/promotion of hybrid faculty engaged in hybrid collaborative research • Partnering and sharing among supercomputing centers • Shared grants- management technology for funders to create interoperable information about shared research intelligence and efficacy

- The main advantages relate to scale and richness of the resulting networks. Having many institutions adopt interdisciplinary work across arts and sciences based on a common set of research and education standards and principles (that address the challenges mentioned above) can have the following benefits:
    - provide needed external collaborators for researchers that cannot locate all needed collaborators within their institution.
    - combine strengths of multiple institutions thus addressing areas of weakness of each individual institution
    - Create better teams with higher change of getting funding and achieving impactful results
    - adoption of projects outcomes at a larger scale (that of the full intra-institution network) thus allowing local achievements to gain national impact
    - creation of common forums for the presentation and review of truly integrative arts and science projects
    - increased legitimacy inside each institution for integrated arts/science work
    - facilitation of exchanges since many institutions will use similar research/education standards and will work on similar projects
- To address fundamental problems of the 21st century which are all systemic problems (transcending the boundaries of individual disciplines)
- The ability to share underutilized resources, leverage talent, increased likelihood of finding kindred spirits.
- Cross pollination of ideas, resources, and expertise benefit everyone. Projects can be undertaken on a larger scale, geographically and financially. Something greater than what can be achieved than by individual institutions alone.
- Combine resources (facilities), different perspectives on an issue, different competencies, potential for more impact – barriers include the complications of moving funds across institutions, not yet fully developed distance

communication infrastructure – depending on project this can be a significant barrier.

- If the institutions have distinctly different expertise and yet a common area of exploration, then the advantages of collaboration may outweigh the inevitable difficulty in coordination and communication
- This would provide greater opportunities for innovation.
- Hmm…I don't know if I do see any particular advantages.
- Sharing of active participants (performers, study subjects). Above all, to have multiple experts working together. Multiple institutions are especially useful in studying the topic of remote collaboration research and production. To make headway for that it is necessary to have many physically remote and cooperative partners. Academic "dynamics" (read "jobs") result in talent being distributed across institutions. Cultures of expertise are often divided up. In contrast multi-institution projects are important when they aggregate or re-integrate talent. Many examples in many fields
- I can't answer this question in the abstract form it is posed. Mostly I see disadvantages where the network is posed as a potential "solution" to yet unspecified problems. Institutional design should proceed from actual human and social needs; not the other way around.
- Can sometimes keep participants participating best intentions and behavior, as it removes some of the intra-institutional politics.
- The whole is greater than the sum of its parts. Through inter-institutional research / inter-national research, a lot more is possible.
- More strength/power by leveraging a bigger community.
- Not all disciplines can be represented at every institution, for example Rensselaer has no medical school and lacks significant segments of the humanities. These must be sought elsewhere – this is an advantage as there are a variety of institutional cultures across universities and each can add perspective to research questions.

What advantages (or barriers) do you see in collaborative *intra*-institutional research projects?

- The two lists above are fractals of the advantages and barriers for intra-institutional research. While being successful at one does not preclude the other, ontological reasoning would imply that if faculty receive local support and are successful undertaking intra-institutional collaborative research on their campus, the potential for creating and sustaining inter-institutional shared research will have a higher probability of success.
- Creation of interdisciplinary teams that can solve complex problems that go beyond one discipline (e.g sustainability, biodesign, digital culture, political and religious conflict etc)
- Creation of diverse teams that spark creativity because of the interactions of the different points of view.

- Better use of resources, avoidance of duplication
  Avoidance of self-referential, incremental work that characterizes many uniform, homogenous research teams
- Emphasis on collective achievement in research and education; a characteristic increasingly sought by employers
- Advantages: face-to-face meeting ("distance still matters"), barriers: limited constituencies
- Easier to decide how to split the IDC, administrators find it easier to "count." There is also the increased likelihood of parochialism, of being satisfied with being the proverbial "big fish in a small pond."
- Advantages:
  Experts are close to home: the work can proceed with greater fluidity; the team can more rapidly respond to changes in direction of work and ideas. Teams command more resources from college administration. Promotion / public acknowledgement of research work has clearer identity coming from one place.
  Barriers:
  In terms of recognition and peer review, with interdisciplinary collaboration comes a distancing effect from one's core discipline. Who are one's peers in this case?
- Visibility and impact can be more difficult to establish with no external participants.
- For those pursuing tenure and promotion, collaborative work can be viewed as a negative. For example, artists are expected to enumerate the number of solo shows completed, and collaborative work is of lesser importance.
- Co-authorship is well understood by those in science and technology contexts, but not as well understood in art contexts. This can create tension, for example, when someone claims to be the "original creator" of a work actually performed in a collaborative situation.
- Joined competencies, greater and broader questioning from different perspectives, co-sponsorship, greater visibility/impact, involve more students, supports development of culture within institution. Barriers can be competition for small resources, one area takes dominance and subsumes other area.
- The advantages are the same as those above, and in most cases face fewer barriers, if only because face-to-face communication is so much easier.
- The advantage: innovation. The barriers: multiple, sometimes conflicting priorities.
- The advantages are everyone is local. The barriers were mentioned in answers to previous questions.
- Proximity is useful in getting down-to-earth quickly in or on a project. Conversely, the day-to-day level of distraction works against doing that. Being outside one's habitat provides periods of focus.
- Within Rensselaer, the main barriers from the standpoint of an arts practitioner/theorist are: poor institutional incentive structures for engineers and

scientists to collaborate with artists; lack of understanding of art and artistic practice at the senior of levels of administration; defunding the Department of the Arts.
- Local access to diverse expertise should be an advantage.
- Same as inter-institutional. Although its easier to do face to face.
- Strengthening the community that's already under one governing body. Becoming more aware of each others' work.
- Tenure and promotion barriers are long standing and well known

How can your interdisciplinary research be integrated into education? What are academic or administrative barriers? How does your institution support such approaches in concrete terms?

- I left the degree-granting world (I was previously a faculty member at MIT and Penn State) to run a continuing education program. I have few barriers in terms of academics because continuing education is generally ignored. This allows me to be flexible and develop new models of academic practice.
- DXARTS is a superb model of research and curricular integration. The list and conditions of support and barriers are too lengthy to discuss in a single input field, but simply put UW realized a university is often the greatest obstacle to its own innovation. So UW taxed itself 1% of its total budget and used this money to innovate the campus. Each unit reapplied for funds to radically recreate their research fields, collaboration, curriculum and impact. Only ten or twelve units (out of 150 plus) receive competitive UIF funds to embark on transformation experiments. After three year pilot programs, only one or two units truly succeed and are funded permanently as new hybrid innovation programs.
- The development of integrated research and education approaches across the arts, sciences and engineering has been a key focus of the School of Arts, Media and Engineering. We first implemented such frameworks at the graduate level and we have recently expanded these frameworks to undergraduate education. Our efforts have been well received and supported. We were awarded an NSF IGERT award for interdisciplinary education, we participated in a Kauffman Foundation award for entrepreneurial education and we recently secured a large private gift for launching our undergraduate digital culture curriculum. I summarize below some lessons learned: One of the biggest challenges is that the goal of such integrative work is not always clearly defined. There needs to be a clear understanding amongst all constituents of the two main possible tiers of integration: transdisciplinary and interdisciplinary. Decisions on such things as faculty resources, curriculum and degree structuring, student selection and training, team structuring, rewards and incentives must be informed by the targeted outcome and its corresponding integration tier.
    - transdisciplinary research and education across arts and sciences primarily aims to solve (and produce people that can solve) complex

problems that transcend disciplines. Decisions in this tier should focus on addressing the targeted problem area(s) and on producing meta level expertise rather than on disciplinary standards and expectations.
    - Interdisciplinary research and education across arts and sciences primarily aims at developing disciplinary experts that can also collaborate (and converse intelligently) with people from other disciplines. Research and learning expectations in this tier must address the expectations of the involved disciplines and the collaboration structures.
    - Efforts that aim at interdisciplinary education can be achieved out of established disciplinary units as long as incentives and rewards are given for reaching out beyond the discipline. Transdisciplinary education efforts require new units with their own resources, educational structures and review procedures.
- I have tried to establish transdisciplinary education and collaboration in my activities as a teacher at a university and I have written papers about it — two examples: Gerhard Fischer and David Redmiles: "Transdisciplinary Education and Collaboration", Contribution to the Human Computer Interaction Consortium (HCIC) Workshop 2008;
  http://l3d.cs.colorado.edu/~gerhard/papers/hcic2008.pdf
  Fischer, G. (2005) "From Reflective Practitioners to Reflective Communities." In: Proceedings of the HCI International Conference (HCII), Las Vegas, July 2005, (published on CD). http://l3d.cs.colorado.edu/~gerhard/papers/reflective-communities-hcii-2005.pdf
- Through cross-listed and team-taught courses, at both the undergraduate and graduate levels. Difficult for individual departments/colleges to know how to "count." Through seed grants and cross-cutting initiatives (e.g., Humanities, Arts and Social Sciences) that involve multiple colleges.
- I have integrated research with education through funded research assistant positions and in coursework where appropriate. Thesis and Ph.D. studies have in some cases led or dovetailed with my research initiatives. I set up a visiting artist course where student research contributes digital knowledge to project goals -- even as alternative ways to realize a planned analog work in true collaborative fashion--with the artist. A few internships have been set up with external researchers.
  Curriculum structure is increasingly focused on learning outcomes. The learning outcomes model is outdated, not conducive to real learning, and in need of change. Compare the "just in time" model of learning many of us practice for project and professional work—which begins with a question. The glacial pace of decision making and administrative approvals can inhibit ambitious research oriented projects, especially in the classroom. Facilities and space are local issues. Solutions include acquiring abandoned spaces far from research labs.

Art exhibitions and performances are acknowledged by written promotion and tenure guidelines, but not always viewed as equal to published papers and funded scientific research in the minds of individuals on PT committees. Our college celebrates a culture of collaboration, which is great. However sometimes faculty and students who work with technology are asked to collaborate by performing "service bureau" activities rather than actual research.

Have long desired to incorporate telematic performance research into teaching through co-teaching across institutions, open video walls for collaboration, other exchange and experiment. Closest I came was at UCSD where co-teaching in special facility with several other faculty from other areas (intra-institutional) as well as outside with RPI and UCB (inter) – I believe this is still continuing. The need for specialized space and equipment was significant and a challenge each week, since there was no designated, secured space for this to happen. As well, we had to fight to have this be considered as part of research agenda – the hard cut-offs between what is understood (and funded) as research and what constitutes teaching and experimentation are profound – especially so in the Arts where research questions are not always clearly defined, and goals are developed and understood through the progress of experimentation and feedback.

- Well, at Northwestern, we've tried to integrate interdisciplinary research into teaching through the PhD program in Technology and Social Behavior. This program brings in students interested in studying and building technology as well as the societal structures that enable its use or result from its use. Getting institutional support from departments in terms of teaching release to teach non-core courses has been a challenge. Getting money from deans or department heads who have no particular interest in or stake in interdisciplinary (e.g. cross-college) projects can be challenging.
- At our department, slots for new courses are at a premium. Adding new topics comes at the expense of teaching the core. A dialog concerning this tradeoff exists (perennially) but moves slowly. Meanwhile, institutional interest in interdisciplinary integration into teaching is huge and the pressure exists.
- Rensselaer has a very poor understanding of the potential for artistic collaboration at the level of graduate education. The mistakes and counter-productive policies can best demonstrated by observing the decline in support for graduate study in electronic arts between 2002-2011. Instead Rensselaer has placed a strong emphasis on commissioning and supporting new creative work from independent artists. This emphasis has so far not been seriously integrated into graduate education.
- We created an Interdisciplinary major to implement this.
- It could be supported through centers, joint graduate programs, etc. NYU supports a new gaming degree in Tisch, Courant, and Steinhardt. Similar programs are in place with PhD IGERT programs

- Teaching the students to do the research. Academic/administrative barriers: competition among specific disciplines within an institution. UCSB is highly interdisciplinary above the departmental/divisional level.
- Professional education in architecture, as well as other disciplines, is regulated through accreditation bodies and a significant portion of the content is mandated as disciplinary specific. Non-professional and post-professional programs can open interdisciplinary research significantly and in the School of Architecture has done so. We expect to continue this trajectory

Topic ideas (research areas, strategic, political) for a network of excellence:

- I hope to have an answer to this question once we get together at the workshop.
- New and hybrid frontier research in creativity, energy, sustainability, systems, climate, health, public policy, etc.
- I believe that the main thing that is currently missing is a national/international forum that fosters truly integrative work across arts and sciences (that fosters the kind of transdisciplinary work referenced above). There are many interdisciplinary forums where arts, science and technology outcomes can be presented but in each case the focus is on a core discipline with other contributions acting as enrichments of secondary importance. For example, both acm siggraph and acm multimedia have a "serious" science track and a "soft" arts track. Work in the science track is primarily judged by its scientific validity with the arts contributions in this work being seen as secondary (and in many cases decorative). This approach is switched in the arts track where the focus is on project specific artistic outcomes with little concern on whether the outcomes of such projects can produce generalizable scientific contributions. I believe we need a forum that fosters fully integrative work – work that achieves outcomes that directly improve the human condition and can be scaled and generalized. In this proposed forum the focus will be on a) direct societal impact and b) production of meta-disciplinary research and education structures. Full integration of arts and science approaches will be another key evaluation and support criterion.
- Transdisciplinary Education and Collaboration
- Reflective Communities
- Neuroaesthetics, routine virtual meetings (maybe through 2nd life?), need to make private foundations a integral part of the mix.
  Become a voice for the importance of interdisciplinary research — elevate its importance on a global scale. UCDARNET is an existing model for inter-institutional research network.
  http://souzaesilva.com/projects/webdesign/ucdarnet/uccampus/ucparticipants.htm
  Develop a synthesized database of resources for funding interdisciplinary research from government, private, corporate, and entrepreneurial sources.

I wonder if there will always be a sense that art or science "plus" technology is a different sort of animal than real art or real science

- The artistic and scientific exploration of ordinary, everyday movement as a form of emergent choreography, with two main subjects of inquiry: the movements of a toddler as she is learning to crawl and then walk; the patterns of children playing in a playground.
- I look to the other participants to provide these ideas and then, as an agency, we'll determine how we can best be supportive.
- Hmm…I'm not sure what a network of excellence is. Therefore I can't answer this question.
- Existing (and new) centers of research and production/presentation could be "granted" a resident, complementary, interdisciplinary expert. A JPL artist, a New World Center scientist, etc. These happen in one-off instances but what about a network of them starting up together? At Stanford, we're thinking of a rotating "resident technologist" for our new concert hall. If there were a network to tap into, it could be a huge multiplier. For any new network of excellence, touring of artistic creations could start tomorrow. I imagine it would involve remote collaboration, multi-site and "no site" venues for production and presentation. Of interest to me are also any new core teams on next-gen computing in the arts and teams integrating cutting-edge science and the arts.
- that depends on the actors who are assembled to discuss the question.
- Take on multiple projects that can simultaneously work across the network to bring different aspects into play. Can foster complex works to be engaged in more traditional arts venues.
- Art&Tech centers around Dance and Movement, Urban Studies / Life in the City Center, Gaming Center, Developing Economies Center
- Residency exchanges.
  Interconnected arts laboratories (facilitating remote arts collaboration).
- I believe that recent trans-disciplinary discussions at Rensselaer concerning 'Communication, Cogniton and Culture' and 'Media and the Arts' have drawn together a wider range of expertise and interest and could form the basis for our participation in a similar or compatible initiative.
  Understanding media and arts activity as a multi-scalar distributed systems that have to do with CCC could form the basis for some integration across these interests.

Which conditions would need to be met by a networked center of excellence so you would engage and contribute to its program?

- • Appropriate longitudinal funding, shared revenue stream development and infrastructure support • Mission primarily dedicated to speculative and daring new hybrid research horizons, with parallel commitment to practical and sustainable applications of mission research toward global problems • Foster the evolution of a new hybrid research culture among the arts, sciences, engineering, medicine and humanities • Organizing structure and management

principles operate through shared governance informed by systems theory • Suite of well-designed, integrated and sophisticated online research and community support tools specific to inter-institutional collaboration (i.e. web 2.0, HD telepresence, live news feeds, archiving, scoring and notation language, etc.) • Participating institutions quickly ratify a flexible policy agreement concerning faculty participation, merit, advancement, release time, intellectual property, etc.

  - sustainability: developing a long term plan that guarantees the sustainability of the proposed network both in terms of continuously evolving ideas that can sustain the participants' excitement and in terms of resources
  - inclusiveness and impact: we should look for ways to include as many of the major education and industry players as possible while also leaving room for up and coming ideas and participants.
  - differentiation: the network must have characteristics that differentiate it from existing networks that engage arts and sciences (i.e. acm siggraph, acm mm, ars electronica) and allow it to complement those forums. I believe that a commitment to both a transdisciplinary and interdisciplinary agenda (as defined above) can help achieve this differentiation.

- Shared interests bringing together expertise from different areas
- Commitment by the participants to the shared interests
- Support for face-to-face meetings
- Support for young minds (e.g.: students) to educate them as reflective communities to engage in basic research on real problems
- Administrative support to facilitate meetings, manuscript editing and grant writing/submission. Possibly travel funding to allow collaborations.
- A center in which the arts, and artistic methods of thinking and working, are established as critical to science and technology (Maeda's STEAM concept). Close study within research areas reveals important ideas: a center should support ways to make connections between focus areas / disciplines, for individual teams and researchers.
- A center that facilitates opportunities for students and faculty: opportunities for funded research, access to individual expertise across institutions, opportunities for peer review. Important for students: broadening the horizon for career options – including facilitation of new career options on the part of potential employers.
- Visionary leadership.
- By "networked," do you mean online – mediated purely through websites, blogs, and such? If so, I doubt my interest would be all that great, though I might contribute some writings or findings to its program. But my own collaborations depend upon side-by-side and face-to-face work, and the artworks we create, though often purely digital, do not lend themselves to the

Web, which displays imagery at too low a resolution and frame-rate and which encourages distraction rather than concentration.

- We would need clearly articulated lines of inquiry presented in proposals form in order to persuade a review panel to provide support. Defining outcomes are not as essential if the lines of inquiry are sound.
- I'm not sure what a network of excellence is. Therefore I can't answer this question.
- Any new venture is potentially one to consider if I can envision having something to contribute from my areas of interest and expertise. It helps to know the coefficients of 1) innovation potential 2) expectations for presentation of creative results and 3) resources that will be available.
- I can't answer this hypothetically; concrete conditions would initially have to be specified.
- Has to be able to support the work taking place. Can provide a means for distributing/exhibiting outcomes which can be technologically complex and difficult to engage at traditional venues.
- Vision, funding, good management, good space.
- Funding is the most important consideration. Also infrastructure such as high-bandwidth networked communication over long distances.

- It needs to attract a group of interesting people. I find that the ability to have high quality interpersonal conversation is the most important attractor and reward.

Appendix B

List of Participants

Eric Ameres	Rensselaer Polytechnic Institute	Senior Research Engineer, EMPAC
Fred Belmont	National Science Foundation (NSF)	Einstein Fellow
Jonas Braasch	Rensselaer Polytechnic Institute	Assistant Professor, School of Architecture
Chris Bregler	Courant Institute, New York University	Associate Professor Computer Science
Selmer Bringsjord	Rensselaer Polytechnic Institute	Professor and Dept. Chair Cognitive Science
Shawn Brixey	University of Washington	Professor Floyd and Delores Jones Endowed Chair Center for Digital Arts & Experimental Media
Sheldon Brown	Univ. of California, San Diego	Professor of Visual ArtsDirector, Center for Research in Computing & the ArtsFounder, New Media Arts for the California Institute of Telecommunications and Information
Winslow Burleson	Arizona State Univ.	Assistant Professor, AME, Department of Computer Science and Engineering
Michael Century	Rensselaer Polytechnic Institute	Professor, Arts Department
Chris Chafe	Stanford Univ.	Duca Family Professor, Director, Center for Computer Research in Music and Acoustics (CCRMA)
Ben Chang	Rensselaer Polytechnic Institute	Associate Professor, Arts Dept. and Games and Simulations Arts and Sciences
Donna Cox	Univ. of Illinois/Urbana-Champaign	Professor, Michael Aiken Endowed Chair, Director, Advanced Visualization Laboratory & eDream Institute
Barbara Cutler	Rensselaer Polytechnic Institute	Associate Professor, Computer Science

Gerhard Fischer	Univ. of Colorado	Director, Center for Lifelong Learning and Design Professor, Department of Computer Science
Johannes Goebel	Rensselaer Polytechnic Institute	Director, EMPAC Professor Arts Department and School of Architecture
Abby Goodrum	Ryerson Univ. Toronto, ON	Associate Dean, SRC Rogers Research Chair in News, Media and Technology Faculty of Communication & Design
Kathy High	Rensselaer Polytechnic Institute	Associate Professor, Arts Department
Adriene Jenik	Herberger Institute for Design and the Arts Arizona State Univ.	Professor and Director, School of Art Katherine K. Herberger Endowed Chair in Fine Arts
Pamela Jennings	National Science Foundation (NSF)	Program Director, CISE Information and Intelligent Systems Division
Paul Kaiser	OpenEnded Group	Digital Artist
Ted Krueger	Rensselaer Polytechnic Institute	Associate Professor, School of Architecture
Carol LaFayette	Texas A&M University	Associate Professor, Department of Visualization
Alyce Myatt	National Endowment for the Arts (NEA)	Director of Media Arts
Wolf von Maltzahn	Rensselaer Polytechnic Institute	Associate Vice President for Research
Gunalan Nadarajan	Maryland Institute College of Art	Vice Provost for Research
Bill O'Brien	National Endowment for the Arts (NEA)	Senior Advisor for Program Innovation
Bryan Pardo	Northwestern University	Associate Professor, Department of Electrical Engineering and Computer Science, Department of Music Theory and Cognition
Thanassis Rikakis	Arizona State Univ.	Professor and Director School of Arts, Media and Engineering
Brian Smith	Rhode Island School of Design	Dean, Continuing Education

Carol Strohecker	University of North Carolina	Director of the Center for Design Innovation
Lou Tassinary	Texas A&M University	Executive Associate Dean, Director of the Environmental Psychophysiology Lab, and ad loc'd to the Department of Visualization
Matt Wright	Univ. of California, Santa Barbara	Research Director, Center for Research in Electronic Arts Technology (CREATE), Media Systems Engineer, AlloSphere Research Facility

Appendix C

Program Overview

Establishing a Network of Excellence for Art + Science + Technology Research: Infrastructural and Intellectual Foundations

March 16–18, 2011

The Curtis R. Priem Experimental Media and Performing Arts Center (EMPAC)

Rensselaer Polytechnic Institute

Troy, New York

Wednesday, March 16	5:00 pm Registration, refreshments
	6:30 pm Dinner *Evelyn's Café*
	7:30 pm Welcome (Johannes Goebel, Jonas Braasch)
	Pamela Jennings, NSF Storymap of the NSF/NEA workshop "RE/search: Art, Science, and Information Technology", September 2010, Washington DC
	8:00 pm Keynote, Abby Goodrum, Ryerson University, Toronto; Director, Social Sciences and Humanities Research, Graphics, Animation & New Media Canada / GRAND, Canada
	Dessert and wine *Evelyn's Café*
Thursday, March 17	8:00 am Breakfast *Evelyn's Cafe*
	9:00 am Full Workshop Meeting
	Discussion focused on topics derived from returned questionnaires
	11:15 am Panel: NSF and NEA Opportunities
	Pamela Jennings (NSF), Bill O'Brien (NEA), Alice Mygatt (NEA)
	12:30 pm Lunch *Evelyn's Cafe*
	2:00 pm Full Workshop Meeting
	Definition of topics for work groups
	2:30 pm Work groups
	5:00 pm Full Workshop Meeting
	Reports from work groups
	6:30 pm Dinner *Evelyn's Cafe*

8:00 pm Mini-Keynotes
Donna Cox, Urbana-Illinois
Gunalan Nadarajan, Maryland Institute
Thanassis Rikakis, Arizona State
Sheldon Brown, UCSD

Dessert and wine *Evelyn's Café*

Friday, March 18

8:00 am Breakfast *Evelyn's Cafe*
8:45 am Brief full workshop meeting, then the same work groups as day before meet and refine their discussions and recommendations.
11:00 am Summary Session (with working lunch)
1:30 pm End of Workshop