

The Transdisciplinary Dilemma: Making SEAD in the Contemporary Research
University

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ABSTRACT

Over the past two decades, many American universities have created transdisciplinary institutes devoted to science, engineering, art, and design (SEAD). These organizations promote research, teaching, and engagement across technoscientific and artistic disciplines, and seek to cultivate creativity and innovation. Their proponents argue that this particular type of transdisciplinary knowledge-making has the potential to transform research universities. However, making and maintaining SEAD institutions is difficult work for the researchers and administrators involved. Practitioners struggle to define the broader goals of their transdisciplinary research; to demonstrate its value; to receive appropriate credit from their peers; and to feel that they belong in their institutions. I argue that these issues result from a fundamental “transdisciplinary dilemma”: the challenge of institutionalizing an ideal of transdisciplinarity that is actually a complex and contradictory set of different actors and motivations.

In my dissertation I examine SEAD and transdisciplinarity through an ethnographic study of Virginia Tech’s Institute for Creativity, Arts, and Technology, a research institute that aspires to work “at the nexus of science, engineering, art, and design.” I identify three significant “matters of concern” for SEAD practitioners, each of which is a tension that reveals an aspect of the transdisciplinary dilemma and the challenges of institutionalizing art and technology research. *Sponsored collaboration* contrasts the idea of transdisciplinarity as an idealized stage of creative knowledge production with the notion of transdisciplinarity as an economic driver for higher education. *Value and belonging* highlights researchers’ simultaneous desire to exist outside of traditional disciplines and to enjoy the comforts of a disciplinary home. *Measurable impact* describes the balancing act between institutions’ need for resources and status, and the nature of researchers’ everyday work. Ultimately, I argue, these tensions are irresolvable aspects of SEAD as it exists within the contemporary research university. The persistence of the transdisciplinary dilemma leaves practitioners in a perpetual state of striving to belong, and SEAD institutions continually seeking to (re-)define themselves.

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GENERAL AUDIENCE ABSTRACT

Over the past two decades, many American universities have created transdisciplinary institutes devoted to science, engineering, art, and design (SEAD). These organizations promote research, teaching, and engagement across technical, scientific, and artistic disciplines, and seek to cultivate creativity and innovation. Their proponents argue that this particular type of transdisciplinary research and education has the potential to transform universities. However, making and maintaining SEAD institutions is difficult work for the researchers and administrators involved. Practitioners struggle to define the broader goals of their transdisciplinary research; to demonstrate its value; to receive appropriate credit from their peers; and to feel that they belong in their institutions. I argue that these issues result from a fundamental “transdisciplinary dilemma”: the challenge of institutionalizing an ideal of transdisciplinarity that is actually a complex and contradictory set of different actors and motivations.

In my dissertation I examine SEAD and transdisciplinarity through a study of Virginia Tech’s Institute for Creativity, Arts, and Technology, a research institute that aspires to work “at the nexus of science, engineering, art, and design.” I identify three significant “matters of concern” for SEAD practitioners, each of which is an issue that reveals an aspect of the transdisciplinary dilemma and the challenges of institutionalizing art and technology research. Ultimately, I argue, these tensions are irresolvable aspects of SEAD as it exists within the contemporary research university. The persistence of the transdisciplinary dilemma leaves practitioners in a perpetual state of striving to belong, and SEAD institutions continually seeking to (re-) define themselves.

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Introduction: SEAD and the Transdisciplinary Dilemma

In August of 2013, I walked into a dingy rented space underneath a coffee shop in Blacksburg, Virginia and, for the first time, met a group of researchers who formed the core of Virginia Tech's Institute for Creativity, Arts, and Technology (ICAT). The group was an eclectic mix of engineers, artists, educators, and a few who rejected disciplinary identities altogether. All had varied career trajectories and research goals, but for the past two years they had worked together to develop an Institute devoted to creating and supporting projects that crossed disciplinary boundaries between science, engineering, art, and design. Scraping together limited resources, the researchers experimented with motion capture and 3D projection. They instituted an annual summer camp where middle school students created electronic musical instruments. They created installations and art pieces that integrated technology and performance. But by the summer of 2013, the Institute was on the cusp of a major change: its faculty, staff, and graduate students were about to move from their out-of-the-way basement into a newly constructed \$90 million arts center and assume a prominent place on campus. The building, and the accompanying expansion of the Institute that its stakeholders anticipated, could help to establish ICAT as a leader among other U.S. university-based institutions devoted to working across the arts and technology.

ICAT's participants were excited about the move. The state-of-the-art facilities in the arts center would enable new ways of creating and expose their work to new audiences and potential collaborators. But they had questions and worries, too. Their Institute had functioned for two years as a loosely defined collective of likeminded researchers. That was about to change, and ICAT's researchers knew it. For one thing,

the researchers wondered how they might make themselves and their work understood on campus. The collaborative projects they pursued at ICAT were an anathema to many at the university, especially when compared to the more traditional arts offerings of Virginia Tech's Center for Arts, with whom ICAT would share the new building. Furthermore, ICAT participants worried about demonstrating the success of their fledgling research institute, and proving themselves worthy of the university's financial support.

The air of uncertainty reflected the larger, underlying questions that motivated researchers' practical concerns, both at ICAT and across the landscape of university-based arts and technology research. ICAT was a research institute, but it was also an ambitious project that sought to re-make some of the functions of the contemporary research university. What would it mean to construct a real *institute*, with legitimacy, rules, organization, and a steady resource base, from a set of people and practices that were bound together by their interest in working outside standard academic disciplines and structures? What kind of knowledge could "transdisciplinary" art-technology collaborations create, and how would this knowledge differ from that produced elsewhere on campus? What would it mean to train students in creativity and innovation, and why was it important to do so? What would happen when ICAT's approach clashed with existing university structures and processes? Participants in ICAT had a strong sense of their individual goals and research agendas and a keen interest in working together, but they struggled to develop collective answers to these foundational questions. "We keep talking about transdisciplinarity," one faculty member said, shortly after the move, "but honestly I'm not really sure what that means."

My dissertation uses ICAT's story to explore an emerging trend towards transdisciplinary knowledge-making that spans the arts and technology; a phenomenon that some participants have come to call SEAD (Science, Engineering, Art, and Design). In the chapters that follow, I discuss the origins, ongoing construction, characteristics, and consequences of institutionalizing transdisciplinary art-technology collaborations within research universities. This is both an intensely local story, relying on people and circumstances unique to ICAT and Virginia Tech, and a national (or in a broader sense, international) one.

Studying a local manifestation of a larger phenomenon resulted in findings on multiple scales. Within the national landscape of American higher education, I demonstrate how the idea of SEAD evolved from previous discourse, and continues to develop. At an organizational scale, I show how attempts to capture "creativity" and "transdisciplinarity" within an institutional framework frequently lead to clashes between existing structures and a desire for change. And on an individual level, I examine how participants in transdisciplinary SEAD environments struggle to navigate complex networks of allegiance, identity, and responsibility.

ICAT and other institutes like it envision themselves as transformational: they imagine a future where creative, collaborative, inter- and transdisciplinary work can revolutionize the academic world. Their purported transformations, however, are ongoing and messy. Attempts to bring together disparate knowledge traditions and practices, and to cultivate "creativity" within an institution, result in complications for participants, as existing structures clash with a strong impetus for change. The *transdisciplinary dilemma* is the problem of institutionalizing these transformational ideals, and it has no simple or

complete solution. This dissertation explores the dimensions of the transdisciplinary dilemma: how can SEAD practitioners and administrators institutionalize a concept that has multiple, conflicting meanings and stakeholders, and furthermore defines itself in part through its opposition to existing disciplinary structures and institutions? I locate the origins of this dilemma in the varied motivations upon which SEAD is built. I discuss how these sometimes-contradictory motivations, which continue to contribute to SEAD's evolution, result in persistent tensions that the people who work in SEAD environments must navigate. Ultimately, I conclude that the messiness of the art-technology institute is not a phase to be worked through, but rather a fundamental component of a form of transdisciplinarity that leaves participants and institutions perpetually striving to belong.

Situating SEAD

Since the early 2000s, the number of American university-based institutions devoted to conducting work across the technoscientific and artistic fields has rapidly expanded. Universities from Stanford to Iowa State have built inter- and transdisciplinary departments, institutes, centers, and degree programs that blend the arts and technology. These institutions differ from each other in many ways: some are very small, some are large; some are degree-granting, some not; all have slightly different specializations and produce different types of work for different audiences. But they share common rhetoric and practices, and they seek to combine research, education, and engagement in the sciences and engineering with that in art and design.

The first art-technology institutes within American universities emerged in the 1960s and 1970s. The rapid expansion of these institutes, however, is a recent

phenomenon that began in the early 2000s. This expansion, which I have characterized elsewhere as an “arts research boom,” also involved the spread of art-technology institutes from elite, private universities to public and land-grant institutions.¹ During this “boom,” inter-university networks developed alongside the individual institutions. One such network is the advocacy group Alliance for the Arts in Research Universities, or a2ru, which boasts 44 member institutions, including Virginia Tech. Another is the Network for Sciences, Engineering, Arts, and Design (SEAD Network), an organization of institutions and individuals that seeks commonalities across universities and projects as it promotes a policy agenda. These cross-university efforts advocate for the value and importance of discipline-spanning work in the arts and technology, while at the same time grappling with describing it.

Year Founded	Organization	University
2016	School of Arts, Technology, and Emerging Communication	University of Texas at Dallas**
2013	enOvation	Louisiana State University**
2013	Iovine and Young Academy for Arts, Technology, and the Business of Innovation	University of Southern California
2012	Arts Business Initiative	University of Wisconsin at Madison**
2012	Open Grounds	University of Virginia**
2012	a2ru	N/A
2011	Digital Art and Textuality Alliance	University of Colorado at Boulder**
2011	SEAD Network	N/A
2010	ArtsEngine	University of Michigan**
2009	Emerging Digital Research and Education in Arts Media Institute (eDream)	University of Illinois at Urbana Champaign**
2009	Digital Arts Initiative	University of Nebraska at Lincoln**
2007	Entertainment Arts and Engineering	University of Utah**
2006	Arts on Earth	University of Michigan**
2005	Center for Design Innovation	University of North Carolina
2005	Creative Campus	University of Alabama**

¹ Matthew Wisnioski and Kari Zacharias, “Sandbox Infrastructure: Field Notes from the Arts Research Boom,” *ARPA Journal*, no. 1 (2014).

2005	Institute for Visual Studies	James Madison University**
2005	Innovation Park	Louisiana State University**
2005	d.school	Stanford University
2004	School of Arts, Media, and Engineering	Arizona State University*,**
2003	Laboratory for Creative Arts and Technologies (LCAT)	Louisiana State University**
2002	Institute for Applied Creativity	Texas A&M University
2002	Digital Media Center	Johns Hopkins University**
2002	School of Interactive Arts and Technology	Simon Fraser University
2001	Digital Worlds Institute	University of Florida**
2000	California Institute for Telecommunications and Information Technology (Calit2)	UC San Diego and UC Irvine
1999	Entertainment Technology Center	Carnegie Mellon*,**
1999	Institute for Creative Technologies	University of Southern California
1997	ATLAS Institute	University of Colorado at Boulder**
1992	Center for Research and Computing in the Arts	University of California at San Diego
1990	Institute for Studies in the Arts	Arizona State University**
1989	STUDIO for Creative Inquiry	Carnegie Mellon
1987	Advanced Computing Center for the Arts and Design	The Ohio State University*,**
1986	Center for Research in Electronic Art Technology	University of California at Santa Barbara
1986	Center for Interdisciplinary Research in the Arts	Northwestern University
1985	Media Lab	MIT*,**
1979	Interactive Telecommunications Project	New York University
1975	Center for Computer Music (CCRMA)	Stanford University
1973	Computer Graphics Research Group (later became the Advanced Computing Center for the Arts and Design)	The Ohio State University**
1973	Electronic Visualization Lab	University of Illinois, Chicago
1967	Center for Advanced Visual Studies	MIT**

*listed as a “peer institution” in early ICAT mission documents

**a2ru partner institution

Figure 1.1: A partial list of university-based SEAD institutions in North America

The motivations and stated benefits of art-technology research are as varied as the institutions that promote it. The mission statements of the SEAD Network and a2ru demonstrate the breadth, and occasional self-contradiction, of these goals.² The networks

² The following text excerpts come from the mission statements of the Alliance for the Arts in Research Universities and the Network for Science, Engineering, Arts, and Design: Alliance for the Arts in Research Universities, “About a2ru,” a2ru.org, accessed September 27, 2018, <https://www.a2ru.org/about/>; Network for Sciences, Engineering, Arts, and Design, “About,” accessed September 27, 2018, <http://sead.viz.tamu.edu/about/index.html>.

cite the practical benefits of cross-disciplinary partnerships, including “innovations” and “strategic partnerships,” while at the same time promoting process-oriented goals like “creative confidence” and “life-long learning.” Art-technology collaborations, we are told, can help solve “pressing, complex, and open-ended challenges,” but they also provide “freedom to experiment.” As far as the institutions’ benefits to the public, we should appreciate both their “intellectual merit” and their ability to stimulate “economic growth.”

Unsurprisingly, the specific outputs of art-technology institutes and collaborations are similarly diverse. Some practitioners tout innovations such as the iPhone as inspirational exemplars of what can happen when engineers and designers work together, while others name the emergence of fields like new media art as key outcomes of such collaborations. Projects may result in visual or performance art pieces, visualizations or sonifications of scientific data, techniques for cultivating creative thinking in students, or new commercial technologies. Specific examples from within the SEAD Network and a2ru include an animated game that simulates the social interactions of high schoolers attending prom; robotic exoskeletons that enable houseplants to seek out sources of sunlight and water; and an intermedia installation and performance that explores plant and animal life in a salt marsh.

The range of people, organizations, goals, and methods involved in the world of transdisciplinary art and technology indicates that we must exercise caution when attempting to label or characterize the phenomenon. Indeed, no consensus exists as to *how* one should talk about this work. A 2017 report from the SEAD Network highlights the linguistic confusion around their subject matter, stating that their editorial committee

“settled on SEAD” as a descriptor above other options which included “Art-Science, ArtScience, STEM, STEMM, STEAM, STEAMM, STEAMMD, ArtSci, SciArt, hybrid, T-Shaped, H-Shaped, Third Culture, and Art4Science, among others.”³ To this list we might conservatively add “arts research” and the “third space,” both of which feature in literature and in casual use at ICAT.

I, too, use “SEAD” throughout this dissertation to refer to the plethora of ideas and practices related to transdisciplinary art and technology work. I base my choice in part, as the SEAD Network committee did, on the “inclusive and approachable” nature of this descriptor as compared to the long list of other options. “SEAD” encompasses possibilities of motivation, method, and agency that “Art4Science,” for example, rules out. More importantly, I use this term because it is the one that ICAT’s participants have settled upon to describe their own institution. “SEAD,” or references to “science, engineering, art, and design,” appear frequently in ICAT’s promotional materials and in practitioners’ internal discussions. It is one way in which ICAT participants understand their work. However, as confusion around the terminology suggests, SEAD is far from an established term, and it does not possess a stable definition. In characterizing people, institutions, ideas, or research as “SEAD” or “SEAD-based,” I call attention to their multiplicity and ongoing evolution.

The instability and openness of SEAD make it a fascinating, if slippery, object of study. As universities continue to develop SEAD institutions, and existing organizations and networks evolve, the foundational issues that ICAT’s practitioners struggled to answer remain persistent sources of tension. Open questions about the SEAD institute as

³ Alex Garcia Topete et al., “SEAD Exemplars: Evidence of the Value of Transdisciplinary Projects” (Network for Sciences, Engineering, Arts, and Design, December 4, 2017).

a site of knowledge production, the meaning and purpose of transdisciplinarity, and the potential roles of humanities and social science researchers in such environments make SEAD an important arena for STS inquiry.

Art, Transdisciplinarity, and the Contemporary Research University

My study of SEAD and of ICAT follows three related lines of inquiry. First, I explore the origins of SEAD, asking how the “arts research boom” began, and how these origins relate to the transdisciplinary dilemma. What ideas, traditions, and discourses is the idea of SEAD embedded in? Second, I ask how practitioners, researchers, teachers, and administrators continue to construct SEAD in practice. What do attempts to cultivate and teach creativity and transdisciplinarity look like on the ground? Finally, I investigate the values and results of SEAD. What are the consequences – for researchers, students, universities, or publics – of institutionalizing this particular kind of transdisciplinarity?

In pursuing these questions, I respond to and build upon scholarship in several distinct domains. I contribute to a developing body of work within STS that examines the connections between art, science, and technology. This emergent STS interest in art and design spans many theoretical arenas, including the involvement of art in scientific knowledge-making and the potential for STS to engage with art to produce new methodological approaches, strategies for communicating research, or forms of political engagement. My work also responds to an ongoing discourse on the nature of inter- and transdisciplinary research within universities. Scholars in this area ask historical questions about the origins and development of transdisciplinarity, sociological questions about the structures and practices of transdisciplinary organizations, and anthropological

questions about such organizations' impacts on researchers' lives. Finally, I hope to engage with SEAD researchers themselves, and to examine some ways in which STS might contribute to SEAD. Many art-technology practitioners are eager for outside study of their work, and curious to hear explorations, explanations, or critique of their situations. I am hopeful that this study can help SEAD participants think about their work in new ways, and perhaps reconsider some of the questions which they have already been asking themselves.

The Art-Technology Institute as a Site of Knowledge Production

In examining the university-based SEAD institute as a site of knowledge production, I contribute to a body of STS work that studies and operationalizes art and design in a variety of ways. In a chapter from the 2017 edition of the Handbook of Science and Technology Studies, Chris Salter, Regular Valerie Burri, and Joseph Dumit provide a comprehensive summary of STS engagements with art and design, which they divide into two categories.⁴ The first, “STS Perspectives on Art and Design,” includes scholarship that offers new perspectives on concepts like performance, performativity, creativity, invention, hacking, disruptive design, and sensory knowledges, which STS scholars have previously brought to bear on science and technology. Salter, Burri, and Dumit argue that new research broadens STS understandings of these ideas by engaging with the arts, resulting in new scholarly directions like “critical making” and “adversarial design.”⁵

⁴ Chris Salter, Regular Valerie Burri, and Joseph Dumit, “Art, Design, and Performance,” in *The Handbook of Science and Technology Studies*, ed. Ulrike Felt (Cambridge, MA: MIT Press, 2016), 139–67.

⁵ Matt Ratto and Megan Boler, eds., *DIY Citizenship: The Art of Critical Making* (Cambridge, MA: MIT Press, 2014); Garnet Hertz, ed., *Critical Making* (Hollywood, CA: Telharmonium Press, 2012); Carl DiSalvo, *Adversarial Design* (Cambridge, MA: MIT Press, 2012).

But it is the authors' second category, "Art and Design as STS Methods," to which my dissertation most closely connects. This category describes STS projects that use art and design to "explore the social," i.e. to ask questions about researchers' lives, organizational functions, and knowledge creation. In particular, Salter, Burri, and Dumit describe "cultural institutions internationally dedicated to art and technology," including well-known international examples like the ZKM in Karlsruhe, Germany; the Ars Electronica in Linz, Austria, and the NTC-ICC in Tokyo. Such institutions have rarely been the focus on STS study, and the authors argue that they deserve increased attention due to their unique perspectives on infrastructure-building; intervention and public participation in the formation of new technologies; and "the role of material knowledge in the formation of new socio-technical imaginaries."⁶

Inter- and transdisciplinary research institutions that do *not* involve the arts have been more popular sites for STS and STS-adjacent scholarship. My dissertation also engages with scholarship that examines hybrid research institutions within the natural sciences and engineering as particular sites of knowledge production. Scholars working in this arena ask questions about the practice of inter- and transdisciplinary collaborations. Previous studies examine researchers' experiences within inter- or transdisciplinary academic environments, showing how they can serve multiple stakeholders with complex and conflicting interests, or detailing the individual journeys that led individuals to practice interdisciplinary research.⁷ Other STS scholars and anthropologists explore the ways that interdisciplinary collaborations work on a

⁶ Salter, Burri, and Dumit, "Art, Design, and Performance," 151.

⁷ John Parker and Beatrice Crona, "On Being All Things to All People: Boundary Organizations and the Contemporary Research University," *Social Studies of Science* 42, no. 2 (2012): 262–89; Eric R. Scerri, "Interdisciplinary Research at the Caltech Beckman Institute," in *Practicing Interdisciplinarity*, ed. Peter Weingart and Nico Stehr (Toronto: University of Toronto Press, 2000), 194–214.

functional level, including the intersections and clashes of organizational and disciplinary “logics,” and the complexities of knowledge creation and ownership in interdisciplinary spaces.⁸

University-based SEAD institutions share common ground with prestigious cultural institutions in art and technology and with interdisciplinary research institutions in the sciences and engineering. In particular, SEAD institutions trace parts of their lineage to the “studio laboratories” described by Michael Century as “hybrid innovative institution[s]” where researchers concurrently developed technologies and their creative applications.⁹ Historical examples of such organizations include Bell Labs, Xerox PARC, MIT’s CAVS, and Stanford’s CCRMA, all of which have been the focus of work by historians and anthropologists of science and technology.¹⁰ I contribute a contemporary, ethnographic perspective on the university-based SEAD organization. How do SEAD practitioners balance the constant, sometimes conflicting demands of multiple stakeholders? How do they engage in “infrastructuring”? What kinds of institutional logics are at play in SEAD? In what ways are these practices and logics similar to, and distinct from, those that exist in other kinds of hybrid institutions? What characterizes SEAD institutions as sites of knowledge production?

⁸ Andrew Barry and Georgina Born, eds., *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences* (London and New York: Routledge, 2013); Marilyn Strathern, “Experiments in Interdisciplinarity,” *Social Anthropology* 13, no. 1 (February 2005): 75–90.

⁹ Michael Century, “Pathways to Innovation in Digital Culture” (Montreal, QC: Centre for Research on Canadian Cultural Industries and Institutions, McGill University, 1999), 3.

¹⁰ e.g. Jon Gertner, *The Idea Factory: Bell Labs and the Great Age of American Innovation* (New York: Penguin, 2012); Lucy Suchman, *Plans and Situated Actions: The Problem of Human-Machine Communication* (Cambridge, UK: Cambridge University Press, 1987); Matthew Wisnioski, “Why MIT Institutionalized the Avant Garde: Negotiating Aesthetic Virtue in the Postwar Defense Institute,” *Configurations* 21, no. 1 (2013): 85–116; Andrew J. Nelson, *The Sound of Innovation: Stanford and the Computer Music Revolution* (Cambridge, MA: MIT Press, 2015).

The Contested Idea of Transdisciplinarity

In addition to studying hybrid research institutes as sites of knowledge production, scholars in STS, history, cultural studies, and sociology have examined the concepts and practices of inter- and transdisciplinarity themselves. These studies take place against a background of emphasis and rhetoric around discipline-spanning research that has gained steam since the 1990s. Nowotny et al. famously characterized transdisciplinarity as part of a “new mode of knowledge production,” and Funtowicz and Ravetz included transdisciplinarity in their characterization of “post-normal science.”¹¹ Amid the increasing general popularity of inter- and transdisciplinary approaches, SEAD institutions are one manifestation of a larger trend within academia and industry.

Existing studies of transdisciplinarity as a concept are mostly historical. Some, in particular European scholars such as Jürgen Mittelstraß, focus on developing taxonomies or hierarchies of disciplinarity.¹² Others, foremost among them American historian Julie Thompson Klein, have charted the evolution of inter- and transdisciplinary fields and ideas in great detail.¹³ Few are interested in the day-to-day function of transdisciplinary spaces. Furthermore, most studies of inter- and transdisciplinarity focus exclusively on either the natural sciences, or the humanities and social sciences, ignoring the arts as well as any programs or initiatives that seek to cross or move beyond the “two cultures.”

¹¹ Helga Nowotny, Peter Scott, and Michael Gibbons, *Rethinking Science: Knowledge and the Public in an Age of Uncertainty* (Cambridge: Polity Press, 2001); Silvio Funtowicz and Jerome Ravetz, “Science for the Post-Normal Age,” *Futures: The Journal of Policy, Planning, and Futures Studies* 25, no. 7 (1993): 739–55.

¹² Jürgen Mittelstraß, “On Transdisciplinarity,” *TRAMES: Journal of the Humanities and Social Sciences* 15, no. 4 (2011): 329–38.

¹³ Julie Thompson Klein, *Interdisciplinarity: History, Theory, and Practice* (Detroit: Wayne State University Press, 1990); Julie Thompson Klein, “The Transdisciplinary Moment(um),” *Integral Review* 9, no. 2 (June 2013): 189–99.

Klein, for example, has shown how fields like American Studies and Women's Studies developed from transdisciplinary ideals, which is an important contrast to popular scientific images of transdisciplinary research.¹⁴

As inter- and transdisciplinarity have become increasingly popular academic buzzwords, many scholars have expressed doubts about their usefulness and potential longevity. Andrew Abbot critiques the lack of specificity present in much of the rhetoric around interdisciplinarity, arguing that “everybody always thinks it [interdisciplinarity] is a great thing, but nobody has figured out how to make it work as a formalized, permanent structure.”¹⁵ Steven Brint suggests that movements towards “interdisciplinary creativity” in universities may be more of a passing trend than a lasting paradigm shift.¹⁶ Most notably, Jerry Jacobs criticizes the trend of academic interdisciplinarity by offering a robust “defense of disciplines.”¹⁷ His book offers two primary counterarguments to common calls for increased inter- and transdisciplinarity. First, he disputes the common claim that disciplines exist as isolated “silos,” and that this isolation stifles innovation, by showing that, in fact, ideas and techniques tend to spread between disciplines quite readily. Secondly, Jacobs demonstrates the power and importance of scholarly communities, and argues that the “interdisciplinary university” will succeed only by incorporating many of the structural elements that its supporters rally against.

Despite these critiques, however, universities including Virginia Tech continue to pursue inter- and transdisciplinarity through new research centers and campus initiatives.

¹⁴ Julie Thompson Klein, *Humanities, Culture, and Interdisciplinarity: The Changing American Academy* (SUNY Press, 2005).

¹⁵ Andrew Abbott, “The Disciplines and the Future,” in *The Future of the City of Intellect: The Changing American University*, ed. Steven Brint (Stanford, CA: Stanford University Press, 2002), 205–30.

¹⁶ Steven Brint, “Creating the Future: ‘New Directions’ in American Research Universities,” *Minerva* 43 (2005): 23–50.

¹⁷ Jerry A. Jacobs, *In Defense of Disciplines: Interdisciplinarity and Specialization in the Research University* (Chicago: University of Chicago Press, 2013).

Furthermore, some scholars including Thomas Osborne suggest that, while interdisciplinarity in general is “not new” nor “particularly surprising,” new *kinds* of disciplinary cross-fertilization including art-science could represent a genuine paradigm shift.¹⁸ To what extent, then, does art-sci-tech transdisciplinarity represent a new direction for research universities? Are SEAD practitioners revolutionaries, or are they simply repackaging old ideas and institutional structures under the guise of transformation?

Critical Participation

Calls for better understandings of art-science and art-technology collaborations do not come exclusively from the humanities and social sciences. Practitioners within ICAT, a2ru, and the SEAD Network have issued formal and informal requests for studies of their work. a2ru employs a full-time researcher to assess the programs and initiatives of its member institutions, and to develop a set of “best practices” for interdisciplinary arts integration.¹⁹ The SEAD Network issued an international call for white papers that would specify the breadth and depth of SEAD research, and later published a summarizing report which included a “meta-analysis” of SEAD.²⁰

Art historian Edward Shanken holds that important questions about the “epistemological and ontological status” of art-technology research cannot be answered by practitioners alone. If the results of hybrid collaborations cannot be characterized by

¹⁸ Thomas Osborne, “Inter That Discipline!,” in *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*, ed. Andrew Barry and Georgina Born (New York: Routledge, 2013), 82–98.

¹⁹ Bruce M. Mackh, “Surveying the Landscape: Arts Integration at Research Universities,” The Mellon Research Project (University of Michigan, 2015).

²⁰ Roger F. Malina, Carol Strohecker, and Carol Lafayette, “Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design” (Cambridge, MA: MIT Press, 2015).

existing disciplinary norms or standards, he argues, one must wonder “what exactly are they? What new knowledge do they produce or enable? What is their function in the world?”²¹ Investigating such questions, Shanken says, requires “an interdisciplinary approach that joins together humanistic methods of interpretation with social science methods of analysis.”

I was able to access ICAT as a research site initially because of the Institute Director’s own desire for feedback on the work of SEAD institution-building. My advisor, Matthew Wisnioski, and I were invited to act as observers and critics, becoming members of ICAT ourselves and providing our input as researchers conducted their projects and Institute leadership directed operations and made plans for the future. However, I did not and do not aim to provide practitioners with a to-do list of best practices, nor a set of complaints about their work. Rather, I strived to critically participate in ICAT’s work, engaging as both an observer and, at times, a SEAD practitioner in my own right. In the spirit of “STS Making and Doing,” I sought to bring a reflective sensibility to ICAT, helping researchers to identify, bring to light, and discuss the important questions with which their work in SEAD often unconsciously engaged.²²

I frame my discussion of institutionalizing SEAD in terms of “matters of concern.”²³ Matters of concern are unsettled problem spaces where people, materials, and ideas come together. Latour contrasts matters of concern with matters of fact, showing how criticism that relies on upending existing facts, or presenting new matters of fact to

²¹ Edward A. Shanken, “Artists in Industry and the Academy: Collaborative Research, Interdisciplinary Scholarship, and the Creation and Interpretation of Hybrid Forms,” *Leonardo* 38, no. 5 (2005): 415–18.

²² Gary Lee Downey and Teun Zuiderent-Jerak, “Chapter 8: Making and Doing: Reflexive Learning in STS,” in *The Handbook of Science and Technology Studies*, ed. Ulrike Felt et al., 4th ed. (Cambridge, MA: MIT Press, 2016).

²³ Bruno Latour, “Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern,” *Critical Inquiry* 30, no. 2 (2004): 225–48.

the public, is a limited approach. Matters of concern are “subjective experiences that constitute political conditions,” which is to say that they take into account both individual lived experiences and the connections of those experiences to larger discourses.²⁴

DiSalvo et al. use the example of climate change, to which Latour also refers in his essay, to illustrate the difference between “fact” and “concern.” Treating climate change as a matter of fact, they argue, would involve recording environmental data and constructing computational models. Viewing the same subject as a matter of concern requires these “factual” approaches *in addition to* considering people’s lived experiences of rising tides and severe weather events; and understanding the charged and politicized forums in which we debate climate change.

I use the framework of matters of concern in my analysis for two main reasons. First, I believe that this approach is an effective way to link the experiences of SEAD participants and stakeholders with the discourses in which these experiences reside, and which they help to construct. The world of SEAD and the story of ICAT are both personal and political. By describing the tensions that exist in these spaces as matters of concern, I suggest connections between participants’ personal lives, motivations, and frustrations and the larger transdisciplinary dilemma. Second, matters of concern are an avenue towards critical participation. In an effort to provide constructive critique for practitioners to reflect on and work with, I aim to produce material for discussion rather than a refutation of their perceived reality.

Important matters of concern within SEAD include ambiguous motivations and practices resulting from sponsored collaborations; struggles among practitioners and

²⁴ Carl DiSalvo et al., “Making Public Things: How HCI Design Can Express Matters of Concern” (CHI 2014: One of a CHIInd, Toronto, ON, 2014), 2397–2406.

others to determine what counts and valuable research, and what kind of researcher belongs in SEAD; and pressure for practitioners to demonstrate the measureable impacts of investments in their research. Ultimately, all of these concerns are parts of the larger transdisciplinary dilemma. In naming and describing matters of concern, I hope to create spaces where practitioners and critics alike can gather to address them.

Methods

In order to study the practice and construction of SEAD, I spent four years conducting ethnographic research at ICAT and exploring its connections to other SEAD institutions and networks. My data collection and analysis incorporated a range of methods and techniques. Two research approaches that seek to connect micro with macro scales had significant influence on my work: feminist sociologist Dorothy E. Smith's approach to institutional ethnography, and the extended case method as described by sociologist and social theorist Michael Burawoy.

Institutional Ethnography

Despite its name, Dorothy E. Smith's "institutional ethnography" does not focus exclusively on institutions in an organizational sense. Rather, Smith's approach seeks to connect the organization of a given site with the larger discourses that relate to that organization, by studying the experiences and localized social worlds of the site's participants.²⁵ Institutional ethnography addresses the ideological practices which participants use (often unknowingly) to make an institution's processes accountable. To

²⁵ Dorothy E. Smith, *Institutional Ethnography: A Sociology for People* (Lanham, MD: Altamira Press, 2005).

do this, the ethnographer first studies the activities through which practitioners are themselves involved in producing the world in which they work and live. Ultimately, the ethnographer's goal is to discover how localized practices operate as part of a larger set of social relations that connect multiple sites.²⁶ The aim is to develop an understanding of how "the local organization of everyday worlds" connects to "relations of ruling."²⁷

The practice of institutional ethnography, like other ethnographic approaches, relies on a mixture of interviews, observations, and textual analysis. However, institutional ethnography emphasizes understanding through participation – experiencing "how things actually work" – as a key component of research alongside standard data collection methods. Smith's approach uses this fusion of data as entry points into social relations, attempting to explain how organizations can have "generalizing effects," rather than trying to generalize about a group of people.²⁸

The Extended Case Method

The extended case method as Burawoy describes it uses participant observation to "locate everyday life in its extralocal and historical context."²⁹ Like institutional ethnography, the extended case method focuses on understanding what participants do, and connecting their day-to-day actions with larger discourses. The extended case method does not aim to produce repeatable or objective results, but rather to promote a reflexive social science that allows for critique and reconstruction of existing theory. Burawoy describes four aspects of the method: intervention, process, structuration, and theory reconstruction. The

²⁶ Peter R. Grahame, "Ethnography, Institutions, and the Problematic of the Everyday World," *Human Studies* 21, no. 4 (October 1998): 347–60.

²⁷ Grahame.

²⁸ Dorothy Smith, ed., *Institutional Ethnography as Practice* (Rowman and Littlefield, 2006), 18.

²⁹ Michael Burawoy, "The Extended Case Method," *Sociological Theory* 16, no. 1 (1998): 4–33.

first aspect, intervention, includes interviews and observations conducted by the researcher. Burawoy views these activities as interventions on the part of the researcher and opportunities to observe social order: he describes observer-initiated “distortion” exerting pressure that forces a social order to reveal itself.³⁰ The process aspect involves the aggregation of situated knowledges derived from interviews and observations into a description of a social process. Structuration then requires making connections between observed social processes and larger social forces, using the distortion and aggregation of the other stages to begin to reach conclusions. Finally, Burawoy describes the aspect of theory reconstruction, whereby the researcher seeks refutation, rather than confirmation, of a theory they started with. Embracing and reflecting on the place of the researcher is an important part of the extended case method. Like institutional ethnography, the extended case method also involves deconstructing texts.

Data Collection

In accordance with both of these methodological approaches, my data collection included participant observation (often in a very direct and prolonged sense), text analysis, and interviews. Between the fall of 2013 and the spring of 2017, I conducted seventeen semi-structured interviews with fourteen people, all of whom had some connection to ICAT and Virginia Tech. Interview participants included undergraduate and graduate students, staff, faculty (including ICAT Senior Fellows), researchers on ICAT-affiliated projects, and administrators who played a role in ICAT’s development. Their relationships with ICAT ranged from deep involvement in the founding and day-to-day operation of the

³⁰ Burawoy, 17.

Institute, to loose and/or temporary affiliation through project work. Some interviews occurred after the participants had discontinued their involvement with ICAT.

However, the bulk of my data derived from observations which I conducted at ICAT meetings and events, and at meetings of the a2ru network. Between 2013 and 2017 I regularly attended faculty meetings between ICAT's Studio Heads, who later became known as Senior Fellows. At these meetings, which occurred first weekly and eventually biweekly, faculty fellows who played important roles at ICAT met with the Institute director and staff to review ICAT's operations, allocate funding for sponsored research projects and graduate student assistantships, plan events, and discuss the future of the Institute. As the lone ethnographer and only graduate student at these meetings, my role was generally that of a silent observer and note-taker, though as my time at ICAT progressed I did begin to occasionally contribute to discussions.

In addition to the Senior Fellows meetings, I regularly attended and observed ICAT's "playdates." Playdates are weekly events at which the ICAT community and members of the public gather to socialize over coffee and baked goods, and to hear a brief presentation from a sponsored researcher or other ICAT associate about their work. They are sites for networking and relationship-building that are both a hub for ICAT affiliates and an introduction point for visitors or those who wish to become involved with the Institute. My role at playdates was closer to that of a participant observer. I occasionally presented my own research, and frequently engaged in discussion with other attendees and presenters.

I also gathered data through direct participation in ICAT projects and activities. For four years I worked as an organizer and instructor at ICAT's Maker Camps, week-

long summer events at which middle-school students (and later local schoolteachers as well) design and build unique electronic musical instruments. In addition, I was an active member of an ICAT-funded project team that created a virtual reality representation of a subatomic particle collisions. I participated in weekly meetings with the project team over the course of one year, observed the beta tests of the VR system, and provided feedback throughout the process. As a graduate student partially funded by ICAT, I also participated as an exhibitor or a volunteer in annual events including ICAT Day, the Institute's annual public research exhibition, and the Virginia Tech Science Festival. Finally, I represented the Institute several times at conferences and public events, including multiple a2ru conferences, the T-Summit in Washington, D.C., and The ACCelerate Festival of Creativity and Innovation at the Smithsonian National Museum of American History. Throughout all of my experiences as a participant, I sought to balance my instrumental contributions with critical observation, attempting to take field notes during or immediately after my active participation. While this proved challenging (and occasionally impossible), it sometimes resulted in rich data, and consistently provided me with an "insider" view of ICAT that would have otherwise been difficult to capture.

Finally, I analyzed documents related to ICAT as well as to a2ru and the SEAD Network. These documents included personal correspondence, minutes from early planning meetings, draft versions of mission and vision statements, presentation materials from job talks, proposals to the Commonwealth of Virginia, and packages for potential sponsors, among other things. Participants provided many of these materials to me from their personal collections. Some documents were publicly available online, and I found others in the archives of Virginia Tech's Special Collections.

My interviews and other ethnographic data collection activities were approved by Virginia Tech's Institutional Review Board under IRB protocol #13-852. All interview participants, as well as anyone who participated in a private event that I observed (e.g. a closed meeting or a project work session), agreed to become a part of my research through completion of an informed consent process. I made audio recordings and transcriptions of all interviews, but my observations from events and meetings consisted of written notes only. I also conducted some observations at public events, e.g. ICAT playdates and the Virginia Tech Science Festival. I did not require visitors at public events to complete the informed consent process; however, my written observations from these events were limited to statements that did not identify the speaker or person being observed.

My informed consent process included an option for participants to consent to having their identities revealed in my dissertation and other publications. This was not a requirement for participation in the study. In cases where the participant did *not* consent to having their identity revealed, I have taken care to use only quotes and descriptions which do not give any reasonable indication of the name or specific position of the person in question. Any quotes or actions in this text which are attributed to an identified person come either from publically available sources, or from a participant who consented to having their identity revealed.

Data Analysis

The nature of my project, including the type of research questions I pursued and the prolonged period of data collection, demanded a multi-stage approach to data analysis.

Following my initial interviews and my first few months of observations at ICAT – the beginnings of what Burawoy describes as “intervention” – I began to build an understanding of how ICAT had developed as an institution, and to identify some of the reasons its participants had become involved. Many of my early interviews focused on participants’ own narratives of their careers, starting with their early academic training and continuing through their reasons for coming to Virginia Tech and their motivations for becoming a part of ICAT. I also collected documents related to ICAT’s establishment and its first two years. Overall, I devoted the initial “process” stage of my analysis to assembling stories – from multiple participants and points of view – of how the Institute came to be.

At the same time, I watched ICAT move into its new home in the Moss Arts Center. As I observed this process both formally (at meetings and events) and casually (as an ICAT student in my own right), the frustrations of many ICAT participants became apparent. Describing, characterizing, and situating these frustrations became the basis for my second phase of “intervention” and “process.” This phase began almost concurrently with the first, but lasted throughout nearly the entire duration of the project. I began to pay particular attention to points of tension during meetings and events, and to speak with ICAT participants, including those who were no longer associated with the Institute, about the challenges they faced. After attending multiple a2ru conferences, including one hosted by ICAT and Virginia Tech, and reviewing publically available documents produced by a2ru and the SEAD Network, I began to identify similar areas of tension across other SEAD sites. The three tensions that I now label “matters of concern” emerged out of this analysis; not through a formalized process of coding or discourse

analysis (though I did code interviews to identify common themes), but rather through continuous reflection, discussion, and review of notes and transcripts.

Eventually, the stage that Burawoy describes as “structuration” – making connections between observed social phenomena and larger forces, or in the framework of institutional ethnography, relating local social organization to “relations of ruling” – began. Again, this stage was messy, and overlapped significantly with the long process of understanding the tensions that SEAD participants experienced. Throughout this stage, the concrete problems that I heard and observed participants dealing with, e.g. “how will transdisciplinary faculty navigate the tenure review process?” became linked with more fundamental issues, e.g. “how can we create new academic structures in a space that rejects traditional disciplines,” or “how can researchers be at home in SEAD?” As I continued to characterize matters of concern in SEAD, relationships developed between these larger issues and the multiple stories I had identified about the origins of ICAT during my initial research phase. This structuration occurred gradually, throughout the preparation of my dissertation proposal, my preliminary attempts at drafting chapters, and the experience of preparing conference presentations and early publications.

Finally, I sought connections between my ethnographic findings and existing literature. During the writing stages of the project, in re-examining some of the questions and writing that had guided my early interventions, I identified and began to theorize what I now refer to as the transdisciplinary dilemma.

Chapter Outline

Each body chapter of my dissertation analyzes a different aspect of the dilemma of institutionalizing transdisciplinarity. The first chapter addresses my initial research question (where does SEAD come from and how has it developed?) through historical analysis that situates ICAT and Virginia Tech within larger national discourses. It explores the origins of the transdisciplinary dilemma by tracing the SEAD's diverse motivations. The following three chapters look at the subsequent two questions (how do people construct SEAD in practice, and what are the values and consequences of SEAD) by examining a different matter of concern in each chapter. These matters of concern each reveal important aspects of the transdisciplinary dilemma as it is reflected in practice.

While there is an interesting chronological story in my ethnographic data, running roughly from the Institute's move to the Moss Arts Center in Fall 2013 to its five-year review (in Fall 2016) and the aftermath of the review process, I do not present my findings in the order that these events occurred. Instead, observations from the time period of Fall 2013 to Spring 2017 appear throughout the dissertation, organized by theme rather than chronologically. While I hope that the material in the introduction and conclusion do give some indication of the Institute's development over these four academic years, my argument is that the matters of concern that were present at the beginning of ICAT's story are the same ones that its stakeholders continue to navigate today. The transdisciplinary dilemma and its associated tensions have persisted as ICAT has matured.

Chapter 1 – Transformational Institutions: Competing Visions of Change in the SEAD Institute

In the opening chapter, I draw from interviews and local archival research to describe how ICAT came to exist at Virginia Tech. University administrators, faculty, and ICAT’s director built an institute that reflects local concerns and their individual sensibilities, but is also embedded in, and contributes to, four larger narratives of transformation. Changes in the land-grant university mission; the nature of art/technology collaborations; the purpose of inter- and transdisciplinary research; and the meaning and necessity of innovation are important parts of ICAT’s institutional identity. ICAT, as a “transformational institution,” is the node at which these visions of change meet. The transdisciplinary dilemma, and the matters of concern which illuminate it, result from this coming-together of disparate motivations.

Chapter 2 – Sponsored Collaboration: Chasing the Creative and Economic Potential of “Transdisciplinarity”

Sponsorship is an essential aspect of SEAD collaborations. However, examining the sponsored nature of SEAD projects reveals the conflict between transdisciplinarity as an ideal of creative freedom and transdisciplinarity as a potential economic driver. In Chapter 2, I examine three ICAT-funded projects, comparing and contrasting how the projects began, how participants collaborated, and how (or if) the projects travelled beyond ICAT. I demonstrate how different types of sponsorship relate to outputs and modes of transdisciplinary collaboration, showing the resulting need for “transdisciplinarity” to become a malleable term with multiple, co-existing definitions.

Chapter 3 – Value and Belonging: Making a Home Outside the Disciplines

Value and *belonging* are two ways to examine boundary construction, and to look at what SEAD practitioners and stakeholders consider “good.” What counts as a quality project, and who counts as an appropriate practitioner? In Chapter 3, I analyze descriptions of SEAD projects, some ICAT-based and others drawn from an inter-university network, to identify four SEAD values: transdisciplinarity, impact, newness, and useful art. Through examining practitioners’ statements about belonging in SEAD, I then identify connections between these values and individuals’ senses of belonging, and struggles to belong. I show how these challenges with defining values and belonging result from researchers’ simultaneous desire to exist outside of disciplinary structures and to enjoy the comfort of a discipline-like “home.”

Chapter 4 – Measurable Impact: Seeking Legitimacy through Assessment

Measurable impact describes the need for SEAD researchers and instructors to evaluate and communicate the quantifiable benefits of their work. In Chapter 4, I draw from participant observation of assessment in several contexts, including ICAT’s Instrument Maker Camps and the Institute’s own five-year review, to discuss what the emphasis on quantification and measurement means for SEAD and its participants. I argue that researchers aspire to use assessment as a means of demonstrating the value and legitimacy of their transdisciplinary work, institutes, and movement. However, they struggle to assess various aspects of SEAD when accepted metrics do not fit their goals.

Chapter 1

Transformational Institutions: Competing Visions of Change in the SEAD Institute

In October 2016, ICAT's director, administrative staff, and faculty fellows met for their regular biweekly consultation on the state of the Institute and its upcoming events. The meeting's main topic of conversation was ICAT Day, the annual public showcase of the Institute's work, and a conference on entrepreneurship that would take place in the same building at the same time. As they had been in previous years, the faculty were concerned with presenting an exciting and representative public face of ICAT to the local community. But this time they were also worried about how the Institute's event would interact with the entrepreneurship conference, which ICAT had a hand in planning.³¹

The conversation moved back and forth between discussing a theme for ICAT Day, selecting exhibitors for an accompanying six-week gallery show, and suggesting activities and participants for the conference. At times, many of the participants were confused about the distinctions between the events, and asked questions about the purposes of all three. Was the conference primarily about making money, or was it meant to showcase the work of Virginia Tech's faculty and students? Similarly, what was the intention of ICAT Day? What could ICAT accomplish with a longer-term gallery show, and what were their aims for the single-day event? What was the relationship between "innovation" and "entrepreneurship," and how did these ideas connect to all three events?

Discussions ensued about performances, artist talks, potential panelists, and the website "We Make Money Not Art."³² Perhaps, suggested one faculty member, the events were all part of the same continuum. ICAT Day and the gallery exhibition might

³¹ Field notes, Senior Fellows Meeting, October 17, 2016.

³² Régine Debatty, "We Make Money Not Art," <http://we-make-money-not-art.com/>, accessed September 27, 2018.

represent “imagination to innovation,” while the conference would showcase the next step, “innovation to entrepreneurship.” But other participants rejected this characterization. Frustrated at the lack of resolution, the faculty member with the largest hand in organizing the conference tabled the discussion. “Send me your crazy ideas,” he suggested, and he would try to put together something that worked.

This discussion, which took place five years after ICAT was founded and three years after the Institute moved into its home in the Moss Arts Center, is emblematic of many similar conversations that occurred among ICAT’s faculty and staff, and among representatives of other universities within a2ru and the SEAD Network, between 2013 and 2017. Even after years of experience funding projects and coordinating transdisciplinary research, participants in SEAD institutions often struggle to define and articulate the goals of their institutions and events.

In this chapter, I argue that the competing motivations upon which SEAD is built are in large part responsible for the difficulties that participants face in defining their work and their organizations. I explore the ongoing construction of SEAD institutions and their associated visions of change, by telling the story of how ICAT came to be. I show how different groups and individuals – high-level administrators, transdisciplinary faculty, educational reformers, and innovation advocates – shaped ICAT, building an institute that is both intensely local and representative of national trends. The differences between these groups and their specific approaches led to tensions that became an inherent part of the institute they created.

Visions of Change

Virginia Tech formally established ICAT in the fall of 2011, following a decade of growth in university-based organizations that occupied the intersections of science, engineering, art, and design. The SEAD Network was founded that same year, and a2ru came into existence in 2012. Arizona State University's School of Arts, Media, and Engineering was seven years old in 2011, and the University of Michigan's Arts Engine had been founded one year earlier. Other, similar institutions dedicated to promoting innovation through creativity and interdisciplinarity were founded in the years immediately following ICAT.³³

SEAD institutions have been founded by different groups of people with wide-ranging motivations. At ICAT, one group included high-level administrators who sought new ways to overcome funding shortfalls, expand research outputs and corporate partnerships, and (re-)connect the university to its community. Another consisted of faculty with strong connections to or interest in the arts, whose passion for working across disciplinary boundaries – or disregarding these boundaries altogether – led them to pursue collaborative art-technology work that challenged traditional notions of research. A third group were researchers and educators dedicated to reforming education, particularly in the K-12 realm. They advocated for creativity and critical thinking alongside new pedagogical approaches. Finally, other administrators and faculty were committed to a new conception of innovation as the output of collaborative problem-solving, and as an essential product of modern research universities. Transformation was

³³ See table in the introduction to this dissertation. In 2013, the University of Southern California opened the Iovine and Young Academy for Arts, Technology, and the Business of Innovation. That same year, Louisiana State University founded enOvation, a joint initiative of the College of Music and Dramatic Arts and the College of Engineering.

at the core of these diverse outlooks: all were visions of change for American higher education in terms of external partnerships (financial and otherwise), research, education, and innovation.

Researchers, educators, and administrators at ICAT shared a belief that transdisciplinarity and arts integration would help bring about these transformations. However, their individual motivations and understandings of what these transformations should be varied considerably. Their collective belief in the potential of transdisciplinarity is the basis for the vision of SEAD, whose advocates hold that working in groups across disciplinary boundaries can produce important and innovative research, that education can be improved by incorporating arts practices and design into curriculum, and that the arts are vital to the future of universities. These understandings of the value of transdisciplinarity and the arts reside within larger discourses on the role of the modern American (land-grant) university; the nature of art-technology collaboration; the meaning and purpose of academic disciplines; and the economic, political, and cultural necessity of innovation. But stakeholders' differing individual motivations complicate the process of institution-building.

ICAT and its sister institutions are nodes at which people and their related, and sometimes conflicting ideas come together. When faculty and administrators attempt to build an institution that will realize their goals, their competing desires clash and result in tensions. And when those institutions are dedicated to transformation, as many SEAD institutions are, competing individual visions also oppose existing university structures and practices. SEAD institutions are attempts to coalesce these desires into single organizations. They are efforts to substantiate a set of multifaceted vision that may be

internally contradictory, and frequently challenges the status quo. These contradictions and challenges are at the heart of the transdisciplinary dilemma.

ICAT as a Transformational Institution

When I arrived at Virginia Tech in the fall of 2013, ICAT was two years old, about to move into a new building, and obsessed with establishing an identity. Conversation at faculty meetings dwelled on the problem of differentiating ICAT from its neighbor, the Center for the Arts, and researchers worried about how best to use the new building's opening week events to present ICAT's public face. ICAT's stakeholders expressed their ideas about identity by recounting the young Institute's origin story. I heard several versions of the story, some at public ribbon-cutting events and others in more private meetings or interviews. Some narratives involved small teams of researchers coming together organically to work on collaborative projects, and persisting despite financial and bureaucratic adversity. Others touted an administrative vision for ICAT, an organization that had been designed to transform the way teaching and learning happen. The different stories echoed ICAT stakeholders' counterparts at other US-based SEAD institutions, who similarly chronicle the development of their own institutions alternately as individual efforts rooted in curiosity and perseverance, and as top-down, administrator-led initiatives.³⁴

³⁴ Presenters at the November 2015 a2ru conference discussed how their transdisciplinary work stemmed from their own needs ("I reached out to artists to help me communicate to different audiences"; "I needed a way to raise awareness") while others referenced the need for "entrepreneurial faculty" to support a bottom-up approach to SEAD work (Field notes, a2ru National Conference, Virginia Tech, November 2015). Others at the same conference noted the importance of top-down administrative initiatives, which some institutions' public histories are quite open about, e.g. ASU (<https://artsmediaengineering.asu.edu/about/history>) and University of Illinois (<http://edream.illinois.edu/about>).

As I began to conduct interviews and delve into ICAT’s history, the relationships between different narratives emerged, as did their complexity. Individual collaborations did form the original core of the Institute’s research and engagement work; however, there were larger forces at play in the institutionalization of SEAD at Virginia Tech. Administrators and researchers built ICAT over two decades as a local response to far reaching changes in American higher education. They were also compelled by personal motivations, attempting to develop a place that would welcome the type of work they wanted to engage in. In creating ICAT, they also constructed a vision of what they each believed Virginia Tech – and other universities in the United States – should become.

The image below, created around the time I arrived at ICAT, demonstrates ICAT’s mission and ideals. Three equally-sized blocks represent the land-grant university’s tripartite mission of research, education, and engagement. The central, colorful diamond image places SEAD and transdisciplinarity at the nexus of the Institute’s work. Finally, an arrow from “imagination” to “innovation” suggests a linear relationship between the two quantities, and positions ICAT as a place that, in all of its pursuits, produces innovation.

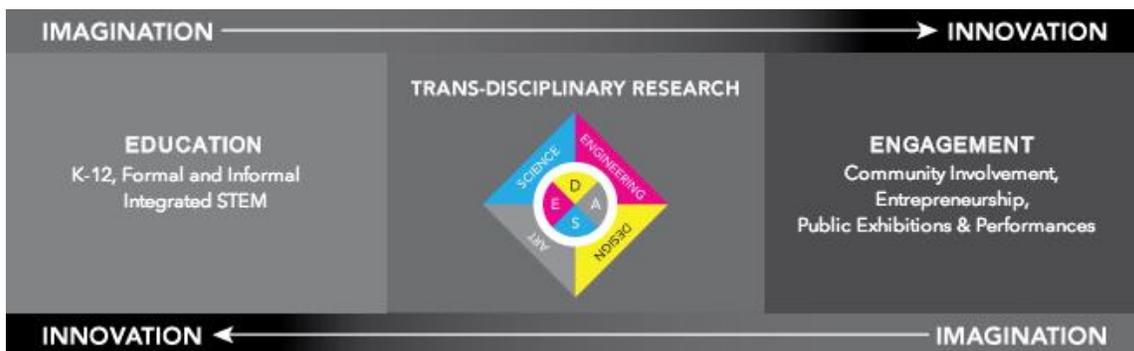


Figure 2.1: ICAT’s transformative mission. Image courtesy of the Institute for Creativity, Arts, and Technology. Used with permission.

Importantly, those involved in the creation of ICAT built (and continue to build) an institution at the same time that they help to construct the idea of SEAD. They simultaneously developed a vision and instantiated that vision in roles, materials, spaces, practices, and policies. To theorize this concurrent creation of organizations and ideas, I draw from literature on sociotechnical imaginaries, infrastructure studies, and boundary organizations.

Participants in SEAD, who reside mostly in academia but include representatives from industry and government, envision SEAD as a transformative work in progress, a space that can “at once describe attainable futures and prescribe futures that...ought to be attained.”³⁵ In this sense of SEAD as a techno-social vision of an imagined future, Jasanoff and Kim’s conception of sociotechnical imaginaries – “imagined forms of social life and social order reflected in the design and fulfillment of scientific and/or technological projects” – is an appropriate touchstone.³⁶ In other ways, however, the language of sociotechnical imaginaries is too grand for the developing vision of SEAD. The institutions which commonly feature in analyses of sociotechnical imaginaries are rarely emergent, nor as minor as a university research institute. They are instead federal ministries, national technology councils, and offices of science policy which have the weight and authority to contribute to visions of the future by stabilizing and publicly performing them.³⁷ Furthermore, sociotechnical imaginaries are national phenomena. Even when an analysis attaches the framing of imaginaries to a local issue, the imaginaries in question are national visions, reliant on shared cultural and political

³⁵ Sheila Jasanoff and Sang-Hyun Kim, “Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea,” *Minerva* 47, no. 2 (2009): 119–46.

³⁶ Jasanoff and Kim, 120.

³⁷ Sheila Jasanoff and Sang-Hyun Kim, eds., *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015).

contexts, that influence local activity.³⁸ Most importantly, however, the vision of SEAD is only collective in a superficial sense. Its individual component goals and motivations are a vital part of its nature. I therefore see SEAD, at most, as part of a potential imaginary in the making. Nonetheless, the description of people working to bring about a collective vision, and in the process creating both materials and ideas together, is vital to my study of institution-building.

The materiality that features in the discussion of sociotechnical imaginaries is just as consequential to infrastructure studies. STS work on infrastructure spans physically diverse examples including large technical systems such as electricity networks, built infrastructures including roads and bridges, and information systems like the Internet. Susan Leigh Star and Karen Ruhleder provide a detailed list of infrastructure's dimensions that include its embodiment of standards, links with conventions of practice, and the condition of becoming visible when it fails, while Stephen Slota and Geoffrey Bowker give a more recent, intentionally simplistic formulation of infrastructure as "the prior work...that supports and enables the activity we are really engaged in doing"³⁹ Infrastructure studies emphasize the "fundamentally and pervasively political" function of materials, standards, and policies that go unnoticed by most people and generally do not need to be reconsidered before beginning work. And infrastructures, too, are related to visions of the future: Brian Larkin argues that they "encode the dreams of individuals

³⁸ See e.g. Weston M. Eaton, Stephen P. Gasteyer, and Lawrence Busch, "Bioenergy Futures: Framing Sociotechnical Imaginaries in Local Places," *Rural Sociology* 79, no. 2 (June 2014): 227–56.

³⁹ Susan Leigh Star and Karen Ruhleder, "Steps towards and Ecology of Infrastructure: Design and Access for Large Information Spaces," *Information Systems Research* 7, no. 1 (1996): 111–34; Stephen C. Slota and Bowker, Geoffrey C., "How Infrastructures Matter," in *The Handbook of Science and Technology Studies*, ed. Ulrike Felt et al., 4th ed. (Cambridge, MA: MIT Press, 2016), 529.

and societies and are the vehicles whereby those fantasies are transmitted and made emotionally real.”⁴⁰

The work of building an institution requires creating new infrastructures, and reckoning with existing ones. Both infrastructures and institutions include materials, rules, policies, standards, practices, and connections between all of these categories. But institutions also care deeply about their identities. Rather than fading into the background until their structures break down, they are concerned with defining themselves and communicating these definitions to people. Their politics are sometimes embedded and invisible, but often very public. The work of building SEAD is deeply, though not entirely, infrastructural. Infrastructure studies challenges researchers to pay attention to the mundanity of institutions alongside their shiny public faces, and as Star has called on us to do, study the “boring things” as well as the exciting ones.⁴¹

Finally, it is important to consider the relationship of SEAD institutions to boundary organizations. David Guston’s definition of boundary organizations brings together Star and Griesemer’s concept of boundary objects with principal-agent theory drawn from political science to describe the activities and relationships of science policy

⁴⁰ Brian Larkin, “The Politics and Poetics of Infrastructure,” *Annual Review of Anthropology* 42 (October 2013): 333.

⁴¹ Susan Leigh Star, “The Ethnography of Infrastructure,” *American Behavioral Scientist* 43, no. 3 (1999): 377–391.

organizations.⁴² Others have extended the concept beyond official policy agencies to analyze other spaces where scientists and laypersons interact.⁴³

Institutions like ICAT are not boundary organizations by Guston's definition. They are not a part of the public policy realm that the term typically connotes. More importantly, they interact with more than two social worlds, and these worlds often overlap one another. SEAD institutions lack the "definite lines of responsibility and accountability" that clearly distinguish their constituent communities from one another, and their actors cannot always be categorized as principals, agents, or mediators. However, John Parker and Beatrice Crona's study of boundary organizations within research universities yields important insights for the study of institutions like ICAT.⁴⁴ In their analysis, they show how university-based boundary organizations exist in "a continuous process of negotiating among tensions derived from inconsistent demands placed on the boundary organization by different stakeholders."⁴⁵ They argue that members of successful boundary organizations view boundary management as an ongoing negotiation rather than an achievement, and that stability, when reached, is tenuous, specific, and temporary. SEAD institutions demonstrate this state of continuous negotiation, and the necessity of managing competing demands from stakeholders with varying levels of power and influence.

⁴² David Guston, "Stabilizing the Boundary between US Politics and Science: The Role of the Office of Technology Transfer as a Boundary Organization," *Social Studies of Science* 29 (1999): 87–111; David Guston, "Boundary Organizations in Environmental Policy and Science: An Introduction," *Science, Technology & Human Values* 26, no. 4 (2001): 299–408; Clark Miller, "Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime," *Science, Technology, & Human Values* 26, no. 4 (2001): 478–500.

⁴³ Anna Carr and Roger Wilkinson, "Beyond Participation: Boundary Organizations as a New Space for Farmers and Scientists to Interact," *Society and Natural Resources* 18, no. 3 (2005): 255–65.

⁴⁴ Parker and Crona, "On Being All Things to All People: Boundary Organizations and the Contemporary Research University."

⁴⁵ Parker and Crona, 267.

ICAT aspires to be a *transformational institution*. It is a collection of materials, people, and ideas that attempt to simultaneously create and instantiate a vision of change. If realized, this vision would affect fundamental aspects of the environment in which it exists: the American research university. The vision of SEAD is collective and future-oriented, and has many proponents who work to make it a reality. But SEAD is also complex, with constituent groups motivated by different goals and subject to demands from a wide array of partners. Building a vision requires building infrastructures to support it, which often clash with existing structures and practices. The individual motivations of SEAD and ICAT stakeholders challenge the very idea of institution-building. By studying ICAT, I draw conclusions about how this vision developed, how it affects its stakeholders, and where it may be headed. In this chapter, I examine the origins of SEAD by exploring the origins of ICAT, locating the Institute's roots in different group's responses and contributions to broad discourses of transformation in higher education, the practice of research and teaching, and the nature of innovation.

Transforming Universities

The first group in our story consists of high-level university administrators responding to economic and cultural transformations in American higher education. As state and federal funding for higher education decreases, universities increasingly turn to inter- and transdisciplinarity as a strategy to engage new stakeholders, including those from industry, and to enhance the research profiles of their institutions. While large research universities' focus on interdisciplinarity does not necessarily or even usually include the arts, administrators sometimes attempt to use their interdisciplinary initiatives to identify

appropriate roles for the arts on their campuses, and to engage members of their local communities. At Virginia Tech, university leaders sought to emphasize interdisciplinarity in order to produce societally-relevant research outputs and turned to art-technology work in particular, in part to find a home for the arts at their technology-dominated university.

Beginning in 1980, the Commonwealth of Virginia drastically reduced funding levels for state institutions of higher education, echoing reductions in government support for universities around the country and internationally.⁴⁶ Throughout the 1980s and 1990s, changes in funding structures and an increasingly globalized economy gave rise to both new kinds of government-university-industry relationships and significant changes in academic labor.⁴⁷ By the mid-1990s, when the State Council for Higher Education for Virginia (SCHEV) once again recommended less state funding and stricter standards, but also increased enrollment, for public universities, Virginia Tech administrators knew they needed to react to the changes.⁴⁸

Over roughly the same time period, administrators at public and land-grant universities were dealing with criticism of their institutions' lack of relevance. The US federal government created land-grant universities in the mid-nineteenth-century with

⁴⁶ David Breneman stated in 1993 that changes in funding patterns were not an aberration but a “new reality.” David W. Breneman, “Higher Education: On a Collision Course with New Realities” (Boston, MA: American Student Assistance, December 1993); Thomas G. Mortenson, “State Funding: A Race to the Bottom,” *American Council on Education*, Winter 2012, <http://www.acenet.edu/the-presidency/columns-and-features/Pages/state-funding-a-race-to-the-bottom.aspx>; Henry Etzkowitz and Loet Leydesdorff, “The Endless Transition: A ‘Triple Helix’ of University-Industry-Government Relations,” *Minerva* 36 (1998): 203–208; Michael Gibbons et al., *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* (London: Sage, 1994).

⁴⁷ Sheila Slaughter and Larry L. Leslie, *Academic Capitalism: Politics, Policies, and the Entrepreneurial University* (Baltimore and London: The Johns Hopkins University Press, 1997).

⁴⁸ Virginia Tech Governance Minutes Archive, November 17, 1993. <https://spec.lib.vt.edu/minutes/cgs/1993/November+17++1993.html>.

community engagement in mind, to promote the “education of the industrial classes.”⁴⁹ By the 1980s, critics feared that land-grant universities had lost their relevance by moving too far from their original priorities.⁵⁰ While most land-grant schools began as agricultural and mechanical colleges, many, including Virginia Tech, became comprehensive public universities in the mid-20th century. These structural changes came with shifts in scale and purpose, as universities looked outward to constituencies beyond the state.⁵¹

Scholars cited the widening gap between society and cutting edge knowledge, along with declines in state funding, as they lamented the temptation for land-grant institutions to follow research money into an academic world increasingly removed from local contexts.⁵² Several critics, including agricultural economist Edward Schuh, focused their attacks on entrenched disciplinarity. Academic disciplines, Schuh argued, were antithetical to the land-grant mission. Furthermore, land-grant universities were uniquely positioned to teach across disciplines and provide the kind of “liberal, comprehensive, and humane learning” that could produce students who would fill the knowledge-society gap.⁵³

⁴⁹ “Act of July 2, 1862 (Morrill Act), Public Law 37-108,” July 2, 1862, Enrolled acts and resolutions of congress, 1789-1996; Record group 11; General records of the United States government, National Archives.

⁵⁰ Harold L. Enarson, *Revitalizing the Land-Grant Mission* (Blacksburg, VA: Virginia Polytechnic Institute and State University, 1989).

⁵¹ James T. Bonnen, “The Land Grant Idea and the Evolving Outreach University,” in *University-Community Collaborations for the Twenty-First Century: Outreach to Scholarship for Youth and Families*, ed. Richard M. Lerner and Lou Anna K. Simon (Hamden, CT: Garland Publishing, 1998).

⁵² Wallace E. Huffman et al., “Winners and Losers: Formula versus Competitive Funding of Agricultural Research,” *Choices: The Magazine of Food, Farm, and Resource Issues*, 2006, <http://www.choicesmagazine.org/2006-4/grabbag/2006-4-13.htm>.

⁵³ G. Edward Schuh, “Revitalizing Land Grant Universities: It’s Time to Regain Relevance,” in *College of Agriculture “Year of the Scholar” Lecture Series* (Faculty Seminar, Columbus, OH: Ohio State University, 1986), 7.

In 1996, the National Association of State Universities and Land-Grant Colleges (NASULGC, later re-named the Association of Public and Land-Grant Universities) convened the Kellogg Commission in response to these concerns. The Commission’s reports, which would prove influential beyond the constituency of land-grant universities, proposed meeting the economic and societal deficits of its member institutions through commercialization, community engagement, and interdisciplinary research.⁵⁴ The Commission argued that promoting “engagement” as a reinterpretation of the land-grant “extension” mission could help close the gap between universities and a changing society, as could investment in interdisciplinary research. “Although society has problems,” the Commission wrote dismissively, “our institutions have ‘disciplines’.”⁵⁵

As NASULGC convened the Kellogg Commission, Virginia Tech published a five-year strategic plan that responded to decreases in state funding, and foreshadowed the Commission’s report in calling for the university to reconnect to its community and reengage with society.⁵⁶ The 1996 plan neglected to mention the arts, and mentioned interdisciplinarity only in passing. However, administrative changes in the early 2000s would lead to a clear emphasis on interdisciplinary research and the arts, led by a group of administrators including President Charles Steger and senior administrator Minnis Ridenour.

When Steger became president of Virginia Tech in 2000, the university was reckoning with two decades of decreases in state financial support. Steger had an

⁵⁴ Howard P. Segal, “Reengineering the Land-Grant University,” in *Engineering in a Land-Grant Context: The Past, Present, and Future of an Idea*, ed. Alan I. Marcus (West Lafayette, IN: Purdue University Press, 2005), 137–61.

⁵⁵ Kellogg Commission on the Future of State and Land-Grant Universities, “The Engaged Institution,” *Returning to Our Roots* (Association of Public and Land-Grant Universities, 1999), 9.

⁵⁶ Virginia Polytechnic Institute and State University, “Strategic Directions, 1996-2001,” *Updating the University Strategic Plan 2001*, accessed September 27, 2018, <https://www.reports.president.vt.edu/stratplan2001/stratdirections.html>.

interdisciplinary background, including a Master's degree in architecture and a PhD in Environmental Science and Engineering, and ambitions for Virginia Tech to become one of the top thirty American research universities. To accomplish this in the face of government funding cuts, pressures to increase enrollment, and critics decrying the lapse of land-grant universities' community engagement, Steger promoted interdisciplinary research and investment in the arts.

The 2001 Strategic Plan, Virginia Tech's first of the Steger era, was explicit in its recognition of new monetary realities, arguing that "the structure of higher education in America is at the beginning of a significant transformation. There is underway a financial restructuring not unlike what has happened in business during the past decade."⁵⁷ The Plan's specific goals included increasing interdisciplinary research and scholarship, establishing "new revenue allocation schemes" that would "reward innovation and risk-taking," and strengthening the "relationship between outreach and extension." In other words, interdisciplinarity could enable corporate partnerships, allow for new revenue streams, and help to increase the university's profile. Interdisciplinarity, administrators argued, was necessary in order for the university to advance.

Interdisciplinarity similarly emerged as a way to re-establish a place for the arts on campus. In the same Strategic Plan, Steger argued that a renewed focus on the arts would broaden the scope of Virginia Tech's scholarly output and open up the university to a new crop of students who sought comprehensive and varied programs of study.⁵⁸ Virginia Tech would create more and better graduate programs in the arts and humanities.

⁵⁷ Virginia Polytechnic Institute and State University, "Virginia Tech Strategic Plan," Updating the University Strategic Plan 2001, accessed September 27, 2018, <https://www.reports.president.vt.edu/stratplan2001/index.html>.

⁵⁸ Virginia Polytechnic Institute and State University.

The university's Board of Visitors (BOV) begins to discuss plans for a new state-of-the-art performing arts center, and talked about building "learning communities" that would be modelled on the design studio.⁵⁹

In 2005, the BOV launched the Arts Initiative, a group of administrators led by Ridenour, tasked with developing and expanding Virginia Tech's arts offerings. Ridenour worked with a group of public administration graduate students to imagine a role for the arts at their "technology-grounded university." Their vision of a traditional, community-engaged arts center combined with a research institute dedicated to the arts and technology became the first concept for the Center for the Arts and ICAT.⁶⁰

In a 2007 report, President Steger introduced the BOV to the Arts Initiative along with his reasons for committing the university to studying and promoting the arts.⁶¹ Firstly, the arts would significantly contribute to "helping young people develop a set of values" and to develop intellectual maturity, both important general functions of a university. Second and more practically, an expanded arts presence would draw "sophisticated" students whose broad interests would not lead them to study at a school with a narrow focus. The arts would also add economic value to the community and "richness to the daily lives of people in the region." Alongside this, Virginia Tech's

⁵⁹ Virginia Polytechnic Institute and State University, "Learning Communities", 2001, p. 25.

⁶⁰ Interview with Minnis Ridenour, 2015. "I took this concept to my graduate students and asked them to think about our university, which had not a strong presence in the arts. We had, you know, some interest in the arts but being a technology grounded-university in some sense, how would they envision an arts center for this campus? What you see today is really the results of [our team] conceptualizing the center for the arts with ICAT." Then-provost Thanassis Rikakis echoed this sentiment in a speech at the 2015 a2ru conference, hosted by Virginia Tech, where he stated that the future of the arts and humanities lay in collaborating with science and engineering, and used ICAT as an example of the potential for the arts to connect to the "full ecosystem of the university." (Field notes, a2ru National Conference, Virginia Tech, November 2015)

⁶¹ Virginia Tech Board of Visitors, Meeting Minutes, August 27, 2007, p.11-12.

partnerships with regional public schools, and the quality of the school systems themselves, would be strengthened.

At the same 2007 meeting, the board approved a request for the state 2008-2010 Appropriations committee, including funding for a Center for Creative Technologies in the Arts (CCTA). The proposal for the state government focused on the Center's potential to enrich K-12 learning, with the Arts Initiative describing the CCTA as a "necessary space to create new applied learning models through the merger of arts and technology."⁶² The Center would leverage the arts with Virginia Tech's existing strengths in technology and education to strengthen learning environments in regional elementary and high schools, and provide arts and culture programming to the broader community. It would also demonstrate the university's broad research portfolio, and show that Virginia Tech was "as strong in its creative enterprises as in its technology ventures." The proposal requested an annual budget of \$2.1 million, which included some one-time equipment costs, with a plan to grow to an annual \$4.8 million base budget. The Center would support 19 full-time faculty devoted to research.

The concept for the CCTA brought together an emphasis on interdisciplinary research and a targeted effort to (re-)engage the local community and schools through the arts. These two ideas were initially separate: interdisciplinary research would attract economic resources and increase the university's rankings, while a focus on the arts would respond to state-issued goals to engage in K-12 education and locate an appropriate place for the arts on a technology-dominated campus. Both interdisciplinarity and the arts might attract new kinds of students to the university. Administrators including Steger and Ridenour brought these two strategies together, laying the

⁶² Virginia Tech Board of Visitors, Meeting Minutes, August 27, 2007.

groundwork for ICAT by advancing interdisciplinarity and the arts as a way to revitalize the university.

Transforming Research

As administrators' efforts brought attention to interdisciplinarity and the role of the arts on campus, individual researchers saw opportunities to engage in types of work that they had limited opportunity to conduct elsewhere. Art-technology collaborations have evolved to increasingly produce researchers who identify as inter- or transdisciplinary, or who reject the confines of disciplines altogether. Within universities, these transdisciplinary faculty members typically balance ties to a "home" academic department with their practical and ideological interest in collaborating with others across the university, or in doing work themselves that falls outside the traditional boundaries of their discipline. Founded in the mid-2000s, Virginia Tech's Collaborative for Creative Technologies in the Arts and Design (CCTAD) gave transdisciplinary researchers the change to help shape ICAT's early research agenda.⁶³

Historical accounts of American art-technology collaboration trace the movement's modern beginnings to the mid-twentieth-century. In the 1960s and 70s, artists, scientists, and engineers pursued "aesthetic virtue" through collaboration, as "creativity" became a means through which to achieve a desirable society.⁶⁴ These motivations manifest in organizations such as Experiments in Art and Technology (E.A.T.) and MIT's Center for Advanced Visual Studies (CAVS), which emphasized the

⁶³ Although they were founded around the same time and have frustratingly similar acronyms, CCTAD (Collaborative for Creative Technologies in the Arts and Design) should not be confused with the CCTA (Center for Creative Technologies in the Arts).

⁶⁴ Wisnioski, "Why MIT Institutionalized the Avant Garde: Negotiating Aesthetic Virtue in the Postwar Defense Institute."

role of the artist, facilitated individual collaborations, and used technology and engineering know-how to create cutting-edge contemporary art.

In the 1980s and 90s, art-technology collaborations began to prioritize research and innovation. At MIT, the Media Lab displaced CAVS as the university's flagship creative technology institute. Its outputs aspired towards revolutionary consumer products rather than art pieces, and artist's roles were secondary to those of design engineers, human-computer interaction researchers, and other "innovators."⁶⁵

Researchers and CEOs identified links between commerce and creativity, culminating in the creation of artist-in-residence programs such as Xerox PARC's PAIR and corporations like Paul Allen and David Liddle's Interval Research.⁶⁶

Smaller, more academic art-tech efforts began to pick up in the early 2000s, just as PAIR and Interval shut down and reports lamented a lack of institutional support for art-tech in the United States.⁶⁷ Still, invested observers like Michael Naimark, a new media artist who had worked at Interval, and art historian Edward Shanken criticized the state of the American art-tech world as compared to Europe, where, they argued, governments and universities recognized the potential of technology-based art and supported it through organizations like Austria's Ars Electronica and the UK National Endowment for Science, Technology, and the Arts, as well as artists-in-labs programs at the Hochschule für Gestaltung und Kunst Zürich.⁶⁸

⁶⁵ Wisnioski and Zacharias, "Sandbox Infrastructure: Field Notes from the Arts Research Boom."

⁶⁶ Michael Naimark, "Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability," 2003.

⁶⁷ See e.g. Jill Scott, *Artists in Labs: Processes of Inquiry* (Vienna, Zurich, New York: HGK, 2006); Hans Ulrich Obrist and Barbara Vanderlinden, *Laboratorium* (Antwerp: Dumont, 1999).

⁶⁸ Naimark, "Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability"; Shanken, "Artists in Industry and the Academy: Collaborative Research, Interdisciplinary Scholarship, and the Creation and Interpretation of Hybrid Forms."

The longed-for institutional support emerged in the United States in the mid-2000s, coinciding with university moves toward interdisciplinary and arts integration. Over the fifteen years following the publication of the Kellogg Commission report, the number of interdisciplinary centers and institutes at public and land-grant universities has skyrocketed.⁶⁹ Many of these initiatives include efforts to bridge the arts and technology, and most echo the Kellogg Commission's call for engaged, entrepreneurial, interdisciplinary work.⁷⁰ Private universities outside of the land-grant system also produced work that adhered to values of collaboration, creative innovation, and community engagement through arts integration.⁷¹

CCTAD began as part of the administrative effort to define a new role for the arts at Virginia Tech. As Ridenour and his Arts Initiative team had proposed, the new arts programs would not be traditional. A focus on technological art would align the art school with the university as whole, and allow for increased engagement across disciplinary boundaries. The restructuring that ensued as the School of Visual Art and School of Performing Arts were created and the previous departments/colleges dissolved

⁶⁹ See table in the introduction of this dissertation. Other examples are listed in Naimark, "Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability"; Shanken, "Artists in Industry and the Academy: Collaborative Research, Interdisciplinary Scholarship, and the Creation and Interpretation of Hybrid Forms."

⁷⁰ ASU's School of Arts, Media, and Engineering, for example, trains students to become "thought leaders" in a complex digital world ("Welcome to the School of Arts, Media, and Engineering," Arizona State University, <https://artsmediaengineering.asu.edu/>, accessed 05-05-2016.) The Institute for Applied Creativity at Texas A&M University explores critical societal problems through collaboration ("About," Texas A&M University Institute for Applied Creativity, <http://creativity.arch.tamu.edu/>, accessed 05-05-2016.) Louisiana State University's Laboratory for Creative Arts and Technologies has established an animation festival that is both an economic development project and an outreach initiative ("LCAT," Louisiana State University Center for Computation and Technology, <https://www.cct.lsu.edu/research/cultural-computing/lcat/>, accessed 05-05-2016.)

⁷¹ Carnegie Mellon University's Frank-Ratchye STUDIO for Creative Inquiry, which in 2015 hosted the p5js Contributors Conference, at which participants worked on outreach and diversity issues related to an open-source programming environment ("p5js Contributors Conference," Carnegie Mellon University Frank Ratchye STUDIO for Creative Inquiry, <http://studioforcreativeinquiry.org/projects/p5jscon>, accessed 05-05-2016.)

was an attempt to render the fine arts both more “beneficial” and increasingly technological.⁷² A 2005 cluster hire began CCTAD, bringing several young faculty members on board who had experience and interest in collaborative, transdisciplinary art-tech work.

The cluster hire saw visual artist Dane Webster join Virginia Tech in the fall of 2005. Ico Bukvic (Music) and Yong Cao (Computer Science) were hired the following year. Under the direction of Art and Art History Department Chair Truman Capone, Webster, Bukvic, and Cao joined Steve Harrison (Computer Science), who had come to Virginia Tech in 2003 after 17 years at Xerox PARC, and Paul Harrill, a faculty member in Communication, as core members of CCTAD. Department heads and senior faculty acted as a bridge between these researchers and senior administrators.

The new hires were interdisciplinary artists and hybrid researchers. Webster had studied photography and was teaching at Kansas State University when he rekindled an early interest in animation, which he began to teach to interested students on the side. Bukvic received his DMA from the University of Cincinnati’s College Conservatory of Music, where he had taught courses in computer music composition as well as Linux and multimedia. Cao was a computer scientist who worked for the video game company Electronic Arts after completing his PhD.

Together, the Collaborative taught courses and began to pursue their interdisciplinary research agendas. Led by Harrison, CCTAD faculty taught a Cyber Arts Studio course in 2006, wherein they took turns presenting their own work to the class and advised interdisciplinary student teams on their collaborative projects. The course

⁷² Somewhat at odds with the high-minded valuations of the arts that Steger often expressed, the 2001 Strategic Plan also stated that “while there is joy in the discovery of knowledge for its own sake, Virginia Tech recognizes its bias toward the beneficial uses of knowledge.”

material drew “on expertise and practices in art, communications, music, and computer science.” Bukvic founded DISIS, the Digital Interactive Sound and Media Studio, which offered cutting-edge technology for research and education in music technology, and later established the world’s first Linux Laptop Orchestra.⁷³ Cao ran the Animation and Gaming Research Lab and, along with Webster, taught courses on video game design for students in art and computer science. CCTAD members also worked on collaborative projects including *Singing Darwin*, a multimedia installation and performance piece that celebrated the 150th anniversary of the publication of *On the Origin of Species*.

But despite administrative support, CCTAD faculty struggled with a lack of direction and organization. The goals of the Collaborative were unclear from the start, which was reflected in its job postings.⁷⁴ Once hired, researchers were unsure how much of their time could or should be devoted to CCTAD projects, and whether/how these projects would “count” as part of their research portfolios for their home departments. They struggled to complete projects and installations together, with a planned art museum project resulting in such conflict that one researcher described it as “one of the worst experiences of my professional career.”⁷⁵

Transforming Education

A second precursor organization shaped ICAT’s early projects along with CCTAD. The Integrated Design, Education, and Arts Studio (IDEAS), originally conceptualized as the

⁷³ “Digital Interactive Sound and Intermedia Studio,” accessed September 27, 2018, <http://disis.music.vt.edu/main/index.php>; “Linux Laptop Orchestra,” accessed September 27, 2018, <http://l2ork.music.vt.edu/main/>.

⁷⁴ Interview 3A, May 2014. “I remember when I read the job description and my wife said, what do you think about this position? I said, they have no idea who they want. This could be an artist or an aerospace engineer.”

⁷⁵ Interview 3A.

research arm of the CCTA, was a working group of researchers based in Virginia Tech's School of Education. IDEAS researchers' work was motivated by the Commonwealth of Virginia mandate for innovative approaches to K-12 education, and many of the faculty and students involved were former K-12 educators themselves. Their approaches to education echoed contemporary discourses on the importance of cross-disciplinary methods and pedagogies, and problem-based learning.

The rise of "interdisciplinarity" as an intellectual and pedagogical virtue parallels the evolution of art-technology collaborations. Interdisciplinarity in the natural sciences emerged in the United States as a post-WWII phenomenon, connected with ideals of creativity and connectivity for the betterment of society and a uniquely American conception of scientific unity.⁷⁶ The size and scope of problem-based technological research expanded at the same time, as large efforts such as the Manhattan Project brought together teams of engineers and scientists to execute a particular mission.⁷⁷ The term "interdisciplinary" remained ambiguous, however, and was applied to both grand theories of unified knowledge and practical approaches to solving specific problems.

Beginning in the late 1960s, government agencies and academics began to formalize their understandings of interdisciplinarity. Educational reformers saw the technologically grounded interdisciplinary work of the previous decades as a way forward for higher education. The Organization for Economic Cooperation and Development (OECD) sponsored a 1969 gathering of German, French, and American academics that in turn launched a 1970 conference and the subsequent publication of

⁷⁶ Jamie Cohen-Cole, "The Creative American: Cold War Salons, Social Science, and the Cure for Modern Society," *Isis* 100, no. 2 (2009): 219–262; Peter Galison, "The Americanization of Unity," *Daedalus*, 1998, 45–71; Jordi Cat, "The Unity of Science," in *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, Winter 2014, 2014, <http://plato.stanford.edu/archives/win2014/entries/scientific-unity/>.

⁷⁷ Klein, *Interdisciplinarity: History, Theory, and Practice*.

Interdisciplinarity: Problems of Teaching and Research in Universities.⁷⁸ The authors and conference attendees, who included university administrators as well as professors of law, mathematics, microbiology, and psychology, developed terminology for discipline-spanning work.⁷⁹ Their hierarchical model placed “traditional” disciplinary knowledge at the lowest level, followed by “multidisciplinarity” and then “interdisciplinarity,” which required that researchers adapt their own approaches to incorporate knowledge and practices from other disciplines. “Transdisciplinarity” remained a “dream” to the OECD conference participants, but Swiss psychologist Jean Piaget conceptualized it as a “higher stage” of knowledge that would succeed the interdisciplinary stage.⁸⁰

Following the OECD conference, discussions of interdisciplinarity and the university intensified in the United States. Two professional associations, the Association for Integrative Studies and the International Association for the Study of Interdisciplinary Research, were founded in 1979. Another major book, *Interdisciplinarity and Higher Education*, was published that same year following a seminar held at Pennsylvania State University.⁸¹ Finally, the OECD determined that interdisciplinarity “exogenous to the university” – the type which focused more on problem-solving than on the unity of science – deserved more attention. Historian Julie Thompson Klein holds that these

⁷⁸ Léo Apostel, ed., *Interdisciplinarity: Problems of Teaching and Research in Universities* (Organization for Economic Cooperation and Development, 1972).

⁷⁹ Guy Berger, “Part I: Opinions and Facts,” in *Interdisciplinarity: Problems of Teaching and Research in Universities* (Organization for Economic Cooperation and Development, 1972), 21–74.

⁸⁰ Jean Piaget, “The Epistemology of Interdisciplinary Relationships,” in *Interdisciplinarity: Problems of Teaching and Research in Universities*, ed. Léo Apostel (Organization for Economic Cooperation and Development, 1972), 127–39.

⁸¹ Joseph J Kockelmans, ed., *Interdisciplinarity and Higher Education* (University City, PA: Pennsylvania State University Press, 1979).

events happened more or less in isolation, though she argues that by the early 1980s, most of the individuals and organizations were at least aware of each other.⁸²

In the United States, problem-solving approaches to interdisciplinarity largely displaced earlier structuralist understandings. Problem-based research and curricula appeared in the natural sciences and engineering, and postmodernists pursued a humanistic interdisciplinarity that rejected the ideal of objectivity.⁸³ While some European scholars took up a systems-based approach that harkened back to the original OECD conference,⁸⁴ others presented descriptive accounts of how new, complex situations in science and society required “transdisciplinary” approaches that integrated scientific knowledge with other kinds of expertise to pursue practical solutions to critical problems.⁸⁵ The rhetoric of “transdisciplinarity” as engaged, “transcendent” interdisciplinary work soon reached the US as well, with the National Cancer Institute and the NSF promoting scientific discovery hand-in-hand with education and public policy.⁸⁶

By the mid-2000s, as CCTAD began, the university had defined an operating budget (\$50 million) for the arts center project, though they had not yet obtained the money. As planning and fundraising continued, the Arts Initiative included the CCTA in their proposal for the arts center. In 2007, an informal effort began in the School of

⁸² Klein, *Interdisciplinarity: History, Theory, and Practice*.

⁸³ Lisa R. Lattuca, *Creating Interdisciplinarity: Interdisciplinary Research and Teaching among College and University Faculty* (Nashville, TN: Vanderbilt University Press, 2001).

⁸⁴ Mittelstraß, “On Transdisciplinarity”; Basarab Nicolescu, *Manifesto of Transdisciplinarity*, trans. Karen-Claire Voss (Albany, NY: SUNY Press, 2002).

⁸⁵ e.g. discourses on “post-normal science” (Funtowicz and Ravetz, “Science for the Post-Normal Age”; Gibbons et al., *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*; Nowotny, Scott, and Gibbons, *Rethinking Science: Knowledge and the Public in an Age of Uncertainty*; Henry Etzkowitz and Loet Leydesdorff, “The Dynamics of Innovation: From National Systems and “Mode 2” to a Triple Helix of University–industry–government Relations,” *Research Policy* 29 (2000): 109–123.)

⁸⁶ Klein, “The Transdisciplinary Moment(um).”

Education to conceptualize an educational research arm for the CCTA. Following the desires of the state government, IDEAS research would focus on K-12 education. It would integrate cross-disciplinary approaches and the “real-world” problem solving that many advocates of transdisciplinarity cited as a main motivation for their work.

Liesl Baum, a former K-12 teacher and instructional designer, joined the team first as a graduate student and later as a post-doctoral researcher, working alongside other educational researchers including Kathy Cennamo and Phyllis Newbill. The CCTA was still in its “proof of concept” stage, and directives from the administration regarding its research mission were vague.⁸⁷ The team from the School of Education was tasked with doing foundational research to “understand better what is creativity, what is critical thinking,” both cornerstones of the plan for the CCTA.⁸⁸

By 2008, as the team entered their second year of working together, they dubbed their collaborative effort the Integrated Design Education and Art Studio. Baum finished her PhD that spring and was immediately hired as a full-time researcher. The School of Education began to offer Educational Enhancement Collaboration Grants: money to fund collaborative, interdisciplinary research that adhered to the methods of enhancing critical and creative problem-solving which the team had identified. The grants were offered to faculty who would work with local teachers on integrating art and design methods into their K-12 curriculum. Recipients of these grants included several core CCTAD faculty, as well as others like Simone Patterson of the School of Visual Arts and Chris Williams from Mechanical Engineering, both of whom later became key contributors to ICAT. Projects that sought to merge arts and engineering education through 3D printing, or

⁸⁷ Interview 2, April 2014. “We knew it was going to be something related to creativity...they knew it had something to do with education and they knew it had something to do with the arts.”

⁸⁸ Interview 2.

create a multimedia game that would introduce elementary school children to Tai Chi, reflected ideals of interdisciplinarity-as-problem-solving, and forged closer ties between researchers from IDEAS and CCTAD.

Researchers' individual interests and motivations played a pivotal role in creating ICAT and defining its research agenda. Webster, Bukvic, Baum, and a handful of others were the key individuals around whom the Institute developed, and from whose expertise ICAT would draw in its early years. Their own motivations for engaging in interdisciplinary art-technology work stemmed from personal interests, but also included a passion from transforming research, education, and outreach inside the university. Their collaborative work, in most cases, reflected the shift in the art-tech world away from "pure" artistic outcomes towards emergent research fields that combined art and design with science and engineering. Their emphasis on cultivating creativity, especially in the K-12 space, reflected an approach to collaborative, "real-world" problem-solving and knowledge creation that scholars of transdisciplinarity had discussed for decades. However, CCTAD and IDEAS were messy organizations. They were top-down initiatives that nonetheless suffered from a lack of direction. No one knew what CCTAD was "supposed" to be, nor how the IDEAS research would be used.

Transforming Innovation

The final important actor in ICAT's early history is R. Benjamin (Ben) Knapp, the Institute's director. Knapp was hired in 2011, after plans for the CCTA had been on the books for some time, and both CCTAD and IDEAS were established, if ill-defined, organizations. He brought with him an engineering sensibility, an emphasis on

innovation, and experience with interdisciplinary work in both industry and academia that helped shape ICAT's development. Knapp's contributions linked creativity with innovation and aspirations of research commercialization. He suggested that investment in SEAD is worthwhile because of the material outputs of art-technology research, but also – more importantly – because of the creative process it fosters among participants and students.

These expressions of the value of SEAD relate to shifts in the ways in which universities perceive innovation, and in the meaning of innovation itself. Popular understandings of the term “innovation” have radically transformed several times over. From its medieval origins connoting heresy or deviance, innovation evolved through mid-20th century shifts towards “creative destruction” and technological or organizational disruption, followed by a strong connotation of innovation and entrepreneurship.⁸⁹

For decades, innovation corresponded to successful technology transfer. Ideas would be developed, commercialized, and defused according to the so-called “linear model.” Universities were a vital part of this process. The Bayh-Dole Act of 1980 permitted universities to retain ownership of intellectual property that was developed on their federally-funded campuses (rather than ceding these rights to the government, as had been the case earlier, unless institutions negotiated Institutional Patent Agreements with the NSF or another government body).

Since Bayh-Dole, research commercialization has become an increasingly important topic in American higher education. Under the “managerial logic” of the

⁸⁹ See Benoit Godin, *Innovation Contested* (New York and London: Routledge, 2015); Joseph Schumpeter, *Capitalism, Socialism, and Democracy* (New York: Harper & Brothers, 1942). Innovation and entrepreneurship have become closely associated since the 1970s: see e.g. Peter F. Drucker, *Innovation and Entrepreneurship: Practices and Principles* (New York: Harper & Row, 1985).

1980s: “educational establishments would require reinvention as business entities.”⁹⁰ This occurred not just in the US, but in Europe as well.⁹¹ Universities sought to define a *process* that could not only improve their productivity but “explain and pattern success” in a replicable way.⁹² Innovation became the process, and a slew of university-industry partnerships developed to encourage it.⁹³

Elizabeth Popp Berman describes this growth of university-industry partnerships as a shift in the institutional logic of universities from a logic of science to a market logic.⁹⁴ In the 1990s, economists began describing universities as “multi-product firms” that would benefit from management techniques to aid processes of rational decision-making.⁹⁵ This, according to Berman, was more than simply a response to funding decreases. Governments encouraged universities to treat science as an economically viable product, while at the same time the concept of technoscientific innovation as an economic driver spread through the policy arena, eventually reaching universities as well. University-industry research centers, argues Berman, are a result of this shift to a market-based institutional logic. Berman also cites technological innovation as a driving force behind incentivizing interdisciplinary work. University initiatives including Arizona State University’s vision of the “New American University” similarly point to broader

⁹⁰ John Harpur, *Innovation, Profit, and the Common Good in Higher Education: The New Alchemy*, Issues in Higher Education (Basingstoke, Hampshire: Palgrave Macmillan, 2010), 13.

⁹¹ See e.g. Burton R. Clark, *Creating Entrepreneurial Universities: Organizational Pathways of Transformation* (Oxford: Pergamon Press, 1998).

⁹² Harpur, *Innovation, Profit, and the Common Good in Higher Education: The New Alchemy*, 175.

⁹³ Etzkowitz and Leydesdorff, “The Dynamics of Innovation: From National Systems and “Mode 2” to a Triple Helix of University–industry–government Relations.”

⁹⁴ Elizabeth Popp Berman, *Creating the Market University: How Academic Science Became an Economic Engine* (Princeton, NJ: Princeton University Press, 2012).

⁹⁵ Geraint Johnes, *The Economics of Education* (New York: St. Martin’s Press, 1993).

understandings of “innovation” than the technology-focused definitions of the 1980s and 90s.⁹⁶

A particular strand of contemporary innovation discourse cites an important connection between innovation and creativity. This approach relates to discourses on industry partnerships and interdisciplinarity in its emphasis on integrating multiple stakeholders; however, it is based in Silicon Valley and rooted in a unique combination of technological expertise and lingering countercultural influence.⁹⁷ The design firm IDEO and Stanford’s d.school have contributed to the popularity of “design thinking” approaches outside of traditional design environments. These techniques hold that creativity is the key to successful innovation, and, moreover, promise that anyone is capable of innovating if they can successfully unlock their inner creative.⁹⁸ Richard Florida’s description of a “creative class” similarly points to creativity as a driver of innovation and progress, but locates creativity within certain professions and character traits.⁹⁹

Narratives of SEAD contribute to a vision of change in innovation discourses by promoting idea and product incubation in a university setting. They also imagine universities creating a generation of innovators. The ICAT pipeline of “imagination to innovation” emphasizes an innovation process enhanced by the integration of art and technology. The “transdisciplinary workforce” that ICAT aspires to create will consist of

⁹⁶ “An appreciation of the role of technological innovation in our knowledge-based society requires less restrictive definitions of both “technology” and “innovation.”” Michael M. Crow and William B. Dabars, *Designing the New American University* (Baltimore, MD: Johns Hopkins University Press, 2015), 155.

⁹⁷ See e.g. Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago/London: University of Chicago Press, 2008).

⁹⁸ Tom Kelley and David Kelley, *Creative Confidence: Unleashing the Creative Potential within Us All* (New York: Crown Business, 2013).

⁹⁹ Richard Florida, *The Rise of the Creative Class: And How It’s Transforming Work, Leisure, Community, and Everyday Life* (New York: Basic Books, 2002).

new types of actors who will succeed “in this era of rapid innovation.” The Institute will “forge a pathway” between research, discovery, and “educational innovation.” It will “fuel future innovation within local, state, and national industrial partners.” Innovation is part of the Institute’s process, and “the ongoing work of building and sustaining” ICAT is necessarily a process of innovation as well.¹⁰⁰ SEAD is a response to an imperative to universities to innovate, and to create environments that nurture innovation. SEAD environments are also innovation “incubators,” “creativity and innovation districts,” and “living labs” in which new ideas thrive and grow.

Knapp is responsible for bringing much of this terminology to ICAT. He is an electrical engineer, trained at North Carolina State University and at Stanford, where he earned his PhD and was an affiliated researcher at CCRMA, the Center for Computer Research in Music and Acoustics. He has also worked in industry, serving as the director of technology at MOTO Development Group in San Francisco and co-founding BioControl Systems, developers of bioelectric measurement devices of artistic interaction. As the PI of the Music, Sensors, and Emotion research group, Knapp coordinates an international research effort to investigate the links between music, affect, and sensory perception.

ICAT’s director search ran through the early months of 2011. By this time, Virginia Tech and its interdisciplinary arts initiatives had felt the effects of the global recession. In late 2009, the state government approved the university’s appropriations request for the CCTA. Instead of a proposed annual budget of \$2.1 million in its first year, the Center would receive \$565,000. The original plans for the Center to eventually

¹⁰⁰ “Overview,” Institute for Creativity, Art, and Technology, <http://icat.vt.edu/content/icat-overview>, accessed January 26, 2018.

include 19 full-time equivalent faculty and staff were no longer feasible, but the approval did allow the university to break ground on the construction site. When the Board of Visitors approved the design plans for the Center for the Arts in March 2010, the CCTA remained an important part of the vision but at a small fraction of its original funding levels.¹⁰¹

The new director would be responsible in large part for determining what the Institute would become. ICAT's specific purpose was still unclear at this point and had been further confused by the budget reduction. In his job talk, Knapp presented himself as a Venn diagram of Education, Arts, and Technology, then used the same diagram structure to represent Virginia Tech, with ICAT in the center. IDEAS figured prominently in the Education bubble; CCTAD, L2Ork, and DISIS in the Arts, and the Center for Human-Computer Interaction in Technology.

¹⁰¹ "Design Plans for University's Center for the Arts Set; Construction to Begin Later This Year," *Virginia Tech News*, March 23, 2010, <https://vtnews.vt.edu/articles/2010/03/2010-201.html>.

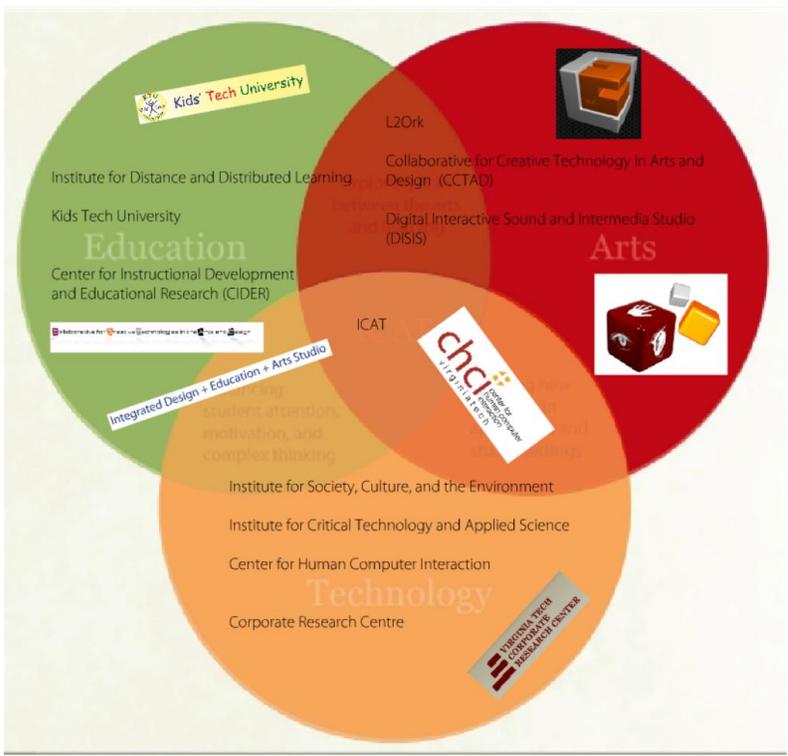
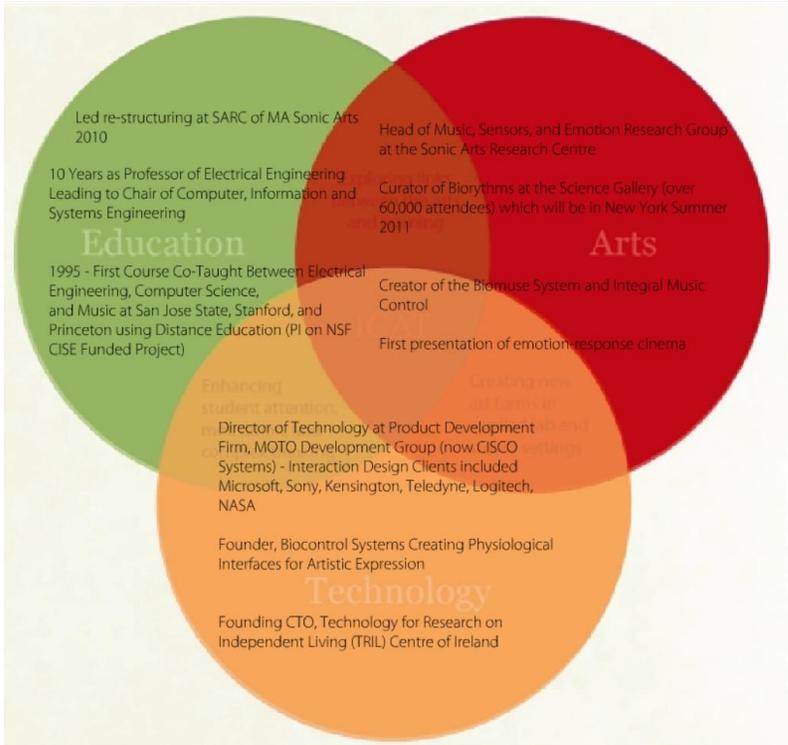


Figure 2.2: Ben Knapp and ICAT as intersections of education, arts, and technology. Image courtesy of Ben Knapp. Used with permission.

Knapp also paid homage to engineer and computer music pioneer Max Mathews, who had passed away several days earlier. Knapp's proposal for ICAT was a tribute to Mathews and to the creative process. ICAT, he suggested, could not be defined by a "goal or a vision or a mission," but instead by "an interactive process...of inclusion, co-creation, and innovation, all contained within a sense of place."¹⁰² His proposal was steeped in Silicon Valley-style innovation-speak, citing user-centered design, stakeholders, collaboration, iteration, and "lots of 'sticky notes'."

Knapp did not define the creative process in detail, but he did lay out some of its important aspects. The creation of research outputs and the creation of the Institute itself would be one and the same. The process would include regional and international stakeholders, ranging from schools to private companies and spanning the arts, sciences, and technology. Scale was important: ICAT would "create a pathway between the fundamentals of technology, art, and educational research to large scale dissemination and teaching," and Knapp listed potential external partners including the Kennedy Center and the Smithsonian under the heading "ICAT everywhere." Application of research, though not necessarily technical, was a major aspect.¹⁰³

Part of this scaling up would involve new funding mechanisms for funding and collaboration, potentially "research clusters" or other large-scale projects that would combine funding from companies and government funding organizations such as the NSF. Importantly, ICAT's creative process should be "self-sustaining." Knapp advocated for "self-perpetuating modes of collaboration and co-creation" that would be measured

¹⁰² Ben Knapp, "The Potential of the Virginia Tech Institute for Creativity, Arts, and Technology: A Personal Perspective," April 2011.

¹⁰³ The presentation also highlighted ICAT's potential to "create pathways from the core disciplines to the integrated applications."

by unfamiliar metrics: establishment of strategic research initiatives, achievement in outreach and engagement, creation of new forms of collaboration, and aesthetic impact. After Knapp's hiring, "innovation" began to figure more prominently in descriptions of the nascent Institute. Where the plans for the CCTA had leaned heavily on "critical and creative thinking" as its *raison d'être*, ICAT's charter described the Institute as "an organization of individuals, teams, and communities that create, innovate, and inspire." ICAT's researchers and educators would still "foster creativity and promote critical reflection," but they would do so by cultivating a creative process "from imagination to innovation."

An early ICAT mission document, created in December 2012, took the emphasis on innovation even further. It first modified the Institute's component parts that Knapp identified in his presentation. Instead of "education," "creativity" would form the third circle on ICAT's Venn diagram, alongside "the arts" and "technology." Furthermore, the document defined all three of these words in terms of innovation: creativity, it claimed, is "the process leading to innovation"; the arts are "the form innovation takes"; and technology is "the function of innovation."¹⁰⁴ This linguistic shift exemplified a fundamental stage in ICAT's evolution. The language repositioned the nascent Institute as a producer of innovations and innovators. It removed education from the privileged position it had previously held, and placed it on equal footing with research and outreach activities. The document also introduced a clear form vs. function distinction between art and technology, one contrasted with the values of many CCTAD researchers.

¹⁰⁴ The document also opens with a quote attributed to Steve Jobs: "The Macintosh turned out so well because the people working on it were musicians, poets, and historians who also happened to be excellent computer scientists."

Virginia Tech's next strategic plan, covering the years 2012-2018 and released shortly after ICAT's creation, similarly evoked the concept of creativity as a process or tool and innovation as a valued product. In contrast to university plans from the early and mid-2000s, this plan made little specific mention of the arts. It did promote "creativity and critical thinking" and promise "quality, innovation, and results." The only sustained discussion of the arts was in the introduction, where the authors list the arts along alongside humanities, business, and the social sciences as part of an educational portfolio that will "kindle curiosity and creativity" and "grow intellectual, entrepreneurial, innovative, and managerial capabilities." Despite the dearth of specifics, the university still aimed to "become the national model for the merger and application of the arts and technology as a catalyst for educational excellence."¹⁰⁵

Knapp defined success for ICAT in three main areas: growing the field of collaborative art-tech, fostering innovation, and creating innovators. These goals echo widespread intentions of SEAD advocates in other places. Growth is a near-universal goal: expanding the influence of institutions and their work, reaching greater numbers of faculty, students, K-12 students, and community members, decreasing barriers to interdisciplinary collaboration, and increasing belief in the importance of creative work on technology-oriented campuses are common aims of researchers and administrators. SEAD stakeholders believe in the inherent good of collaborative, transdisciplinary art-tech work, so greater numbers of people doing this work in more and more places must necessarily be a sign of success.

¹⁰⁵ "A Plan for a New Horizon: Envisioning Virginia Tech, 2012-2018" (Blacksburg, VA: Virginia Tech, n.d.), 2.

Fostering innovation and creating innovators are similarly widespread ambitions. Materiality is an important aspect of SEAD’s value, and something that sets it apart from other parts of the university. Knapp cites the iPhone as a prime example of what SEAD can create, and talks up the Institute by saying that, unlike other parts of campus, “we make things.” This materiality provides ample opportunity for external investment and public engagement. At public events, both local and national, SEAD researchers strive to present projects that “look cool.”¹⁰⁶ This is related to the goal of creating innovators. Through showcasing enticing and engaging SEAD projects, participants hope to attract and develop new kinds of students and thinkers.

Knapp’s role in creating ICAT brought an emphasis on innovation and on process. He articulated a plan to bring together work of CCTAD and work of IDEAS. However, his desire not to over-determine the direction of the Institute meant that the meanings and implications of “innovation” and “transdisciplinarity” remained unclear to many other stakeholders.

Realizing the Vision(s)



¹⁰⁶ Field notes, Senior Fellows meeting, October 2016.

Figure 2.3: ICAT’s mission as a meeting point of transformative beliefs. Image courtesy of the Institute for Creativity, Arts, and Technology. Used with permission.

By the fall of 2013, ICAT’s stakeholders had pulled their individual goals together into something like a collective vision, which they synthesized in their widely-used visual mission statement. The high-level administrators who had initiated the development and funding of the Institute were no longer part of its day-to-day operation, but their influence remained in the image’s emphasis on K-12 education, cross-disciplinary approaches (now labelled “trans-disciplinary”), and engagement with communities and external partners. As an institution, ICAT was neither “top-down” nor “bottom-up,” but rather a meeting point of potentially transformative beliefs and motivations.¹⁰⁷ Senior Virginia Tech administrators provided the reasoning and funding for ICAT’s development, and researchers’ individual interests played a major role in steering its agenda.

The CCTAD faculty who had helped to define ICAT’s research now had a descriptor for their work: they had become transdisciplinary SEAD researchers. Though few of them gave much thought to the terminology, ICAT gave them time, facilities, and money to pursue the research they had begun with CCTAD, or earlier. Webster, Bukvic, and Cao were now “Studio Heads,” each responsible, in theory, for leading a group of “faculty, students, industrial partners, and community volunteers” that would engage in collaborative work in a particular domain. Webster and Cao were co-heads of the IMAGE Studio, dedicated to 3D visualization, sonification, gaming, and interaction. Bukvic led the IMPACT Studio, through which he would expand his work with L2Ork and DISIS to explore the integration of creative technologies into everyday life. Their transdisciplinary research agendas were placed at the center of ICAT’s mission.

¹⁰⁷ Jerry A Jacobs and Scott Frickel, “Interdisciplinarity: A Critical Assessment,” *Annual Review of Sociology* 35 (2009): 43–65.

IDEAS had been absorbed into ICAT as the “IDEA Studio,” and Baum too became a studio head. K-12 education, now confined to just one of five studios, was no longer the most important part of the Institute’s work. However, since IDEAS had been a functioning research group and collaborative effort for far longer than any of the other, brand new studios, Baum’s work and that of her colleagues dominated much of ICAT’s early agenda. While their initial efforts were grounded in educational research, IDEAS and its participants soon became responsible for the vast majority of ICAT’s education and engagement efforts.

Baum, Webster, Cao, and Bukvic were joined by Ann Kilkelly, professor of theatre arts and women’s and gender studies, and Tom Martin, professor of electrical engineering, who each led their own studio (INTERACT and IMPLEMENT, respectively). Together, the studio heads formed an advisory council that met regularly with Knapp to discuss ongoing projects and the future of the Institute.

As director, Knapp played a dual role as a researcher with his own passion projects and an administrator with particular ideas about how to sustain ICAT as an institution. His vision of art-technology work as a catalyst for innovation became the dominant way in which ICAT expressed its own value. In the visual mission statement, this took the form of an arrow from imagination to innovation, meant to symbolize the overarching emphasis on a process leading to innovation that would guide all of ICAT’s work.

In September 2013, I began to attend private meetings at which Knapp and the studio heads discussed ICAT’s direction. I also attended weekly community gatherings (later renamed “playdates”), open to anyone, where ICAT-affiliated researchers presented

their work informally over coffee and muffins. The upcoming move to a new building, the gleaming, \$90 million, as-yet-unfinished Center for the Arts, dominated the conversations.

I witnessed tremendous hope and excitement as well as great frustration about the move, the building, and the future of the Institute. ICAT's small group of faculty and graduate students, used to their cramped spaces and makeshift equipment, were at once thrilled with the potential of their new home and uncertain about what the changes would mean. "New spaces," as Knapp acknowledged at a community meeting, "lead to new ways of using spaces."¹⁰⁸ Few people had been allowed inside the Center for the Arts, which was due to open in November but still saw a steady flow of construction workers in and out. The new spaces were unknown, and there was a sense of ICAT on the cusp of being something greater, a "real" research institute after its initial years of scraping together funding and facilities. ICAT was about to bridge Naimark's art-tech binary of "small poorly funded...students and Fellows determined to make art" vs. "a sparkling new, corporate-funded building full of interesting technological activity," and no one knew how that would turn out.¹⁰⁹

The faculty, administrators, and students who build transformational institutions attempt to stabilize the vision of SEAD through their actions. As we have seen, however, while all of these actors may use similar terminology to argue for the importance of SEAD, or ICAT, their own reasons for engaging in the work differ. Some were dedicated to developing productive innovation processes; some wanted to pursue unusual research

¹⁰⁸ Field notes, ICAT Community Meeting, November 1, 2013

¹⁰⁹ Naimark described the split between CAVS and the Media Lab split at MIT as "microcosmic of what was going on elsewhere in the US." Naimark, "Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability."

programs; and others aspired to save public K-12 education. Their varied motivations led to multiple understandings of what ICAT, and SEAD, were for, and multiple local meanings of terms like “innovation” and “transdisciplinarity.”

There is inherent tension between individuals’ competing motivations, especially when everyone involved is attempting to create a “stabilizing” institution. These tensions are not externally imposed, but rather an integral part of the institution-building process. Built-in tensions produce real and unavoidable challenges for everyone involved in SEAD. Who will fund the work, and how might power relations and collaborative processes change as a result? How can researchers tell when their work is successful, and how can they communicate this to external stakeholders? How do you evaluate the outcomes of transdisciplinary work, or judge the performance of the researchers who engage in it? These questions are what is at stake in SEAD institution-building, and they were at the center of the project that I and the rest of ICAT were about to embark upon.

Chapter 2

Sponsored Collaboration: Chasing the Creative and Economic Potential of “Transdisciplinarity”

By December 2013, ICAT was beginning to settle into its new home. The Institute, along with the Center for the Arts, hosted successful opening week festivities including a ribbon-cutting ceremony, an open house, and a concert by Philip Glass. Artists presented a successful video installation in the Cube, ICAT’s flagship “black box” research and performance space, which was equipped for motion capture, immersive virtual and augmented reality environments, and spatial sound. Soon after the opening week, ICAT held Tech or Treat, a children’s Halloween event, and co-sponsored the first public TEDx Virginia Tech. The new arts center housed all of these events, and ICAT showcased its projects and ideas for thousands of visitors. However, as the logistical storm of the opening weeks subsided, unsettled questions about ICAT’s future, including its structure, spaces, projects, materials, and funding, rose to the surface of discussions.

During a Senior Fellows meeting in December, Knapp and the ICAT Studio Heads took a tour of the now-mostly-occupied Moss Arts Center. Knapp told the faculty that ICAT was entering its second “phase.” The Institute had a new profile and a new home. These conditions meant that new resources were available, or at least attainable. The arts center and its facilities were obvious examples, but along with the new building came new opportunities for promotion and partnerships. It was time, Knapp indicated, for ICAT to shed its identity as a ragtag band of transdisciplinary and become a driving force for change on campus.¹¹⁰

¹¹⁰ Field Notes, Studio Heads Meeting, December 9, 2013.

Sponsorship would be an important part of this transition. As the meeting continued and the group entered ICAT's Experience Studio, the conversation turned to a discussion of potential funding sources outside the university. Frustration over the state of the studio, which still lacked a certificate of occupancy, fueled an already contentious sponsorship conversation. Donors had snapped up naming rights for many of the Center for the Arts spaces – everything from the main performance hall to the lobby elevator had a patron's name attached to it – but most of the ICAT spaces remained unsponsored. As an unknown institute devoted to hybrid research, ICAT lacked the donor base of a more traditional performing arts organization or scientific research facility.¹¹¹

What did this mean for ICAT's sources of external funding? The university was footing ICAT's bill, albeit at well below the level they had originally intended, but expanding the institute would require more money than the university alone could provide. The Studio Heads knew that questions about sponsorship were also questions about what ICAT would become. Knapp floated the idea of naming rights for ICAT's spaces within the arts center, as well as the possibility of cooperating with a large defense contractor. Did the Studio Heads want a corporate name on the Cube? If so, did it matter what that name was? What would it mean for ICAT to function in a space named after a cigarette company, or a weapons manufacturer? The meeting ended without resolution, having brought up more questions than it answered.

In the previous chapter I discussed some of the historical narratives, both local and national, that contribute to SEAD, and to which SEAD practitioners continue to contribute themselves. For the remainder of the dissertation, I turn to the practice of SEAD. How do faculty, staff, students, administrators, and individuals outside the

¹¹¹ Field Notes, Studio Heads Meeting, December 9, 2013.

university turn their visions for SEAD into material, structural, and institutional realities? How do they achieve the material support necessary to facilitate transdisciplinary collaborations? How do these collaborations function? How do teams come together, thrive, struggle, or fall apart?

In this chapter, I examine the intersections of day-to-day SEAD practices – in particular, creating and disseminating sponsored projects – with the funding mechanisms that enable this work. Many practitioners at ICAT aspire to rise above the base economic calculus that views education as a problem of human capital, and the benefits of college as a return on financial investment. However, as we saw in Chapter 1, this viewpoint is in opposition to some of the very reasons that ICAT exists. SEAD institutions are, in part, the results of efforts by government and industry to create a new type of workforce, and to drive the economy through creative innovation. They are also an attempt by university administrators to overcome funding shortages and to open up new potential revenues through industry and community partnerships. Sponsorship and economics are an integral part of ICAT’s identity, and this plays a significant role in the Institute’s work.

Sponsored Collaboration as a Matter of Concern

SEAD participants are well aware of the important role that funding and sponsorship play in their work. In 2003, just as the number of US-based SEAD institutions began to expand, two reports were published that addressed the economics of art-technology work. Both reports foreshadow the rise of SEAD-based organizations within research universities, but they present very different visions of the rationale and maintenance of art-technology institutions. The first, “Truth, Beauty, Freedom, and Money,” written for

the journal *Leonardo* by new media artist Michael Naimark, asks how technology-based art can be supported and sustained.¹¹² After reviewing numerous contemporary models of art-technology institutions from around the globe, Naimark proposes a hypothetical hybrid arts center and research facility that he dubs the “Arts Lab,” which would fund eight concurrent projects at a budget of \$4 million per year.

The second report, the National Research Council’s “Beyond Productivity,” targets a larger audience. Rather than proposing small-scale solutions for funding art-technology collaboration, the report identifies creativity as a driver of both cultural and economic growth and argues that cultivating creativity ought to become a national priority.¹¹³ The report’s two advisory boards comprise a large group of faculty, administrators, and policy analysts from the NRC and a host of universities and technology corporations. Its three editors are policy analysts Marjory S. Blumenthal and Alan S. Inouye, and former MIT Media Lab faculty member William J. Mitchell. They argue that university administrators, government officials, industry partners, and foundations should all invest in promoting creativity and developing proficiencies in the arts and design.

Despite their similar subject matter, the two reports locate the relationship between sponsorship and collaboration in very different places. While he is matter of fact about economic realities, Naimark sees art/technology work as inherently virtuous. He views the struggle for economic sustainability as an unfortunate necessity. In contrast, “Beyond Productivity” focuses on demonstrating the economic value of art and

¹¹² Naimark, “Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability.”

¹¹³ “Beyond Productivity: Information Technology, Innovation, and Creativity” (Washington, D.C.: National Academies Press, 2003).

technology. In its authors' view, the main challenges to transdisciplinary work are “cultural”: society has yet to recognize the usefulness of transdisciplinary collaboration, and so we have yet to create structures that acknowledge and support it.

It is no coincidence that Naimark, himself an artist, locates the value of art-technology collaboration in the work itself, while the authors of the NRC report measure worth in economic and cultural impact. These contrasting motivations are the same ones that exist at ICAT. Where individual faculty members may see potential for new creative explorations, university administrators see pathways to corporate partnerships, or a way to integrate the arts on a technologically-dominated campus that “recognizes its bias towards the *beneficial* uses of knowledge.”¹¹⁴ Sponsored collaboration is an important matter of concern because it exemplifies the tensions between the “dream” of transdisciplinarity as creative freedom and the function (or intended function) of transdisciplinarity as an economic force.

The idea of universities as economic engines is not new, and certainly did not arise with SEAD. As discussed in Chapter 1, universities have increasingly made technology transfer a key element of their resource models since the Bayh-Dole Act of 1980.¹¹⁵ Conventional wisdom puts this development down to budget crunches and universities' corresponding search for new resources, as well as industry actors looking to academia for help with basic research, but scholars like Elizabeth Popp Berman argue that the situation is more complex. The US government, she says, has for decades encouraged universities to treat science as economically valuable. Additionally, the idea of innovation as an engine of economic growth has become pervasive, transforming first

¹¹⁴ Virginia Polytechnic Institute and State University, “Virginia Tech Strategic Plan.” Emphasis added.

¹¹⁵ Elizabeth Popp Berman, *Creating the Market University: How Academic Science Became an Economic Engine* (Princeton, NJ: Princeton University Press, 2012).

policymakers' and later universities' own understandings of their purpose and precipitating a shift within universities to a "market logic." Critics view this development as evidence of market forces' sinister encroachment into academia, arguing that focusing on creating profitable research has eroded the foundations of the academy.¹¹⁶

The other narratives of change upon which SEAD is built also demonstrate some of the intersections of university sponsorship and collaboration. The goals and products of university-based art-technology collaborations changed considerably from the 1960s to the 1980s. Technological innovation, including the development of intellectual property, became a dominant goal of art-technology institutions. Similarly, the widespread recognition of inter- and transdisciplinarity as approaches to solving "real-world" problems, as well as a pervasive understanding of innovation as a creative process, informs a focus on practicality and application that is common in SEAD research. Partnerships with companies and other sponsors are an important aspect of SEAD institutions, including those after which ICAT modeled itself. In ICAT's early mission documents, its stakeholders discussed how institutions that were role models for ICAT managed sponsorship and promotion.¹¹⁷ At Carnegie Mellon, for example, the Entertainment Technology Center worked closely with corporate partners. At MIT, the Media Lab focused on developing and selling viable technologies. Both of these examples served as inspirations for ICAT's potential future revenue streams.

Such institution-level economic concerns, however, are not always considered in studies of how academic collaborations work. In trying to understand what makes a

¹¹⁶ e.g. Philip Mirowski, *Science-Mart: Privatizing American Science*. (Cambridge, Massachusetts and London, England: Harvard University Press, 2011).

¹¹⁷ "The Institute for Creativity, Arts, and Technology at Virginia Tech: Overview and 20-year Vision," 2011.

collaboration successful, some studies look at the characteristics of researchers who engage in them, while others examine organizational barriers to collaboration including conflicting schedules, different visions of project objectives, budget negotiation, intellectual property concerns, sharing indirect costs, and geographic distance.¹¹⁸ Other work categorizes collaborations by type, from the “bureaucratic” to the “participatory.”¹¹⁹ The vast majority of this research concentrates on collaborations within the sciences and medicine, with a particular focus on physics. Among STS studies of interdisciplinary collaborations, Centellas et al.’s work on cancer research is notable for its finding that successful interdisciplinary collaboration can occur without synthesis or even consensus, though the strength of individual disciplinary expertise and careful “calibration.”¹²⁰ In this mode of collaboration, researchers do not see themselves as politically motivated, nor as part of a “movement” to create a new type of knowledge. In contrast, Mikaila Arthur shows how, under different circumstances, new disciplines can emerge through collaboration, through the collective action of “political and intellectual outsiders.”¹²¹ Funding is a constant background presence in such discussions, but rarely the focus.

SEAD Projects as Sites of Sponsored Collaboration

¹¹⁸ e.g. Frank J. van Rijnsvoever and Laurens K. Hessels, “Factors Associated with Disciplinary and Interdisciplinary Research Collaboration,” *Research Policy* 40 (2011): 463–72; Jonathon N. Cummings and Sara Kiesler, “Collaborative Research across Disciplinary and Organizational Boundaries,” *Social Studies of Science* 35, no. 5 (2005): 703–22; Branco L. Ponomarev and P. Craig Boardman, “Influencing Scientists’ Collaboration and Productivity Patterns through New Institutions: University Research Centers and Scientific and Technical Human Capital,” *Research Policy* 39 (2010): 613–24.

¹¹⁹ Wesley Shrum, Joel Genuth, and Ivan Chompalov, *Structures of Scientific Collaboration* (Cambridge, MA: MIT Press, 2007).

¹²⁰ Kate M. Centellas, Regina E. Smardon, and Steve Fifield, “Calibrating Translational Cancer Research: Collaboration without Consensus in Interdisciplinary Laboratory Meetings,” *Science, Technology, & Human Values* 39, no. 3 (May 2014): 311–35.

¹²¹ Mikaila M. L. Arthur, “Thinking Outside the Master’s House: New Knowledge Movements and the Emergence of Academic Disciplines,” *Social Movement Studies* 8, no. 1 (2009): 73–87.

Sponsorship is important for individual projects, for institutions, and for networks in SEAD, though the meanings of sponsorship vary between these levels. Within ICAT, the Institute offers salaries for staff and graduate students; buyouts for faculty; major and minor grants for projects; the use of space and tools; the expertise of associated faculty, staff, and students; sites to display completed work or prototypes; connections to community organizations; and facilitation of potential collaborations. ICAT's mission is to offer the "time, space, and permission" for work that researchers may not find support for elsewhere.¹²² Of course, ICAT itself also requires sponsorship, which it receives in large part directly from the university in the form of its facilities and annual budget. The institute also seeks sponsorship from government agencies, private companies, foundations, networks, and individual donors. Both ICAT itself and these external sponsors, or potential sponsors, are important stakeholders for ICAT-affiliated work. Their influence helps to shape the formation, organization, and outcomes of projects.

Projects are particularly important sites at which to explore the intersections of different narratives and motivations. Across SEAD institutions and networks, projects are the primary framework for research. The SEAD Network called for reports and summaries from individual projects when they prepared their five-year report, and they gathered and assessed projects when preparing their collection of "exemplars."¹²³ a2ru similarly showcased individual projects (as opposed to organizations, researchers, or publications) as exemplars at their national conference.¹²⁴ ICAT, which provided grants

¹²² "Emerge: Projects at the Nexus of Science, Engineering, Art, and Design," 2016.

¹²³ Malina, Strohecker, and Lafayette, "Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design"; Topete et al., "SEAD Exemplars: Evidence of the Value of Transdisciplinary Projects."

¹²⁴ Ico Bukvic, "Transdisciplinary Exemplar," Linux Laptop Orchestra, October 21, 2015, <http://l2ork.music.vt.edu/main/transdisciplinary-exemplar/>.

on a project basis since 2012, quickly moved away from the studios/Studio Heads model after moving into the new building, as researchers experienced confusion distinguishing physical spaces from conceptual studios, and had difficulties reconciling project-based funding with studio-based management.¹²⁵ After ICAT's first year in the Moss Arts Center, the formal studios were dissolved; the Studio Heads became "Senior Fellows"; and funded projects were no longer formally associated with particular ICAT spaces or personnel.

In addition to providing facilities and the expertise of staff and graduate students, ICAT has several different mechanisms through which it offers financial support to researchers. Faculty may apply for \$3000 "mini" grants, which ICAT offers each month, or annual "major" grants, which range from \$10,000 to \$30,000 each. Graduate students are eligible for monthly \$500 grants to support their own work. The Senior Fellows and ICAT administration consult together annually to allocate funding for the major grants, while the Director, Associate Director, and selected Institute staff choose the recipients of the monthly mini and student grants.

Since ICAT began offering grants in 2012, the Institute has formally supported over eighty projects. Project contributors have come from every college at Virginia Tech, and the projects themselves range from a sociological exploration of female infanticide in India, to armor designed for a humanoid robot. (A complete list of ICAT-funded projects can be found in Appendix B.) ICAT provides limited criteria for prospective funded projects, beyond stating that proposals "must be transdisciplinary in nature" and should

¹²⁵ Field Notes, Studio Heads Meeting, April 26, 2014.

“directly align with the mission of ICAT.”¹²⁶ Any project that can make an argument for meeting these criteria, and includes representatives from at least two of the Institute’s constituent disciplines, is eligible to apply.¹²⁷

In the remainder of this chapter, I examine three ICAT-funded projects to observe how the tensions between transdisciplinarity as creative exploration and transdisciplinarity as an economic driver play out through collaboration. The first project, Salt Marsh Suite, was awarded two mini-grants during the 2013-2014 academic year, and used the Cube for its initial installation and performance. The second, SeeMore, received a major grant in 2013-2014, and subsequently received additional mini-grants to help fund its transportation to conferences and events. Finally, the Belle2VR project received a major grant in 2016-2017, and involved a major commitment from ICAT staff, in addition to the use of the Cube.

Salt Marsh Suite

The audience enters the Cube. Sheer curtains hang diagonally on either side of the space, and a floor-to-ceiling screen covers the front of the room. Constantly shifting images of animals and landscapes from a North Carolina estuary are projected on all three surfaces. But for the projections and a spotlight on the floor in front of the screen, the room is dark. Sound seems to emanate from all around us, filling the air with the noise of water, wind, and birdsong. As the audience settles around the perimeter of the room and dancers wait on stage, the director encourages attendees to move around during the

¹²⁶ “2018 Request for Proposals,” Institute for Creativity, Arts, and Technology, <http://icat.vt.edu/funding/>, accessed September 27, 2018.

¹²⁷ As of 2018, ICAT asks for representatives from at least two of the following areas: design, architecture, behavioral sciences, education, engineering, computer science, human sciences, humanities, social sciences, visual arts, and performing arts.

*performance and experience the piece from different angles. If you encounter a dancer, she says, you have two choices: “get out of the way, or join in.”*¹²⁸



Figure 3.1: Dancer Rachel Rough performs in Salt Marsh Suite during the piece’s initial run at ICAT in April 2014. Image courtesy of Carol Burch-Brown. Used with permission.

Salt Marsh Suite is an intermedia installation and performance piece that debuted in ICAT’s Cube in April 2014. Through its five movements – water, mud, crabs, birds, and grass – the piece immerses its audience in the sights and sounds of a North Carolina salt marsh. Project leader Carol Burch Brown, a professor emerita of visual art and former ICAT Senior Fellow,¹²⁹ began collecting data for the project in 2010 from a marsh near Bird Island in Brunswick Country, NC. Her initial data collection included field observations, video, and audio recordings, and it eventually expanded to 3D laser scans which she gathered alongside a team of collaborators from Virginia Tech. Ann Kilkelly,

¹²⁸ Field Notes from the ICAT debut of *Salt Marsh Suite*, April 2014.

¹²⁹ Burch Brown retired from the university in 2015, the year after *Salt Marsh* debuted in the Cube.

another former Studio Head/Senior Fellow and a professor emerita in the School of Performing Arts, choreographed the dance components of the piece and was a major part of the project's creative and organizational team.

The inspiration behind Salt Marsh Suite percolated for years, as Burch Brown and Kilkelly visited the Bird Island salt marsh annually for several summers. Exploring the marsh via kayak, Burch Brown became fascinated with its life and ecology. Eventually she began collecting observations and data from the marsh, pursuing her curiosity about the natural habitat as well as her longstanding research interests in the ways that technologies mediate knowledge and sensory experience in both art and science.¹³⁰ She continued to collect data at the marsh each time she returned, knowing that she wanted to use it to create art, but unsure of the what the structure of the work would be.

Burch Brown and Kilkelly are frequent collaborators, and had worked on previous intermedia projects which explored connections between art and science. Most notably, in 2009, Burch Brown produced *Singing Darwin*, a celebration of the 150th anniversary of the publication of *On the Origin of Species*, with the assistance of Kilkelly and numerous CCTAD faculty, including Dane Webster, Steve Harrison, Ico Bukvic, and Simone Patterson. Many other artists became involved in Salt Marsh through projects and experiences connected to ICAT. Joan Grossman, who served as the video editor for Salt Marsh, had been commissioned in 2013 to create the video installation *This Edge I Have to Jump*, the first piece to premiere in the Cube during the art center's opening week festivities, and had worked with Burch Brown, Kilkelly, and others during her residency in Blacksburg. Composer Thom Judson and artist Thomas Tucker had worked with each

¹³⁰ Interview with Burch Brown: "Salt Marsh comes out of a similar set of interests that I have and kind of connections between science and art-making that use technology in order to really mediate sensory experience and knowledge."

other in the past, and approached Burch Brown and Kilkelly with the intention of putting together a project for the Cube. An ICAT mini-grant enabled Judson, Tucker, and Burch Brown to conduct laser scanning and collect other additional data from the marsh during a week-long trip.

Salt Marsh Suite is a comparatively rare example of a prominent, artist-dominated ICAT project. This was not a case of scientists and artists working together to create something; rather, Burch Brown's own "transdisciplinary" curiosity and skills were the driving force behind the project. The collaborations that occurred happened largely between artists, who had varying degrees of technological expertise. Burch Brown, with help from Judson and Tanner Uptegrove, built a computer on which to run the piece in the Cube, after finding that the existing technology lacked the capabilities she required.¹³¹ She programmed the image sequences using Max/MSP, and collected the 3D laser scans in collaboration with Tucker, another visual artist. Even Kilkelly, a self-avowed technophobe, committed herself to understanding "enough about this technology that we're using that I can at least talk about it."¹³² Significant collaborations with scientists, including representatives from US Fish and Wildlife, did not occur until the first iteration of the project neared completion.

Salt Marsh Suite is less a collaboration between researchers from different disciplines than it is an exploration and tribute that occurred without much regard for disciplinary standards; one during which any interested parties were invited to "join in." While Salt Marsh is both artistic and technological, it is an "inter-media" piece rather

¹³¹ Interview 6.

¹³² Interview with Kilkelly.

than an interdisciplinary one.¹³³ Burch Brown and the Salt Marsh team used ICAT's technology and sponsorship to pursue a line of artistic questioning which had existed before the Institute did. Salt Marsh's creators are aware of the limitations of their work from a scientific standpoint, and profess an interest in collaborating with scientists who have a different type of knowledge about the marsh. As one involved faculty member said, "I mean we, I think, legitimately know enough to do a project like Salt Marsh, but there's other knowledge that we can't express in the way it should be expressed."¹³⁴

Salt Marsh Suite was extremely well received within ICAT, both as a demonstration of the Cube's capabilities and as an example of the type of creative work that ICAT could facilitate. At a panel discussion following the first performance, Knapp and other ICAT faculty praised the project for its accomplishments and its potential.¹³⁵ Salt Marsh Suite has since featured at showcases of ICAT's work on the Virginia Tech campus and elsewhere, and has had a long life beyond its initial presentation in the Cube.¹³⁶ Other communities showed similar enthusiasm for the work: from October 2015 to January 2016, Burch Brown and Kilkelly presented the piece at the Taubman Museum of Art in Roanoke, Virginia. In 2017, artist Celeste Miller joined the project, adding the prelude "Tides" to the existing five movements. Burch Brown, Kilkelly, and Miller

¹³³ Elise Witt, "Salt Marsh Suite," 2015, <https://elisewitt.com/web/salt-marsh-suite/>. Witt describes the piece as "...what happens in inter-media and inter-action among world, science, and art when the makers understand how to add to the piece's stunning technology...all of it exquisitely coordinated as if despite massive technological resources the gap between a richly saturated "there" and the here of an exhibition space were transcended along with any of the often sterile intrusive feel of technology per se."

¹³⁴ Interview 5.

¹³⁵ Field Notes, April 2014.

¹³⁶ "Salt Marsh Suite," ACCelerate Festival, accessed September 27, 2018, http://acceleratefestival.com/acc_project/salt-marsh-suite/.

subsequently presented Salt Marsh Suite at the Piedmont Arts Center and Virginia Museum of Natural History in Martinsville, Virginia.¹³⁷

Despite the fact that artists led all major aspects of Salt Marsh Suite, praise within ICAT centered around the piece's combination of "disciplines" and its potential to expose its audiences to science. During the post-performance panel discussion at ICAT in 2014, Knapp complimented the piece for its ability to educate the public about marsh conservation, a sentiment which was echoed by the representative of US Fish and Wildlife on the panel. Many of the ICAT and Virginia Tech events in which the Salt Marsh team later participated centered around presenting new, creative sides of science and technology.¹³⁸ While artists who worked on Salt Marsh note that "all this is not about making STEM studies somehow more palatable than they already are," Salt Marsh's ability to present an interesting, approachable side to "science" was an important part of the project's value to ICAT.¹³⁹

SeeMore

At 8:30 on a Friday morning, drowsy faculty, graduate students, and visitors flow into the Sandbox, a cavernous "fishbowl" on the ground floor of the Moss Arts Center, for one of ICAT's weekly "playdates." Usually the coffee carafes near the door are the first stop. This week, however, the enormous, blinking tower on the other side of the room commands everyone's attention. Too large to fit into the normal gallery spaces, a team of

¹³⁷ Linda Frye Burnham, "Review: Salt Marsh Suite," February 23, 2017, <https://lindaburnham.com/writings/review-salt-marsh-suite/>.

¹³⁸ Mike Allen, "Blacksburg and Roanoke Kick off Statewide Virginia Science Festival," *Roanoke Times*, October 2, 2014, https://www.roanoke.com/arts_and_entertainment/blacksburg-and-roanoke-kick-off-statewide-virginia-science-festival/article_8b2afe9e-e6df-5873-a1ca-50a67310d3c3.html.

¹³⁹ Witt, "Salt Marsh Suite."

*graduate students has spent the past several days assembling SeeMore here, in the largest room the Center has to offer. A sculptor, one half of the leadership team behind the humming machine, paces slowly around, inspecting it from all angles. His collaborator, a computer scientist, readies the PowerPoint.*¹⁴⁰



Figure 3.2: SeeMore displayed at the 2015 Maker Faire. Image courtesy of Jud Froelich. Used with permission.

SeeMore is a kinetic sculpture, a parallel computer, and a public demonstration tool. It consists of a nine-and-a-half-foot cylindrical metal frame and 256 small Raspberry Pi

¹⁴⁰ Field Notes, ICAT playdate: SeeMore, 2014.

computers, each mounted on a plate that can be moved by an attached servo motor. As the parallel computer cluster performs a task, the computing work is divided between the Raspberry Pis. Whenever an individual computer makes a calculation, its servo motor moves the attached plate. The result is a demonstration of parallel computing in action: a whirring field of colorful plates which move independently as they work together.

The project began when Kirk Cameron, a professor of computer science and director of Virginia Tech's Scalable Performance Laboratory (SCAPE Lab), became frustrated with the difficulties of explaining parallel processing to a wider audience. To overcome the opaque, "black box" nature of standard parallel processors, he contacted the School of Visual Arts in search of an artist who might help him create a physical demo. The school's director put him in touch with Sam Blanchard, the lone sculptor on the Virginia Tech faculty. Blanchard frequently experiments with technology in his work, including in pre-SeeMore projects like *Polaroid Matrix Camera*, a self-portrait machine which he exhibited at the New York City MakerFaire.¹⁴¹

Blanchard and Cameron met, and Cameron shared his motivations for the project. Making visible the process of parallel computing, he reasoned, could have many benefits. On a practical level, it would render Cameron's research more comprehensible to the public, and to the politicians and VIPs who toured his lab. More poetically, it might communicate some of the beauty and creativity that Cameron and his colleagues saw in their own work. Finally, Cameron reasoned that the exposure that such a project could bring to the field of parallel computing might spark interest in computer science among

¹⁴¹ Sam Blanchard, "Polaroid Matrix Camera," <http://www.samblanchard.com/#/polaroid-matrix-camera/>, accessed September 27, 2018.

underrepresented communities, and perhaps let them imagine pursuing careers as computer scientists.¹⁴²

Cameron had envisioned a stationary sculpture that approximated the form of the server racks which he already used in his lab. However, Blanchard's experience with kinetic sculpture led him to imagine individual moving pieces that could tell a larger story about parallel processing. Through their discussions and Blanchard's own research into the history of computing, they settled on a design that recalled the shape and scale of early supercomputers, with an hourglass form and movement that referenced the fluid dynamics and weather calculations that massive parallel computers often perform. The pair obtained a major ICAT grant in 2014 which allowed them to begin constructing prototypes. Just a few months later, after a grant application process guided by Cameron, the project received \$200,000 from the NSF to fund the construction of the full-sized piece.

The nature of the project forced researchers to reconcile the different modes of funding and feedback built into the academic structures and practices of their respective fields. Blanchard, unlike most computer science researchers, had never worked with funding on the scale of the NSF grant. Like many artists, he rarely depends on influxes of money to fund his output. Blanchard contrasted his usual mode of working with that of many computer scientists, for whom "money becomes a huge factor" when they are responsible for large research teams and dependent on expensive equipment in need of frequent replacement or repair.¹⁴³

¹⁴² Interview 13.

¹⁴³ Interview with Blanchard.

SeeMore also embodied differences in research practice related to these different funding models. For Blanchard, research is based in making, materials, and tactile sensation and generally done either alone or in small groups. In contrast, Cameron and other computer science faculty often work as leaders of large teams made up of students and postdocs, overseeing and guiding projects. Cameron's SCAPE Lab produces both hardware and software, but their transportable outputs tend to be papers rather than physical pieces. Aspects of SeeMore were therefore outside the realm of normal research for both parties.

SeeMore's development followed these dual streams of practice, at least at first. Blanchard assembled the structure in his studio, alone or with a single assistant, while Cameron guided a large team in producing the software. Working back and forth between Blanchard's studio and Cameron's lab, the team produced a one-node prototype with a single Raspberry Pi; then a nine-node version; then one with thirty nodes; and finally the full size piece. Eventually the assembly required more hands than were available in the studio. Art and computer science students joined forces with volunteer recruits from outside both departments, to chaotic effect.¹⁴⁴ Later, when displaying the project in a gallery-like setting, computer science graduate students were faced with showing their work in a new arena. Their impulse was to explain the piece to passers-by as quickly as possible. The artists involved were uncomfortable with this even as they realized their hybrid piece did require some explanation.¹⁴⁵

¹⁴⁴ Interview 13. "We had a quality control set up with myself and the student that was working for me and there was something like a 95% failure rate for what was being assembled. So it wasn't working and we were, it was taking twice as long because we'd have to take them apart and put them back together again so there were all these like little learning experiences. Like I even went so far as to make a ten-part tutorial on YouTube about like how to assemble these things."

¹⁴⁵ Interview 13. "It was like their [computer science students'] reaction was to go and like stand by the object and when somebody would come up they would be like this is this, this is this, let me tell you about

SeeMore has traveled great distances, literally and figuratively, beyond ICAT and Virginia Tech. For its initial public exhibition, a team of students drove a van full of SeeMore's components from Blacksburg to Vancouver, Canada, to display the project at SIGGRAPH 2014.¹⁴⁶ Following this, the team showed SeeMore at the 2015 World Maker Faire, SXSW 2016, and at the NSF pavilion at the 2016 USA Science and Engineering Festival. The MagPi, a Raspberry Pi magazine, profiled the project in 2015, and the following year named SeeMore the second-greatest Raspberry Pi-based project of all time.¹⁴⁷ Blanchard and Cameron also published an overview of the piece in art-technology journal *Leonardo*.¹⁴⁸

SeeMore's hybridity, and its ability to serve different audiences, are key to its positive reception. For Blanchard, projects like SeeMore are a "parallel trajectory" to his normal studio practice and teaching. He points out that SeeMore is "obviously not...exclusively an art object," nor is it an efficient computer for practical purposes.¹⁴⁹ With the exception of the Science and Engineering Festival, SeeMore has been exhibited in notably hybrid spaces that celebrate its fusion of art and computer science. Its success requires these spaces that exist outside of disciplinary practice and venues, and depends on understanding SeeMore as an explicitly hybrid object.

SeeMore has been well received by a variety of audiences, but did it accomplish its ostensible goal of educating the public about parallel computing? The project team

this, let me tell you about this which of course is not how I do things. I'm not there like just, you know, the work is speaking for itself. It just does that, like if you're doing it good then it's communicating what you want it to communicate."

¹⁴⁶ SIGGRAPH (Special Interest Group on Computer GRAPHics) is an annual computer graphics conference convened by the Association for Computing Machinery. SeeMore was displayed at SIGGRAPH's art show, which has been a part of the conference since the 1980s.

¹⁴⁷ "SeeMore: The Pi-Powered Parallel Computing Sculpture," *The MagPi*, December 2015; "50 Greatest Raspberry Pi Projects," *The MagPi*, October 2016.

¹⁴⁸ Sam Blanchard and Kirk Cameron, "SeeMore," *Leonardo* 47, no. 4 (August 2014): 414–15.

¹⁴⁹ Interview with Blanchard.

conducted a survey among visitors to the International Maker Faire and the Science and Engineering Festival who interacted with SeeMore. The survey results indicated that a majority of those who interacted with SeeMore believed that it had educational value, with participants indicating that the piece “personalized the importance of parallel computation” and “inspired participants to learn more.”¹⁵⁰ However, aside from these surveys, SeeMore’s utility as an educational tool remains untested. Due to its size and maintenance requirements, the sculpture is no longer on display at Virginia Tech. Blanchard remains an active contributor to ICAT and has participated in other funded projects, though Cameron has not. When ICAT practitioners recall SeeMore, they do so with fondness not for its function as an educational tool, but for its success in obtaining NSF funding, its ability to travel outside of the Institute, and its status as a “massive fusion of art and technology.”¹⁵¹

Belle2VR

At the weekly team meeting, the group’s focus is on preparing for the upcoming beta tests. After nearly eight months of work, the team’s virtual reality environment and lesson plans are almost ready. Undergraduate physics students are about to step into a VR particle detector and attempt to complete a lab exercise that the team has designed. After a brief general discussion, the group splits up and I try to follow the different threads of conversation around the room. In one corner, two students explain the technical details of the lab exercise to the visual artist who created the VR environment. In another, a

¹⁵⁰ Bo Li et al., “SeeMore: A Kinetic Parallel Computer Sculpture for Educating Broad Audiences on Parallel Computation,” *Journal of Parallel and Distributed Computing* 105 (2017): 183–99.

¹⁵¹ “Parallel Computing Sculpture SeeMore Named One of the Top Projects in the World,” VT News, October 18, 2016, <https://vtnews.vt.edu/articles/2016/10/icat-seemoreaward.html>.

physics education student goes through her plan to lead the lesson with an education professor. “I feel like I’m in my element now,” the professor says. “I guess that’s what they got me for.”¹⁵²



Figure 3.3: A student presents the Belle2VR project to an audience inside the Cube at the 2016 Virginia Tech Science Festival. Image courtesy of the Institute for Creativity, Arts, and Technology. Used with permission.

The Belle2VR project created a virtual reality environment to use as a tool for teaching particle physics to undergraduate students. The Belle II experiment, upon which ICAT’s project was based, is a massive international physics collaboration, involving over 500 physicists and engineers from nearly 100 institutions around the world. The experiment uses the SuperKEKB accelerator and the Belle II particle detector, both located in Japan, to conduct cutting edge research in particle physics. ICAT’s project used the Cube to

¹⁵² Field Notes, Belle2VR team meeting, March 21, 2017.

display an immersive, virtual reality model of the Belle II detector, which users can walk through and interact with using VR headsets and game controllers. Users can choose from a variety of particle collision events to view in the virtual reality simulation, which they can then pause, reverse, and walk through.

Key members of the ICAT project team included Leo Piilonen, a physics professor whose own research is part of the international Belle II collaboration; George Glasson, a professor from the School of Education who specializes in science education; and Zach Duer, a visual artist who at the time of the project was employed as ICAT's "immersive environment specialist."¹⁵³ Undergraduate students from Virginia Tech's physics program and from PhysTEC, an NSF program designed to prepare students for careers as K-12 physics teachers, supported the faculty members. ICAT's immersive sound specialist Tanner Upthegrove was also a member of the project team.

Though it occurred several years after both Salt Marsh Suite and SeeMore, Belle2VR represented a number of ICAT "firsts." The project was among the earliest to test a model of ICAT staff as "concierges" for transdisciplinary collaborations, an idea that Institute leadership began to promote throughout 2016 and 2017. In this model, ICAT immersive environment specialists would participate in funded projects as facilitators and technical experts. The concierge model would allow researchers who had ideas and data, but no expertise with virtual reality, motion tracking, or immersive sound, to use facilities like the Cube without needing to develop site-specific knowledge. For Belle2VR, the main ICAT concierge was Zach Duer.

Duer had not been included in the initial grant proposal for the project. Glasson and Piilonen, the project PIs, knew each other through their involvement with the

¹⁵³ As of fall 2017, Duer is an Assistant Professor in Virginia Tech's School of Visual Arts.

PhysTEC program, and had approached Knapp with the idea for a VR physics project. During the grant writing process, ICAT administrators connected them with Dane Webster and other long-time ICAT affiliate Nicholas Polys and Todd Ogle, who together had expertise in virtual reality, motion tracking, and use of the Cube. Once the project began, however, Webster, Polys, and Ogle withdrew from the project in favor of Duer, who became ICAT's de facto representative on the project in addition to serving as Cube concierge.

Another first for Belle2VR was its simultaneous use of the Cube's capabilities for motion capture, virtual reality, and immersive sound. While many previous projects used one or two of these aspects of the Cube infrastructure, none had yet attempted all three at the same time. This trifecta meant that the project had the potential to become a flagship ICAT event, one that demonstrated the power of the Cube to diverse audiences. Finally, ICAT administrators were excited that the project included a natural scientist as PI. The Senior Fellows had lamented the relative absence of science-based projects in ICAT's portfolio, especially as compared to those that featured engineers or computer scientists. A project led by a physicist would swing ICAT's collaboration balance closer towards an equal distribution of "S," "E," "A," and "D."¹⁵⁴ For all of these reasons, the Fellows eagerly awarded a \$30,000 grant to the Belle2 project in the spring of 2016.

Belle2VR is notable in that it was a successful cross-disciplinary collaboration that did not require most of its participants to individually cross disciplinary boundaries. Team members met weekly for group discussions throughout the course of the project, but they did the bulk of the work individually or in small groups based on their own areas of expertise. Duer, a visual artist with expertise in programming for virtual reality and

¹⁵⁴ Field Notes, Senior Fellows Meeting, April 18, 2016.

immersive environments, created the model based on data provided by Piilonen. Deep knowledge of the detector itself was unnecessary for the work of creating the VR environment and importing the necessary data: at the time that he created the initial visualization, Duer was uncertain whether the datasets he used were genuine results from the physical particle detector, or artificially generated.¹⁵⁵ Piilonen and an undergraduate physics student continued to adjust the data as necessary for the model's constraints, and served as fact checkers, answering questions and correcting information that related directly to particle physics. They, in turn, had little knowledge of how the model worked, or how to facilitate its display in the Cube. Upthegrove, who had been with ICAT since its beginnings and worked on numerous projects, designed spatial sound for the Cube model. Glasson, an expert in science education, worked with two PhysTEC students to develop curriculum in conjunction with the simulation.

In this sense, the Belle2VR project is a textbook example of “multidisciplinary” work. Participants did develop new knowledge and vocabulary during the project – for example, after the first few meetings, all became familiar with some basic terminology in both particle physics and the Unity programming environment – but they were rarely called upon to deeply integrate this knowledge with their existing expertise. This aspect of the project was planned from the beginning, and in fact was an important aspect of the ICAT's concierge model. “Tanner and I,” explained Duer, “aren't disciplinary to begin with.”¹⁵⁶ Their role was what ICAT's sponsorship brought to the project: ICAT- and site-specific expertise that would allow the other project contributors to work within their own

¹⁵⁵ As Duer soon learned, the physical detector was not yet online at the time that he created the Cube model, and the datasets had been generated as estimates by the physicists involved in the collaboration.

¹⁵⁶ Field Notes, September 2016.

knowledge areas. Duer additionally took on the project management role, setting meeting times, creating agenda, and taking notes.

The team presented a prototype version of the project at the Virginia Tech Science Festival in the fall of 2016, using the Cube’s new curved projection screen (the “Cyclorama”) to allow multiple visitors to view the project at one time, without the need for VR headsets. By early spring 2017, the VR headset version of the project was ready for beta testing, which the team conducted with small groups of undergraduate physics students. Shortly after the first beta tests, Piilonen brought a version of the project to a meeting of the Belle II experiment collaborators. Following this meeting, Belle II physicists at universities around the globe voiced their interest in the VR project. Piilonen and Duer decided to make their work available to anyone who was interested in it. They created a shareable version of the project and made it available via Piilonen’s website under a Creative Commons license. The project has since been used by many other groups, including at the University of Hawaii.¹⁵⁷ In March of 2018, Duer and Upthegrove uploaded the project to the online Steam platform for use by the general public.¹⁵⁸ Duer, Piilonen and Glasson also published an article about the project in IEEE Xplore.¹⁵⁹

Despite this exposure, as well as a general consensus within ICAT that the project was a success, practitioners and ICAT leadership do not hold up Belle2VR as an exemplar of ICAT’s work, in the way that they have done with both Salt Marsh and SeeMore. Unlike both of the other projects, Belle2VR participants have not continued to

¹⁵⁷ Zach Duer, “Belle2VR around the World!,” *Institute for Creativity, Arts, and Technology* (blog), June 23, 2017, <http://blogs.icat.vt.edu/blog/2017/06/23/belle2vr-around-the-world/>.

¹⁵⁸ Steam is an online gaming community and store, and not to be confused with the STEAM movement in education.

¹⁵⁹ Zach Duer, Leo Piilonen, and George Glasson, “Belle2VR: A Virtual Reality Visualization of Subatomic Particle Physics in the Belle II Experiment,” *IEEE Computer Graphics and Applications*, June 2018, 33–43.

display the project at ICAT-affiliated events since the conclusion of the funding period. And unlike SeeMore, whose team member Sam Blanchard became a significant contributor to the ICAT community, none of the major players from Belle2VR have pursued ICAT funding for other projects, or have continued to attend ICAT events. Part of this can be explained logistically. Neither Piilonen nor Glasson were affiliated with ICAT prior to the beginning of the project, and neither locates their own research within SEAD. Duer, the main ICAT-affiliated contributor to Belle2, started a new job in Virginia Tech's School of Visual Arts immediately following the conclusion of the project. The other major contributors were undergraduate students who have since graduated. Still, considering the project's emphasis on building STEM education through ICAT-friendly techniques including virtual reality and motion capture, the project's subsequent low profile is notable.

The Transdisciplinary Catch-All

In Naimark's hypothetical, not-for-profit Art Lab, operational costs would be covered by grants, selling art, consulting, licensing technologies or processes developed at the Lab, and developing corporate partnerships. Naimark divides the eight projects that the lab would fund annually into categories: half would be openly solicited, one quarter would be intentionally commercial, and the final quarter would be intentionally activist. The activist projects would be supported through grant funding and through the Lab's other revenue producing activities, such that they would be "free of commercial obligations." Practitioners would be free to do what they wanted with these projects: Naimark

describes how the money to fund them would be “similar to what Irving “Swifty” Lazar, the legendary Hollywood agent, liked to call his “fuck you” million.”¹⁶⁰

ICAT has no such structure in place to stratify its outputs. Its projects do not have simplicity of being “strictly commercial” or “strictly activist.” In the absence of these categories, any proposed project that convinces ICAT’s leadership of its appropriateness and its potential for a return on investment in some sense – financial in terms of future grant money, publicity in terms of exposure for the Institute, etc. – is ready to be funded. All ICAT-funded projects, however, must also be “transdisciplinary,” and must navigate the tension between creative freedom and economic impact upon which the Institute is built. As a result, participants’ interpretations of transdisciplinarity become malleable and expansive. We can observe some of the differences between the characteristics of the three projects discussed above by considering their characteristics as sponsored entities and as sites of collaboration.

ICAT’s sponsorship is vital for supporting work that would otherwise struggle to find a home on Virginia Tech’s campus. SEAD-specific sponsorship can allow certain types of projects to happen, often ones that could not have accrued immediate funding from another source. In other cases, SEAD sponsorship can assist with certain aspects of a project, or with additional logistics of a project that is already well underway. Salt Marsh, SeeMore, and Belle2VR all have different relationships with ICAT as a sponsor. Salt Marsh required only minimal funding from ICAT, and the project team used the money they received to collect additional data from the marsh, i.e. to support and strengthen work that they had already begun. The original installation was inspired in part

¹⁶⁰ Naimark, “Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability,” 30.

by the physical space and capabilities of the Cube, and relied on these resources a great deal in its initial production phase. However, the project's subsequent transformations and installations elsewhere demonstrate that Salt Marsh's team of artists do not need the Cube in order to continue to develop their ideas. In this case, ICAT provided welcome support for a project that would likely have come to exist eventually, in some form, through other means. In contrast, SeeMore required a much larger amount of money, and relied on ICAT to provide classic seed funding. This project was born out of ICAT in the sense that few other organizations would have provided the money to build a prototype for a massive, kinetic parallel processing sculpture. SeeMore's hybrid nature required a hybrid funding organization to believe in its potential. Once the team had a prototype in place, they relied on Cameron's experience as a grant writer and the project's purported educational potential to acquire the needed sum of money from the NSF. Finally, Belle2VR did not need a large amount of money to operate, but it did need significant help in the form of facilities and expertise. Without the resources of the Cube and the knowledge required to work within it, the project would not have begun.

These different types of sponsorship relate to the ways in which participants conducted the three projects, and the understandings of "transdisciplinarity" that were present in each. As an artist-led project that came late in its primary creators' academic careers, Salt Marsh's collaboration evolved organically from Burch Brown and Kilkelly's professional networks. Most of the project's main participants were fellow artists, and its discipline-spanning nature resulted from Burch Brown's own wide-ranging curiosity. SeeMore's two creators came from very different disciplines and research traditions, and the project's development reflected this dual origin. Throughout most of the design,

prototyping, and building processes, the participants worked separately on their own tasks in their own spaces. Eventually, the enormity of the physical structure, the scale of the hardware and software integration, and the public environments in which the team displayed SeeMore required participants to work more closely together. This did not happen without some struggle, as team members were slow to recognize and appreciate the unfamiliar practices of their collaborators. On Belle2VR, team members continued to work mostly separately for the entire duration of the project. However, in this case, weekly group meetings and Duer's efforts as team leader and coordinator enabled these separate work streams to harmoniously co-exist. When it came time to run beta tests on the VR environment and the lesson plans, team members complimented each other on these separate aspects of the project, satisfied with the general outcome even though they did not fully comprehend the details of the component parts. Like the cancer researchers in Centellas et al.'s study, members of the Belle2VR team succeeded through individual disciplinary competence and strong "calibration" on the part of ICAT's "conciierge."¹⁶¹

Despite their differences, all three projects shared two characteristics in addition to their affiliation with ICAT. First, all three had some potential – whether genuine, intended, or perceived – to serve the instrumental purpose of educating and inspiring people about STEM subjects. Even Salt Marsh Suite, whose creators did not name education as a primary goal, gained value within ICAT as a project based in part in (hypothetical) public outreach. Second, all three were passion projects for their PIs. For Piilonen and Cameron, working with ICAT was an opportunity to see material they had researched throughout their careers represented in a new medium, for new audiences.

¹⁶¹ Centellas, Smardon, and Fifield, "Calibrating Translational Cancer Research: Collaboration without Consensus in Interdisciplinary Laboratory Meetings."

Piilonen's repeated exclamations of "holy cow! Holy cow!" upon viewing the virtual reality environment for the first time reinforced the personal value of the project for him.¹⁶² With the exception of Burch Brown, none of the PIs used ICAT resources to pursue their primary research agenda. Piilonen and Cameron were producing new, public-facing interpretations of their existing work, and Blanchard viewed SeeMore as a side project, though a time-consuming one.

ICAT requires that its funded projects are transdisciplinary, but it allows for multiple meanings of the term for different people and at different times. Looking at a range of ICAT-sponsored projects, we see how transdisciplinarity becomes a malleable term, adjusting to fit new definitions and boundaries as necessary and reflecting both the connotation of creative freedom and that of practical economic or educational purpose. Like "innovation," transdisciplinarity carries an association with positive change and a vagueness that makes it difficult to exclude collaborative projects from the category. The question, then, of how participants conduct boundary work, and attempt to enshrine these sometimes-contradictory definitions into standards and practices, is one that I explore in the following chapters.

¹⁶² Field Notes, Belle2VR team meeting, November 18, 2016.

Chapter 3

Value and Belonging: Making a Home Outside the Disciplines

“That’s the problem with ICAT,” said Knapp, “we *only* do everything.” A month before the Institute was scheduled to move into its new building, its Director was balancing the logistical hurdles related to the move with conceptual ones, about how the nascent institution was evolving and how its output would be evaluated.¹⁶³

Knapp was worried about university administrators misunderstanding the goals of the Institute, or misinterpreting its outputs. He described ICAT as a prism, through which research is refracted and refocused. ICAT’s function, he said, was to bring people and resources together, take in and encourage disparate ideas, and, in the end, help researchers create new things. The Institute was a “matchmaker” between researchers across campus. Knapp, and others at ICAT, believed deeply in the importance of this work, but they were concerned about ICAT’s perceived lack of specificity. ICAT’s subject areas were no more detailed than the description in the name of the Institute: creativity, arts, and technology. Knapp worried that the university lacked a way to evaluate the success of this kind of work.

The issues that Knapp and other ICAT stakeholders faced were emblematic of a widespread problem for SEAD participants: in the intentional absence – or attempted cross-pollination – of traditional academic standards, how can you tell when something is “good”? In trying to build an academic space that exists across and outside of disciplines, how can participants develop new sets of values and practices to guide their work? How can they demonstrate the value of what they are attempting to create? And how do researchers navigate their existence in an extra-disciplinary space?

¹⁶³ Field Notes, September 2013.

Participants in SEAD must, of course, evaluate the potential success of proposed projects, and the demonstrated success – or failure – of completed ones. They must also make regular decisions about the people with whom they collaborate. But they cannot always explain how they make these decisions, especially to those who do not live and work in the same world. Furthermore, there is no guarantee that the qualities they value in projects and people are the same ones that universities, funding organizations, or existing academic disciplines encourage or reward. Questions about the meanings of quality and success are therefore at the root of many discussions at ICAT, and within cross-university networks including the SEAD Network and a2ru.

This chapter asks questions about values and belonging in SEAD. In previous chapters, I've described the origins of SEAD, and looked at how projects function on the ground. Here, I ask how participants think about and evaluate SEAD's potentials and outcomes. I first look at what goes into making a successful *project*. Examining explicit and implicit criteria employed by SEAD network stakeholders and ICAT-affiliated faculty, I identify commonalities between exemplary works and relate these shared qualities to a set of SEAD values. These values, I argue, play an unacknowledged role in defining a good project and in building the vision of SEAD itself.

Second, I ask what makes a *person* successful in SEAD. What are participants' motivations for engaging in SEAD-related work, and for maintaining or discontinuing relationships with ICAT? How do they navigate their own senses of belonging, and how do they conduct the boundary work that determines who and what else can belong? I argue that recent efforts to develop review standards for transdisciplinary work are attempts to alleviate crises of belonging for SEAD participants. Through codification of

existing, implicit SEAD values, stakeholders try to make their values understandable for people and organizations outside of SEAD. All of this is an attempt to deal with another aspect of the transdisciplinary dilemma, namely the tension between creating one's own academic community while existing outside of existing disciplines.

The frameworks of values and belonging are two different ways to think about how SEAD participants determine what is good and how they draw boundaries around the idea of SEAD itself. Values relate to macro-level ideals. While values can feel deeply personal, they describe the set of socio-cultural ideas and practices in which an actor is embedded. Belonging, too, is both intensely individual and connected to large-scale structures. Developing a sense of belonging (to a field, organization, institute, group, etc.) requires grappling with the values which pervade that space. By exploring value, belonging, and their intersections, we can understand the boundaries of SEAD across the micro and macro scales, from the national and institutional to the personal.

Value and Belonging

The idea that values play important roles in the development and use of science and technology is a foundational STS concept. Formative STS works in laboratory studies demonstrated the value-ladenness of science and production of scientific facts.¹⁶⁴ Other fundamental texts show the values inherent in the creation and use of technologies and

¹⁶⁴ e.g. Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Beverly Hills, CA: Sage Publications, 1979); Karin Knorr-Cetina, "The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science (Oxford," *Pergamon Press*, 1981; Michael Lynch, *Art and Artifact in Laboratory Science: A Study of Shop Work and Shop Talk in a Research Laboratory* (London: Routledge and Kegan Paul, 1985); Joan H. Fujimura, "Constructing 'Do-Able' Problems in Cancer Research: Articulating Alignment," *Social Studies of Science* 17, no. 2 (1987): 257–293.

infrastructures.¹⁶⁵ More recently, scholars in STS, philosophy, human-computer interaction, and communications have explored the values of design in great detail, describing how conscious and unconscious biases shape everything from park benches to internet search engines.¹⁶⁶

Two important characteristics of values are their mutability and their potential to link micro and macro scales. In her study of the co-production of a search engine imaginary in Europe, Astrid Mager shows that values are not fixed quantities.¹⁶⁷ Rather, social and cultural values can evolve alongside technologies and sociotechnical imaginaries, as occurred in her context of EU data protection. Studying values can also bridge the national and the local, as Yasushi Sato demonstrated in his analysis of values in systems engineering.¹⁶⁸ Through a comparison of engineering cultures in the United States and Japan, Sato shows how sociocultural values are deeply embedded in day-to-day engineering techniques and practices.

Literature on inter- and transdisciplinarity tends to address values questions implicitly, or ignore them. Although many studies of discipline-spanning research focus on research institutes, few are concerned with the day-to-day efforts of building and maintaining these institutions, and the corresponding boundary work that their participants carry out. Instead, scholars tend to study inter- and transdisciplinarity as

¹⁶⁵ e.g. Langdon Winner, “Do Artifacts Have Politics?,” *Daedalus* 109, no. 1 (1980): 121–36; Lucy Suchman, “Do Categories Have Politics? The Language/action Perspective Reconsidered,” in *Human Values and the Design of Computer Technology*, ed. Batya Friedman (Cambridge, UK: Cambridge University Press, 1997); Susan Leigh Star and Geoffrey Bowker, *Sorting Things out: Classification and Its Consequences* (Cambridge, MA: MIT Press, 1999).

¹⁶⁶ e.g. Robert Rosenberger, *Callous Objects: Designs against the Homeless* (Minneapolis, MN: University of Minnesota Press, 2018); Safiya Umoja Noble, *Algorithms of Oppression: How Search Engines Reinforce Racism* (New York: New York University Press, 2018).

¹⁶⁷ Astrid Mager, “Search Engine Imaginary: Visions and Values in the Co-Production of Search Technology and Europe,” *Social Studies of Science* 47, no. 2 (2017): 240–62.

¹⁶⁸ Yasushi Sato, “Systems Engineering and Contractual Individualism: Linking Engineering Processes to Macro Social Values,” *Social Studies of Science* 37, no. 6 (2007): 909–34.

macro-level phenomena. They examine the ways in which transdisciplinarity reflects a new mode of knowledge production; the historical development of transdisciplinary discourses; or taxonomies of discipline-spanning work.¹⁶⁹ With few exceptions, notably some discussion of the value of aesthetics and beauty across disciplinary boundaries, the same is true of studies of art-science collaborations.¹⁷⁰

SEAD reflects the values of the worlds that its participants and stakeholders inhabit. American research universities, and land-grant universities in particular, come with their own sets of norms and ideals. In Chapter 1, I discussed the importance to the land-grant mission of knowledge extension, and the reimagining of extension as “engagement” in the 1990s. The idea that universities should maintain a strong connection with their local communities, and endeavor to positively influence their surroundings through their research, is one example of a land-grant value. Discourses of art and technology, inter- and transdisciplinary, and creative innovation reflect similarly value-laden ideas and practices. How do these high-level concerns interact to construct values within SEAD? How do these values influence the work that practitioners do and the institutes they build? And how does the work shift SEAD values in return? One issue that participants must manage is the number and variety of stakeholders involved in SEAD. What makes SEAD valuable to external audiences is not necessarily the same at the reasons practitioners engage in the work. For SEAD participants, there is a difference

¹⁶⁹ On transdisciplinarity and contemporary knowledge production, see Nowotny, Scott, and Gibbons, *Rethinking Science: Knowledge and the Public in an Age of Uncertainty*; Barry and Born, *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*; Klein, “The Transdisciplinary Moment(um)”; Julie Thompson Klein, “Discourses of Transdisciplinarity: Looking back to the Future,” *Futures* 63 (2014): 68–74; Mittelstraß, “On Transdisciplinarity.”

¹⁷⁰ See discussions on the aesthetic values of art and science in Arthur I. Miller, *Colliding Worlds: How Cutting-Edge Science Is Redefining Contemporary Art* (New York: W.W. Norton & Company, 2014); Leonard Schlain, *Art and Physics: Parallel Visions in Space* (New York: Quill, 1991).

between explaining what makes SEAD important to the world at large, and reflecting on their own reasons for belonging.

Belonging is another category that literature on inter- and transdisciplinarity rarely explores. The same tendency towards macro-level histories and typologies that often excludes values as an analytical object similarly tends to sideline belonging. In this case, however, some notable exceptions exist. An edited volume on interdisciplinarity in Canadian universities includes a rare set of personal essays that provide unique outlooks on the nature of interdisciplinarity. While the essays do not explicitly focus on belonging, the individual narratives provide a rare first person perspective on searching for a place in interdisciplinary spaces. One author, Ellen Balka, describes how her pursuit of particular research questions led her to borrow and synthesize disparate disciplinary techniques and theories.¹⁷¹ For Balka, the existence of an interdisciplinary PhD program at her university challenged her to define her own norms and values. Another contributor, Margrit Eichler, uses the metaphor of pathfinding to pay tribute to pioneering interdisciplinary scholars.¹⁷² She argues that their coping strategies of creating paths between disciplines resulted in the creation of new structures that subsequent generations of researchers could use and continue to build upon. Beyond this work, Eric Scerri discusses the formation of interdisciplinary research institutes and researchers' reasons for joining these spaces, and

¹⁷¹ Ellen Balka, "Perseverance, Pictures, and Parts," in *Outside the Lines: Issues in Interdisciplinary Research*, ed. Liora Salter and Alison Hearn (Montreal and Kingston: McGill-Queens University Press, 1996), 46–51.

¹⁷² Margrit Eichler, "On Finding One's Way in the Uncharted Swamps of Interdisciplinarity," in *Outside the Lines: Issues in Interdisciplinary Research* (Montreal and Kingston: McGill-Queens University Press, 1996), 58–62.

Myra Strober explores cultural and interpersonal barriers to interdisciplinary communication.¹⁷³

Academic studies of belonging in other fields date back to the earliest days of cultural anthropology. Within STS, scholars have explored belonging in scientific communities including high energy laboratories and hacker and makerspaces.¹⁷⁴ A significant body of work on belonging has emerged in engineering studies, much of it concerned with how race and gender relate to feelings of belonging, which in turn help to form engineering professional identities, as well as shaping student decisions to complete their engineering studies, or not.¹⁷⁵ SEAD is a minefield of professional identities, as stakeholders attempt to build a unique identity for their institutions and ideas that encompass a wide range of other, existing identities.

SEAD is not a standard academic space in which to belong. While the interdisciplinary research institute is gradually becoming a more established concept in American universities, SEAD institutions continue to make unique demands on their participants. They not only ask researchers to collaborate across disciplines; they encourage participants to challenge the boundaries of their own disciplinary expertise and professional identity. Furthermore, SEAD's status as an emerging phenomenon means

¹⁷³ Scerri, "Interdisciplinary Research at the Caltech Beckman Institute"; Myra H. Strober, *Interdisciplinary Conversations: Challenging Habits of Thought* (Redwood City, CA: Stanford University Press, 2010).

¹⁷⁴ Sharon Traweck, *Beamtimes and Lifetimes: The World of High Energy Physicists* (Cambridge, MA: Harvard University Press, 1988); Sarah R. Davies, "Characterizing Hacking: Mundane Engagement in US Hacker and Makerspaces," *Science, Technology, & Human Values* 43, no. 2 (2018): 171–97.

¹⁷⁵ e.g. Wendy Faulkner, "'Nuts and Bolts and People': Gender-Troubled Engineering Identities," *Social Studies of Science* 37, no. 3 (2007): 331–356, <https://doi.org/10.1177/0306312706072175>; Cynthia E Foor, Susan E Walden, and Deborah A Trytten, "'I Wish That I Belonged More in This Whole Engineering Group': Achieving Individual Diversity," *Journal of Engineering Education* 96, no. 2 (2007): 103–115; Mary Ayre, Julie Mills, and Judith Gill, "'Yes, I Do Belong': The Women Who Stay in Engineering," *Engineering Studies* 5, no. 3 (2013): 216–32.

that participants are often encouraged to lean into a strong transdisciplinary identity in order to help solidify their institutions' own place in the university landscape.

SEAD and ICAT offer rich territory to explore issues of value and belonging. As an emergent phenomenon, stakeholders, participants, and publics are still defining SEAD. This definition requires making many conscious and unconscious decisions about values and belonging, and engaging in boundary work around both of these quantities.

At ICAT, I've been able to observe four years of participants' decision-making. I have seen boundary work occur on a project level, as researchers pick their collaborators, apply for funding, consider which external organizations might make appropriate partners, choose how and to whom they present their research, and decide whether, or in what form, they want to continue once their project has reached an end point. I've also observed the process on an institutional level, as ICAT leadership formed the group of Studio Heads/Senior Fellows, managed changes to this group, formed partnerships with existing departments, institutes, and research groups on campus, decided which graduate students to support and which proposed projects to fund, continued to pursue external partnerships, and conducted their five-year review. Finally, I've observed these decisions to a lesser extent on a larger scale, as the SEAD Network and a2ru expanded to new member organizations, pursued new policy directions, and chose which projects to showcase. Questions about value and belonging are integral to these decisions on all three scales.

Value in SEAD: Making Appropriate Projects

The Value of Projects and the Values of Researchers

Talking about values makes many ICAT researchers uncomfortable. They work in a place that strives to facilitate collaborations between distant people and fields. To suggest that a value system might privilege certain people and types of work over others feels like a misunderstanding of their core mission, or a challenge to it. And yet, ICAT participants, and all other participants in SEAD, do make frequent value judgements. They regularly decide which projects to fund, which work to showcase, and which other practitioners and institutions they should work with. They make these decisions according to criteria which they rarely articulate, and sometimes do not recognize.

Furthermore, SEAD stakeholders frequently attempt to explain the value of their work to administrators, funding organizations, potential community or industry partners, and others outside their transdisciplinary environments. As Knapp expressed through his worry that the Virginia Tech administration would fail to meaningfully comprehend and appreciate ICAT's work, successfully articulating this value to external actors is difficult, but necessary for the survival of SEAD institutions. When faced with the challenge of justifying their work to external audiences, SEAD researchers juggle external stakeholders' demands with their own motivations.

Recently, SEAD networks have showcased and attempted to evaluate examples of successful SEAD projects. In 2015, a2ru showcased five "transdisciplinary exemplars" at its national conference, which Virginia Tech and ICAT hosted. In 2017, the SEAD Network similarly curated a list of successful transdisciplinary projects, and presented them in an online gallery and a public report, titled "SEAD Exemplars: Evidence of the

Value of Transdisciplinary Projects.”¹⁷⁶ In the report, curators categorized the exemplars and argued for their contributions to “education, culture, and economic resurgence.”¹⁷⁷

These exercises demonstrate the balancing act that SEAD researchers engage in when they attempt to define what good work is. The SEAD Network report and website are outward-facing, but the curation committee consists of members who are deeply enmeshed in the SEAD universe. The a2ru experiment mixed internally oriented reflection with a first run at a peer review system which facilitators hoped would reach beyond the organization’s member institutions. At ICAT, participants work to convey both the value and breadth of their work to general audiences through the Institute’s many public-facing events. All of these efforts strive to present a broad range of SEAD projects, but also to demonstrate a unity of mission and vision. Participants want to categorize the projects such that their evaluations are digestible for unfamiliar audiences, without losing the complexity that makes the work valuable in the first place.

The SEAD Network report presents an array of projects that the curators chose to “highlight their importance and impact.”¹⁷⁸ The fourteen projects presented in the report are organized into seven categories: Innovating, Exploring, Educating, Bridging, Engaging, Questioning, and Pioneering. Most categories contain two projects (with two exceptions: the Exploring category includes three projects and the Pioneering category honors a single individual rather than a set of projects). Each category has a set of associated characteristics, e.g. “patent awarded” and “significant public/non-expert engagement,” some of which are more easily measurable than otherwise.

¹⁷⁶ “SEAD Exemplars,” <https://seadexemplars.org/>, accessed September 27, 2018.

¹⁷⁷ Topete et al., “SEAD Exemplars: Evidence of the Value of Transdisciplinary Projects,” 3.

¹⁷⁸ Topete et al., 4.

If the report is a demonstration of the value of SEAD, these categories provide some indication of the breadth of this value, but do not articulate its core. The categories fail to capture the similarities that exist across all the exemplar projects, and give no indication of the overarching qualities that led to their selection in the first place. In short, they present SEAD as a space in which practitioners “only do everything.”

To better understand which qualities SEAD stakeholders value, cultivate, and promote, I analyzed the public-facing summaries of each exemplar project, as presented in the report and the digital gallery. I also looked at the project descriptions of exemplars identified by a2ru two years earlier, and I compared the results of both analyses with a more informal survey of the ways in which participants at ICAT articulate the value of their own work and the work of their peers, drawn from interviews, observations of meetings, and analyses of written materials. This analysis resulted in an initial list of twenty-two qualities that participants or curators used to describe the value of at least two SEAD projects.

Of these twenty-two initial qualities, some featured in only a small handful of projects. Others were similar enough to one another that they could be grouped into a larger category. In the end, five major value categories emerged. I found that successful SEAD projects demonstrate all or most of the following values: Transdisciplinarity, Impact, Newness, and Useful Art.

SEAD Values

The first of these values, transdisciplinarity, is foundational. To identify transdisciplinarity as a value of explicitly transdisciplinary work may seem trivial;

however, in addition to the complicating definitional issues discussed in Chapter 2, SEAD participants understand transdisciplinarity in two distinctive ways. First, for SEAD stakeholders, crossing disciplinary boundaries is an inherently valuable characteristic of projects and people. While practitioners' efforts to convince external audiences of the value of transdisciplinary work may focus on articulating *why* this is the case, they do not question its importance when it comes to internal reviews or assessments. Second, the farther apart the disciplines in question are perceived to be, the more valuable the project. A proposal that brings together physicists and performance artists is superior, in this sense, to one that involves biologists and mechanical engineers.

In the exemplar report, the breadth of disciplines bridged by the showcased projects is often the first quality that the curators note in their descriptions. *Kiatsu*, an installation of noise soundscapes that represent the experience of living near Japanese airports, is praised for its integration of “sound art, anthropological research, and acoustic science.” *Self-Reflected*, which visualizes brain science by etching neurons into gold sheets, “fuses neuroscience, optics, mathematics, physics, and art.” With the notable exception of the two projects in the “Innovating” category, all of the SEAD exemplars feature transdisciplinary collaborations between art or the humanities on one hand, and science or engineering on the other. These unusual-seeming disciplinary combinations – acoustic science and anthropology, neuroscience and visual art, physics and opera; film and biology – are part of what renders these projects extraordinary enough to be considered exemplars.

Importantly, the projects' transdisciplinarity is usually described not as an end goal, but as a necessary means through which the outcomes of the project were achieved.

Another exemplar project, *Prom Week*, “required developing novel computer science simulation techniques and artificial intelligence models, guided by arts storytelling and humanities, media studies, and social science approaches.” In this example, the project’s eventual output was made possible by the integration of computer science and storytelling.

Participants at ICAT use similar techniques to describe the transdisciplinarity of successful projects. While ICAT funds a wide variety of projects, the work that ICAT stakeholders most often hold up as exemplary brings together forms of art and forms of technoscience that seem far apart. OPERAcraft, a project in which high school students worked with Virginia Tech faculty to create and perform an opera set within the world of Minecraft, synthesizes the performing arts with video game design and K-12 education. SeeMore is both sculpture and computer science. Salt Marsh Suite includes dance, visual art, and ecology; L2Ork and Maker Camps include music, education, and computer science; and the Belle2VR project involves physicists, science educators, and artists. However, these transdisciplinary projects involve very different modes of working together. On the OPERAcraft project, team members valued a lack of “pigeonholing”: each participant could engage in a broad range of activities, and the same person could end up programming, performing, and writing parts of the libretto.¹⁷⁹ On Belle2VR, in contrast, as discussed in Chapter 2, each team member conducted tasks that fit within his or her discipline. Physicists provided the raw data and scientific expertise, a virtual environments specialist created the virtual reality model, and science educators designed the curriculum. This range of collaboration types runs from “cross-disciplinary” to truly

¹⁷⁹ Field Notes, ICAT Community Meeting, October 25, 2013.

“transdisciplinary” within established typologies, but ICAT participants are happy to label it all as transdisciplinary.

A second SEAD value is what I have broadly labelled “impact”: the ability of a project or person to facilitate public/non-expert participation or interest in their work. Practitioners themselves generally frame this quality as “engagement”; however, participation very often evokes a deficit model of science communication, whereby the researchers/experts use their SEAD work to explain scientific concepts to an uninformed public. Whether or not any of the targeted groups are truly “engaging” in the material, therefore, is not always clear. SEAD work and ICAT projects in particular frequently involve K-12 students, but impact can include many other groups as well. Sometimes the concept extends to including the target non-expert audience in the development of a project, but usually it is limited to interaction with a completed work.

“Impact” is not a perfect descriptor for this category. It lacks the clarity and linearity of “transdisciplinarity,” in that it is much more difficult to describe a project’s degree of impact than it is to determine how many different disciplines it encompasses, or how wide the gulf between those disciplines may be. Furthermore, participants’ understandings of impact are not even limited to actual participation: a project may be considered impactful if it has the potential to raise awareness or begin a future discussion. Nevertheless, influence on non-expert groups is an important SEAD value. In Chapter 4, I discuss some of the implications of valuing “impact” in this ill-defined and wide-ranging sense.

Among the SEAD Network exemplar projects, some descriptions cite specific connections that a project has made with companies or governmental organizations. The

makers of *Prom Week* have partnered with DARPA, the European Union project SIREN, and other simulation game developers, “thanks to [the project’s] success in engaging players and its research output.” Other projects “spark conversations” (*Hieroglyph*) or “trigger discussions” (*Hypermusic*). *Hypermusic*, an opera designed to communicate the basic principles of a model of space-time, locates its impact in the discussions it has sparked within the international physics community. Inspiring knowledge or discussion among the public is a common refrain: *Kiatsu* “makes a scientific problem accessible and relevant to the general public,” while *Self-Reflected* “inspires a broader appreciation” of neuroscience.

Numerous ICAT projects also demonstrate impact as a SEAD value. SeeMore was designed to use its array of Raspberry Pi computers to visually demonstrate the power of parallel processing to its audiences, “to educate and inspire computational thinking.”¹⁸⁰ In addition to framing SeeMore’s value in terms of its ability to educate, ICAT and Virginia Tech personnel praise the publicity that SeeMore has generated for the Institute and University. Its recognition at SIGGRAPH, the NSF, and by the readers of a magazine devoted to Raspberry Pi-based projects demonstrate the effects that SeeMore has had on publics well beyond the university. Projects like Instrument Maker Camps and Belle2VR also have impact at the core of their missions. Belle II aims to affect particular groups, namely university-based physics educators, and Maker Camps have the broader goal of changing the ways middle-school teachers approach STEM subjects in their classrooms.

SEAD stakeholders also view newness and novelty as inherently valuable. Reviewers praise projects that result in innovative methods, models, or curricula, even

¹⁸⁰ “Parallel Computing Sculpture SeeMore Named One of the Top Projects in the World.”

when these new things are not necessarily standard research outcomes. Newness on its own, like transdisciplinarity, is a prized category, independent of the project's perceived results or effects. This is an important part of the identity of SEAD, which loses some of its own value if it begins to resemble too closely existing projects or institutions.

The SEAD Network exemplars express their newness in a variety of formats. These range from the abstract (the “new perspectives” offered by *Transplant and Life*), to the practical (*STEAM Lab*'s “novel educational practices”), and from the specific (*Prom Week*'s “new model” for making scientific concepts playable) to the wide-reaching (the “new industries” that sprung from Charles Csuri's pioneering work). This range of projects values newness independent of the manner of thing that is new, and the effects that the new thing has. The value is in the novelty itself.

ICAT similarly emphasizes the newness of its projects and events. L2Ork is the first open-source laptop orchestra in the world, and the annual Cube Fest event is the first to open up multichannel music for public consumption. But another part of ICAT stakeholders' work is to demonstrate the newness of the Institute itself. Knapp frequently refers to ICAT's position on the “bleeding edge” of transdisciplinary knowledge production. The Institute's vision statement is “to create new possibilities for exploration and expression” through the creative process.¹⁸¹ This language evolved from the Institute's original mission documents, which touted “promotion of new cross-disciplinary research domains” and the co-creation of “new ideas.”¹⁸²

¹⁸¹ “About Us,” Institute for Creativity, Arts, and Technology, <https://icat.vt.edu/about-us/>, accessed September 27, 2018.

¹⁸² “The Institute for Creativity, Arts, and Technology at Virginia Tech: Overview and 20-Year Vision” (Blacksburg, VA: Virginia Tech, 2011).

The final SEAD value is “useful” art. A successful project emphasizes specific ways in which the arts and design are important. Many projects demonstrate the use of the arts in communicating science or teaching STEM subjects. Others focus on the ability of the arts to facilitate empathy. The common thread is that a SEAD project will demonstrate that the arts are materially or practically *useful*. Other potential demonstrations of the value of art, such as a piece’s dialogue with existing works of art; its provocation, critique, or social commentary; or its contributions to an artistic discipline, rarely feature in discussions of SEAD projects. Art in SEAD is often the means by which impact is achieved: it is a vehicle through which audiences connect with the work, with an abstract or complex idea, or with each other/the researchers.

The ability of the arts to promote empathy and facilitate human connections is a common theme. The SEAD Network report describes *Transplant & Life*, for example, as a demonstration “of how artists can provide a new human perspective to scientific and technological issues.” Some projects unapologetically describe the role of art as subservient to scientific or technological interests: in *Hypermusic*, the arts are a “bridge among experts across scientific fields.” The project description does not remark upon the music, staging, or performance of the opera that is central to the project, choosing instead to describe how the process of creating the piece, and later its dissemination, provoked conversations within the international physics community. Even in cases where art and technoscience are granted more equal attention, the descriptions still tend to highlight technoscientific *research* opposite the *impact* or *connection* facilitated by art. For example, *Malamp & Season in Hell* manage to “both raise awareness through art and produce good research in the process.”

At ICAT, as with the SEAD Network report, not all projects have outcomes that are strictly artistic. However, the value that SEAD participants and stakeholders find in useful art is present regardless of the focus of a project. Though participants in Instrument Maker Camps do create musical instruments as a material end result, camp facilitators do not emphasize art making over other experiences and skills. Participants spend more time learning to code and create 3D-printed objects than they do thinking about the sound their instrument makes, or the ways in which they will perform with it. The camps promote the ideal of art's utility to inspire collaboration, critique, and the inventive process. On the other hand, projects that do have art-based outcomes garner acclaim within ICAT for their utility, even when this is not the primary aim of their creators. Salt Marsh Suite, an installation and performance piece, was praised by ICAT administrators for its ability to educate the general public about marsh ecology, and inspire conservation.

SEAD Values as a Matter of Concern

Values are a matter of concern in SEAD first because they relate to the narratives of transformation that contributed to creating ICAT, and to which ICAT stakeholders themselves contribute. We can see in these values the diverse motivations and different stakeholders that go into making ICAT what it is, and into building SEAD. For university leaders at Virginia Tech, transdisciplinarity was a reinvigoration of the land-grant mission, a connection between disparate parts of the campus, and a path towards new revenue streams. For faculty at CCTAD and IDEAS, it was a name for the art-technology research and the design- and problem-based pedagogy they were already pursuing. And for administrator-practitioners like Knapp, it was a way to encourage innovation. Impact

is an essential value of the land-grant university, and also a primary goal for educational reformers and innovation advocates alike. Newness most obviously stems from an increased emphasis on universities as innovation machines, but it is just as important for art-technology researchers who push methodological and practical boundaries in their research. Finally, the idea of useful art reflects the evolution of the art-technology world since the 1980s, and is an important aspect of arts integration in problem-based education.

Transdisciplinarity, impact, newness, and utility are not totally unfamiliar criteria to academics, as any researcher who has completed a grant proposal can attest. However, they also do not correspond to the ways in which academic disciplines typically value and evaluate their work. These are open-ended ideals. They leave room for many types of projects and people, but they do so with a vagueness that calls for some other kind of boundary work to delineate who and what belongs in SEAD. Building institutions and practices around these values results in open questions about who should become involved in SEAD, why they should do it, and how participants will receive credit for their work.

Evaluation is a key part of these questions. Just as SEAD values leave the door open to many different kinds of people and projects, they also allow for many different types of evaluation. Or, in practice, they lead to uncertainty about what kinds of evaluation might be fair, reasonable, or appropriate. How can we judge the amount of transdisciplinarity that a project exhibits? How might we tell what its impact will be based only on a proposal? How does a new method or technology compare with the potential of new perspectives? Most pressingly for practitioners, as stakeholders develop

SEAD evaluation practices, how do these practices relate to those within their own disciplines?

Finally, valuing “useful” art raises questions about agency and power between disciplines and individual practitioners in SEAD. If the role of artists and designers in SEAD is to render science and technology palatable for publics, the agency of the artist is reduced to that of a facilitator. Furthermore, it is unclear what enticements such projects might offer for artists. This value also raises the issue of for *whom* the art, or the project in general, should be useful. Who is the target audience for SEAD? How does it differ between projects? What motivations do various publics have to engage with SEAD, to the extent that practitioners invite them to?

Belonging in SEAD: Making Appropriate People

“I like to say,” said the graduate student, grinning, “that ICAT is a home for technophile artists and misfit engineers.” We were in the Sandbox, surrounded by bits of cardboard, 3D-printed prototypes, and computers humming with activity. At my desk in the corner, I glanced at an adjacent bookshelf, the only one in the room. Before I could ask the student to say more, a nearby professor and Senior Fellow joined the conversation with a chuckle: “We’re the island of misfit academics.”¹⁸³

SEAD as a Place to Belong

Expressing their discomfort with other parts of academia is one of many ways in which participants in SEAD articulate their attachment to transdisciplinary spaces. Navigating one’s own sense of professional belonging in these spaces is important and difficult.

¹⁸³ Field Notes, November 30, 2015.

SEAD environments challenge researchers to reconcile the domain's narratives of transformation (to which researchers also contribute) with their personal interests and research goals, and the disciplinary standards of their "home" departments. In addition to dealing with this complex terrain of loyalties, the unfamiliarity of SEAD demands a degree of introspection from its participants. Asking, "why do I belong in SEAD?" requires interrogating what my value is to the emergent vision, and what its value is to me. There is therefore a great deal at stake for SEAD researchers as they navigate their own senses of belonging.

As they figure out their own reasons and ways of belonging, participants also regularly decide which other people and projects belong in SEAD. Researchers at ICAT engage in this boundary work on a daily basis, often unconsciously. As they recruit team members, review project proposals, or even describe their work to acquaintances, they articulate the qualities that make people and their work appropriate for ICAT. Asking why or where a project belongs necessitates thinking about what SEAD should become, and how certain work might contribute to that vision. Project-level challenges with belonging and value are common issues across SEAD institutions.

The same issues that make value in SEAD a matter of concern also connect SEAD values to researcher's senses of belonging. People participate in SEAD environments for many different reasons, and with different levels of commitment and longevity. Among researchers who are deeply engaged in SEAD institutions, the values outlined in the previous section are often what attracts them. However, SEAD's values can also be sources of tension and frustration. Dealing with these value questions affects participants' senses of belonging, and their decisions to join, stay, or leave SEAD

environments. Finally, value questions, and the general challenges of long-term work in a transdisciplinary academic space, also privilege certain types of people, and the demographics of ICAT and other SEAD institutions reflect this.

ICAT Origin Stories

Researchers participate in SEAD environments for a wide variety of reasons. They also participate in different ways and to different degrees. Some researchers' interests are inherently transdisciplinary. Their expertise may be trans- or antidisciplinary in and of itself, or they may be interested in problems that are beyond the scope of their own skills and experience, and require input from those in other disciplines. For some, institutions like ICAT are a comfortable primary home for their work. Others use ICAT's resources to pursue side projects that are on the periphery of their usual research. Still others, of course, are not at all interested in belonging at a place like ICAT.

Unsurprisingly, the question of *why* people engage with ICAT is one that deeply interests the Institute, and its researchers are eager to share their own tales of joining ICAT and coming to belong there. Some of these origin stories include an initial resistance to engage in transdisciplinary research, followed by a realization that this was work they were meant to do. Researchers often describe how their passionate curiosity or commitment to solving complex problems led them to ICAT. Others simply enjoy working with the kindred spirits whom they have found in SEAD.

Very often, participants tell how a chance encounter with ICAT-affiliated project, class, or person rekindled their latent interest in working across disciplines. "I had no idea what I was getting myself into," said one student, who responded to an email about

undergraduate research opportunities at ICAT based on nothing more than a vague interest in interdisciplinary work. She told me how she had always had an “inherent, unconscious” interest in art and technology, but had begun to “miss the art part” after beginning her major in computer science.¹⁸⁴ A faculty member noted that while she was drawn into ICAT through a specific project, she has “always been interested in interdisciplinary work.”¹⁸⁵ A graduate student, who later became a key player on a flagship ICAT project, recalled seeing a poster for an ICAT-sponsored course that invited students to “make something awesome,” took the course, and decided to “keep going with it.”¹⁸⁶

While researchers often describe a tendency towards transdisciplinarity as an important part of their involvement with ICAT, not everyone who is involved with the Institute shares this quality. One faculty member in the arts described her surprise at feeling drawn towards ICAT projects:

I heard about it, the idea of arts and technology, and really for me to be interested in something that had the word technology attached to it was odd to me, but I went...there was a call for a meeting talking about this new institute. I had met Ben and I found him delightful and I was very thrilled that he himself did performance, that he put himself in the genre.¹⁸⁷

¹⁸⁴ Interview 8.

¹⁸⁵ Interview 6.

¹⁸⁶ Interview 7.

¹⁸⁷ Interview 5.

For this artist, ICAT did not at first seem like a place where she would be comfortable. It was only after meeting the people involved, and noting the incoming Director's experience in her own field, that she began to convince herself. The presence of other people like her, which in this case included artists, women faculty, and those with an interest in critical pedagogy, were integral to her forming a sense of belonging: "I was extremely skeptical but...but then I kept admitting to myself, you know, and Liesl [Baum] was there and Phyllis [Newbill] was there and there were people working with pedagogy, with critical pedagogy in a way that I really responded to, so I just kept going to the meetings."¹⁸⁸

Many people also felt themselves drawn in to ICAT through a particular project or experience, though not all experiences are initially positive. A senior fellow recounted, with a laugh, how he had eventually been convinced to sign on to an ICAT-sponsored grant proposal that he initially had little interest in, noting that one of the ICAT-affiliated PIs "can be very persuasive."¹⁸⁹ A former faculty affiliate told me about her extreme opposition to leaving the research group she had worked in as a graduate student in order to get involved with the IDEA Studio. She recalled "pushing, yelling and screaming and saying no no no don't take me out of the lab...I cried about it, I yelled about it, I fought it and they finally said you don't have a choice, if you want funding this is what you're doing." Following this reluctance in one case, and dramatic unwillingness in the other, to joining ICAT, both of these researchers went on to become integral members of the ICAT community during its early years.

¹⁸⁸ Interview 5.

¹⁸⁹ Interview 9.

Making Boundaries of Belonging

Several ICAT participants give their own, unprompted versions of the above statement about “misfit academics.” One faculty member even echoed the “misfit” terminology as she noted that, at ICAT, “there’s a lot of people that...feel like they’re misfits in other places.”¹⁹⁰ This description of ICAT as a home for researchers who don’t belong elsewhere brings together the intrinsic sense of transdisciplinarity with the need for community. Those who claim a strong connection to ICAT express their belonging not only by describing their previous bad experiences or lamenting a lack of understanding in their home departments, but also by stating how, in ICAT, they found a group of familiar oddballs. Curious about the idea of “misfits” after our encounter in the Sandbox, I asked the graduate student who made the initial statement to expand on what he meant:

So the line, the standard line I use is, ICAT is a place for misfit engineers and technophile artists. It’s for engineering people who value things outside of their discipline, who can and like to collaborate with others and I don’t mean engineering strictly but I mean sciences and engineering, disciplines that don’t normally mix with art and design. And it’s the art and design people who like the technology, who like the, you know I shouldn’t say technology, just technology and smart systems and trying to combine them together. And it’s a home for those people to exist sort of outside their traditional departments or silos.¹⁹¹

¹⁹⁰ Interview 5.

¹⁹¹ Interview 10.

His statement reiterates the uniqueness of ICAT as a place where certain types of people work and build community. But it also puts boundaries around those types and the disciplines they belong to; boundaries that are not as universal as the speaker believes. In his telling, normal engineers and scientists do not collaborate well, and normal artists are unfamiliar with technology. However, even within Virginia Tech itself, it is easy to find examples of scientists and engineers working on cross-disciplinary collaborative projects wholly unrelated to ICAT. And the field of contemporary art is full of technologically savvy artists who nevertheless do not associate themselves with SEAD. Setting boundaries like these, which can be widely accepted and repeated within ICAT but may not exist elsewhere, is a common blind spot for SEAD participants.

One way in which participants' boundary work becomes obvious is when they explain how other people belong, or don't belong, in SEAD. In this case, rather than telling origin stories, participants tend to describe characteristics that relate to SEAD's values. When asked to describe how an Institute administrator came to join ICAT, a senior fellow recalled his own enthusiasm at the time of the administrator's hire. "He understands all this science stuff but you look at his work and it's totally weird. I mean it's like, what is that? So I was like, that's a perfect blend. That's what we need."¹⁹² In addition to describing bringing another misfit into the fold, this excerpt demonstrates the importance to the speaker of newness and transdisciplinarity. Not only did the researcher in question exhibit transdisciplinary qualities; they did it in a way that the speaker hadn't seen before. He immediately identified this new combination as an important contribution to ICAT.

¹⁹² Interview 3A.

Sometimes ICAT stakeholders demonstrate SEAD values by noticing that the institute lacks something, and seeking out a new person to come and supply this. Describing a faculty member and potential new Senior Fellow, an existing Senior Fellow said of her, “ICAT already has a pool of people that can do that one thing very well. I think ICAT needs someone like her saying well, what about this other part that’s not getting fed, the other part of the equation that’s not getting its fair due.”¹⁹³ Here, the speaker is seeking to balance disciplinary power within the Institute, to ensure a more equitable kind of transdisciplinarity.

Participants also use values unconsciously to dictate belonging. If a project isn’t transdisciplinary enough, or isn’t showing something new, it’s likely to be rejected with an “it’s just not quite ICAT enough,” or sometimes, “it’s not ICAT-ian.” Rather than articulating the exact reasons why something or someone doesn’t fit, researchers often cite ICAT or SEAD as its own category.

Struggling to Belong

People often struggle to belong at ICAT, for a variety of reasons. The values I previously discussed can also turn people away from SEAD. Some struggles to belong stem from a mismatch of researchers’ interests and SEAD values, or from different interpretations of what those values mean. In the statement below, a faculty member takes issue with the type of “impact” that she has been asked to measure.

I look at the quantitative data and I just want to use it as a coffee coaster, like this doesn’t mean anything to me. I don’t care that you had 2000 people here.

I don’t care, you know, because people can walk through this building to use

¹⁹³ Interview 3A.

the bathroom and you've counted them as being here, that doesn't matter.

What matters is that child saying whatever they have to say, right, or then using language that they've heard through an experience that they've had and then becoming much more mature in their science, their practice.¹⁹⁴

For this researcher, impact cannot be evaluated over the course of a single event. Rather, she understands impact on an individual level, and would prefer to study it long-term, following the students who have participated in studies or ICAT events and observing the qualitative differences in their behavior and vocabulary. While she believes deeply in the value of impact as an object of study, she struggles to conform to the interpretation of impact that ICAT demands of her.

Other struggles to belong are rooted in disparities in funding or prestige between the home disciplines of ICAT researchers. As previously discussed, valuing “useful art” can lead to loss of agency and power for collaborators from art and design fields. Different mechanisms of evaluation and funding allocation can also result in struggle. During one Senior Fellows meeting, as the group discussed potential hurdles to bringing new faculty to the Institute, Knapp shared that his artistic work was not part of his promotion and tenure portfolio. This work, in large part, was what made him an appropriate and popular choice as ICAT director, yet it did not factor into what he believed (or, at least, what he believed his department and college would believe) made him a successful engineering professor.¹⁹⁵

Even within ICAT projects, differences exist between artists, designers, scientists, and engineers. One participant in a project that included artists and architects as well as

¹⁹⁴ Interview 14.

¹⁹⁵ Field Notes, a2ru conference planning meeting, January 15, 2015.

engineers and computer scientists shared their frustration with the kind of work they had been able to do on the project team.

KZ: “Do you think [this] is a project for artists?”

I7: “No. And I say that pretty quickly, because every time an artist has wanted to do something, there’s been a fight...I don’t think there’s a place because of the mentality of the people on [the project]. Not because of what the project could offer. I think there’s tons of offerings for people.”¹⁹⁶

This project had NSF funding, and so, in the eyes of this participant, its leaders favored scientific and technical outcomes over the significant artistic potential that the project offered.

Some researchers find a natural home at ICAT because the type of work the Institute favors includes the type of work they are skilled at, or already do on their own. For these practitioners, finding an initial sense of belonging is relatively easy. They have a natural, longstanding interest in work that bridges the arts and technology, and their existing portfolios and skillsets reflect this. After a short period of getting to know the Institute and its members, these researchers feel a strong sense that ICAT is the right place for them to be. However, over time, those whose skill sets prove valuable or popular can be overwhelmed by ICAT’s demands on their time and energy.

This will sound maybe a little egotistical, but the kind of work I do maps on very well to what [ICAT] wants to show, constantly, like I mean I’m demo

¹⁹⁶ Interview 7.

boy...on the one hand it feels great to have people think highly of your work and want to do that, but it also is like, you know, providing really good cocaine to a drug dealer.¹⁹⁷

I'm struggling because I'm so far removed from, I feel so far removed from my personal research goals because I have not had the time to develop them and I haven't had the time to write proposals and I haven't had the time to collect appropriate data because I'm doing all these other things.¹⁹⁸

The above quotes are from former Senior Fellows, both of whom eventually stepped down from their positions at ICAT. The first researcher talked about how he began to avoid certain ICAT events and public meetings because he was afraid that he would meet new people, whose work he was genuinely interested in, but which would continue to drag him away from his other responsibilities. In contrast, the second researcher continued to attend and organize ICAT events, but as a result lost time to pursue her own research agenda. In addition to the time commitment, both researchers felt underappreciated by other ICAT affiliates, who they believed tended to take their work and resources for granted.

Finally, some people struggle to belong because ICAT's demographics. Researchers who join ICAT because of their interests in a project or their internal pull towards transdisciplinarity will still struggle to belong if they do not recognize a place for themselves in the Institute's community. This is a real struggle for many people: without

¹⁹⁷ Interview 3A.

¹⁹⁸ Interview 14.

any malicious or exclusionary intent on the part of its leadership, the diversity of ICAT's core faculty and staff largely begins and ends with their disciplinary differences. As of 2018, all fifteen ICAT staff and senior fellows are white, and the division of labor within the Institute is highly gendered. The Institute's director and associate director are both male engineers. The office staff, with the exceptions of the media engineer and web developer, are women. The researchers in the Center for Research SEAD Education – a group focused on K-12 education and outreach that grew out of the former IDEA Studio – are all female, while the Center for Human-Computer Interaction, another research group located within ICAT, is largely male. The 2015 retirements of Ann Kilkelly and Carol Burch-Brown led to a gender disparity within the group of Senior Fellows that has only recently been rectified. Among the Institute's funded graduate students, the racial disparities are less apparent, but the gender biases are even more obvious. Between 2013 and 2018, I was the only female graduate student to stay with ICAT for more than one year, and women researchers departing the Institute confided that they found ICAT's atmosphere "toxic."

While I lack the type of robust data necessary to make any definitive claims, ICAT's demographics and my anecdotal experiences of a2ru, the SEAD Network, and other SEAD institutions, suggest that there is something about long-term work in transdisciplinary environments that demands a degree of privilege. Laurel Smith-Doerr and Jennifer Croissant have shown how women are often expected to take on the tasks of facilitating interdisciplinary research, including communication and coordination, even while their supervisors and department heads advise them against pursuing

interdisciplinarity.¹⁹⁹ The intersections of gender, race, and transdisciplinarity are a topic that I hope to pursue in greater depth in future work.

Creating Structure and Boundaries through Codifying Values

A key part of defining what SEAD is supposed to be is identifying what its norms and values are, and who participates in it. These categories are complicated, and related to one another. By studying values and belonging, we can better understand the boundaries that constitute SEAD. Stakeholders value four main properties that connect successful projects despite their wide range of other characteristics: transdisciplinarity, impact, newness, and useful art. Due in part to the challenges that these values raise, negotiating belonging in SEAD spaces is a complex task for participants. Ultimately, SEAD does not do everything, nor is it for everyone.

Paying attention to value and belonging draws out larger issues that exist beneath the surface of the idea of SEAD. It is my hope that participants can use these reflections on value and belonging to help design new review processes, decision-making protocols, and ways to communicate that are honest, transparent, and useful to everyone involved. I further hope that these new processes can help make SEAD a more diverse, and most importantly a more equitable place. But beyond these practical considerations, questions about value and belonging are important because of the complexities they reveal about SEAD as a phenomenon.

ICAT's rhetoric of openness and inclusiveness suggests a value-neutral environment where all ideas are welcome and anyone can succeed, but in fact belonging

¹⁹⁹ Laurel Smith-Doerr and Jennifer Croissant, "Gender Equity and Interdisciplinary Collaboration," *Interdisciplinarity Now* (The Social Science Research Council, November 1, 2016), <http://items.ssrc.org/gender-equity-and-interdisciplinary-collaboration/>.

in spaces like ICAT is a challenge for many. The simultaneous uncertainty and prescription of SEAD values leads to crises of belonging for participants.

The multiple narratives upon which SEAD is built, and to which its practitioners continue to contribute, give rise to vague and uncertain values. Inter- and transdisciplinarity emerged as catch-all solutions for universities struggling with financial issues while also working to reinvigorate their approaches to engagement and, for Virginia Tech in particular, seeking a home and a purpose for the arts on its campus. However, the meanings of these terms vary considerably depending on who is using them. Often, practitioners and administrators lack a deep sense of what they mean at all. This leaves them pursuing goals that they do not understand, for reasons that often seem unclear.

Meanwhile, the evolution of the art and technology world within American universities has moved from small, artist-led programs focused on individual collaborations, to more technologically focused institutions attempting to influence national policy. The sensibilities of early art/tech programs and founders still influence today's practitioners, but are increasingly at odds with the economic and cultural landscape in which modern SEAD institutions exist. Innovation discourses call for collaboration and celebrate failure even as they valorize tech pioneers known for their loner status and financial success. Taken together, these influences result in a complicated and conflicting mess of values, which SEAD practitioners must sort through.

Of course, practitioners also take their own values and needs into account as they make sense of the organizations to which they belong, and which they help to build. The projects that they engage in are individualized and often personal. While researchers

themselves are not always able to put a name to this frustration, their attempts to force the work they want to do into boxes that are acceptable to their institutions is challenging.

In its emphasis on the material and the practical, SEAD tends to prioritize new ways of *making* or *doing* things over new ways of *understanding*. These priorities invariably influence which researchers and projects find homes in SEAD.

In an attempt to combat uncertainty, institutions and networks try to codify their values in the form of “exemplars” and review processes. By creating typologies of good SEAD projects, they aim to celebrate their success, provide direction for future researchers, and create structure for participants in the absence of a disciplinary “home.” Codifying values also tends to render SEAD ideals more comprehensible – and measurable – to external actors. In the next chapter, we turn to the idea of measurement in SEAD as a matter of concern in its own right.

Chapter 4

Measurable Impact: Seeking Legitimacy through Assessment

As stakeholders in SEAD tout the benefits of transdisciplinarity, they work to verify that their aspirations mesh with reality. An instructional designer struggles to quantify the effects that a week-long instrument maker camp has had on its middle-school-aged participants, wondering how well her analytical instruments align with the goals of the camp. Elsewhere, a director searches for metrics that will demonstrate return on investment and make a case for the continued existence of the research institute he runs. At a national conference, a coalition of arts researchers and educators calls for large-scale studies with which to argue for an emphasis on arts integration in national education policy.

Measurable impact – demonstrable, shareable evidence of positive change resulting from SEAD research, education, or engagement – is one way to determine the success of SEAD work. As SEAD practices and ideas spread, university budgets tighten, competition for resources increases, and institutions grow, demonstrating this success becomes a necessary and influential aspect of SEAD work itself.

Measuring impact has practical importance for researchers, educators, administrators, and advocates, all of whom carry out measurement activities in different ways, by examining different quantities. For researchers and educators, measuring impact is a generally question of verifying that their outputs meet their goals. For administrators, department heads, or institute directors, impact often equates to financial stability. Their main objective is to secure or maintain resources for their organizations, which are often new, experimental, or looking to expand. For broader networks in SEAD, which include

members of both of the aforementioned groups, impact is a matter of movement building. Networks measure their success by the reach and resonance of their message, both within universities and on a national policy level.

But established metrics for evaluating the impact of SEAD work do not yet exist. Accordingly, the story of measurable impact is one of measurement in the making. Evaluating SEAD requires developing or adapting techniques of evaluation: techniques that in turn define something about both their creators and the fields in which they work. And importantly, as discussed in Chapter 3, understandings of what “impact” is vary between projects as well as between actor groups. In this chapter, I use examples from my fieldwork to illustrate measurable impact at three scales, and to discuss the implications of different manifestations of impact assessment. I identify a common thread that runs through the cases, namely that while many of the practical motivations for measurement are external, the measurement process is often personal. It consists of stakeholders’ attempts to transform their intrinsic beliefs and lived experiences into facts and data, often in the service of establishing the legitimacy of their work and organizations. In other words, participants’ goals and the metrics that they use to measure their success are decoupled. When participants struggle to reconcile their goals and their metrics, they are responding to another aspect of the transdisciplinary dilemma: the tension between institutions’ need for legitimacy and resources, and the everyday practice of SEAD work.

Measurement in the Making: Quantifying, Standardizing, Classifying

STS scholars and historians of science have demonstrated the importance of measurement to the construction and dissemination of scientific facts.²⁰⁰ Not only are measurement and quantification essential aspects of scientific inquiry: important relationships exist between measurement and the processes, organization, and cultures of scientific work. Using quantification for measurement can change the production of scientific facts,²⁰¹ and cultures and instruments have co-constructed understandings of terms such as “precision” since the 19th-century.²⁰² More recent scholarship has examined the standards and classifications at work in scientific measurement techniques, showing them to be inevitable by-products of measurement that alter the outcomes of work and have profound effects on our lives.²⁰³

Measuring impact requires some degree of standardization and classification. Which quantities should be measured? What counts as “impact,” and to whom and under which circumstances? Determining this requires the creation of categories and the sorting of quantities into those categories. Moreover, these categories must allow for recognition across different contexts. A successful method of measuring impact will align with Bowker and Star’s definition of a standard, consisting of a “set of agreed-upon rules” that

²⁰⁰ See summary in Alexandre Mallard, “Compare, Standardize, and Settle: On Some Usual Metrological Problems,” *Social Studies of Science* 28, no. 4 (1998): 571–601.

²⁰¹ Simon Schaffer, “Late Victoria Metrology and Its Instrumentation: A Manufactory of Ohms,” in *Invisible Connections: Instruments, Institutions, and Science*, vol. 10309 (SPIE Institutes for Advanced Optical Technologies, London, UK: International Society for Optics and Photonics, 1992).

²⁰² Kathryn M. Olesko, “The Meaning of Precision: The Exact Sensibility in Early Nineteenth-Century Germany,” in *The Values of Precision*, ed. M. Norton Wise (Princeton, NJ: Princeton University Press, 1995), 103–34.

²⁰³ e.g. Star and Bowker, *Sorting Things out: Classification and Its Consequences*; Martha Lampland and Susan Leigh Star, eds., *Standards and Their Stories: How Quantifying, Classifying, and Formalizing Practices Shapes Everyday Life* (Ithaca, NY: Cornell University Press, 2009).

span multiple communities of practice and “are deployed in making things work together” over heterogeneous conditions.²⁰⁴

Measuring impact also typically requires quantification, which is related to standards and classifications. This too is a social and cultural practice. The act of counting is not separate from recognizing, classifying, and arranging things.²⁰⁵ Counting, as Aryn Martin and Michael Lynch describe, is “context-laden, invisible, socially organized work” that always implies a determination of “what counts” in the field being examined. Furthermore, counted objects will eventually become stable and taken for granted, seen as permanent “as though the resulting numbers were there all along.” Quantified measurements arise through negotiation and interaction, and often through struggle. Indeed, for some, any resulting acceptance of accuracy or objectivity results above all from the desire to establish and represent consensus.²⁰⁶

The negotiations that establish techniques of measurement also define something about both the negotiators and the quantities they seek to measure. When we make metrics and standards, we both reflect and construct our values, creating measurements that balance human consensus and natural phenomena.²⁰⁷ This analysis is not limited to scientific worlds with ideals of quantification and objectivity.²⁰⁸ When “external” metrics challenge these conventions, as Sara Malou Strandvad shows in her analysis of a design

²⁰⁴ Star and Bowker, *Sorting Things out: Classification and Its Consequences*, 13.

²⁰⁵ Aryn Martin and Michael Lynch, “Counting Things and People: The Practices and Politics of Counting,” *Social Problems* 56, no. 2 (2009): 243–66.

²⁰⁶ Linda Derksen, “Towards a Sociology of Measurement: The Meaning of Measurement Error in the Case of DNA Profiling,” *Social Studies of Science* 30, no. 6 (2000): 803–45.

²⁰⁷ e.g. Nikolas Rose, “Governing by Numbers: Figuring Out Democracy,” *Accounting, Organizations and Society* 16, no. 7 (1991): 673–92; Theodore Porter, *Trust in Numbers* (Princeton, NJ: Princeton University Press, 1995); Lampland and Star, *Standards and Their Stories: How Quantifying, Classifying, and Formalizing Practices Shapes Everyday Life*; Mallard, “Compare, Standardize, and Settle: On Some Usual Metrological Problems.”

²⁰⁸ Becker suggests that presentation and division of labor in the visual and performing arts are based on socially-defined, unspoken conventions that define the set of normal behaviors for participants in the art world. Howard S. Becker, *Art Worlds* (Oakland, CA: University of California Press, 1984).

school admissions process, they can be overpowered by unspoken, internalized markers of quality.²⁰⁹

ICAT, and SEAD writ large, are currently in a pre-standards mode. Rather than forming part of established systems of measurement, the techniques and standards I've observed in practice are in constant flux. The move toward a mode of evaluation and standardization, or the aspiration toward this mode, is common across interdisciplinary efforts in universities as these efforts expand. Interdisciplinarity complicates measurement techniques, yet the need to evaluate the outcomes and effects of interdisciplinary work remains strong.

Julie Thompson Klein highlights this in her review of inter- and transdisciplinary research evaluation, noting the incompatibility of traditional notions of discipline, peer, and measurement with emerging research paradigms.²¹⁰ Klein's call to reject a single standard or set of metrics and instead embrace variability of goals and criteria across different kinds of interdisciplinary work rings true to many SEAD stakeholders, but does not help them address the practical problems of measurement, nor the directives from administrators, external partners, and potential funders to demonstrate the impact of SEAD work. Accounts of standards development between universities reflect Klein's analysis, describing how external, "objective" input is not adequate for the design of definitions and measurement parameters, and noting that creating indicators was "a social

²⁰⁹ Sara Malou Strandvad, "Contingencies of Value: Devices and Conventions at a Design School Admission Test," *Valuation Studies* 2, no. 2 (2014): 119–51. Strandvad demonstrates how quantitative metrics used to score admissions tests were used by admissions officers only after they had already made their decisions based on their collective understandings of the value of a candidate and their work.

²¹⁰ Julie Thompson Klein, "Afterword: The Emergent Literature on Interdisciplinary and Transdisciplinary Research Evaluation," *Research Evaluation* 15, no. 1 (2006): 75–80.

process of definitions and boundaries' negotiation."²¹¹ SEAD values of openness, experimentation, and boundary crossing are difficult to reconcile with established measurement systems, and new techniques of evaluation have proven difficult to create.

Developing measurement techniques in SEAD highlights tension between its micro and macro scales. Though Bowker and Star define standards in part by their ability to span multiple communities of practice, they note in their study of nursing interventions that classification also produces tensions, as it “implies a drive to abstract away from the local, the particular” and strives to “make nursing the same entity wherever it may appear.”²¹² SEAD struggles to do this because of the intense situatedness of most SEAD efforts, and the desire of individual entities to present themselves as unique. SEAD entities often emphasize their individuality as a strategy for attracting funding or personnel, or audiences. Furthermore, institutions, projects, and schools develop differently in different contexts. Though many institutions share common goals and motivations, SEAD is not the same wherever it appears. Efforts to create measurements and standards that apply across boundaries exist – at least in part – in opposition to the current realities of SEAD. This drive to standardize and yet simultaneously showcase uniqueness again reflects the dilemma of institutionalizing transdisciplinarity.

Due in part to these challenges, measurable impact manifests differently at different scales. For individuals and their projects, impact is most frequently a question of effectiveness: are our ideas working? Does our work reflect our values? For institutions beholden to multiple stakeholders, it is necessary to demonstrate return on investment:

²¹¹ Benedetto Lepori and Andrea Bonaccorsi, “The Socio-Political Construction of a European Census of Higher Education Institutions: Design, Methodological and Comparability Issues,” *Minerva* 51, no. 3 (2013): 271–93.

²¹² Star and Bowker, *Sorting Things out: Classification and Its Consequences*.

are we getting back more than we put in? Are we meeting the demands of our diverse stakeholders? For cross-institutional networks, impact is a matter of movement building: are our ideas and values spreading? Are we demonstrating relevance outside of the university? In each of these cases, I note two things: firstly, the imperative to measure is often at odds with the quantities that SEAD stakeholders desire to evaluate. Secondly, as a consequence of this, the measurement work that SEAD stakeholders carry out affects the nature of SEAD itself, as it both challenges and conforms to the expectations of external partners.

Measuring Impact

Effectiveness: Verifying the Success of Projects

An obvious facet of measuring the impact of SEAD is assessing the effectiveness of work being done. Are we accomplishing what we've set out to do? Do our outcomes align with our goals? While this kind of assessment is important at all scales, it is most prevalent within the scope of individual projects or research initiatives.

ICAT's Instrument Maker Camps represent a case of uncertain measurement techniques and evolving assessment goals. ICAT faculty and staff developed the camps, which are inspired by both the STEAM movement in education and by Maker culture.²¹³ Advocates of both STEAM and Maker culture refute a perceived division of learning into separate areas of skill and knowledge, arguing that learning is better achieved through

²¹³ STEAM is a pedagogical approach whose proponents seek to integrate the arts and design ("A") into curriculum designed to teach science, technology, engineering, and math ("STEM"). The STEAM movement has roots in both the Rhode Island School of Design (RISD) and in educational consultancy. The Maker movement is an unofficial social movement that emphasizes tinkering and technology-based DIY projects. It intersects with hacker culture and active learning movements. Make Magazine (<http://makezine.com/>) and its affiliated Maker Faire events are associated with the movement.

participatory, active instruction.²¹⁴ ICAT's Maker Camps, though they are informal summer activities and not part of any official curriculum, align with these goals and ideals.

The camps began in the summer of 2012, following ICAT's first year of existence. Baum, a former K-12 teacher, spearheaded the effort with Knapp's support, after being inspired by a trip to a national MakerFaire. The camp was both an outreach effort and a testing ground for the tools and techniques that ICAT relied on, and followed a basic format that persisted over five years: faculty and graduate student volunteers recruited middle school-aged participants from the area, who spent four days at ICAT. Over the first two days, the facilitators cobbled together informal workshops in some of their areas of expertise: 3D form, basic circuitry, and kid-friendly CAD software and computer programming languages. The young participants then used this knowledge to design and build electronic musical instruments as part of a collaborative team.

Maker Camp has since evolved from a small, spontaneous effort to a larger, well-established annual event that takes over much of the Moss Arts Center, including the performance hall, where participants showcase their creations in an end-of-week performance. Many of the camp's core faculty and staff have maintained their involvement. Wishing to extend the camp experience into local classrooms, organizers added an additional camp for teachers in 2015, following the same format as the children's camp but adding additional resources and support for extending the material into teachers' own classrooms.

²¹⁴ Malina, Strohecker, and Lafayette, "Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design," 25.

The camps have multiple goals. They exist in part, as many public, ICAT-sponsored efforts do, to spread the word and mission of ICAT. As a facilitator states regarding the development of the camps, “It was just another step in the direction of this thing [ICAT] and what we want it to be. Overall it was let’s create an opportunity for young students to participate in ICAT type work and culture. That was our goal.”²¹⁵ ICAT researchers also express a related desire for participants to associate ICAT and Virginia Tech with creativity and interdisciplinarity, and for ICAT events to have long-term implications: “that’s what I would hope the long term effect would have been is that I went to Virginia Tech one night when I was a child, and I saw what they were doing here.”²¹⁶

Though the camps are not part of any school curriculum, camp organizers aim to teach both STEM skills and “soft” skills such as collaboration and creative thinking. Maker Camps represent a move from “skill-based” to “fluency-based” education that is central to the land-grant engagement mission and common in the rhetoric of STEAM and Maker culture.²¹⁷ The camps emphasize experimentation, encouraging students to focus on process rather than product. These goals are evident in both the rhetoric surrounding the camps and the assessment tools that researchers use to evaluate their effectiveness. Camper self-assessment sheets, which participants complete both before and after the camp, ask about their ability to do computer programming, create circuits, and visualize 3D forms. Other forms of evaluation record campers’ speech patterns throughout the week, as assessors look for “any progression in the way they speak about these things

²¹⁵ Interview 14.

²¹⁶ Interview 1A.

²¹⁷ Paulo Blikstein and Dennis Krannich, “The Makers’ Movement and FabLabs in Education: Experiences, Technologies, and Research,” in *Proceedings of the 12th International Conference on Interaction Design and Children* (ACM, 2013), 613–616.

throughout the week. A more mature understanding of what they're learning and can they speak more eloquently."²¹⁸

Most importantly in the eyes of the camp organizers, the Maker Camp experience should teach creative thinking and collaborative skills. Public-facing information tells prospective participants and their parents that Maker Camps are “designed to harness students’ creativity and encourage them to act on their curiosity.”²¹⁹ Parents are asked to sign an IRB-approved consent form that allows for researchers to maintain contact with previous campers, as they “hope to learn how you and your child(ren) develop critical and creative thinking skills over time.”²²⁰

The evaluation techniques used at Maker Camp have changed over its first five years, as the camp itself has evolved from a spontaneous summer program to a flagship event for ICAT’s Center for Research in SEAD Education. In the camp’s first year, the entire experience was planned and executed within three weeks. Facilitators paid no time or attention to assessing outcomes, beyond providing in-the-moment feedback to instructors about participants’ engagement levels. Any informal “assessment” tasks were done with an eye towards improving camp mechanics, rather than as part of a research program. The second year saw a failed expansion of the camp to a satellite location and the addition of a full-time observer to note the failures and successes of the week; however, there was still no assessment scheme in place.

In the summer of 2014, the third year of ICAT’s Maker Camps, both the camp structure and the evaluation methods changed significantly. An ICAT graduate student

²¹⁸ Interview 14.

²¹⁹ “Maker Camp,” Institute for Creativity, Arts, and Technology, 2015, <http://www.icat.vt.edu/idea/project/maker-camp>, accessed May 2017.

²²⁰ “Institute for Creativity, Arts, and Technology Longitudinal Study,” <http://www.icat.vt.edu/content/icat-outreach-program-forms>, accessed May 2017.

adjusted the timing of the workshops and attempted to integrate skill types more smoothly, while a faculty member from Virginia Tech’s Department of Engineering Education helped ICAT staff construct a “toolkit for evaluation.”²²¹ Campers began to fill out the self-assessment forms that asked them about specific skills, meant to help facilitators figure out “where [kids] thought they were” and “look at their growth.”

Maker Camp Self-Review
ICAT MAKER CAMP 2015

We'll use this information to form your working group for the rest of the week at Maker Camp. Your answers will not be shared with anyone.

1) Name:

2) Every team member will have important work to do on your project. We will form teams to make sure each group has the skills it needs to succeed. Please let us know how you feel about your skills and circle the skills that you'd like to use in this camp.

How well can you...	Really well	Pretty well	Kind of	Not so much
...lead a group?				
...work with other people?				
...manage time and other resources?				
...think creatively?				
...solve problems?				
...make a movie?				
...do computer programming?				
...create circuits with wires and breadboards?				
...make 3D forms out of cardboard and other materials?				
...visualize things in 3D?				

3) Pretend you are going to Virginia Tech next year. What would you like to study?

Figure 5.1: Pre-Camp Self-Assessment Form. Image courtesy of the Institute for Creativity, Arts, and Technology. Used with permission.

²²¹ “She was pulled into ICAT to help establish a toolkit for evaluation and this was one of the first projects she helped work on and kind of get at this how do we measure engagement, how do we measure creative process?” [Interview 14]

Facilitators also used their own feedback forms to rate all the participants on their skills in the areas covered by the workshops. Team formation became an important aspect of the camp, as facilitators used the feedback forms, campers' preferences, and qualitative observations from the first day to assign teams they believed would be balanced and work well together. Once again a researcher was assigned to observe the entire camp and record notes. Finally, the participants also recorded daily video reflections on their activities and progress.

The huge amount of data generated reflected researchers' desire to collect as much information as possible: "I think we were trying to collect as much data... The first two years we got to the end and there wasn't specific data we collected from the camp."²²² However, researchers also expressed frustration with the bulk of material they had generated and the formats in which they had collected it, noting that the material was "very school-like almost, what are we going to do with this level of information, right?"²²³

The subsequent two years of the camps stuck roughly to the 2014 formula. Facilitator ratings of student ability were eventually abandoned after proving too onerous for faculty and graduate student volunteers to complete. In 2015, camp facilitators and guests began to fill out "final presentation observation guides" during the end-of-week instrument showcase. The guides contained sections for notes on audience engagement, exhibition of knowledge, idea generation, process documentation, and group dynamic. Researchers used all of these assessment tools for the teacher camp as well. Specific video reflection guides (for facilitators) were added in 2016, and photos of campers were

²²² Interview 14.

²²³ Interview 14.

taken throughout the week for analysis. Volunteers conducted brief interviews with parents on the final day of the camp.

Five years after the initial Maker Camp and three years after evaluation began in earnest, the bulk of the collected data remains untouched. Researchers agree that the importance of evaluating these programs is critical, but struggle when their approaches meet the realities of assessment. In addition to practical difficulties with lack of time and personnel, researchers remain uncertain about the value of the metrics they have created. Establishing a process-oriented learning environment is difficult, devising a metric for identifying transdisciplinary thinking within it even more so.

Other accounts of evaluating the outcomes of “Making” echo ICAT researchers’ struggles with evaluation, and their practical and theoretical questions.²²⁴ What exactly are they trying to measure? How do they conduct this measurement when the quantities in question – “creativity,” “curiosity,” “interdisciplinarity” – are difficult to understand? Out of perceived necessity, researchers build their assessment protocols around questions they can answer: did the campers build a simple circuit? Did they have a good time? Are they considering a STEM career? Responses to these questions at Maker Camps have been consistently positive, however, the connection between assessments and whether campers “harnessed their creativity” or became better transdisciplinary thinkers remains unclear.

Measurement also matters to the structure and organization of the camps. As the assessment mechanisms progressed to include participant reflections, organizers

²²⁴ “One answer, derived from *The Art of Critical Making*, is that we must evaluate the products of design work alongside more traditional academic products, more deeply understand the learning and other cognitive processes involved in creating these artifacts, and better measure their impacts on society at large.” Evan Barba, “Three Reasons Why the Future Is in the Making,” *Science, Technology & Human Values* 40, no. 4 (2015): 638–50.

instituted regular breaks to prompt students to reflect on their progress using metrics provided by camp facilitators. Two or three times per day, campers gather in small groups with their adult facilitator and answer questions like, “what have you learned about design today?” and “have you seen or learned things this week that have changed your ideas about how you might spend your time as an adult?” Generally, the campers are eager to get back to their work and reluctant to stop and commit to forced reflection. As one camper asked me, her group facilitator at the 2016 camp, when told it was time to sit and talk for a minute, “are you going to ask us about design *again* today?” She begrudgingly sat and told me that she hadn’t learned anything new that day, before hurrying back to the computer program she had been eagerly building for hours.²²⁵

Emphasizing measurement also affects the camp structure. The imperative to assess outcomes subjects the camps to new forms of rigidity, despite researchers’ best efforts to free their work from disciplinary structures. Returning campers who understand how the event works can dominate their groups and enforce unintended control over the making process. In a reflective moment during a camp debrief, facilitators acknowledged that the camps had become much more manageable over the years, but wondered whether the musical instruments that campers create had also become less original, or less interesting.²²⁶ To what extent were researchers unintentionally creating a how-to guide for creativity or transdisciplinarity? What value and results would this have?

In many cases across three years of pre- and post-camp self-assessments, researchers have seen a reported decline in campers’ evaluations of their own skills, as they realize over the course of the week that “they know less than they thought they

²²⁵ Field Notes, July 2016.

²²⁶ Field Notes, 2015.

did.”²²⁷ Researchers express similar sentiments as they reflect on their experiences with five years of Maker Camps:

I feel like that’s where we’re at in the curve is like we’ve gotten to the point where we see that those things aren’t what we need to know and that measuring impact is a thing, there’ll probably be a way where we can articulate an impact, but we’re at a point where – I read this whole book, I was so excited about it, *Learning from Museums*, and there’s a whole chapter about evaluation and I read the whole thing and it said “it’s really hard.” Like no, I want the answer! So the more I read the less I’m sure there’s an answer.²²⁸

Learning what they don’t know is both frustrating and liberating for researchers. They are eager to find answers and at the same time more comfortable with uncertainty and with qualitative assessment. One researcher and Maker Camp facilitator cited her increased interest in qualitative data, particularly in the personal stories of some of the children who have attended multiple camps, or in several cases come back to help out as co-facilitators. This is the kind of data that is meaningful for her, that reinforces her conviction that her work is inducing positive change. Though university and Institute administration may dismiss it as anecdotal or see a story as a single data point in need of corroboration, for the researcher it is these stories that demonstrate the impact of the camps. “I look at the

²²⁷ Interview 14.

²²⁸ Interview 14.

quantitative data and I just want to use it as a coffee, like whatever, coaster, like this doesn't mean anything to me [anymore].”²²⁹

Within the Maker Camps and on larger scales, the desire to collect *different* kinds of data sometimes manifests in the collection of *more* data. In 2016, ICAT became the home of the newly-established Center for Research in SEAD Education (CRSE), a “university-level mechanism to propagate expertise” that includes the creation of a massive database to study the “overall impact” of the university.²³⁰ The faculty and administrators behind the Center want to study the influence that VT programs has “if we reach a student at age 5 through the early childhood FabLab...and they repeatedly participate in VT programs...Did what we did with them have an impact on their decisions and their path?” Researchers involved in CRSE variously express the need to collect more data, to collect longitudinal data, and to place more value on qualitative data, however, it remains to be seen whether the CRSE database can succeed in reconciling researchers’ and administrators’ ideas about what kinds of data are most valuable.

Return On Investment: Demonstrating the Value of Institutions

For university-based institutions, impact is not only tied to the effectiveness of their work and the quality of their outputs. Institutes, schools, departments, and centers represent significant investments on the part of universities, often in partnership with government or industry. Measuring return on this investment is an important aspect of demonstrating impact at the institute level.

²²⁹ Interview 14.

²³⁰ Field Notes, 2016

When ICAT began in 2011, measurement was a distant consideration for Institute faculty and staff. ICAT was a brand new “transformational institution,” a research institute borne out of several groups from across the university.

ICAT administrators were interested in self-reflection and improvement from the beginning: iteration, prototyping, and critique were familiar modes of working that were common to their backgrounds in design. They were comfortable with giving and receiving feedback on their work, and wanted to apply this strategy to the Institute as well. This desire for reflection manifested in regular conversations among the core group of faculty known first as “Studio Heads” and later as “Senior Fellows,” and also began the process that led indirectly to this dissertation and its associated publications.

However, these sincere efforts to reflect and grow did not take the form of shareable, measurable outcomes. ICAT participants found the value of their own work in their experiences with students and research partners and in their facilitation of other transdisciplinary activities. Much like the Maker Camps that ICAT organized and sponsored, the need to measure impact intensified as the Institute evolved and grew. ICAT staff struggled to obtain the “time, space, and permission” to conduct assessments of its own work.

In the fall of 2016, a committee consisting of Virginia Tech faculty, deans, and directors conducted a five-year review of the ICAT. Throughout the spring and summer of 2016, as the deadline approached, was postponed, and approached again, ICAT staff struggled to pull together documents and testimonies that demonstrated the success of the Institute. The results of the review would help determine ICAT’s future: a favorable review could improve the Institute’s standing at the university and allow it to maintain or

increase its funding and resource base. A negative result could call the necessity of the Institute into question.

At the same time, massive, university-wide efforts to emphasize collaboration and transdisciplinarity were underway at Virginia Tech, and ICAT faculty also worried about the Institute's place in the university's evolving academic ecosystem. Discussions of the five-year review took place across a background of anxiety over Virginia Tech's proposed "destination areas," fields of study that the university would emphasize when hiring new faculty and proposing new classes, and which should attract grants and donors. Since the destination areas were designed to be explicitly interdisciplinary, ICAT's leaders were unsure of the role that the university's existing research institutes would play in the Destination Areas, and were concerned for ICAT's future. As one faculty member candidly put it at a meeting in December 2015, "if we don't get a destination area that has arts and design in it, we're screwed."²³¹ The five-year review process became an effort to demonstrate the return on investment (ROI) that ICAT had delivered to the university over its first five years, and to argue for its continued importance in a shifting organizational landscape.

The most obvious way to look at ROI is in terms of money: how many dollars are produced vs. the original investment. For ICAT, financial returns can come from funding relationships with external partners or internal allocation of university money. Over its first few years, ICAT administrators focused on building the profile of the Institute within the university and community at the expense of vigorously pursuing external funding, leaving their financial ROI largely dependent on the university. However, ICAT's structure, combined with the university's funding distribution models, produced

²³¹ Field Notes, December 14, 2015.

challenges to this approach. Virginia Tech distributes funds based on research grants to associated faculty and numbers of students enrolled in affiliated courses. Since nearly all faculty at ICAT have a primary affiliation with another academic department, the Institute's ability to recoup funding through external grant money is limited. Similarly, there is no official designation for an ICAT course – classes taught at ICAT require course codes from a department or the Virginia Tech Honors College – and this restricts the Institute's ability to gain funds based on teaching classes.

In response to these challenges, ICAT's director and senior fellows attempted to demonstrate ROI in ways other than pure dollar amounts. During a meeting in August 2016, as the review process was ongoing, the director initiated a discussion about how the impact of ICAT could be measured. What metrics might be appropriate measures of what the Institute and its affiliates had accomplished? Suggestions from the Fellows included seemingly straightforward accounting measures (number of affiliated faculty or students; number and type of external partners; grant money resulting from initial SEAD grants; number of publications resulting from projects; number of events, performances, or installations held by ICAT; subsequent involvement of funded faculty in other ICAT-related projects) as well as more ephemeral standards ("generate different kind of student/faculty"; "shaping messages at VT and beyond"; the "domain of the Cube" including its internal and external use; and mapping ICAT's social network).²³² Faculty noted the difficulty of assessing message-shaping and the generation of new academic types, but even the simpler metrics presented some questions. The definition of "affiliation" for faculty members and students would have to be determined. Distinctions between work done for ICAT and work done for home departments were unclear. How

²³² Field Notes, August 2016.

far could subsequently-funded work branch off from an ICAT grant and still be considered related?

The review process sparked an enormous data-gathering effort at ICAT. The institute director and staff gathered project reports and held meetings with previous recipients of ICAT grants, asking them how their projects had progressed since the grants. Was the project still ongoing? What related work had the team members accomplished since receiving the grant? Did the original ICAT grant lead, as intended, to a larger grant from a different source? In addition to following up on grant recipients, staff collected other countable information related to the institute's development. One folder submitted to the review committee, called "Measuring the Impact of ICAT," includes a list of Memoranda of Understanding between ICAT and various entities,²³³ a subfolder of articles written about ICAT,²³⁴ a report on staff and GA salaries, and a chart of increasing coffee consumption at weekly playdates. It also includes a series of reports on "informal learning" efforts including Maker Camps, ICAT Day, and the Virginia Science Festival.

²³³ Some of these entities are internal to VT (Pamplin College of Business, Technology-Enhanced Learning and Online Strategies) and some are external (NASA, Science Museum of Western Virginia, Montgomery Country Public Schools).

²³⁴ Mostly from popular sci-tech publications, but also including two that I co-wrote: Wisnioski and Zacharias, "Sandbox Infrastructure: Field Notes from the Arts Research Boom"; Kari Zacharias and Matthew Wisnioski, "Land-Grant Hybrids: From Art and Technology to SEAD," *Leonardo*, Forthcoming.

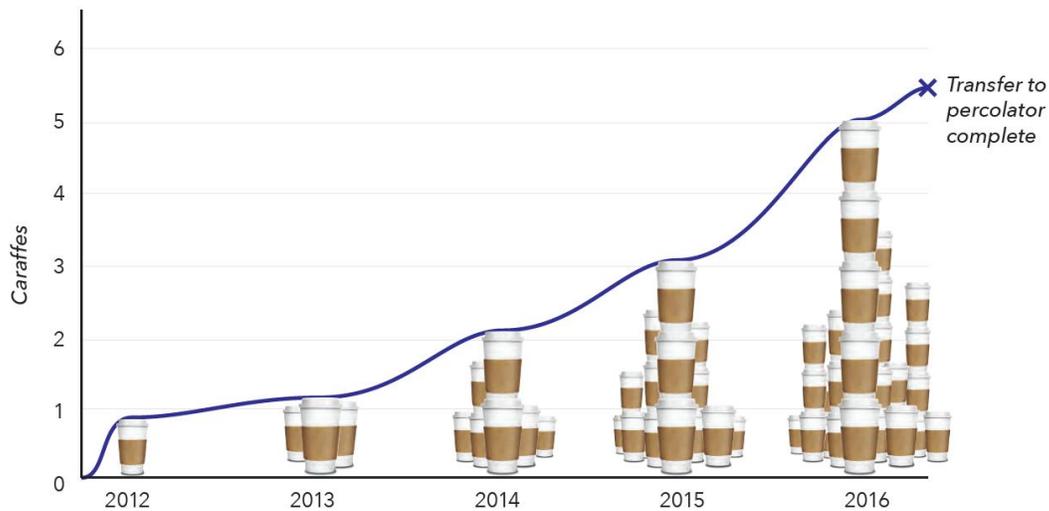


Figure 5.2: One vision of impact from the Five-Year Review: increasing coffee consumption at ICAT Playdates. Image courtesy of the Institute with Creativity, Arts, and Technology. Used with permission.

The folder of documents provided to the review committee demonstrate the complex and varied nature of the impact that ICAT stakeholders attempted to show. In the director’s narrative that opens the document package, Knapp emphasizes transdisciplinary collaboration as the unique quantity that ICAT values and supports. The Institute, he writes, has sponsored projects which span all eight Colleges at Virginia Tech. He cites several cross-departmental cluster hires, including CCTAD, that led to the formation of ICAT. His narrative is also self-conscious about financial matters, noting the discrepancy between the university’s original vision for ICAT (including 30 FTE faculty and staff and a multi-million-dollar budget) and the current financial realities: “Thus, the question five years ago was how can an Institute with no faculty, no students, only three staff positions,

and \$728,000 to invest make an impact on arts integration at Virginia Tech, the region, and the nation.”²³⁵

All of the five-year review documents aim to connect metrics to mission. ICAT’s official vision, mission, and goals changed very little between 2011 and 2016. Its vision to “foster the creative process, from imagination to innovation” is expressed identically in founding documents and in new prose created for the 5-year review. Its original mission, to “forge a bidirectional pathway between transdisciplinary research and artistic output, scientific and commercial discovery, and educational innovation,” suffered only the removal of the word “bidirectional” over five years. Similarly, the primary goals expressed in 2016 (learning, discovery, and engagement) closely adhered to the originals. ICAT’s demonstration of its own impact relied on coming up with metrics that reflect their success in these areas.

ICAT’s self-imposed measurements are an attempt to demonstrate its adherence to these goals. Put differently, ICAT staff tried and struggled to measure the cultural change that ICAT had catalyzed within the university. However, the lack of a clear message or solution based in their measurements highlights the decoupling between goals and metrics. The documents presented to the review committee mix “activity,” “output,” “impact,” and “outcome” metrics.²³⁶ Some simply present evidence that research has been conducted and performances and camps have taken place, while others aspire to prove that change has occurred. This is an inherently difficult task, particularly in an

²³⁵ R. Benjamin Knapp, 5-Year Reflection. ICAT’s initial operating budget for FY2011-12 was over \$728,000, and this budget grew to over \$1 million in subsequent years. The bulk of the budget is spent on salaries for Institute staff and graduate students, in addition to project funding. Depending on whether facility operation and maintenance is counted, ICAT is either the lowest or second-lowest-funded of Virginia Tech’s seven research institutes.

²³⁶ Ronald N. Kostoff and Elie Geisler, “The Unintended Consequences of Metrics in Technology Evaluation,” *Journal of Infometrics* 1, no. 2 (2007): 103–14.

interdisciplinary environment. There is no agreed-upon vision of what metrics are for SEAD. Stakeholders in both SEAD and the corporate world acknowledge that this is difficult work, and that most of the metrics in use are insufficient to measure change. Klein highlights the disconnect between standard metrics and the complexity of interdisciplinary work, noting that “appropriate evaluation is made, not given... Traditional methodology and statistics have a role to play, but they are not sufficient.”²³⁷

The report locates the value of ICAT in several different metrics. It emphasizes activity in terms of research collaboration across disciplines, through counting the number of collaborations that ICAT has facilitated. It also counts outputs: events, presentations, performances, etc. that ICAT-affiliated teams and projects produced. The report is both an attempt to conform to the university standards of ROI and a transgressive argument against them. The assembled documents redefine ICAT’s place within the university, positioning ICAT as the Little Institute that Could: an underfunded, ragtag group of committed researchers that punches above its weight and has quietly transformed the university landscape. The documents position ICAT as an agent of cultural change within Virginia Tech.

It is difficult to measure transformative change with metrics that rely on counting and comparison. Demonstrating what ROI means shows how the Institute values itself, and how this sometimes parallels and is sometimes at odds with the value of ICAT to the university and external stakeholders. Convinced of the inherent value of the Institute and their work, ICAT stakeholders try to express this value to university administrators using

²³⁷ Klein, “Afterword: The Emergent Literature on Interdisciplinary and Transdisciplinary Research Evaluation.” Metrics should “facilitate informed definition of the task and credible tracking of the actions and outcomes attendant to the substance, constitution, and value of the research.”

recognizable metrics, while also pushing at established understandings of value. The review package demonstrates the differences between “what counts” for ICAT and university administration, and presents ICAT’s view of what should count in the future.

Networks and Advocacy: Measuring National Progress

Other, larger organizations in SEAD are also in the business of promoting cultural change. Looking at the large-scale impact of the SEAD movement requires measurement of change not only within universities, but also in industry, funding organizations, and national policy. National networks including the SEAD Network and the Alliance for the Arts in Research Universities (a2ru) are interested in how SEAD is relevant outside of the university, and how SEAD spreads and coordinates itself. Making progress in establishing a national conversation about SEAD is a goal for both networks.

In November 2015, Virginia Tech and ICAT hosted the annual meeting of a2ru. A group of over 145 faculty and administrators from the then 33 a2ru partner institutions attended the conference. Amid panels, performances, and peer review working groups, a2ru leadership presented *Surveying the Landscape: Arts Integration at Research Universities*, the result of a three-year study funded by the Andrew W. Mellon Foundation. The report lays the groundwork for a2ru’s ongoing work on the expansion of arts integration within American research universities, and outlines what impact looks like on a national scale.²³⁸

²³⁸ Mackh, “Surveying the Landscape: Arts Integration at Research Universities,” v. a2ru’s explicit focus is on “arts practice” and “arts integration” rather than “SEAD” per se; however, many of its key members engage in cross-disciplinary work that spans science and technology as well as arts and design. ICAT faculty, including director Knapp, have been central players in a2ru initiatives. One of seven “major accomplishments” listed in the 2016 a2ru strategic plan is “Expansion of national awareness and the catalyzing of research around emerging and evolving arts-integrative and transdisciplinary fields (e.g., arts

The a2ru began following a 2011 meeting hosted by ArtsEngine at the University of Michigan. At this meeting, interdisciplinary working groups outlined short, mid-, and long term goals for the nascent organization. Their long term aspirations included universities emphasizing quality of life over efficiency, a cabinet position in the arts, a lobbying community for arts integration, and policy formulation based on the results of their research.²³⁹ A grant from the Andrew W. Mellon Foundation allowed for the creation of a2ru and sponsored the project that led to *Surveying the Landscape*. This report represents the successful completion of some of the short term goals outlined at the Michigan meeting, including “mapping the field of institutions and resources” and “creating the infrastructure for a repository of best practices.”

The SEAD Network, another national organization, combines research goals with economic development and education. It formed following two workshops, jointly sponsored by the National Science Foundation (NSF) and the National Endowment for the Arts, in 2010 and 2011. The workshops led to separate but related NSF-funded initiatives: the Virtual Exchange for Science, Engineering, Arts, and Design (XSEAD) and the Network for Sciences, Engineering, Arts, and Design (NSEAD). These groups have since coalesced into the SEAD Network, which aims to connect and support a distributed community built around “products, methods, and questions that are fundamentally hybrid.”²⁴⁰ The SEAD Network’s long-term goals are similar in scope to a2ru’s: at one of the founding workshops, participants noted their aspirations to “work

and health, creative placemaking, arts entrepreneurship, science-engineering-art-design [S.E.A.D.], and arts and humanities).”

²³⁹ D. Fox Harrell and Sneha Veeragoudar Harrell, “Strategies for Arts + Science + Technology Research: Executive Report on a Joint Meeting of the National Science Foundation and the National Endowment for the Arts,” 2010.

²⁴⁰ SEAD Network, “SEAD Working Group Meeting Minutes,” February 2, 2016, National Academy of Sciences, Washington, D.C., <http://sead.viz.tamu.edu/seadwg.html>.

with partners and allies in shifting Dept. of Labor metrics on economic development and creatives.”²⁴¹

While the long-term goals of both a2ru and the SEAD Network are national and look beyond the university, their immediate work has concentrated on building and strengthening their networks and on assessing the current state within universities of arts integration and SEAD, respectively. This is evident from documents produced by both organizations, notably *Surveying the Landscape* from a2ru and the SEAD Network’s 2015 report, *Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design*.²⁴²

Surveying the Landscape is the initial result of a massive data-gathering effort by the report’s author, Bruce Mackh. Mackh, formerly the Mellon Research Project Director at the University of Michigan, spent three years interviewing faculty, administrators, and students involved in arts integration activities at over 40 American universities, including Virginia Tech. The report is foremost an explanation of the status of arts integrative activities, but it is also a strong statement of progress. “The productivity of the first four years of a2ru is quantifiable,” states a2ru in their subsequent Strategic Plan, citing the report and its findings as one of their major accomplishments.²⁴³

The SEAD Network report, in contrast, was not an individual effort. *Steps to an Ecology of Networked Knowledge and Innovation* is a collection of 55 white papers sourced through the network’s partnerships with individuals and universities, along with synthesis and meta-analysis from the report’s editors Roger Malina, Carol Strohecker,

²⁴¹ “Network for Sciences, Engineering, Arts, and Design Workshop Summary,” September 30 – October 2, 2011, Center for Design Innovation, University of North Carolina, Winston-Salem, NC.

²⁴² Malina, Strohecker, and Lafayette, “Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design.”

²⁴³ Alliance for the Arts in Research Universities (a2ru), “A Four-Year Strategic Plan,” 2016.

and Amy Ione. The papers cover topics ranging from studies of specific interactions between scientists and artists to mappings of the SEAD landscape in the UK and Brazil. The a2ru report is unapologetically goal-oriented, focused on establishing categories, definitions, and recommendations that will aid the organization in its mission. The SEAD Network report, perhaps necessarily as a result of its many diverse contributors, is more open-ended and exploratory, suggesting possible obstacles and ways forward without insisting on their relevance. Both reports, however, share common themes and recommendations.

Unsurprisingly, both reports emphasize the importance of network building, speaking to the importance of establishing networks on a larger scale to avoid pitfalls that result when “visionary” founders of interdisciplinary collaborations “change focus or lose funding.” As one of the SEAD Network white papers suggests, while individual collaborations may not be reproducible in different contexts, it is entirely possible to create a structure of support for matchmaking to broker, and resources to stimulate customized partnerships on larger scales.²⁴⁴

Surveying the Landscape goes further, identifying institutionalization as a tool for identity- and community-building in interdisciplinary work, and even suggesting ways to measure it. Institutes provide a “physical and conceptual home” for interdisciplinary work, and empower the arts to “serve as more than an embellishment to research in other disciplines.” Beyond this, institutions establish unique identities for both collaborative research areas and individual scholars, “fostering an intangible sense of community” and

²⁴⁴ Malina, Strohecker, and Lafayette, “Steps to an Ecology of Networked Knowledge and Innovation: Enabling New Forms of Collaboration among Sciences, Engineering, Arts, and Design,” 27.

providing environments in which these things can “thrive.”²⁴⁵ Institutionalization can be measured quantitatively, by counting numbers of institutions or numbers of people and projects involved in and supported by them. Qualitative, localized characteristics such as identity and community can also be measured, but require different approaches. Calls for more data and new ways of measuring are common across reports and organizations. a2ru claims that *Surveying the Landscape* fulfills “the need for a document that articulates models, obstacles, implementation, strategies, costs, and impact,” but notes that “many more discoveries...remain unexplored.”²⁴⁶ Multiple SEAD Network white papers similarly bemoan a lack of best practices for interdisciplinary work, citing a dearth of “significant data that constitutes the most effective practices that promote creative and innovative thinking at these intersections”²⁴⁷ and asking “how do we begin to understand what it means to integrate arts and sciences in education to create creative, innovative, <fill in other adjectives here> learners? How will we know when we’ve accomplished this?”²⁴⁸

These calls for evidence also exist outside of SEAD-specific organizations. In March 2017, the National Academy of Sciences issued a request for a study “examining the evidence behind the assertion that educational experiences that integrate the

²⁴⁵ Mackh, “Surveying the Landscape: Arts Integration at Research Universities,” 111. The report also notes the unique, contextual characteristics of interdisciplinary institutions, noting that “factors of longevity, organizational structures, participating disciplinary areas, funding sources, and research design appear to be specific to each location rather than sharing common features.”

²⁴⁶ Mackh, 132.

²⁴⁷ Lucinda Presley, “The Innovation Collaborative,” in SEAD Network, “SEAD Working Group Meeting Minutes,” February 2, 2016, National Academy of Sciences, Washington, D.C., <http://sead.viz.tamu.edu/seadwg.html>, p. 17.

²⁴⁸ Brian K. Smith, “Evaluating the SEAD Approach in Education,” in SEAD Network, “SEAD Working Group Meeting Minutes,” February 2, 2016, National Academy of Sciences, Washington, D.C., <http://sead.viz.tamu.edu/seadwg.html>, p. 17.

humanities and arts with science, technology, engineering, math, and medicine lead to improved educational and career outcomes for undergraduate and graduate students.”²⁴⁹

A major push for gathering evidence is underway within the larger SEAD networks, in tandem with the continued expansion and coordination of the networks themselves. An additional Mellon grant is currently funding the SPARC Project: Supporting Practice in Arts, Research, and Curricula, carried out by a2ru. The primary goal of SPARC is to disseminate best practices in arts integration, but the project’s core research questions address the major practical concerns uncovered by the initial round of a2ru data collection: clarifying language and definitions, navigating the tenure and promotion process, developing tools for collaboration, and gathering evidence on the impact of the arts. The a2ru continues to hold conferences, sponsor working groups of faculty and administrators, and expand its membership to include additional partner institutions. Their Thirdspace working group is tasked with studying peer review standards for transdisciplinary work and ultimately creating new ones, building on the previous work of the XSEAD project.

SEAD at a national policy scale is a quantity even more “in the making” than it is at the scale of individual projects or institutions. Before a2ru and the SEAD Network can follow through with their national policy ambitions, they have decided to focus on coordinating and evidence gathering on the state of interdisciplinary work within universities. In order to measure national progress, organizations must first determine the state of the art, establish a set of best practices, and compile a body of evidence which proves that arts integration and transdisciplinarity create or encourage positive change. It

²⁴⁹ National Academies of Sciences, Engineering, and Medicine, “The Integration of the Humanities and Arts with Sciences, Engineering, and Medicine in Higher Education: Branches from the Same Tree” (Washington, D.C.: The National Academies Press, 2018), x.

is necessary to organize, standardize, and produce evidence before moving on to other things on a national level.

Despite the noted gaps in data and evidence of impact, one major result of the both the SEAD Network and a2ru reports (particularly emphasized in *Surveying the Landscape*) is the guidance to build places and frameworks for collaboration and interdisciplinarity in the face of uncertainty: to “begin even if the result is unclear.” Lack of structure and guidance, state the reports, should not be a barrier to creation and institutionalization. If we build it, they will come (and when they come, we can measure our impact).

Valuing SEAD: “Until we measure it, it’s quite hard to describe”

SEAD is new, experimental, and seeking to define itself. Stakeholders, convinced of its value for themselves but desperate to demonstrate that value to outsiders, attempt to measure their work while they conduct it, in an effort to articulate something that they experience and feel innately. “Begin even if the result is unclear,” they urge their fellow researchers.²⁵⁰ “Until we build it,” they assure themselves, “it’s quite hard to describe.”²⁵¹ As they create metrics, they attempt to translate their experiences into “facts” that can be shared and widely understood.

Making an argument about the value of one’s work to an external audience is one reason for measuring impact. At the project level, this audience can be university administration or funding organizations, institute directors. At the institute level, university administration and local or state government. At the network level,

²⁵⁰ Mackh, “Surveying the Landscape: Arts Integration at Research Universities.”

²⁵¹ Interview 1C

organizations such as the NSF or NAS, as well as government. These arguments may conform to or reject the standards that such organizations typically use. In fact, for cases in SEAD, it is typical for value arguments to attempt both of these at once.

Through attempts to determine their work's impact, stakeholders seek to express the value of SEAD. At the same time, however, they define who they are. What counts as SEAD work is determined alongside and through the measurements and standards that are used to evaluate it. Both participants and evaluators have a hand in deciding what is important to SEAD, and how SEAD and the university will continue to develop and change each other. Challenges in measurement mirror (and relate to) challenges in the work, and the difficulty in measuring the impacts of SEAD reflect another aspect of the transdisciplinary dilemma, namely the disconnect between researcher's goals and the strategies of institutionalization.

Even though they may not be aware of the arguments their metrics and reports are making, stakeholder's frustrations and challenges also shape what counts as SEAD. Evaluators aim to express the value of SEAD to diverse audiences, while the quantities that they look for are tied to a constantly shifting political and economic landscape.

Conclusion: Managing the Dilemma?

In the fall of 2015, ICAT began its third year in the Moss Arts Center; celebrated the successful conclusion of its fourth annual Instrument Maker Camp; and eagerly awaited the development of its new funded projects for the year. The Institute awarded major grants to five teams, whose work included a design for protective body panels for a humanoid robot, an experimental digital choreography project, and a study of emotional responses to lighting in virtual environments.²⁵² Many of the grant recipients had pre-existing relationships with ICAT – Sam Blanchard, who was one of the two leaders behind SeeMore, was a member of the humanoid robot team – and the Fellows looked forward to what these researchers would produce through their continued involvement. That fall also marked the arrival at Virginia Tech of Thanassis Rikakis, who took over the position of executive vice president and provost following the retirement of his predecessor, Mark McNamee.

A general mood of excitement and optimism had pervaded ICAT since Rikakis's appointment was announced the previous spring. Rikakis was the founding director of the School of Arts, Media, and Engineering at Arizona State University, and arrived at Virginia Tech fresh from Carnegie Mellon, where he served as Vice Provost for Design, Arts, and Technology. He was one of the PIs of the XSEAD project, had connections with a2ru, and already had a working relationship with Knapp, who had been a member

²⁵² "ESCHER Humanoid Robot," Institute for Creativity, Arts, and Technology, https://icat.vt.edu/icat_projects/escher-humanoid-robot/, accessed September 27, 2018; "Extending Creativity through a Multidisciplinary Choreographic Dance Project," Institute for Creativity, Arts, and Technology, https://icat.vt.edu/icat_projects/extending-creativity-through-a-multidisciplinary-choreographic-digital-project/, accessed September 27, 2018; "The Emotional Response and Impact of Visual Stimuli in Virtual and Built Environments," Institute for Creativity, Arts, and Technology, https://icat.vt.edu/icat_projects/emotional-response-and-impact-of-visual-stimuli/, accessed September 27, 2018.

of Rikakis's hiring committee. The AME program at Arizona State, founded in 2003, was a forerunner of the SEAD "boom." The program had been a model for ICAT during the Institute's planning stages, and Rikakis himself consulted with administrators at Virginia Tech prior to ICAT's official founding.²⁵³ ICAT participants perceived the university's hiring of Rikakis in such a high-profile role as a win for the Institute and a symbol of increased acceptance of their transdisciplinary ideals.

Months into his tenure, Rikakis and Virginia Tech President Tim Sands announced a plan to reorient some of the university's resources towards so-called "Destination Areas." The Destination Areas would be transdisciplinary research and education foci for the university, based in existing research strengths but targeting fields and topics with promising revenue streams through government and industry partnerships. While the Areas would not replace traditional majors or departments, students would be able to specialize in a Destination Area if they wished, and the university would conduct major cluster hires across departments to supplement existing faculty expertise in each Area. Neither the precise number nor the content of the Destination Areas were immediately announced by university leadership: instead, Sands and Rikakis invited faculty proposals for potential areas of interest.

The prospect of institutionalized transdisciplinarity on a university-wide scale was both gratifying and frightening for ICAT's practitioners and administrators. On one hand, the university seemed to be recognizing the value of transdisciplinary research and education, for which they had advocated for the past four years. In this sense, the advent of Destination Areas validated ICAT's work and mission. On the other hand, what good was a transdisciplinary institute that "only did everything" if it existed within an already-

²⁵³ "The Institute for Creativity, Arts, and Technology at Virginia Tech: Overview and 20-Year Vision."

transdisciplinary university? Amid worries that ICAT may break apart, or that the university might cease to fund it, Institute leadership decided to advocate for Destination Areas that corresponded with ICAT's own research and affiliated personnel. At a strategy meeting, one faculty member declared his intention to "win this game" by getting ICAT-affiliated faculty involved in at least three of the Areas. ICAT-affiliated faculty began to mobilize, organizing groups around proposed Areas in "Built Environments," "Innovation and Entrepreneurship," and "Digital Arts, Communication, and Marketing."²⁵⁴

The announcement of the Destination Areas posed an extreme solution to the dilemma of institutionalizing transdisciplinarity, namely the prospect of changing how the university worked such that SEAD researchers would no longer need to balance disruption with attempts at conformity. Where the premise of institutionalization clashed with the individual goals that motivated ICAT's existence, the Destination Areas presented ways to divide ICAT's work into sub-specializations, perhaps with different aims. Tensions related to the struggle to exist outside of disciplinary structures might be relieved if the structures themselves changed. Difficulties with measuring and communicating impact, at least the local difficulties, could change if the metrics by which the university judged success changed as well. And where the idea of transdisciplinary as creative freedom opposed its promise as an economic driver...well, the new plan seemed like a clear win for economics to most observers, but the structure could still provide freedom to conduct transdisciplinary research.

²⁵⁴ Field Notes, December 14, 2015.

However, in October 2017, amid increasingly public faculty criticism, Rikakis stepped down as provost.²⁵⁵ Through surveys and a proposed Faculty Senate no confidence vote, faculty members expressed their disappointment with the provost's communication strategies, as well as with the changes to promotion and tenure processes that went along with his vision for the university. The Destination Areas remained a part of the university's strategic plan, but the idea that the university would be suddenly remade faded from view. Although Sands and the interim provost continued to discuss the university's transdisciplinary future, ICAT's participants no longer feared for the Institute's existence.

Virginia Tech's hiring of Rikakis and the resulting administrative vision for Destination Areas raised significant questions about the potential to re-make the research university in more transdisciplinary terms. The Destination Areas proposal promised to expand ICAT's ideals of transdisciplinarity and collaboration to the entire university, while at the same time threatening to dissolve the institute itself. As the Destination Areas were introduced, discussed, and debated, ICAT's participants faced the prospect of resolving the transdisciplinary dilemma but losing their academic home in the process. Due to the fact that these events occurred after much of my data collection was complete, as well as my limited access to many of the forums in which faculty and administrators discussed the Destination Areas, a complete analysis of how these questions played out at Virginia Tech is beyond the scope of this dissertation. However, studying the interplay of

²⁵⁵ Robby Korth, "Virginia Tech Provost Announces Resignation in the Wake of Faculty Unrest," *Roanoke Times*, October 30, 2017, https://www.roanoke.com/news/education/higher_education/virginia_tech/virginia-tech-provost-announces-resignation-in-wake-of-faculty-unrest/article_fd2a3975-391e-5067-b926-608cd7df8ea0.html.

such administrative visions with existing SEAD organizations and other university institutions will be an important part of future studies of SEAD.

Any process of *re*-making will necessarily involve some *un*-making along the way. Many Virginia Tech faculty – including constituencies well beyond ICAT – saw a threat to their existing institutions and review structures in the Destination Areas’ promise to re-make the university and its approach to transdisciplinarity. Ultimately, Rikakis’s tenure as provost did not survive this perceived un-making. When he resigned, the potency and immediacy of the Destination Areas plan, both positive and negative from ICAT’s standpoint, retreated. Still, the vision and the questions behind creating transdisciplinary research universities remain relevant. In the meantime, ICAT’s participants have continued to produce and support groundbreaking projects while continually struggling to (re)define their Institute’s place within the university.

Following all of these university-wide developments, ICAT was left facing many of the same issues it had been dealing with before Rikakis arrived. The Institute did eventually achieve a significant presence in one of the Destination Areas – “Intelligent Infrastructure for Human-Centered Communities,” formerly “Built Environments” – as well as in one of the proto-Destination “Strategic Growth Areas” (“Creativity and Innovation,” an amalgamation of aspects of the proposed “Innovation and Entrepreneurship” and “Digital Arts, Communication, and Marketing” areas). But it was still a small research institute struggling to punch above its weight. Its transdisciplinarity still opposed some of the ways in which the university functioned. And it still reflected the differing goals and motivations of its stakeholders and participants. The majority of the original Studio Heads and prominent Senior Fellows left the Institute between 2014

and 2017: Yong Cao, Kilkelly, Burch Brown, Webster, and Baum all retired or departed ICAT for new positions. Of the Studio Heads who moved with the Institute to the Moss Arts Center in 2013, only Ico Bukvic and Tom Martin, who is now ICAT's Associate Director, remain. As a result, ICAT has gradually established a new group of core faculty members, each of whom have their own research interests, motivations for participating in ICAT, and understandings of SEAD and transdisciplinarity.

ICAT's broad research agenda, too, remains. The Institute is now home to two semi-independent research "Centers": the Center for Human-Computer Interaction (CHCI) and the Center for Research in SEAD Education (CRSE). CHCI's 3D Experiences group uses the Cube and the Institute's other VR resources and expertise to study perception, sense-making, and design in virtual and augmented reality environments. CRSE is built on the foundations of the former IDEA Studio/IDEAS research group, and aims to foster relationships with local PK-12 schools, and to develop assessment and evaluation plans for SEAD education at multiple levels.²⁵⁶ Both Centers house their personnel within the Moss Arts Center, and their directors are members of ICAT's core faculty group. However, the connections between the Centers themselves, the relationships between the Centers and ICAT's funded projects, and the extent to which the two groups are intended to circumscribe ICAT's main research goals, are often unclear.

The Transdisciplinary Dilemma Persists

²⁵⁶ "Center for Research in SEAD Education," Network of STEM Education Centers, <https://serc.carleton.edu/StemEdCenters/profiles/143742.html>, accessed September 27, 2018.

The uncertainties that ICAT faces as an Institute, and the personal frustrations that its researchers navigate, are not temporary challenges. The matters of concern that I outline in this dissertation are fundamental aspects of SEAD institutes as they exist within American research universities. These tensions result from the differing and contradictory goals of the people who create SEAD. They are part of what characterizes the university-based SEAD institute as a site of knowledge production.

There is a dilemma at the heart of efforts to establish transdisciplinary art-technology initiatives as core components of American research universities. Attempts to institutionalize SEAD-based transdisciplinarity encounter two major obstacles. First, the ideals that participants seek to institutionalize are actually a complex set of motivations and desires. University administrators have different reasons for wishing to institutionalize transdisciplinarity than many researchers and educators have for wanting to pursue it. Yet, most participants in SEAD tend to describe their goals using malleable language, which includes the term “transdisciplinarity” itself. While vague language can obscure ideological contradictions, the underlying tensions remain. Second, building institutions requires standardization and legitimization, but the transdisciplinary ideals and practices that practitioners seek to institutionalize exist outside of, and often oppose, existing university structures. Building SEAD into a university institution contradicts an important part of what SEAD is.

Three important tensions, which I have described as “matters of concern,” each reveal aspects of this transdisciplinary dilemma. *Sponsored Collaboration* highlights the tension between transdisciplinarity as creative knowledge production and transdisciplinarity as a potentially lucrative economic driver for universities. This tension

has implications for projects and researchers, as projects that tend towards one interpretation of “transdisciplinarity” are nevertheless expected to represent both. A project like Salt Marsh Suite, which celebrates the connections between art and science that its creators find in curiosity and close observation, therefore attracts praise not only for its artistry and uniqueness but also for its potential to render science more approachable. The computer/sculpture SeeMore, equal parts art and computer science and a project which would have struggled to find support outside of a hybrid space like ICAT, leans into its potential as a STEM education tool to attract external support and explain its existence to viewers. Belle2VR, intended from the beginning to be an exercise in physics education, is celebrated as a fusion of art and science even when the artist on the project team acts mostly as a technical expert and coordinator. The meaning of “transdisciplinarity” within SEAD is made expansive through these dual understandings, and as a result loses some of its distinction. When a single term acts as a catch-all descriptor for many different types of collaboration and outcomes, it becomes less powerful as a justification or desired characteristic of extraordinary research.

Questions about *Value and Belonging* relate to tensions between academic disciplines and SEAD’s existence outside of and across disciplinary structures. One of the defining aspects of SEAD is its lack of subservience to any particular discipline or school. However, existing outside of disciplines also means doing without the common practices, accepted methods of review and assessment, and built-in academic communities that disciplines possess. Researchers who want to leave the confines of a disciplinary home are confronted with the need to develop new values and practices within their transdisciplinary spaces, while simultaneously establishing and justifying the

value of their transdisciplinary work. Furthermore, when participants codify these new values, for example in showcases of their work or in new review practices, they (often unintentionally) create boundaries that define who and what belongs in their transdisciplinary spaces. This tension has obvious practical consequences for researchers when it comes to problems like finding publication venues and navigating promotion and tenure processes. It also has more subtle effects, such as potentially limiting the types of people who can comfortably participate in SEAD.

Finally, *Measurable Impact* emphasizes the tension between SEAD institutions' need for resources and legitimacy and their researchers' day-to-day work. In order to justify their continued funding, SEAD organizations, researchers, and educators must show that their work has had an impact, and that they are providing some form of return on investment. However, since the goals of SEAD research are difficult to assess using the type of metrics traditionally preferred by universities and funding organizations, practitioners are left with the problem of either forcing their work into existing metrics that do not always reflect their true goals, or trying to find or define new metrics that are more appropriate for their work.

All of these tensions, and the core of the transdisciplinary dilemma itself, are a legacy of SEAD's history and its multiple past and present-day stakeholders. In ICAT's case, one relatively small research institute – with a budget much smaller than what was originally intended – has shouldered the burden of creating a place for the arts on a technologically-dominated campus; revitalizing the university's land-grant mission by forging new connections with the community; revamping Virginia Tech's profile and research output through its emphasis on transdisciplinarity; building relationships and

revenue streams with industry partners; providing a home for “technophile artists,” “misfit engineers,” and others to engage in hybrid research; revolutionizing education through transdisciplinarity and creative problem-solving; cultivating new kinds of student and faculty “innovators”; and producing innovations in research and technology through a creative process. Not only are these objectives too many and too large for one small group of researchers to reasonably achieve: some of the intended outcomes are, at times, incommensurable. An institute cannot be consistently dedicated to developing new revenue streams and to allowing its researchers the freedom to realize their passion projects. ICAT’s practitioners and administrators have pursued their multiple goals with passion and commitment, and often with a degree of success. However, the nature and scope of their objectives leaves ICAT in a perpetual state of fighting for legitimacy, attempting to please multiple stakeholders while remaining a challenging place for many researchers to make their academic home.

Moving Forward

We now come to the end of the dissertation, and to a stage where I’m afraid I may alienate two of my primary audiences. After so many pages spent dissecting the idea of SEAD and diagnosing its participants’ frustrations, I feel I owe it to those readers who work or have worked in SEAD environments to offer some potential way forward out of the dilemma that I have just described as irresolvable. Following four years of data collection and five total years of affiliation with ICAT, I am compelled to provide at least a hint of what I know many of my colleagues at the Institute wanted from the start: some indication of what they might do; of how they could be better. My apologies, therefore,

go out to any STS readers who have developed allergic reactions to normativity. At the same time, however, I will disappoint my friends at ICAT and the rest of my SEAD audience by failing to offer fully straightforward, actionable answers. I cannot provide a list of best practices, nor a set of concrete suggestions for creating measurable, robust, administrator-approved transdisciplinary outcomes.

Instead, as my framework of matters of concern encourages, I will offer what I hope are three productive ways to begin a practical conversation about the future of SEAD. These are my own informed suggestions, based in my analysis and irrevocably influenced by my personal experiences and opinions. They are not intended as directives, but rather as invitations to discussion. Each is connected with a different aspect of the transdisciplinary dilemma; however, my intent is not to solve the issues that I have discussed. I present the following suggestions as strategies that might alleviate some of the effects of the dilemma, and perhaps make SEAD a more manageable space for those who live and work in it.

First, SEAD participants should be intentional about sponsorship, and should not seek growth for growth's sake. Second, practitioners should be aware of the values that they codify in their processes and policies, and should devote serious time and energy to considering how their choices might privilege or exclude certain groups. Third, researchers in SEAD should carefully consider the alignment of their goals with their metrics, and should develop and promote new types of assessment when this is appropriate and achievable.

The first recommendation addresses the unspoken requirement for SEAD projects to be “transdisciplinary” in several different ways at once, as well as the perceived need

on the part of many SEAD participants to expand the reach of their work and their institutes by seeking external sponsorship. There is nothing inherently suspect about sponsorship; indeed, all academic endeavors rely on sponsors or patrons to some degree. Nor is it necessarily impossible for one institute to create projects that encompass multiple understandings of transdisciplinarity. However, I suggest that the dissonance that some researchers feel about the identity and purpose of their transdisciplinary work could be lessened if participants in SEAD were up front about what they mean by “transdisciplinary” in different contexts. There is no reason for every SEAD project to attempt to be all things to all audiences. Furthermore, consciously pursuing different types of sponsorship according to the specific needs of different projects could alleviate pressure on researchers and educators to attempt to please large numbers of stakeholders simultaneously. Much like Naimark’s hypothetical Art Lab, SEAD institutes could decide on several different goals, and work to align individual project proposals and funding/sponsorship plans with one or two, but not all, of these.

A related suggestion is for the leaders of SEAD institutes to reconsider the necessity of expanding their institutions’ size and reach. Institutes like ICAT excel at cultivating interesting hybrid work that would struggle to find support elsewhere. Some of the outcomes and processes of projects like Salt Marsh, SeeMore, Belle2VR, and Maker Camp are indeed “new,” “surprising,” and distinct from other types of inter- and transdisciplinary work in the ways that Osborne suggests they might be.²⁵⁷ ICAT has supported research and teaching that encourages participants to understand and respect the expertise of different knowledge traditions, and to reflect on the strengths and limitations of their own disciplines. But SEAD advocates have not developed persuasive

²⁵⁷ Osborne, “Inter That Discipline!”

arguments for remaking research universities in the image of transdisciplinarity. As Jerry Jacobs demonstrates, academic disciplines are very effective at producing knowledge; exchanging techniques, materials, and strategies with one another; and providing community and structure for their inhabitants. Not every researcher – not even every technophile artist or misfit engineer – is interested in pursuing SEAD work, and the larger a SEAD institute grows, the more it will come into conflict with existing academic structures. SEAD participants should weigh carefully the costs and benefits of expanding their scope vs. pursuing a smaller, and perhaps more limited, vision.

The second recommendation encourages practitioners and administrators to take care when translating their values into standards and practices. As discussed in Chapter 3, past attempts to codify the value and values of SEAD have resulted in vague, open-ended categories that leave much of the decision-making up to individual preferences. This puts the onus on SEAD participants to choose, without much formal guidance, which projects they will support, with whom they will work, and which criteria to emphasize during review processes. Based on my data from ICAT and my more casual observations of a2ru and the SEAD Network, I suggest that this lack of specificity might push participants to favor people, processes, and materials with which they are already familiar. At the same time, the uncertainty of what it means to conduct a SEAD project, or to identify as a SEAD researcher or educator, could make it difficult for people to enter a SEAD environment or continue working there, particularly if they occupy a less privileged position than others (e.g. if they are untenured, and/or a member of an underrepresented group). I suggest that any time a SEAD participant curates a showcase, pilots a review process, writes a mission statement, or otherwise encodes values into standards and

practices, they have both an opportunity to define what SEAD is, and a responsibility to create an equitable version of it.

Finally, I recommend that SEAD participants pay close attention to the design of the metrics they use to measure their work. It is understandably tempting for researchers and educators in SEAD to try to describe their outputs using measurements that they know will be acceptable to university administrators, funding organizations, and other external audiences who may review their work. However, as described in Chapter 4, this practice often fails to capture what practitioners see as the true value of their work or institutions. It also has the tendency to result in disappointing-looking outcomes as assessed by standard metrics. An annual camp attended by 20 children will not seem impressive if the metric used is total number of people reached, regardless of how transformative the experience was for the participants. If assessment is an appropriate strategy for obtaining the legitimacy that research institutes need to survive – and I believe that it is – I suggest firstly that SEAD institutes make evaluation a priority. Consider metrics early on, and not simply as deadlines for grant applications and reviews approach. Secondly, I recommend that researchers pay close attention to the alignment of their goals with their assessment tools. Are the quantities being measured really the things that a process was designed to create? Finally, I suggest that SEAD participants should make strong arguments for the validity of new metrics and measurement techniques, to the extent that this is feasible. ICAT's five-year review documents struggled to convey the Institute's accomplishments because the criteria for success were unclear, but also because the authors did not include detailed description or measurement of the ways that ICAT had cultivated and sponsored transdisciplinarity (in its different

forms), creativity, and collaboration. While I recognize that there are limits to this approach, I suggest that SEAD should embrace the qualities that its proponents believe makes it different and special, and attempt to convey the importance of these qualities to evaluators.

The challenges of institutionalizing SEAD in research universities are significant. In the absence of significant compromises to the current vision of SEAD, or sweeping structural changes to American higher education, I do not believe that participants will be able to fully resolve the transdisciplinary dilemma. Researchers and educators in SEAD will always need to navigate the demands of multiple stakeholders, and they will continue to make difficult decisions that will shape the identity and boundaries of their work and organizations. Nevertheless, my time at ICAT has convinced me not only that SEAD is a significant and valuable site of knowledge production, but that there are ways to make SEAD a more manageable and equitable transdisciplinary space. I hope that the analysis and recommendations I have presented here can be a useful part of both the ongoing study and the continued construction of transdisciplinarity across science, engineering, art, and design.

Appendix A: Timeline of ICAT Events, 1996-2016

1996

Virginia Tech releases a new Strategic Plan. The stated goal to reconnect the university to its community and society echoes the Kellogg Commission recommendations, and responds to a 1993 SCHEV report that recommended reduced state funding and higher enrollment for Virginia universities.

1998

Virginia Tech releases a report titled Learning Communities: Shaping the Agenda. The report elaborates on Strategic Plan goals, including the anticipated design and introduction of interdisciplinary “learning communities.”

2000

Charles Steger becomes President of Virginia Tech.

2001

Virginia Tech releases a new Strategic Plan, focusing advancing the university’s profile through interdisciplinarity and a renewed focus on the arts. Steger’s goal is to become one of the top 30 research universities nationwide, in part through emphasizing interdisciplinary research.

2003

The Virginia Tech Board of Visitors make their first mention in meeting minutes of funding for a new arts center.

Steve Harrison joins the Virginia Tech faculty after 17 years at Xerox PARC, with a joint appointment in computer science and visual arts.

2005

The Board of Visitors launches the Arts Initiative.

March: The Board of Visitors makes a capital budget recommendation for a \$5 million supplement to the planned Performing Arts Center.

Fall: Minnis Ridenour, after officially retiring in spring 2005, begins working with graduate students from the public administration program in the School of Public Policy and International Affairs on defining a place for the arts at Virginia Tech. This work occurs in loose conjunction with the Arts Initiative.

Fall: Dane Webster is hired as assistant professor in the School of Visual Arts, marking the first part of Collaborative for Creative Technologies in the Arts and Design (CCTAD) cluster hire.

2006

Virginia Tech releases an update to their Strategic Plan, which cites the planned arts center and CCTAD as part of “discovery scholarship domains” that will include both “social and individual transformation” and “innovative technologies and complex systems.”

August: The Board of Visitors lists the budget for the Performing Arts Center project as \$50 million.

Fall: Ico Bukvic and Yong Cao join Virginia Tech faculty as second part of the CCTAD cluster hire. Truman Capone is appointed Interim Director of CCTAD.

Bukvic and a team of graduate students begin work on a CCTAD branding project, designed to ensure “seamless integration with Virginia Tech’s latest ‘Invent the Future’ initiative.”

2007

March: The Board of Visitors approves a plan for a “Cyber Arts and Creative Technologies Laboratory” as part of a six-year plan to renovate Shultz Hall and provide space for VT-STEM. They request \$1.9 million in general funds for 2008-2010.

Spring: Bukvic founds DISIS, the Digital Interactive Sound and Intermedia Studio.

Summer: CCTAD faculty begin work with the Art Museum of Western Virginia on an interactive art piece with the theme of evolution.

August: Steger briefs the Board of Visitors on the Arts Initiative, sharing an article he has written called “Why Study the Arts?”

August: The Arts Initiative releases a report that includes a full proposal for the Center for the Arts, which is to include a “Creative Technologies Lab” as a “prototype” for the Center for Creative Technologies in the Arts (CCTA). The Board of Visitors approves a request to the state appropriations committee for funding for the CCTA, re-naming the previously proposed Cyber Arts and Creative Technologies Laboratory. The initial annual budget request for the CCTA is \$2.1 million, with plans to grow to a \$4.8 million annual base budget with 19 FTE faculty.

Fall: A group within the School of Education, including Liesl Baum, Phyllis Newbill, Sue Maggiero, and Kathy Cennamo, begin to conceptualize an educational research arm for the CCTA.

2008

The School of Education research group is formally named the IDEA Studio (Integrated Design, Education, and Art Studio).

The School of Education begins to offer Educational Enhancement Collaboration grants to fund collaborative, interdisciplinary research that includes work with local teachers and schools. Five teams, many of which include CCTAD faculty, are awarded grants for academic year 2008-2009.

March: Virginia Tech's Department of Art and Art History becomes the School of Visual Arts, which includes CCTAD. Board of Visitors meeting minutes describe CCTAD as a "major university emphasis on the arts, education, and outreach begun in 2005."

March: The annual budget request for the CCTA is downgraded from \$2.1 million to \$565,000 in 2008-2009 and \$636,000 for 2009-2010.

August: The Board of Visitors approves an MFA program in Creative Technologies.

2009

Bukvic founds the Linux Laptop Orchestra.

Three additional teams receive Educational Enhancement Collaboration grants for 2009-2010.

Webster and Bukvic become Assistant Co-Directors of CCTAD.

Fall: Virginia Tech establishes an Arts Policy Board, chaired by Provost McNamee.

November: *Singing Darwin: A Collaborative Intermedia Arts Project* is exhibited and performed at the Armory Gallery. Collaborators include Carol Burch-Brown, Steve Harrison, Ico Bukvic, Ann Kilkelly, Simone Paterson, Dane Webster, and others.

November: Of the four budget requests that Virginia Tech submits to the state government for 2010-2012 appropriations, the request for CCTA funding is the only one approved.

2010

March: The site plan for the Center for the Arts is presented to the Board of Visitors.

June: Ground broken on Center for the Arts construction.

November: The Board of Visitors meeting minutes refer to the CCTA as "transdisciplinary" for the first time. ("a collaborative, trans-disciplinary environment that supports research projects focused on the intersections of arts, technologies, and learning.")

2011

The CCTA becomes the Institute for Creativity, Arts, and Technology (ICAT).

Ben Knapp hired as ICAT director.

Liesl Baum hired as ICAT research associate.

The Network for Sciences, Engineering, Arts, and Design (SEAD Network) forms, following the conclusion of two NSF- and NEA-funded projects on coordinating transdisciplinary research across the arts and technology.

Fall: Virginia Tech releases an initial Call for Proposals for Interdisciplinary Graduate Education Programs (IGEPs).

Fall: Doug Bowman becomes director of Virginia Tech's Center for Human-Computer Interaction.

October 1: ICAT's formation is officially noted and approved in the Board of Visitors meeting minutes. Its total budget for FY11-12 is \$728,000, which is set to grow to \$1,273,895 by FY15-16.

Baum and Teri Finn draft ICAT mission document, in which they compare plans for ICAT to institutions at other universities and define "characteristics of an ICAT project."

2012

The Alliance for the Arts in Research Universities (a2ru) forms, following a meeting at the University of Michigan.

November: Provost McNamee presents on the university's "Innovation Ecosystem," including ICAT in the presentation.

May: Baum attends World Maker Faire, and subsequently begins planning for ICAT's inaugural Maker Camp.

July: First ICAT Maker Camp occurs.

Summer: ICAT awards its first SEAD grants, offering funding for the 2012-2013 academic year.

2013

July: An ICAT-based faculty team receives NSF funding for the Mirror Worlds project, which will establish research infrastructure within the new Center for the Arts building.

Fall: Virginia Tech creates a new IGEP in Human-Centered Design, associated with ICAT and the Center for Human-Computer Interaction.

October: ICAT moves to the Center for the Arts building. ICAT and the Center for the Arts open to the public.

The building that houses both the Center for the Arts and ICAT is renamed the Moss Arts Center, following a \$10 million donation from artist P. Buckley Moss.

Summer: ICAT awards SEAD grants awarded for 2013-2014 academic year, including to the SeeMore team.

2014

January: The Alliance for the Arts in Research Universities (a2ru) holds their inaugural student conference, Emerging Creatives, at Stanford University.

April: Salt Marsh Suite debuts in ICAT's Cube.

ICAT hosts its inaugural ICAT Day, a showcase of research and teaching that the Institute has supported.

June: Tim Sands begins his tenure President of Virginia Tech, following Steger's retirement.

Summer: ICAT core faculty change their nomenclature from "Studio Heads" to "Senior Fellows."

October: ICAT and the Moss Arts Center are hosts for the Virginia Science Festival.

2015

May: Thanassis Rikakis is named Executive Vice President and Provost of Virginia Tech, following McNamee's retirement.

Fall: Sands and Rikakis launch the Beyond Boundaries initiative.

ICAT faculty and staff begin gathering information and resources for ICAT's five-year review.

November: Virginia Tech hosts the a2ru national conference.

Virginia Tech approves its first individualized PhD student, who will complete a project based in Human-Centered Design, in association with several ICAT-affiliated faculty.

2016

Spring: Belle2VR receives an ICAT SEAD grant for 2016-17.

March: Virginia Tech sends several ICAT-affiliated projects, including SeeMore, to the South By Southwest festival.

Fall: The ICAT five-year review occurs.

Appendix B: Table of ICAT-Supported Projects, 2011-2017

Project Title	Year of ICAT sponsorship	Type of ICAT support
Linux Laptop Orchestra (L2Ork)	2011 (ongoing)	Faculty/student involvement; facilities
Maker Camp	2011 (ongoing)	Faculty/staff/student involvement; facilities
Four Four Beat Project	2012-2013	Major grant
Lantern Field	2012-2013	Mini-grant
Studio STEM	2012-2013	Major grant
Sound of Fractions	2012-2013	Major grant
Oddfellows Hall project	2012-2013	Mini-grant
Gendered Arrangements	2012-2013	Mini-grant
Community Voices	2012-2013	Mini-grant
Ordinary Wars	2012-2013	Mini-grant
Nature Explorer	2012-2013	Student grant
NASA wearable technology projects	2012-2013; 2013-2014	Mini-grant; faculty involvement
Puppy Project	2012-2013; 2013-2014; 2014-2015	Major grant (2012-2013); mini-grants (2013-15)
OPERAcraft	2012-2013; 2014-2015	Major grant (2012-2013); mini-grant; facilities
Origins of Innovation	2013	Faculty involvement
CaSPER	2013	Displayed at Tech or Treat
This Edge I Have to Jump	2013	Commissioned for Cube grand opening
Mirror Worlds	2013 (ongoing)	Faculty/staff/student involvement; displayed at Tech or Treat
3D printing flexible textile structures	2013-2014	Faculty involvement
Modeling organic 3D surfaces with flexible input	2013-2014	Major grant; faculty involvement
Macronaut	2013-2014	Mini-grant
Cloud	2013-2014	Mini-grant
Dynamic Responsive Façade	2013-2014	Major grant
Between the Pyramid and the Labyrinth	2013-2014	Faculty involvement; ICAT-sponsored course; displayed at Tech or Treat
Salt Marsh Suite	2013-2014	Mini-grant
Blacksburg High School Arts Integration Project	2013-2014	Major grant
Bio-inspired Visualization	2013-2014	Major grant; faculty involvement
Food Emotions	2013-2014	Major grant
Connected Vehicle Derby	2013-2014	Faculty/student involvement
Kinesthetic Fields	2013-2014	Mini-grant
Text Analytics Toolbox	2013-2014	Mini-grant
Digital Storytelling	2013-2014	Mini-grant

3Dcology	2013-2014	Mini-grant
Omni	2013-2014	Student grant
Transformable Boundaries: Development and Demonstration of the AURA Transformable Building Enclosure System	2013-2014	Mini-grant
SeeMore	2013-2014; 2015-2016	Major grant (2013-14); mini-grant (2015-16); student grant (2015-16); facilities
Extending Creativity through a Multidisciplinary Dance Project	2013-2014; 2015-2016	Mini-grants
Be the Data	2014-2015	Major grant; facilities
Blacksburg 16 Squares	2014-2015	Major grant
New Town project	2014-2015	
Bridge Deck Mapping	2014-2015	
3D visualization for the Moss Arts Center	2014-2015	Faculty involvement
Tornado in the Cube	2014-2015	Major grant; staff involvement; facilities
Matrix Redux	2014-2015	Major grant
Medical Avatar: The Time Health Machine	2014-2015	Mini-grant
Parametric Sign Shack	2014-2015	Mini-grant
Innovation Fashion	2014-2015	Student grant
Capturing Data Shape	2014-2015	Student grant
Pyschopathy	2014-2015	Student grant
Human Crowd Dynamics	2014-2015	Mini-grant; facilities
Percussion Ensemble	2014-2015	Mini-grant
Transportation Infrastructure Mapping	2014-2015	Mini-grant
Dialed In	2014-2015	Major grant
Flying Snakes	2014-2015	Mini-grant; facilities
Escher Humanoid Robot	2015-2016	Major grant
Emotional Response and Impact of Visual Stimuli in Virtual and Built Environments	2015-2016	Major grant
REAL Pedagogy	2015-2016	Major grant
Fusality for Stream and Field	2015-2016	Major grant
Additive Manufacturing and Automated Construction Technologies	2015-2016	Major grant
Hear ME	2015-2016	Mini-grant
Virtual IAWA	2015-2016	Mini-grant
Marcellus Shale Project	2015-2016	Mini-grant
Moss Arts Center Projection Mapping Project	2015-2016	Mini-grant
Freshwater Heritage	2015-2016	Mini-grant
Pulse 16	2015-2016	Student grant
Constructing the Parametric Envelope	2015-2016	Student grant

Krinkle Cube	2015-2016	Student grant
Can Innovators Be Made? 4S Making and Doing	2015-2016	Student grant
Alternate Realities	2015-2016	Student grant
Brain Matrix	2015-2016	Student grant
PRT for parents of children with ASD	2015-2016	Student grant
Identifying Collaboration and Creativity in Instrumented Building to Support Innovation	2015-2016; 2016-2017	Mini-grant (2015-16); Major grant (2016-17); facilities
Drillfield Paths	2016-2017	Major grant
Stepping into the Past through Visualization	2016-2017	Major grant
Belle2VR	2016-2017	Major grant; staff involvement; facilities
VTArtWorks	2016-2017	Major grant
FogHarp	2016-2017	Major grant
Building Communities of Fitness	2016-2017	Major grant
Measuring the Engineer's Brain	2016-2017	Major grant
Mixed Library	2016-2017	Major grant
GAMES Project		Faculty involvement
Emergency Evacuation Planning for Lane Stadium		Faculty involvement
Load Balancing for Massive Model Rendering		Faculty involvement

Appendix C: Annotated List of Figures and Image Permissions

Figure 1.1: Author-created image; no permission necessary.

Figure 2.1: Image courtesy of the Institute for Creativity, Art, and Technology. Permission granted via email from Melissa Wyers on October 1, 2018.

Figure 2.2: Image courtesy of Ben Knapp. Permission granted via email from Ben Knapp on October 4, 2018.

Figure 2.3: Same image as Figure 2.1.

Figure 3.1: Image courtesy of Carol Burch-Brown. Permission granted via email from Carol Burch-Brown on September 29, 2018.

Figure 3.2: Image courtesy of Jud Froelich. Permission granted via email from Jud Froelich on September 30, 2018.

Figure 3.3: Image courtesy of the Institute for Creativity, Arts, and Technology. Permission granted via email from Holly Williams on October 4, 2018.

Figure 5.1: Image courtesy of the Institute for Creativity, Arts, and Technology. Permission granted via email from Melissa Wyers on October 1, 2018.

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Appendix D: IRB Approval Letter



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4806 Fax 540/231-0859
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: September 30, 2013
TO: Matthew Wisnioski, Kari Elizabeth Zacharias
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: An Analysis of Cross-Disciplinary Art-Technology Institutes in the Contemporary University
IRB NUMBER: 13-852

Effective September 30, 2013, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: Expedited, under 45 CFR 46.110 category(ies) 6,7
Protocol Approval Date: September 30, 2013
Protocol Expiration Date: September 29, 2014
Continuing Review Due Date*: September 15, 2014

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

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