SEAD THEMES AND INSIGHTS META-ANALYSIS: FROM CONFLICT TO COHERENCE

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Introduction

The following survey of insights was developed for the Network for Science, Engineering, Art and Design (SEAD) White Papers project. Its goal is to raise awareness of the impacts, values, opportunities and challenges of cross-disciplinary research and creative work.

The SEAD project solicited White Papers contributors and asked for Suggested Actions around advocacy and collaboration with the goal of fostering innovation, learning, community sustainability, and economic development. White Papers contributors provided an array of comments and Suggested Actions, and I have tried to synthesize many of them here. The White Papers submissions and more information about the project can be found at the SEAD White Papers project's website http://seadnetwork.wordpress.com/about/.

Approach

A qualitative survey of the White Papers was undertaken by 1) identifying relevant themes, insights, and concepts from each submission, 2) clustering similarities and differences, 3) identifying patterns, and 4) researching the literature for frames reference that could bring coherence to the range and diversity of themes presented. Several overarching concerns were identified by the White Papers authors: (1) equity and identity among disciplines and stakeholders, (2) funding resources, (3) workspaces, and (4) process and common ground.

To build on the emerging themes presented in the White Paperss, I grouped insights into the broad domains of *people, platforms, and practices*. Similar themes are presented by Tardif and Sternberg (1988) who identified processes, persons, products, and places as important clusters from a corpus of research on creativity. Similarly, in the emerging literature of social practice and innovation, Shove et al. (2012) have gone a step further, describing in detail how the dynamic interactions of *meaning, competencies, and materials* drive changes in the consumption and use-patterns of everyday life. Both frameworks recognize that the critical infrastructure of creativity, diversity, and coherence is driven by the ongoing churn between people's thoughts, practices, and the materiality of our environment.

The Suggested Actions are in no particular order.[1]

People

People are agents of change for sustainable communities and economic development, and they are intermediaries for learning and innovation. Group dynamics are as important as individual characteristics. Human communication processes that help to uncover shared goals and perspectives assist in creating cooperation. Political dissonance, power dynamics, and social relationships underscore the diversity paradox, according to which the costs of cross-disciplinary coordination increase with the size, diversity, and complexity of a community.

This section suggests actions that impact people and their ability to work cooperatively toward shared objectives. This includes the skills and qualities of people engaged in cross-disciplinary work; how people are appreciated, valued, and engaged as members of organizations; and how organizational design influences the impact of learning and innovation on society.

Research behavior and skills in cross-domain research and creative work

Suggested Action: Develop insights around the skills and competencies of practitioners in diverse disciplines and around how those behaviors are manifested in collaborative research, and how they can be improved.

New skills are constantly emerging, and old and existing skills are being reapplied to new tasks. Because knowledge, research, and organizations change, the kinds of skills we value are constantly in flux. Students and practitioners should be able to identify and communicate skills. They should also be able to assemble skills and goals into stable, long-term career trajectories within and across disciplines. But to do that, they need better resources for learning how skills translate across domains.

Being able to identify and communicate skills and their value is an emerging social and technical challenge in the era of big data and deinstitutionalized labor markets. Communicating skills reduces friction in job markets, and it improves face-to-face and virtual group collaboration through better understanding of individual roles and abilities, resulting in many positive psychological benefits.

In order to increase engagement and create new attractors for connected learning, skills and competency clusters can be recast in compelling language and representation.

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Incorporate conflicting values by reframing research and creative work objectives
Suggested Action: Identify and develop frameworks for research and creative work that help to clarify objectives, communicate scope, and incorporate conflicting values. Using case studies and process-based steps, build links to larger societal concerns as well as incentives for participation around those concerns.

Diverse teams often experience higher coordination costs than homogeneous ones, and research objectives and contexts may need to be actively reframed to align values and provide clear goals for participants and stakeholders. Active and iterative research framing is a participatory research process, and it develops from explicit discussions of goals, assumptions, and processes.

The two-cultures debate has not yet developed a productive research agenda. Instead we could look toward the periphery, where the future of cross-domain work involves diverse institutions, projects, and individuals who can find their own alignments to work from instead of overly simple art/science or academia/industry bifurcations.

As a society we are quickly scaling up our ability to observe unseen processes from beyond our human observer status, and our capacity for doing so is expanding toward larger, more complex forms of organization. We are critically short on the tools, practices, and training needed for working collaboratively with diverse teams on ill-defined problems.

A “moonshot” goal of dampening climate change-related behavior is a good example of how to enable active research, define common pathways for success, create identifiable communities, and condense clusters of activity. For one thing, it creates a common “North Star” for people to identify and orient their activities. In addition, many tiny research experiments with well-defined commonalities would create “scattershot” solutions to simpler problems and provide short-term successes to build on, out of which would emerge case studies to demonstrate the efficacy of different approaches. Longer-term research agendas with detailed approaches and degrees of complexity could build on these communities and small solutions.

One important obstacle needs to be considered. Practitioners in the sciences, arts, and other domains can often rely on values that incorporate moral beliefs and drive action in ways dissociated from their prospects for success. These are called sacred values, and they arise from metaphysical commitments and expectations about culture. Sacred values can complicate people’s assumptions about who and what counts as evidence, how research can and should be communicated, or about the role of individual subjectiveness in self-expression. In the past,

statements like “Science is objective,” “Designers don't belong in hospitals,” or “Artists should be able to say or do whatever they want” demonstrate deeply held commitments. Because these values tend to emerge in cross-domain work, they should be identified as such and actively understood by participants to reveal their full intent and meaning.

Reframing scared values can open up new pathways for participation and advocacy in research, and this comes from understanding researcher's needs as well as new interpretations of the research questions. Because sacred values can reveal intense social conflicts, they often form the vanguard of broader societal concerns.

Understanding and having a plan for working through sacred values in cross-domain research enables better translations of research insight and technologies into everyday social practice.

Extend project-based curriculums to develop cooperation, coordination, communication, and collaboration skills
Suggested Action: Develop project-based curriculums and programs that build skills for cooperation, coordination, communication, and collaboration across a variety of cross-disciplinary and creative research contexts with varying levels of goal-orientation and problem fuzziness.

One of the biggest impediments to learning and change in cross-disciplinary research is recognizing the important differences that people bring to common goals and how those differences positively impact creative work.

Teamwork, meanwhile, is not merely cooperative but highly coordinated, with special communication and cognitive skills. It requires intimate acquaintance with each other’s knowledge, motivations, physical capabilities, the ability to respond instantly and together, solutions for reevaluating on the fly in the face of sudden situational changes, unexpected threats, and each others’ unforeseen failures and successes; it also involves clear signaling to one another what course of actions to take (Atran 2010, 314).

Describe new and emerging skills in compelling language and representation
Suggested Action: Identify new and emerging skills and describe them in compelling language and representation.

New and Emerging Skills Attractors

Reframing and re-creating new skills descriptions that positively reinforce our goals and people roles in society can be a good way to redefine what it means to do creative work and research. A "firstarter" is the ability to take an idea and influence others in a group to adopt and act on it. A "longbroader" is someone who can think and act on a much bigger picture—thinking in terms of multiple systems, bigger networks, and longer cycles. "Emergensight" is the ability to prepare for and handle surprising results and complexity that come with coordination, cooperation, and collaboration on extreme scales. What are the cross-disciplinary work and creative research skills that will drive economic growth and community stability in the future? What are the words and terms we will use to describe the kind of work we do in the future?

Disseminate best practices as toolkits for pop-up, locally produced initiatives

Suggested Action: Create sets of best practices that can serve as toolkits and starting points for new groups attempting to undertake new endeavors.

One of the most successful outcomes from any organization or initiative is when others can learn from successes, failures, and practices that were used. Toolkits that provide ready-made templates, descriptions of processes, or plug-in activities and methods create a starting point for others to follow. This lets new projects decide what is important about their local needs without reinventing the wheel for each and every endeavor.

Identify and create new business models, resources, and mechanisms of support

Suggested Action: Identify sustainable modes of support, resources, business models, and funding that will serve as durable engines of growth.

Economic growth is remarkably agile, and some anticipate that the real economic growth will not come from saving labor but in creating new kinds of things to do. Greater degrees of playing, creating, and exploring are only constrained by the boundaries and priorities we set.

Emphasize entrepreneurship skills, negotiation strategies, and metacognition-based competencies

Suggested Action: Provide access to developmental tools, training, and resources for building broad competencies in entrepreneurship, negotiation, and metacognition.

Entrepreneurship Unbound

A broad base of entrepreneurial skills is necessary to participate in the new economy. Training in business tools and skills—including finance, operations, marketing, and negotiating—are

critical, even if not used for the purposes of business. Emerging work practices span long distances, involve deep collaboration, and are often not connected to large organizations as the primary source of employment. As the friction in employment markets decreases and people with the right skills are more easily accessed, the ability to form groups and manage one's own employment trajectory is becoming increasing more important. And by combining entrepreneurial training more openly with other forms of training, it is also likely that many new forms of financial, marketing, operational, and negotiation strategies will emerge, enabling innovation beyond the confines of the business class.

Negotiation and Influence

Interpersonal and technology-mediated cooperation skills need to be more actively developed and built into the curriculum. Because globalization and interdisciplinary work are expanding rapidly, negotiation skills are perhaps the most valuable tools that students and professionals can acquire in the next two decades. These metacognition skills help us think about how we think and focus attention on how we operate in diverse groups and in contexts with shifting priorities. Broadening the base of these so-called soft skills for research and creative professionals will enable better forms of cooperation and more positive influence from creative practitioners across organizations. This comes at a critical time when the ability to influence and define what matters in an increasingly noisy environment pays dividends in our capacity to respond to global challenges.

Use insights from social studies of science and technology as a bridge

Suggested Action: Develop applied programs and projects that translate insights from social studies of science and technology to creative practice in the context of science, engineering, and other domains.

The field of science and technology studies (STS) is an important disciplinary link for cross-domain work between art, design, science, and engineering. By observing and reporting on the social activities of different disciplines, STS can identify common research currents and future pathways for mutually reinforced agendas. It is precisely because STS includes both human and non-human entities and processes that it can work as an arbiter and bridge between disciplines, fostering creative outcomes.

In *Leviathan and the Air Pump* (1989), Steven Shapin and Simon Schaffer describe three types of public witnessing of science: the direct performance of experiments in social spaces, reporting experimental methods in a manner that enables someone to replicate the experiments themselves, and virtual witnessing by producing in a reader’s mind an image of an experimental scene that

displaces the need for direct witness or replication. Each of these three types of witnessing provides an example of a pathway for cross-disciplinary work.

Other mediation activities, such as those described by Callon (1986) and Lee and Roth (2001), translate research across social and physical domains for the purpose of proposing, deciding upon, and implementing preferred design actions. Funtowicz and Ravetz (1991) describe a post-normal science framework as a bridge between complex systems and environmental policy, while Frame and Brown (2008) go further to identify specific post-normal technologies for organizing cross-domain creative work.

Spanning social gaps and assembling diverse constituencies is a feature of innovation, and Burt (2000) proposed the term "network entrepreneur" to describe and quantify a kind of persona and the role it plays in organizations. Burt's description formalizes Fuller's (1963) description of the Comprehensive Designer, which Turner (2008) expanded with a profile on Stuart Brand in a book that looked at how art, technology, and entrepreneurialism developed into contemporary digital utopianism—a general feature of today's technology and economic landscape.

STS can also offer cross-cutting ways to rework cross-disciplinary relationships. Steven Jackson (forthcoming) discusses how a recentering of maintenance and repair may help with the necessary project of building bridges to new and adjacent fields including material studies, craft, technology for development, sustainability studies, and new media. In Jackson's words, "It may also help build new analytic connections to cultural phenomena—maker and DIY communities, craft and slow food movements, and cultural forms from fan fiction to the Steampunk movement—that feature breaking, maintenance, and repair as central sites of activity and meaning."

Show applicability of skills and behaviors across domains while reinforcing domain-specific expertise

Suggested Action: Develop shared knowledge and understanding of how skills are realized (along with trade-offs) across different sectors in industry, academia, and civil society.

One of the biggest impediments to learning and change in cross-disciplinary research is recognizing the important differences that people bring to common goals and how those differences positively impact creative work. There has been a long and intense effort for domains such as science, art, design, and engineering to develop skills valuable for work. There has been less attention focused on how those skills can translate to and become valuable for other, unintended domains. This means expanding the definition of expertise to include the ability to

understand when naive others are trying to communicate, verifying it, and offering assistance with the language tools to express it.

Survey organizations and initiatives to identify best practices, insights, and organizational tactics

Suggested Action: Canvas organizations, initiatives, networks, institutions, events, and activities for best practices, insights, organizational tactics, and missions using a common survey.

Cross-domain research and creative work are already practiced, but instances are unevenly distributed across domains, institutions, and geographies. A wide variety of institutions and organizations are helping to create platforms for research and creative work, but many of these activities do not fit into the canons of established domains. An important task is to identify the kinds of partnerships and organizational designs that are successful and to clearly share those strategies and models more broadly.

Hack weekends and festivals provide event-driven context and momentum for creative work; they also help people find others who have shared interests and complementary capabilities. Regional cultural organizations like the Grey Area Foundation for the Arts (GAFTA; http://www.gaffta.org/) provide courses on new technologies, art and hacking weekends, and festivals that explore emerging areas. GAFTA recently held the first Urban Prototyping festival, providing a forum for projects and discussions to explore how technology experimentation and urban infrastructure are creating new paths for economic development and community sustainability in cities.

Science Hack Day (http://sciencehackday.com/) is an event series that brings designers, scientists, engineers, artists, and others together to collaborate on focused tasks during this short period, building on the premise that small groups of hackers are capable of producing remarkable results. Science Hack Day demonstrates an important design consideration for cross-disciplinary work. Collaboration on focused tasks is essential for participant experience; it takes consideration and effort to develop and implement the social infrastructure for collaboration and focus.

Other organizations like TechShop (http://www.techshop.ws/) are more agonistic in their approach, providing high-quality tools and workspaces for collaborating and creating prototypes and products. There are no restrictions on membership except for a monthly fee, and it's a common occurrence for nascent start-ups to use TechShop as their hub and workspace. Similarly, hacker spaces like Noisebridge (https://noisebridge.net/wiki/Noisebridge)

maintain an open, free space for hackers, makers, and creators of all kinds, including journalists, apps developers, biology researchers, and educators, who can find tools, connect with different communities, and have a place to call home. One important feature of emerging spaces like these is their tendency to experiment with different forms of organizational governance. While TechShop simply charges a fee to maintain and provide resources with relatively little role for members in governance, Noisebridge has open governance, placing more responsibility for maintenance on members and participants.

The MIT Media Lab (http://www.media.mit.edu/)is a well-know example of how a institution can create a long-lasting impact and provide training opportunities, entrepreneurial partnerships, and global influence. Smaller sites, like the GROCS Lab (http://www.dc.umich.edu/dl1/) at the University of Michigan, have seeded small working groups to define and assemble innovative projects, although more entrepreneurial assistance is often needed to help small groups achieve larger impact. Many investment firms have long recognized this need; firms like Innovation Endeavors (http://innovationendeavors.com/) provide support in areas ranging from strategy to operations and offer community development through hackathons, brainstorming sessions, and block parties.

Initiatives such as the Creators Project (http://thecreatorsproject.com/), a partnership between Intel and Vice, were created to elevate the impact of art and technology in the media, supporting media artists, scientists, and entrepreneurs of all kinds. In the Creators Project example, there is mutual interest at work. Vice, a media company, aims to catalyze the development of new content. Intel, a microchip manufacturer, aims to understand examples of emerging uses and develop microchips that will support future computing needs. By partnering as the Creators Project, they empower others to actively make the future, providing Intel and Vice better proximity to emerging use cases, talent, and technology.

Amplify and validate strengths-based learning of unique skills and collaboration tactics
Suggested Action: Create strengths-based learning about skills across domains. Help students and practitioners concretely describe and validate their self-reported strengths and skills and match them to those of others for collaborative endeavors and teams.

The task of research and creative work requires collaboration. In a report conducted on behalf of Google, The Future Foundation (2010, http://goo.gl/zjnGny) found an 81 percent correlation between collaboration and innovation based on respondent self-reporting and agreement in a survey of 3,500 employees, 100 HR managers and 100 IT managers across the United Kingdom, France, Germany, the United States, and Japan.

In the "IBM Global CEO Study 2006," 75 percent of respondents ranked collaboration as a "very important" part of innovation—and of business success in general (http://www-935.ibm.com/services/us/gbs/bus/pdf/ceostudy.pdf). The study found that extensive collaborators tended to outperform their peers in key business performance indicators such as revenue growth and operating margins. What's more, companies collaborating with external sources reported higher revenue growth, on the whole, than companies not collaborating with external parties.

One of the most compelling strengths-based training platforms was a free, open, social network game (http://www.urgentevoke.org) whose goal was to help develop skills that would empower people all over the world to come up with creative solutions to our most urgent social problems.

PRACTICES

Practices are the behaviors that people utilize in everyday life to achieve their goals. People find ways to cooperate and dissent, frameworks to think and act through, and rubrics to structure their assessments of others. Rules and social norms pattern our practices, and these practices may develop along explicit or implicit disciplinary boundaries.

This section suggests actions to help us understand and develop practices that result in better forms of learning, innovation, sustainability, and development. It identifies domains and strategies for communication, collaboration, coordination, and cooperation, and it marks pathways for creating, acquiring, and normalizing infrastructure to support these practices.

Promote and install projects that build and contribute to creativity research

Suggested Action: Promote and install projects that build and contribute to creativity research.

Combinatorial theories about innovation and creativity describe how entrepreneurs and researchers remix various parts to create better solutions. Getting more of those parts, whether they are Legos, genes, concepts, screwdrivers, paintbrushes, or peaches, on the table for diverse cross-disciplinary research and creative work is a key to the next generation of the creative economy. Most of those combinations will fail, but there will also be massive successes. Right now the bits and objects of software are driving the latest combinatorial explosion, much like reproducible parts did for manufacturing. Soon, reconfigurable genetic material, financial tools, governing resources, and communication techniques will drive another wave of technological and social change.

Develop reciprocity-based research procedures and outcomes
Suggested Action: In order to facilitate broader social engagement for creative work and cross-disciplinary research, identify and develop new opportunities for public engagement, participation, and reciprocity-based outcomes.

Creative work and cross-disciplinary research that fosters engagement, participation, and reciprocity creates a broader base of support, with more durable communities and resources for economic growth emerging as a result.

Participation increases in intensity from information extraction, to feedback of information, implementation, goal setting, ownership, and ultimately to influence and migration beyond the original initiative or community.

Projects and policies that enable reciprocity and provide mechanisms for participants to realize mutually beneficial outcomes for themselves and others are more willing and able to create, own, and disseminate the products of creative work and cross-domain research. That is, if people can have a stake in the results, they are more likely to engage with it, add their talents and skills, and broaden its impacts across diverse communities.

Develop art and design-based practices for conceptual change management and innovation in science and technology
Suggested Action: Develop a comprehensive art and design-based practice for conceptual change management and innovation in science and technology.

The outcome of enhanced participation is new avenues for conceptual change. People who are engaged in a participatory way tend to modify their existing beliefs more readily. They have to justify their assumptions and attend to the differences shared by others, and this can reshape the scope and direction of creative research and its results.

A program that situates art and design as interlocutors of conceptual change in science and technology can result in research that highlights innovation tools and strategies.

Assemble collaboratively produced, cross-disciplinary cartographies of science and technology issues using controversies as a lens
Suggested Action: Controversies in science, technology, and public policy provide a useful lens for unraveling the concerns and interactions of scientists, researchers, creators, and their tools.

The Mapping Controversies curriculum (Venturini, 2009, 2012) *provides a practice-based collaborative approach for journalists, scientists, technologists, designers, and cartographers to examine creativity and community stability in socio-technological dynamics.*

Technological development creates new controversies in society. Although many cross-disciplinary research activities are ad hoc, some methodologies are being developed as pedagogical tools for training students in the collaborative tasks and skills to explore, visualize, and engage with emerging technoscientific issues. One of these methodologies is the cartography of controversies, and it assembles tools and research practices to explore the relationships across democracy, science, technology, design, subjectiveness, innovation, and social change (http://www.demoscience.org/)

The cartography of controversies aims to develop the skills of researchers working together in diverse roles ranging from research scientist, journalist, information designer, and cartographer. The goal of this pedagogy is to demonstrate how people, platforms, and practices create new knowledge and how social and political choices impact creativity and innovation opportunities for research and discovery. The broader impacts of this kind of work are that it provides an extensible platform for public engagement with (though not exclusively limited to) technoscientific issues—while fostering the participation of designers, artists, journalists, and others in the documentation process.

Develop SEAD/NSF as a platform for peer-to-peer connectivity and networking between researchers

Suggested Action: Provide networking tools for collaboration with both funded and unfunded researchers. Develop SEAD and/or the NSF as a platform for peer-review, peer-to-peer connectivity, and networking.

The National Science Foundation has a unique hub-like position between many researchers, policy makers, institutions, and endeavors. It can play a more active role in building cross-disciplinary research and creative work simply by making the activities of those with whom it engages more visible to others in the network.

SEAD can extend this visibility among stakeholders. Where size and institutional constraint delay action from the NSF, SEAD can act as a bridging organization, connecting like-minded individuals and research endeavors while brokering discourse, funding, and diverse communities of practice. SEAD can engage more directly with departments, schools, societies, individuals, vendors, and policy makers to organize an emerging research agenda.

Employ visual and analytic tools to explore the edges of cross-domain research and creative work

Suggested Action: Employ tools and people and projects that search for and uncover processes, practices, and paradigm shifts at the edges of cross-domain research and work using aggregated data sources. Use these economic insights and relationships as leverage points for understanding networks of cross-disciplinary research and creative work.

Meta-perspectives based on images and insights from whole research domains and patterns of economic exchange can be used to glean new practices and procedures in developing fields. Meta views compiled from content analyses provide maps of information flow and can reveal community structure in complex networks (Rosvall and Bergstrom 2007). These new "macroscopes" help describe the changing landscape of science and show transitions from stars to teams, users to contributors, disciplinary to cross-disciplinary, specimens to data streams, and from instruments to cyberinfrastructures (Börner 2011).

Movement, communication, and activity patterns can inform design and the development of infrastructure (Jiang et al. 2012), the role of media in the adoption of innovations (Jameson, 2012), creativity and problem-solving in groups (Kidane and Gloor 2007), the relationship between personality and social networks (Hildago 2011), and gaps and opportunities for economic development (Hildago et al. 2007).

Many data sources abound, including a trending Twitter hashtag called #overlyhonestmethods that was started to explore the diversity of human practices underlying the scientific method. Part tongue-in-cheek humor and part open confession, each post in the stream captured examples and stories about how research was conducted—stories and examples unlikely to make it into published research accounts but nonetheless serve as examples of norms and creativity among research practices.

Data-driven meta-analyses provide useful insights about gaps, relationships, temporal patterns, and activities that can be used to focus questions around cross-disciplinary research and creative work. Insights, analytics, and first-hand observations enable comparative approaches and can help justify research objectives.

Identify the impacts and emerging skills of social production for cross-disciplinary and creative work

Suggested Action: Identify new and emerging forms of social production (from citizen science to task routing and DIY) and explore how they will create broader impacts—including the skills that will be needed to engage across disciplines and creative modes.

Social production describes a model of socioeconomic production in which the creative energy of large numbers of people is coordinated (often with the aid of the Internet) into meaningful projects, mostly without traditional organizational hierarchy. Forms of social production include crowdsourcing, peer review, open innovation, open source, formal and informal education, co-creation, citizen science, collaboration, and crowd financing—among many others.

Social production is shifting the benefits that many organizations provide, destabilizing many traditional forms of work and organization in the process. Science, engineering, art, and design will all be affected. Issues, skills, impacts, and best practices can already be identified and used as catalysts for cross-disciplinary and creative work.

Encourage and support communities of practice and bridging organizations

Suggested Action: Create, curate, develop, and maintain focused communities of practice around core themes, concerns, and topics.

Digital humanities has emerged as a field over the last decade, driven by the emergence of new digital tools for communicating and for processing information from online social media collaboration to data illustration. The Humanities, Arts, Sciences, and Technology Advanced Collaboratory (HASTAC; http://hastac.org/) has led by example with platforms, conferences, competitions, courses, and best practices. Among the many outcomes, peer-grading and badges have garnered significant attention in recent years as ways to make teaching and learning more participatory while providing new tools for people to transfer their expertise to other domains. HASTAC administers the MacArthur Foundation's Digital Media and Learning Competition and works in collaboration with Mozilla and other organizations, as well as internationally with many universities and schools. By assembling a mix of talent, platforms, best practices, scholarship, funding, and cross-institutional networking, HASTAC not only supports the development of an emerging field, but it has helped launch new creative endeavors and research questions along the way. Significant is the role that HASTAC plays as a bridging organization between the foundation, universities, community schools, and research communities.

Support open-source innovation, skills, and practices around the "Internet-of-things"
Suggested Action: Support open-source innovation around the Internet-of-things, including the development of skills and practices.

An Internet of things is being built by connecting many different kinds of objects, sensors, actuators, people, and other organisms to the Internet. Cars, cameras, coffee machines, and even Band-aids are becoming networked technologies, and this means that the practices and products of science, design, engineering, and art are poised to undergo a massive transformation. New practices will emerge to monitor, track, and develop new constellations of toolsets and services. Organisms and phenomena will have additional "voices," making design for meaning a critical skill. The era of big data made possible through low-cost sensing, storage, and networking is also making it more critical for people to develop the skills needed to manage a wider array of information and meaning.

Make all NSF-supported research open-source and accessible to the general public
Suggested Action: Make all NSF-supported research open-source and accessible to the general public.

Research products, including data, reports, tools, and software, should have some minimally viable presence as a resource for the public to access and learn from–independent of institutional affiliation or sponsorship.

PLATFORMS

Platforms are physical or social tools, environments, and enabling resources that let people communicate, collaborate, coordinate, and cooperate effectively. Specifically, we can define a platform as a form of infrastructure that increases the likelihood of improved learning, innovation, community sustainability, and/or economic development. As a consequence, platforms should reduce barriers to participation and action.

An analogy for platforms is that they lower the "activation energy" or the amount of work needed to perform a task. By scaffolding different forms of support, platforms may reduce transaction costs, aid in memory recall, or script people's behavior in a specific way that leaves time and attention available for more creative activities. For example, WordPress is a platform for writing blog posts without much coding. A bed is a platform for better sleeping. A grading rubric is a platform for assessing objectives and achievements.
http://www.mitpressjournals.org/doi/abs/10.1162/desi.2007.23.2.3

This section suggests actions to support the development of platforms that lower the burden of cross-disciplinary research and creative work. Successful platforms often maintain multiple, diverse forms of support, and not all platforms are designed.

Activate experimental infrastructure and event-driven architecture
Suggested Action: Develop insights, best practices, and incentives for experimenting with the architecture and the collaborative spaces of research and creativity.

The spaces, architectures, and infrastructures that different communities use to carry out their work may need radical transformation, or they may simply need a nudge. Different kinds of spaces support different kinds of interactions, but opening spaces up to the possibility of experimentation may be enough to foster knowledge transfer, information exchange, and/or focus. Examples of abound in news articles and the literature, while the legendary status of spaces like Building 20 at MIT provide ready-made examples of how architecture and knowledge-spillover are tightly linked.

The Stanford d.school is a cross-domain program that provides courses and research opportunities for students from all of Stanford's departments. As a result of having moved multiple times in its short history, the program captured the knowledge of how it used different spaces to support different kinds of interactions and has provided those insights in the form of a manual (Doorley and Witthoft, 2012).

Furniture companies like Herman Miller and Steelcase regularly capture insights around the relationships among space, architecture and collaboration, and they fold them into their design process. Not all solutions work all of the time, but the solutions provide new models to try in new contexts for diverse users, along with the license to try new configurations. It's also critical that assumptions about those spaces are shared with the community—in case the community feels differently.

One of the most important areas of research in the next decade will be the relationship between information and architecture, where knowledge spillover carries long distances and the Internet is no longer confined to a screen.

Sustainability through new forms of community-based financing, bridging organizations, co-production, and transparency
Suggested Action: Experiment with and develop new forms of community-based financing, bridging organizations, co-produced research, and tools for organizational transparency.

Deinstitutionalized infrastructures utilize crowdsourcing, crowdfunding, bridging organizations, and other forms of transparency to decrease the barriers to accomplishment and increase people's engagement around the problems they are trying to solve—from research to implementation. However, the result is not necessarily a reduction in hierarchy and accountability. Rather, resources and tools that increase feedback and accountability can help increase institutional responsiveness and the ability of any one individual or group to make positive change and impact.

Extend sustainability-based values, accounting transparency, and budgeting standards deep into the research supply chain

Suggested Action: Require accounting transparency and budgeting standards that extend sustainability-based values deep into the supply chain.

Deinstitutionalized infrastructures that utilize crowdsourcing, crowdfunding, bridging organizations, and other forms of transparency can decrease the barriers to accomplishment and increase people's engagement around the problems they are trying to solve.

However, new tools and information practices are needed to surface increasingly hidden accounting practices and inhibit feedback and accountability. Feedback and accountability are critical for institutional responsiveness and the ability of any one individual or group to make creative positive change and cross-disciplinary impacts for community sustainability and economic growth.

Hybridize virtual and physical learning and research mash-ups

Suggested Action: Create hybrid learning and research mash-ups that expose teachers and learners to multiple forms of content, engagement, and goals, both online and off.

Innovations in education, ranging from Massive Open Online Courses to video games, are rapidly becoming learning platforms that can scale teaching and instruction using the Web, videos, assignments, activities, discussion forums, and other forms of engagement.

While a great deal of attention has been given to massive online classrooms and these other new forms of learning platforms, their most important feature is their ability to provide resources and memorable learning experiences.

Therefore, hybrid learning and research mash-ups that utilize blended environments and both physical and virtual tasks can expose teachers and learners to multiple forms of content, engagement, communities, and goals.

Create comprehensive training grants around new and emerging themes
Suggested Action: Create comprehensive training grants for researchers and students around new and emerging themes.

Training grants such as NSF's IGERT program and cross-disciplinary synthesis centers can facilitate the research improvement, international engagement, and other broad impacts with support for residencies, workshops, and meetings. The National Evolutionary Synthesis Center, for example, hosts a variety of researchers who contribute to efforts that integrate knowledge within the field of evolutionary biology and systematics.

Residency programs in specialized disciplines can creatively reinforce their own mission and impacts by inviting cross-cutting proposals for residencies and activities from other domains. It is essential that calls for proposals and participation include an explicit invitation to a wide array of creative applicants. Otherwise, self-selection often eliminate potential applicants.

Redefine participation criteria
Suggested Action: Redefine the criteria for participation and broaden access beyond traditional institutional boundaries and definitions. Create new pathways for PhD and non-PhD researchers and PIs. Facilitate innovative funding models and support for international engagements.

Building parity is critical, but it doesn't only have to happen through traditional methods like compensation or degrees. Creative solutions can increase parity and the prospects for cross-domain collaboration using a variety of incentives, boundaries, resources, and outcomes. The PhD, institutional incentives, and tenure are significant negotiating points for the future of cross-domain work in the academy. Mechanisms that level the field of partnerships, provide better incentives for longer-term thinking, collaboration, and genuinely creative outcomes. Institutional affiliation and principal investigator designation may be one pathway for extending an individual's ability to create, assemble, and implement promising research.

Innovate around proposal requirements, submittal, and peer evaluation of research
Suggested Action: Innovate around the peer-review process and proposal requirements, submittal, and evaluation.

Grant-based funding often resembles a competition, and this can be experimented with as an institutional mechanism for evaluating proposals and/or for supporting creative work. Competition can be generative, and it does not always have to be a winner-take-all affair.

Although there are many reasons to believe that competitions favor diversity, they can also serve to hide institutional biases towards established players and solutions, limiting the value and frequency of innovative work. Many small experimental funding and proposal mechanisms may uncover new sources of creativity and diversity that tap diverse actors and less common solutions.

Incentivize professional organizations as catalysts for change
Suggested Action: Professional organizations can play a more supportive role as catalysts for change, harbingers of skills and emerging behaviors, and cross-disciplinary relationship building. They should be incentivized to do so.

Strong, supportive, and value-driven professional organizations need to identify and develop the unique capacities of their members, especially where formal institutions are unable to. They can do this by providing assessments that demonstrate the social benefits that their constituency brings to society, models for best practices, developmental opportunities for skills, cross-functional relationship building, and objective standards for decision making around jobs, grants, and other forms of negotiation. Professional organizations can serve emerging and/or established constituencies by developing mutual understanding of the strengths that people bring to teams and new endeavors. Professional organizations can also take the lead as a bridging organization for themes of critical interest.

Integrate design thinking into the scientific method and other forms of creative research
Suggested Action: Develop and integrate design thinking into the scientific method. Extend cross-disciplinary collaboration from individuals and groups to entire organizations and inter-organizational challenges.

“Design thinking” is the term used to describe how people can share ideas from across different perspectives and iteratively add new insights to create and define something that a single individual could not have developed on his or her own. One of the major reasons for the success of design thinking is that it often takes group dynamics into account and relieves some of the social costs of brainstorming. Design thinking can encompass a variety of stable, standardized techniques to encourage creative thinking and collaboration while minimizing the common pitfalls of group-based collaboration. Design thinking has even been codified into online

platforms (http://www.hcdconnect.org, http://www.openideo.org) for designing solutions to difficult problems like education, nutrition, and sanitation.

Support inter-operable tools and Advanced Programming Interfaces (APIs) that can bridge people, machines, artifacts, and non-humans

Suggested Action: Fund and support human/object/machine/nonhuman interoperable tools and APIs for science, engineering, and creative research.

Interoperable interfaces and tools can help lower the learning curve of complicated technologies and cyber-infrastructures. Tools and APIs that connect people to people, machines to people, objects and tools to machines, nonhumans to people, and more provide a basic infrastructure for cross-functional research and new creative uses of technologies. By offering advanced scientific, artistic, design, and engineering capabilities (such as shared time on supercomputers, telescopes, or sequencers) at a lower cost (from the increased scale of use), new creative work activities may result in transformative research outcomes.

Encourage institutional "plug-ins" to provide access and lower transaction costs

Suggested Action: Provide plug-in opportunities for organizational and institutional access emphasizing low transaction costs, ease of movement, and support for basic creative research needs.

Organizations are starting to understand the value of open-source innovation and creativity, and as a result they are starting to develop platforms for people and processes to plug into their internal work. These organizational plug-ins may extend collaboration and institutional capacity by allowing outside researchers greater levels of engagement with an organization, along with the rewards of increased access to internal knowledge resources. Or it may entail the measured release of research products, from data to tools. Many organizations are finding that in order to innovate across disciplines and produce creative work, they must share their knowledge and resources, even with their enemies. Cooperation is the new competition.

Mozilla, the nonprofit that produces the Firefox browser and operating systems, has recently started providing gateways for participants from outside of the organization to access contacts with people, internal data, and services. The Mozillians' API is a vouched-status key that allows people who have demonstrated their trustworthiness access to different layers of the organization.

Amazon has built its entire cloud-service business model on the basis of designing all of its service interfaces to be externalizable from the ground up. The company designs its entire technology base for the purpose of exposing it to developers in the outside world.
Many models for this kind of institutional access exist, from courtesy and affiliate faculty appointments to guest library and computing accounts. By creating new forms and capabilities for people to access and interface across institutions and boundaries, institutional gateways like these reduce obstacles for collaboration and communication, providing better resources for creativity and innovation.

Spread awareness of inter-operability benefits and flexible standards
Suggested Action: Spread awareness about the benefits and values of interoperability and standards-based flexibility in technology development. Create incentives for building linkages between locked-in systems.

Gateways are simple platforms that help connect different perspectives, institutional processes, and technologies. They are a lot like the travel adapter we use when traveling abroad to connect a plug to a local outlet. Gateways provide additional flexibility, interoperability, and compatibility between diverse sub-systems.

APIs are a common example of how gateway technologies can be used to create cross-compatibility between different software services. Typically, an API lets a service (like Google Maps, Facebook, or Twitter) publicly expose some of its data or functionality to outside developers who then use "hooks" to call those resources and apply them creatively to another service. This open architecture facilitates a rapid increase in the ways that services and resources can be recombined. Companies like If This Then That have even sprung up around APIs and are developing simple tools that let anyone connect different services together in useful and creative ways.

An artifact-based example of a technology gateway is The Free Universal Construction Kit, which provides adapter pieces that fit different types of toy building systems—from legos to tinker toys—together. Gateways technologies are thus meant to create a common link between two or more standardized systems, expanding the flexibility inherent in those systems. Similar kinds of interfaces are now being developed to provide gateways for molecular systems in synthetic biology (e.g., Biobricks) and across design tools and living systems (Autodesk Research). Creating tools that help users connect different resources and objects can augment existing forms of innovation, cross-domain work, and creative research.

Gateway technologies and other forms or adapters that provide interoperability are reasonably well understood in technological contexts, and they are valuable because they operate below the level of the actual work, making them invisible for the most part. However, gateways can be used to create cognitive or interinstitutional linkages as well.

Gateways don't always have to be based on objects or tools, per se. Cognitive gateways enhance shared understanding, cooperation, and creativity. Brainstorming is one widely used gateway platform for ideation. Often, the simple acts of restraining judgment or making ideas visible for others to see can help connect people's divergent assumptions and interpretations. In this way, people and their perspectives are the subsystems being connected by a social gateways technology, namely, cognitive coupling.

Incorporate foresight perspectives into cross-disciplinary work and creative research
Suggested Action: Incorporate forward-looking perspectives into cross-disciplinary work and creative research.

Foresight involves critical thinking about long-term developments, debate and effort toward wider participatory democracy, and tactical media aimed at shaping the future, especially by influencing public policy.

Artifacts of the future and design fiction are examples of how foresight—embodied as objects, products, or services—can portray a version for how different actors and community needs will align in the future. Artifacts of the future provide a tangible experience of the future and the benefit that, as community stakeholders weigh in, they are anchored by the concrete representations of the artifact. This helps scaffold their long-term thinking around entities and processes.

Build communities of practice around boundary objects with specific goals and objectives
Suggested Action: Build communities of practice around boundary objects with specific goals and objectives.

One of the ways that heterogeneous, cross-domain cooperation and creative work has been able to incorporate multiple goals and perspectives is through the use of boundary objects. “Boundary objects” describe the social function of objects and artifacts that emerge and exist at the intersections of multiple communities and manage emerging tensions (Star and Griesemer, 1987).

Boundary objects can be repositories for knowledge such as databases, cabinets of curiosity or natural history collections; ideal types like diagrams, flags, or even stems cells; artifacts with coincident boundaries like maps or metaphors; or standardized forms for common communication like jargon or species designations. These objects are plastic enough to respond to local needs, but they are also static enough to carry meaning across many locations. They satisfy the informational and evidential needs of different communities while supporting certain forms of work and extending to others.

Boundary object-based research endeavors would help link past practices to future work goals with defined objectives (e.g., how to integrate underrepresented communities). Often this work involves creating alignments between political, economic, social, technological, and ecological goals. Because boundary objects are objects, they are highly amenable to creative work from product designers, interaction artists, performance artists, architects, and many others.

Clarify, diversify, and incentivize NSF broader impact requirements
Suggested Action: Clarify and diversify the broader impact requirements for grantees. Reward innovative broader impact proposals disproportionately.

Broader impact statements are required by all NSF proposals, and, in addition to demonstrating technical merit, they can be a significant and powerful place for cross-disciplinary research and creative work to demonstrate its value. More effort and attention should be directed at identifying concrete objectives and impacts for cross-domain research and creative work. Solutions for creating broader impacts, and appropriate rewards for those proposals that do, can call attention to and reinforce the societal benefits they offer, providing a goal-driven mechanism to communicate the benefit of research to society.

Helga Nowotny, president of the European Research Council, has, with others, been arguing for the development of "socially robust science" (Nowotny, 2003; Gibbons, 1999) Broader impact requirements could be developed for projects that include professionals from the arts, design, and humanities within scientific project teams to articulate and address interest. Scientists usually feel that peer review by scientists is sufficient, but there is a growing argument that science needs to open new peer review systems that include people outside the specific discipline.

Bibliography

Atran, S. 2010. *Talking to the Enemy: Faith, Brotherhood, and the (Un)Making of Terrorists*. New York: HarperCollins.

Börner, Katy. 2011. "Plug-and-Play Macroscopes." *Communications of the ACM* 54 (3): 60-69.

Burt, R. S. 2004. "Structural Holes and Good Ideas." *American Journal of Sociology* 110 (2): 349-99.

Callon, M. 1986. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay". In John Law, ed., *Power, Action, and Belief: A New Sociology of Knowledge?* Sociological Review Monograph 32. Keele, UK: University of Keele.

Doorley, S., Witthoft, S., & University, H. P. I. of D. at S. 2012. *Make Space: How to Set the Stage for Creative Collaboration* (1st ed.). Wiley.

Frame, B. and Brown, J. 2008. Developing Post-Normal Technologies for Sustainability. *Ecological Economics* 65 (2): 225-41.

Fuller, R. B. 1963. *Ideas and Integrities: A Spontaneous Autobiographical Disclosure.* Englewood Cliffs, NJ: Prentice-Hall.

Funtowicz, S. O., and Ravetz, J. R. 1991: A new Scientific methodology for Global Environmental Issues, in Costanza, R.: Ecological Economics. The Science and Management of Sustainability. New York, Oxford: Columbia Press, pp. 137-152.

Gibbons, M. 1999. Science's new social contract with society. *Nature*, *402* (6761 Suppl). C81–84.

Hidalgo, C. A. 2011. "The Value in the Links: Networks and the Evolution of Organizations." In P. Allen, S. Maguire, and B. McKelvey, eds., *Sage Handbook on Management and Complexity,* ch. 32. Thousand Oaks, CA: Sage Publications.

Hidalgo, C. A., B. Klinger, A.-L. Barabasi, and R. Hausmann. 2007. "The Product Space Conditions the Development of Nations." *Science* 317: 482-87.

Jackson, S. J. "Rethinking Repair," in *Media Meets Technology*, eds. Pablo Boczkowski, Kirsten Foot, and Tarleton Gillespie (MIT Press: forthcoming, 2013).

Jiang, S., J. Ferreira, and M. C. González. 2012. "Clustering Daily Patterns of Human Activities in the City." *Data Mining and Knowledge Discovery* 25 (3): 478-510.

Kidane, Y. H., and P.A. Gloor. 2007. "Correlating Temporal Communication Patterns of the Eclipse Open-Source Community with Performance and Creativity." *Computational & Mathematical Organization Theory* 13, 17-27.

Lee, S., and W.-M. Roth 2001. How Ditch and Drain Become a Healthy Creek: Representations, Translations and Agency during the Re/Design of a Watershed. *Social Studies of Science* 31: 315-56.

Nowotny, H. 2003. Democratising expertise and socially robust knowledge. *Science and Public Policy*, *30*(3), 151–156.

Rosvall, M., & Bergstrom, C. T. 2007. Maps of random walks on complex networks reveal community structure. *arXiv:0707.0609*. doi:10.1073/pnas.0706851105

Shapin, S., & Schaffer, S. 1989. *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life.* Princeton, NJ: Princeton University Press.

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and how it Changes*. SAGE.

Star, S. L., & Griesemer, J. R. 1989. Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science*, *19*(3), 387–420.

Tardif, T. Z., and Sternberg, R. J. 1988. "What Do We Know about Creativity?" In R. J. Sternberg, ed., *The Nature of Creativity: Contemporary Psychological Perspectives,* 429-40. Cambridge: Cambridge University Press.

Toole, J. L., M. Cha, and M. C. González. 2012. "Modeling the Adoption of Innovations in the Presence of Geographic and Media Influences." *PLoS ONE* 7(1): e29528.

Turner, F. 2010. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago Press.

Venturini, T. 2009. Diving in magma: How to explore controversies with actor-network theory. *Public Understanding of Science*.

Venturini, T. 2012. Building on faults: How to represent controversies with digital methods. *Public Understanding of Science*, *21*(7), 796–812.