A SEAD WHITE PAPERS WORKING GROUP META-ANALYSIS

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Abstract

This SEAD White Papers Working Group meta-analysis comments on a subset of the papers presented that relate to sound/music, dance, pedagogy, thinking with things, sci-art projects and common language. It focuses on emphasizing strengths for meta-discussion and advancing the SEAD agenda in a broader context in order to return us to the same debate as it was addressed in the 1950s and 1960s at the National Science Foundation (NSF). It critique the papers in terms of the way in which they respond to and rely on the underlying dominance of C. P. Snow's popular notion of two cultures (Snow 1963) considering that this unexamined thesis is taken as an article of faith dividing the worlds of art and science. Nowhere in any of these papers is the thesis and the history of the concept, or Snow's simplistic notion of culture, adequately or even rudimentarily addressed. In that regard it might come as a matter of surprise to the SEAD community that Snow's thesis was soundly rejected on empirical grounds at the start of this debate. Nevertheless it retains its popularity precisely for its unexamined simplistic stereotyping.

This meta-analysis highlights papers that transcend the distinction in practical ways in their substance and in their Suggested Actions. It emphasizes the Root-Bernstein paper as paradigmatic of how far cross-disciplinary research has come in theoretical and practical terms over the intervening decades. It then emphasizes two points: 1.This very same debate over the necessity of bridging work in science and culture (read as the arts, humanities and social sciences) was a subject of fundamental importance to scientists, anthropologists, and art historians participating in the NSF analysis of the problem as it was 60 years ago. 2. Revisiting the Leavis and Yudkin (1962) critique of Snow and that NSF history, it proposes that White Papers projects should carefully consider the emerging critical evaluations of previous art-sci projects such as those at the Wellcome Institute in the United Kingdom and the Xerox PARC project in the United States. In doing so, they would avoid making the mistake of proposing the justification of funding on the basis that art can contribute to basic science without providing evidence. Instead, what all these papers do document is how SEAD can advance science education, the public image of science, and the creative impulse and rigor across the disciplines that bind them.

Introduction

The first part of this meta-analysis introduces some guiding questions in terms of qualifications and cautions that I have taken into consideration in commenting on some aspects of the papers that I, as a social scientist with a science background, have found especially compelling. The second part of the paper provides critical comments on select papers. The third and fourth parts present a historical perspective on the debate over the science/culture schism. Finally, the conclusion revisits the UK SciArt Project to provide a cautionary tale.

The essay discusses the problem of the instrumental hopes and logics for art-science collaboration and expands upon the common problems in many of these papers. These are as follows. First, the "two cultures" worldview constitutes the underlying ideology and epistemology of virtually all these White Papers. Second, this insufficiently considered paradigm significantly compromises the network's potential. Third, there is as a manifest rhetorical rather than evidence based claim over how the Suggested Actions can advance basic science. In short, I ask: Is there evidence here for the elemental principle of justification for funding SEAD, that the combination with non-science disciplines advances science? [1]

To begin with, a clarification of the SEAD network context and the various audiences addressed in the Suggested Actions is necessary. SEAD, NSEAD, XSEAD, the SEAD Network and the SEAD White Papers Working Group are different entities connected by a common history and concern. SEAD was created as a network to link and expand debate initiated by two separate initiatives, NSEAD and XSEAD, both of which were funded by NSF EAGER grants.[2] This clarity is necessary to avoid confusion, especially any notion that the Suggested Actions are calls for NSF funding. They are open-ended ideas about potential distributed funding initiatives for such cross-disciplinary projects in many different global contexts. Nevertheless, though they are specifically not to be read as funding proposals, there is a clear tendency for all participants to have used this as a context to put forth the Suggested Actions as calls for future funding.

The SEAD White Paper project is then a forum for widely varying ideas about the arts and sciences. As regards the specific concerns of this meta-analysis, the project was not designed as an effort to claim that art can advance science or vice versa, though certain papers may advance one or either position (Carol Strohecker, pers. com). In the final analysis the White Papers

1 See Glinkowski and Bamford (2009) for evaluation of the UK sci-art projects

2 The project is an outcome of NSF Grant No. 1142510, IIS, Human Centered Computing Collaborative Research: EAGER: Network for S.E.A.D (NSEAD). I thank Carol Strohecker, Carol LaFayette, Roger Malina, Amy Ione and Robert Root-Bernstein for providing information and clarifying these and other important art-sci issues.

initiative is an advocacy project. It seeks to socialize globally the value of research and work across the arts and sciences while creating a network. The SEAD objectives and the Suggested Actions in the papers are not necessarily the same. The White Papers project provides a means of measuring and recording the pulse and some of the diversity in the emerging global SEAD community (Carol La Fayette, pers. com.). Collectively however, the papers obviously have generative potentials for the purposes of grant preparation and curriculum innovation across the spectrum of potential funding agencies both governmental and non-governmental. In that context, this meta-analysis considers a few of the SEAD Suggested Actions in the White Papers relevant to the SEAD conversation as it might concern scientists and especially those making decisions at NSF about funding potential projects.

The Four Questions: Qualifications and Cautions

My guiding questions in this meta-analysis are these: 1. What do these White Papers potentially contribute to science? 2. How do they not do so? 3. What purpose do they serve if they will not advance science? And lastly: 4. If the papers do not provide evidence of how they will contribute to the advancement of science itself, but do advance science education and public relations, should we not be more careful about stating the reasons for seeking future funding from NSF for the movement from STEM to STEAM? These questions require attention because they are insufficiently substantiated as a primary logic in too many papers. Once again, though this SEAD White Papers project is explicitly not a fund-seeking mechanism, virtually all of the individual Suggested Actions are clearly composed with that intention in mind, they are in effect, calls for funding for each project's particular aims and agenda. As such they constitute public records of those visions of curriculum innovation and educational transformation.

I believe that it is important to inject greater rigor into the SEAD debate over evidence and what constitutes evidence for whether art can advance science. Specifically I argue that one should not make claims that art advances science as a justification for NSF funding initiatives if one cannot provide the evidence. One can use other compelling arguments as I expand upon throughout the essay. However, as this axiom is not a position unanimously held in this community, I emphasize that this contrary position is in no way intended to devalue Root-Bernstein's overview of the critical importance of the arts and crafts to science or any of the papers that do so. Indeed, as Root-Bernstein observes, "an increasing number of investigators are suggesting that for exploring the human dimensions and implications of science and technology, artistic methods may even be superior to scientific ones" (2003, 272). There he quotes first Desmond Morris, "In reality, people today are not scientists or artists . . . they are explores or non-explorers," and then

Sir Kenneth Clark, "Art and science . . . are not, as used to be supposed, two contrary activities, but in fact draw on many of the same capacities of the human mind" (2003, 276). [3]

One main goal of this meta-analysis is to explore the four questions I introduced above in the broader historical context out of which this contemporary debate has emerged. The idea of "two cultures" was created and popularized by C. P. Snow in 1959 and re-published in modified form in 1962 after much criticism inspiring a largely one-sided debate that continues (Snow 1959, 1962; Elkins 2008 contra Leavis and Yudkin 1962; Sielke 2010; Zilberg 2011). This idea of a fundamental schism in the modern world runs through virtually all of the papers as a dominant underlying theme. It is by and large taken uncritically as a self-evident truth which the authors universally seek to overcome. Indeed, the way in which Snow's axiom is taken as an article of faith without returning to the original texts and the criticisms of those texts across the decades is nothing short of remarkable. This issue is significant as we need conceptual clarity on basic principles in order to achieve any productive cross-disciplinary outcomes. To do that we have to return to the history of this schism and unpack this root assumption that motivates and yet at the same time makes working across the sciences and humanities so problematic.

There are other problems to consider. For instance, people tend to conflate science and technology and the purely visual arts tend to dominate the SEAD discussion (Roger Malina, pers. com.). There is also the problem of the competing plethora of terms and initiatives for cross-disciplinary interactions, be they interdisciplinary, multidisciplinary, paradisciplinary, transdisciplinary and most recently antidisciplinary. The transdisciplinary axiom is clarified in Blasnigg and Punt's White Paper and amounts to this: if SEAD activities cannot contribute to each component of whichever disciplinary collaborations are involved in a fundamental manner that does not compromise their disciplinary integrities, then they are technically not transdisciplinary (also see Punt 2010). Too often it is either explicitly or implicitly proposed that the justification for moving from STEM to STEAM is that art can advance basic science and bridge the "two culture" divide. That being said, there is clearly a generative interaction between art and design, technology and engineering, and there is clear evidence for the productivity for combining basic research in music and science to their mutual enhancement. Yet, for all the interdisciplinary activity in art and science, the results for many commentators despite their proclivity for the collaborative potentials are so far not encouraging (Pepperell 2011, 268).

Critical Comments on Select Papers

[3] The extensive literature on the relationships between the arts, humanities and science is too vast to comment upon in this context, but for a snapshot of views across time, see Bork (2007), Clarke and Rossini (2011), Kepes (1965), Labinger (2011), Milburne (2011), Pepperell (2011), Roof (2011) and Ruskin (1872).

I begin, if very briefly, with the Root-Bernstein White Paper on the importance of a persistent education in the arts and crafts and the references therein as it serves well as a guiding theoretical base for SEAD (also see Root-Bernstein 1995, 2000, 2001, and Root-Bernstein et al. 2008). This paper is also important for my purposes as Root-Bernstein clarifies the systemic need to distinguish between transdisciplinary processes and disciplinary products (Root-Bernstein 2003, 268). In essence, the White Papers I have chosen to discuss further below confirm Root-Bernstein's definitive discussion on how "the ways in which artists and scientists discover and invent problems, experiment with them, and generate and test possible solutions is universal" (ibid.). They constitute primary documents for any SEAD collaboration particularly as concerns the relevance of the arts and humanities to the sciences, technology engineering, math (STEM) and thus the move to sciences, technology, engineering, arts and math (STEAM), and, ultimately to include the humanities (THEMAS).

Batson's paper, "Ex-scribing the Choreographic Mind" is important on many levels, beginning with the fact that it introduces us to ten years of art-sci lab practice in the investigation of "choreographic cognition" and "the embodied mind." Batson notes that the "cognitive processes generated in dance making" offer "tangible benefits" to science and medicine and have proven and significant outcomes. She points to Edwards (2011) to substantiate the claim that art-sci collaborations are leading twenty-first century research and pedagogy. Referring to DeLahunta (2004), Batson adds that in physicalizing thought dance generates problems and problem solving. This provides "new ways of conceptualizing the inter-relationship of thought and motor skills" and allows for practice-led research with new materials and technologies at centers for cognitive neuroscience which concern theoretical issues in neuroscience, phenomenology, and human movement science. Such cross-disciplinary work clearly offers exciting possibilities but academic rigor should require far more systematic and careful documentation of evidence of what such a ten-year project has produced.

Despite their obvious importance, the problem is that a few of these SEAD White Papers provide any evidence, outside of using citations, to substantiate their claims. Far too many of them are merely rhetorical exercises. In Batson's case for instance, though results are claimed for specific projects, they are not provided nor are any relevant references for them cited. In the case of the Freemantle paper on the British Heart Foundation's art-sci project, the evidence for the value of art to science and thus the collaborative value of such a project to a medical research institution is so scant as to raise serious concerns. Nevertheless, Freemantle retains tenacious commitment to the principle and the ultimate potential values of art-sci work. To highlight this manifest problem, consider the one instance illustrative as to the contrary: Kuhn's paper, "Thinking with Things: Feeling our Way Into STEM," which addresses mathematics and craft

Kuhn's White Paper provides a fascinating example of the value of art-sci projects for math education using object- and practice-based enquiry. It has enormous potential as a model of an art-sci math project precisely because it bridges two domains few would ever imagine could be so usefully connected - the art of crotchet and higher-order math. Kuhn's paper is also instructive as she provides a case study of how the fear of science, in this case mathematics, inhibits learning. Her paper is exemplary in demonstrating how one of the most important functions of sci-art SEAD projects is to provide contexts, materials and methods for overcoming this problem. Fear is a critical limiting factor for the advancement of science. Fear often prevents young people from engaging and entering science. In essence, this and the other papers do not so much advance basic science as science education. In the long run however this advances science itself through broadening the potential pool of scientists and bringing in creative individuals who might not have ever entered the world of science. Beyond that, the creativity in this and all these papers has a major potential catalytic function.

From my perspective Sarah Kuhn's paper is essential for its pedagogical importance and more generally the nature of the extensive and her Suggested Actions. Set in the context of a fascinating conjunction in hyperbolic crotchet, Kuhn provides a compellingly brief discussion on the "useful arts" and common cognitive developmental roots of art and science. In terms of "Thinking with Things" and "Objects for Enquiry," Kuhn refers to Silver and Ozin's Periodic Table of Nanomaterials and Tatar's Sowed Circuits. These expand the case for how learners of all ages can benefit from working with concrete objects and images or visual and sonified data rather than concepts, as is traditionally the case. And as she notes, "The history of STEM fields is full of examples where discoveries were sparked by objects and images, not just abstract reasoning." Yet to substantiate such claims, the evidence and not just the claim or citation for the said evidence must be provided. In Kuhn's case, the evidence is that Richard Feynman's mother was a Frobelian. This suggests that Feyman's visual approaches to solving math problems, to seeing mathematical relations in terms of patterns, must have been informed by his early childhood experience.

I do not doubt or contest the connection. But as someone with a scientific training I imagine that NSF proposal evaluators would prefer to have stronger evidence for the claim. Fortunately, in this case Kuhn clearly states that though the evidence is circumstantial, the inspirational relation obvious. This kind of clarity would enhance the critical value of all such White Papers to the SEAD project in terms of the persuasive power they could have for the NSF scientific community which after all often includes artists, designers and musicians. . In future SEAD

network discussions and papers, the criteria of evidence-based claims should be clarified. [4] Research needs to be conducted in order to assess the significance of the papers and particularly the justifications for the individual Suggested Actions.

Finally, in a SEAD paper on neuroscience, Cynthia Wagoner and Robert Wilkins consider Ubeats as a model for learning science and music. Involving collaborations with musicians, it alerts one to the fact that NSF grants have been made in the past for sci-art projects. While the Universal BioMusic Education Achievement Tier in Science is thus a critical model for art-science interaction and while many of the authors propose standardization for the purpose of measurement and evaluation of SEAD-type projects, some might question these efforts in that direction. Will they not constrain the creative quest whether or not they are effective at measuring learning? Would it not lead to something like DBAE (Discipline-Based Art Education, see Parsons and Blocker 1993) or some form of multiplex SEAD Standard Achievement Testing and statistical analysis. Such measures are all well and good for justifying and monitoring state and federal programming and perhaps measuring the effectiveness of art-sci projects but do they serve the creative logic of why there should be an "A"in SEAD? Being a proponent of practice-based application, I prefer the outcomes-based achievement criteria rather than assessment. Nevertheless, many of the papers advocate for the former approach and in my paper with Kitto, Kostis, Long, and Trenshaw we have also emphasized standardized testing to evaluate the pedagogical effectiveness of such proposed SEAD projects.

Scott Gresham-Lancaster adds to these fascinating SEAD Network papers on music, sound, and dance in terms of data sonification, a rapidly emerging field for design and research in the context of art-sci collaborations. He notes that in the combined use of both sonic and visual analysis, the synthesis "increases the likelihood of exposure of new features and interconnections hidden in more standard 'visual only' modes of investigation." Here though sonification is a new tool for scientific discovery, it is too early to tell what it might or might not lead to. He makes the important qualification that sonic collaborations have to be carefully orchestrated over time to create functional and aesthetically pleasing results that are self-explanatory and can transcend the data. Similarly in Essle's paper on mobile music and education, we see further evidence of exciting developments in this domain of art-sci activity. Though Essle's project contributes to computer science and obviously has significant value for technologically assisted education, again, the fundamental problem is that no evidence for the advancement of basic science per se is given. In contrast, Braasch's White Paper, "Creative AI Agents for the Arts", brief as it is at two pages, is exemplary in terms of the specific deliverables it proposes and the action plans for

4 See Lévy-Leblond, La science (n')e(s)t (pas) l'art (2010) and Roger Malina's response, "Curiosity, Borders of the Real and Multiple Futures" (2011).

precise research ends. This is the specificity that scientists would want to see in all these papers in terms of the clarity of the obstacles and the goals to be achieved.

Onfescu's White Paper, "The Nano Art 21 Project" is of special relevance across the board for its clarity of language and purpose. Onfescu's project is also interesting because it proposes a global program. It situates nanoart as a conjoined aesthetic and scientific activity and showcases the collaborative work at Future Lab at UCLA and LACMA. Yet the two projects that Onfescu notes as having delivered "new scientific innovations" in the 1990's, namely Interval and PARC (at Xerox), were discontinued despite having both patented innovations. What were these innovations and patents? Why were these programs discontinued if they were successful in these critical dimensions of measurement and evaluation? Fortunately, Michael Naimark's Leonardo report, Technology-Based Art and the Dynamics of Sustainability" provides such data. But in Onfescu's case, clarification is required given the contradiction between the title of this report and the lack of sustainability of the two projects at Interval and PARC.

Such critical analysis of said evidence-based assertions is essential given Onfescu's conclusion. There he states, "art projects in a research environment will stimulate the researchers adding aesthetic and emotional value to the scientific work, will provide grounds for developing new skills, and lead to new discoveries." The claim is explicit: new scientific discoveries will result as a consequence of SEAD funding. To substantiate this rhetorical assertion we need to know exactly what were the relevant innovations and patents so as to be able to assess their importance and thus justify the claim. If Xerox had concluded that the PARC program had been of generative value to science and technology, would it have discontinued the project? Onfescu concludes by noting that in the future NanoArt 21 will shift its focus to education. And there, as for the value of art to science in the illustrative sphere, the synergies are already well established (see Ursyn 2012). In the end, it is the argument for improving science education, science outreach, engineering and creative illustration that provides the strongest logic for NSF funding of the SEAD mandate.

Arguably the strongest White Paper on all levels, especially pedagogy, application and programmatic outcome-based collaborative project planning is Fishwick's "Learning Computing through Game Experiences". His basic principle is that learners should be enticed into participation through something which they find relevant and interesting. There, the most successful experiences draw upon pre-existing cultural forms. In this case, gaming culture provides a "curricular vehicle for introducing learning objectives."

While Fishwick's paper has strengths in several domains, its power lies above all in its precision of achievable goals and its use of language. For instance, he introduces the notion of leverage. This term has fundamental value as a basic concept for these SEAD White Papers project proposals as a guiding principle in the Suggested Actions. As he writes, the idea behind learning computing through gaming is "to leverage game-based social networks, culture, and gameplay as a means for introducing computing concepts . . ." namely iteration, branching, and recursion and object orientation. Moreover he also provides explicit goals for the different audiences in his Suggested Actions. These are to connect, combine and integrate subjects in a way that allows the computer science students to learn about the above concepts, as well as about alogrithms and automation. For humanities students, the goal is to advance their skills in narrative analysis and critique. For artists, it is to create new sensory experiences. Lastly, the applicability and established rather than proposed practice, is obvious. Most compelling of all, Fishwick has taught a class on "aesthetic computing" for a decade now. Perhaps one day, if not somewhere already, there will be classes being taught on "aesthetic approaches to biochemistry," or conjoined classes on "aesthetic biology" and "aesthetic math."

Fishwick's paper also alerts us to the importance of regional innovation centers for SEAD, in this case the Transtech ATEC Center Hub at the University of Texas at Dallas. Each of these centers has particular strengths and some regional hubs complement others interests as in the case of embodiment. Perhaps UTD ATEC's strongest potential lies in its cross-cutting collaborative structures and programs with multiple institutions in the Research Triangle in North Carolina. There is considerable opportunity at hand for better understanding the connections between cognitive process and the body, specifically embodied learning (Hahn 2007). Pointing us in such directions, Fishwick concludes with two fascinating questions and opportunities. First he asks: To what extent do metaphors involving gestures and body sensations (movement, orientation, tactile sensation and sound) embed themselves in the artificial artifacts found in computing? We could ask similar questions for our representations of atoms and molecules and process in a more highly process oriented vision of biochemistry. Second he asks: What are the thought processes underlying modular coding, conditional branching, and understanding large scale, complex data structures? The very same question could be asked of molecular structures and processes and the large-scale complex data involved in stochastic and synergistic biochemical reactions.

The Fishwick paper stands out as it provides the most sophisticated example of a bridge between technical and humanist language in the art-science SEAD challenge. Noting that disciplinary pedagogy is typically script-based, he emphasizes the alternative value of audio-visual learning as an explicit project to overcome a "crisis of representation." Adding to Kuhn's shift to the visual from the abstract, he asks two vital questions: 1. "Can the humanist's rhetorical mandate

employ audiovisual artifacts?" and 2. Could criticism "be defined by perceptually enabled interaction?"

Fishwick is on the cutting edge. For instance, he asks, "Where embodiment does play a role in cognition connected with these software artifacts, new forms of representation will be required to leverage and capitalize upon the embodiment hypothesis". Going even further, and most interesting of all, consider the potential for this: "Game environments provide excellent breeding ground for the human subject experiments as well as contributing highly sensory embodied experiences." Continuing in this vein, the White Paper by Carol Davis "Smart Games and Tools: Using Immersive 3D Cloning Technology" demonstrates that there are strong potential synergistic relations across sub-sets of the SEAD papers. While the Davis paper complements Fishwick's well, and a more extended meta-analysis elucidating common ideas and goals in such grouped White Papers could clarify this point, it is more practical for the purpose of brevity to recall Root-Bernstein's paper. It has a fundamental relevance and application across the board. In particular, it provides a range of materials relevant to the central issue in this particular meta-analysis – Can art advance science?

To emphasize the relevance and ongoing importance of this critical issue to these papers, Cohen's paper "Bridging the Divide" is especially useful in terms of institutionalization of the art-sci nexus. It describes the establishment and the aims of the MA in Arts and Science at the Central Saint Martins (CSM) and University of the Arts London the city being an all-important context for art-sci projects and exhibitions. [5] Cohen's second Suggested Action is to enable the exchange of ideas that could "lead to the development of new ideas, technologies and applications." Again, not without reason, we are back to instrumentalism and outcomes-based justification.

Also in the United Kingdom, to return to Freemantle's paper, the British Heart Foundation's continuing art-sci program and its expansion into a proposed doctoral program will be of equal interest to follow up on, particularly considering that no single participating scientist at the BHF responded to the survey intended to assess the previous program. A critical reader of that paper would I suspect immediately question whether there might be something else behind the 100 percent failure rate in assessing the Sci in the SciArt project, rather than the Director's seemingly tongue-in-cheek explanation that it was due to an unwillingness among scientists to respond to online assessment requests.

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5 See "A Nervous Encounter." 2013. University of the Arts London Central Saint Martins and the Medical Research Council, Institute of Neuropharmacology, Oxford, http://blog.nervousencounter.com/

Perhaps the take-away point here is that SEAD projects clearly have enormous transdisciplinary potential. But any claims that engaging the arts can directly result in innovations and advances in basic science should either be expressed in the most qualified indirect and potential fashion or evidence should be provided rather than mere rhetoric and reference as is currently the case in these SEAD White Papers and in previous art-sci work (Ione 2003, Mitchel Inouye and Blumenthal 2003). Finally though I barely mention the term "engineering" in this meta-analysis, I imagine that the arts can and do contribute to this field. By way of concluding this first part of the essay and expanding this discussion toward considering the "two cultures" problem in the final part of this meta-analysis, I close with five concerns that these papers raise in my mind.

First and foremost, it seems to me that for any participant in the SEAD network discussion to overemphasize a transdisciplinary agenda without considering the logic and ramifications for the White Papers as a whole is problematic. There is a significant diversity of languages and frameworks being used by different authors particularly as regards the terms interdisciplinary, multidisciplinary, and even paradisciplinary. Each seems to be attempting to use the SEAD Initiative as a context for self-validation and centrality.

Second, the preponderance of evidence from these papers and the relevant reports unfortunately seems to be that art does not directly advance basic science, as reluctant as we might be to accept this conclusion. Yet this does not undermine the fact that cross-disciplinary work can and does contribute to scientific creativity and science education. For those in the transdisciplinary circuit, in terms of the most basic and direct criteria, SEAD cannot be a trans-disciplinary project because it has not been demonstrated that the arts can contribute to basic science. Or have they (see Clarke and Rossini 2011)? Towards future debate and "proof" for whom that matters, it seems then that not only is clarity required on the nature of how each discipline will enhance knowledge and practice in the other, but perhaps some basic research should be conducted to look into this transdisciplinary dilemma more closely.

Third, the difference between the nature and the quality of the papers and evidence-based Suggested Actions between those led by or collaborating with scientists and the non-scientists is so striking that it raises a red flag concerning SEAD. Polemical calls for funding by NSF at the behest of nonscientists is unlikely to be persuasive. For seeking any future funding from scientific organizations, the tactic of pushing the transdisciplinary agenda as a theoretical base should perhaps be seriously addressed if indeed it is the case that the arts have not been proven to advance basic science.

Fourth, in spite of these critical preliminary and guiding issues stated so starkly, the White Papers clearly show long-standing and emergent evidence of SEAD activity. Accordingly, a national program with cross-cutting state- and regional-level projects is logical in that there is a securely established evidential and institutional base. SEAD is obviously ready for synergistic leveraging. As a platform for the advancement of science and its relation to all other disciplines it could also serve to overcome the persistent public misconceptions of science and what constitutes science.

And finally fifth, should the argument that the arts can advance basic science be avoided? If it is to be included in any White Paper, should it rather not be carefully qualified and redirected in terms of the use value of the arts for science education, for engaging the public in better understanding and appreciating science, for improving science's public image and for enhancing scientific sensibility through artistic creativity?

A Meta-Discussion in Historical Perspective: Cautionary Comments

In essence, across the board the SEAD Suggested Actions are action plans for overcoming the institutional and social reality of two perceived separate cultures. Yet, it is striking how the same issues that all these SEAD papers address were issues of special concern to the NSF 50 years ago. And while there is evidence of significant change, the fundamental issues and challenge appear to remain the same. With that continuing dilemma in mind, this meta-analysis is a meta-critique in that it critically comments upon the root assumptions behind almost all these papers. There are however notable exceptions, such as the papers by Root-Bernstein and Fishwick and others I have highlighted here as exemplary.

As Root-Bernstein's important paper and his larger work underlying it demonstrate conclusively, the reality is that the more successful a scientist is, the more likely he or she is to have a life-time engagement with the arts in terms of a persistent disciplined practice. It is the attention to discipline, detail, and aesthetics that unites and feeds both domains. This reality of the generative importance of artistic experience in many scientists' lives is so obvious and so well known (especially to many an NSF scientist) as to raise again a major red flag over too many of the papers. They assume that the "two cultures" perception of reality is an axiomatic truth and an obstacle for SEAD to overcome.

Major problems exist regarding disciplinary barriers in the educational system. All the Suggested Actions work towards ameliorating these problems. They are unrealistic (being visionary) for large-scale pedagogical and curricular transformation at the school, district, state, and national

levels. However, if funded as smaller and subsequently scalable germinal initiatives, they could well take root and grow over time by force of productivity and inspiration in the same manner as the scientist/educator Froebel achieved with the kindergarten concept. In that, this meta-analysis considers the specific projects and programs proposed at the following innovation centers—namely at UTD, UCA/CSM, DXART, SARC and the BHF—to be exemplary. They have clearly defined, relatively limited and wholly achievable objectives. On the other hand, the BHF and UCA/CSM projects perfectly exemplify the established challenge for art-sci projects in the United Kingdom, a particular subject of concern addressed below. The issue is simple: can art advance basic science?

These papers return us to C. P Snow's highly inaccurate and unnecessarily divisive notion of "two cultures". Snow's polemic, though well intended, was based on grossly simplified stereotypes and contexts and fostered a radical misunderstanding of science by non-scientists. The unfortunate situation we face is that the public, and many academics and artists are convinced of its truth value. Moreover there is another problem that while scientists if sufficiently intellectually and artistically oriented can easily engage art and social science with the requisite effort, it is very difficult for an artist or nonscientist to be able to seriously engage science. Any collaborative proposals have to keep this problem foremost in mind.

In effect, through these White Papers the SEAD network is gathering into the same context participants with wholly different notions of what constitutes science and scientific data, as well as who has the right to make that determination. This is extremely dangerous for scientists and should be very carefully addressed. At the same time it is perfectly true that the rigors of science, the peer review system, and the professional system as it exists radically constrains more creative work above and beyond "normal" science.[6] Going beyond such truisms and generalities is difficult. It is a challenge that requires nuance and complexity. Fortunately, a good many of these papers do so precisely because they are proposed by scientists.

Another reason why it perhaps should be explicitly addressed, is that C. P. Snow's reactionary and simplistic idea un-reflexively informs the fundamental logic of far too many of these papers, whether it is or is not a reality in most people's minds (and in lives). The fact that Snow's divide has established such a powerful presence even in the imagination of those social scientists who should have known better, had they given proper attention to the original paper and the critique of it at Cambridge at that time, is extraordinary.[7] Taking Richard Dawkins's notion of the

6 As for the problem of the politicization of NSF funding, see Megan Tracey, "NSF, Peer Review and Debates over Congressional Oversight", *Anthropology News*, July/August 2013, 17.

7 See for instance, James Elkins, 2008.

"meme" as an example of the affective life and evolution of a concept (1976), we see that the cartoon-like perception of science and scientists as wholly Other, as separate from the world, not only continues as a dominant idea in popular culture but potentially sets the base for SEAD science programs if not directly addressed.

It is important then to note that this idea is becoming increasingly pervasive. It also holds true in the minds of those scientists whose ever-narrowing training and experience may have led them into sterile territory in which the arts and humanities, the philosophy and history of science are topics that are considered to be of no practical or theoretical consequence to their work. These SEAD White Papers should address this. It should be taken as axiomatic in the science community, and in the public at large, that a scientist has a vastly higher chance of making major contributions to the advancement of science and becoming a Nobel laureate if she or he is a practicing artist, particularly a musician (Root-Bernstein et. al. 2008). Briefly, the fact that involvement in an artistic endeavor increases the entire tenor of a person's life in terms of the quality of their work and their intellectual life—and, for those inclined, their spiritual development—is well known across cultures and throughout history. It completely negates Snow's thesis.

The Science/Culture Schism

The notion of a cultural "schism" was so pronounced in the late 1950s that the National Academy of the Arts and Sciences was given a grant by the NSF in 1963 to investigate the relationship between the sciences and the arts as well as between the social sciences and humanities. The goal was to examine the connections and relations between these fields and to reflect upon their methodological differences and how and if they were affecting each other. Anthropologists and art historians figured prominently in that project, and The National Academy duly published the results in a special issue of Daedalus titled "Science and Culture" published in 1965. That study is of extraordinary relevance to SEAD today because the editors' intent was to investigate just how accurate "the constant repetition of the idea of a 'schism'" was at that time.

The anthropological notion of schismogenesis effectively describes this cultural process of specialization and separation far better than Snow's popular simplification (Bateson 1935). As Bateson defined it, schismogenesis is "a process of differentiation in the norms of individual behavior resulting from cumulative interaction between individuals" or in our case professional groups (Bateson 1958, 175). In essence, I am proposing here that American anthropology offers

the most appropriate assessment ground for taking into account the long history of interdisciplinary research and its practical application.

The popular idea that the sciences and the non-sciences were working in isolation and that those in one domain did not understand what was going on in the others is clearly a tenacious one. Unfortunately, almost all of the SEAD papers uncritically recapitulate this notion of "two cultures"—the scientists versus the rest. This is why I emphasize Root-Bernstein's work as foundational. It effectively bridges the divide without reducing the irreducible disciplinary differences. In any event, this deeply flawed axiom runs through the papers virtually as a matter of faith. Thus C. P. Snow's foundational lecture at Cambridge has clearly directly or indirectly informed all these papers, whether or not the authors have actually read Snow. Certainly SEAD researchers seem wholly unaware of the fact that the idea was thoroughly pilloried at the time, with such devastating critique that it poses a serious problem to the intellectual integrity of these collected papers. Across the board the SEAD community is un-reflexively recapitulating Snow's dualism.

This deserves attention as there are fundamental differences between science and non-science which require clarity for any such debate over the proposed value of SEAD for the NSF mandate. The problem scientists face in collaborating with nonscientists, particularly artists and the philosophically inclined, is not only a matter of method. Falsifiability and evidence matter. The epistemological reality of measurable observations regardless of principles of uncertainty and relativity matters. It allows us to distinguish between fact and fraud (see Goodstein 2010).

The dangers for SEAD and the potential consequences are nowhere more symptomatic than in the Wellcome Report on the decade-long SciArt project in Britain that lasted from 1996-2006. The report concluded that the collaboration between artists and scientists had not delivered on the initial justification that such collaboration would lead to scientific innovation. The same question must surely be considered for those White Papers that would justify their Suggested Actions on these grounds as it seems an established fact that interdisciplinary initiatives with the arts have not directly contributed to the advancement of basic science itself.

In that context, one must ask: Are the SEAD projects collected here be so different from the UK SciArt project that significant innovation in science and industry and beyond might result? I would argue that the answer is resoundingly yes. SEAD is so much more than art-sci as it was in the UK SciArt project. Many of the practitioners have clearly identifiable material and pedagogical goals in mind. In the final analysis, whether one conceptualizes these SEAD White Papers projects as interdisciplinary, multidisciplinary, trans- or paradisciplinary, the proven

value of such collaborations for science more broadly are not insignificant. They demonstrably enable enhanced public engagement, improve science education and add value in expanding the reach and relevance of each discipline to another, as well as internally across specializations within disciplines.

To return then to the 1965 NSF Report, consider Edmund Leach's comment: "As the category distinction scientist/non-scientist becomes more sharply defined, there is feedback into cultural behavior; the scientist takes pride in the exclusive incomprehensibility of his activities, so that the group to which he belongs takes on for him many of the attributes of a religious sect" (Leach 1965, 33). Showing how "we groups" exist in every social system, he takes the cult analogy further by commenting on specialization being a function of dynamic sect formation over points of dogma in which sectarian groups are innately conservative and transmit basic principles of belief over time through actively indoctrinating recruits. Individuals use different vocabularies depending on their context and group membership, and in the case of scientists, "each small group of technical experts feels impelled to create its own special jargon language which makes its esoteric activities quite unintelligible to everyone else." (32).

Renee Dubos states that the "two cultures" may be an illusion, but in practice science is still regarded in our communities as a kind of foreign God, powerful and useful yes, but so mysterious that it is feared rather than known and loved" (1965, 228). Dubos adds that the root cause of the hostility to science at that time among the youth and the fall in the number of students entering the sciences was a matter of anxiety (229). Dubos noted that though there had been much debate over a lack of communication between the sciences and humanities, the "disjunction is not as critical as is often suggested" and can be addressed through a common language based in the senses or images (238). He calls on specialists to return to basics in order to communicate with society at large. We are then back to Root-Bernstein and the guiding principle underlying all these SEAD White Papers, to bridge the divides without compromising the integrity and advancement of each discipline.

The SEAD papers project a desire to engage science so as to increase communication about science. Yet I see little or no evidence that any of the SEAD papers here can or do demonstrate scientific advances except perhaps for Kuhn's case. What they all do is show how strong the desire is by so many scientists, engineers, artists, and others to collaborate across their respective disciplinary specializations. Whether it be in computer gaming, nanotechnology, music, biology, neurochemistry, or dance, they each exhibit a turn to the senses and an overwhelming commitment to education that ameliorates the antipathy to science. Collectively then, all of the

Suggested Actions, at least for these 15 papers I discuss, have a basic purpose of enhancing science education and its application through collaborative cross-disciplinary activity.

Conclusion: Cautionary Observations from the UK SciArt Project

A cautionary note might be useful in line with the above observations and comments. In Europe and the United Kingdom, sci-art projects and SEAD-type initiatives are far ahead of those in the United States. In the best-known case, the Wellcome Project in the United Kingdom, the cautionary advice for proposing any such projects in the future from the perspective of science is very clear. [8]

The stated purpose of the Wellcome Project was to advance innovation and creativity in science through art. The evidence presented in the report does not support these rhetorical claims. One critical participant interviewed noted that it was dangerous to assert that the artists had encouraged the scientists to be significantly more creative and specifically stated that these claims were merely rhetorical (Glinkowski and Bamford, 2009). It is not so much that it is dangerous for science, being a known fallacy in the UK SciArt Project. It is dangerous for those who would argue that this should be the reason for funding art-science collaborations and by extension, SEAD. However, it is most certainly the case that the arts can enhance science education and communication about science to society - never mind indirectly inspire scientific minds.

Ultimately, the Wellcome Report shows how pernicious and ill-informed is the two cultures" stereotype. Is the world really divided into scientists and the non-scientists? It is not that there is no truth in the difference between the way scientists work and reason or in the professional and institutional divide; the problem lies in the idea that scientists are not creative, do not take risks, cannot effectively communicate their results, and do not have any interest in the arts. Consider one artist interviewed who first asks: "What could be more 'other' than a group of scientists at work?" Later the artist modified this saying, "I realized that scientists could actually be excellent communications, and very approachable . . . . wonderful collaborators and spurrers-on of ideas." (Glinkowski and Bamford 2009, 65). Other comments in the report are even more telling: "They (scientists) are human and they don't want to spend their life churning out papers, they want to find some meaning in what they are doing" (67). Or consider this: "Normally, our sense of scientists is that they are very dour people." Scientists are seen by such artists it seems virtually as aliens. They are considered to be unhappy, repressed, and unfulfilled. Yet as one artist learned along the way, "Scientists are conflicted, ambivalent; they describe how they do their science in

8 For the Wellcome Trust's own analysis of the project, see Glinkowski and Bamford (2009).

a strict way, but when you probe more they begin to soften around the edges, and you find that art is being used by the scientists to help them understand some of their ambivalences about their professional culture."

Overcoming the above stereotypes, and the idea that scientists might be any more ambivalent than anyone else about their lives and work, the Wellcome ArtSci project did note that a very few UK scientists were profoundly positively affected by their collaborations. Their science itself was not affected, but their sense of the importance of bringing their work to the public and in some cases an awakening need to explore their creative interests. This is all well and good but these scientists were few and far between and we do not know anything about those who did not respond and why. The fundamental problem is that the said evidence of the usefulness for science is grossly inflated in the report. The only demonstrated instance of innovation was in a pathology laboratory in which the presence of the artist resulted in the use of more colorful stains. Yet the report builds upon this as: "SciArt projects were felt to have evidenced a range of type of innovations across the arts and sciences and at a technical as well as at a conceptual level." The claim was modified, however, as such: "It didn't affect the science per se, but it affected the way that it was delivered." (Glinkowski and Bamford 2009, 57).

I emphasize this rather harsh judgment as a precaution on two levels. First none of the SEAD White Papers, except in some sense for Kuhn's work on hyperbolic planes, have provided evidence that the collaborations have made or can make proven contributions to science. It is all in the realm of rhetoric and thus a very dangerous proposition considering the demonstrated failure of art to directly contribute to science. As problematic, almost to a paper they recapitulate the "two cultures" axiom as an article of faith. Leading on from that axiom, they almost uniformly propose that overcoming the "two cultures" divide is the essential practical function of the goals to be achieved through the Suggested Actions.

In the humanities and social sciences, efforts to overcome the crisis of scriptural representation have been building up steam since the post-modern era and the turn to the sensory dimension in the 1980's. At this point we have emerging fields such as sound studies, sonic anthropology, acoustemology, these being outcomes of the movement to embodiment in the social sciences. In fact, research on typical SEAD questions has been going on in anthropology and allied disciplines, in art, neuroscience, dance, musicology and ethnomusicology since the 1960s.[9] In order to ameliorate these shortcomings, as to what is new or not, and what might be achieved or has already been achieved, never mind the "two cultures" conundrum, SEAD might need to more effectively engage such large academic audiences (including engineering and architecture) in

9 See *Science and Culture*, *Daedalus* (Journal of the American Academy of Arts and Sciences), Winter 1965.

more targeted ways than this open initial call which has resulted in this emergent network as it currently exists.

My concern as someone with both a scientific training and research experience is that basic principles of science should not be compromised by collaborations with non-scientists. The non-scientists too often do not sufficiently appreciate the nature of data and the fundamental importance of falsifiability. This is where the danger lies. For myself, even though I am a social scientist trained during the post-modern art era, when entering into a discussion such as this as it concerns potential funding, I maintain that one principle has to be established a priori. If one claims that one's project should be funded because it is going to advance basic science, one had better be able to prove it. With all that in mind, and returning to the first part of this meta-analysis on subsets of the White Papers, if one examines the Suggested Actions in those and all the papers what could we conclude on the basis of general principles applicable to all?

Perhaps the conclusions could be as follows:

1. Cross-disciplinary research and teaching is important because it allows scientists and specialists working in one field or sub-field to cross-fertilize methods and techniques and information with others;

2. The arts undeniably help science and engineering for the purpose of education and public communication of scientific knowledge;

3. All are enriched by collaboration in different and complex ways;

4. We should not reduce the entire complex equation to whether it advances science or not because the gains are demonstrably exciting across the disciplines as can be seen in all of these White Papers. They are not only exciting pedagogically. As Fishwick's paper proposes, they may have potentially significant outcomes for the understanding of and consequences for embodied learning, and they have demonstrated capacity for product development and design.

The Suggested Actions in these White Papers should perhaps be approached with caution in terms of the fact that the failure of the UK SciArt project to deliver on its initial logic has left a "residual skepticism" (Glinkowski and Bamford 2009, 72). And yet SciArt has certainly taken off in Europe and the US and the UK scientists interviewed, though it was only a small sample, were "positive about the value of SciArt and its benefit" (71). Clarifying this distinction, one respondent noted, "I don't think that artists really challenge the scientists scientifically, but I

think they challenge them about the purpose of their science and raise questions about different ways there might be of looking at their science and presenting the outcomes" (70). Therein, the collaborative experience allowed the scientists to take a more historical perspective on their work and to better appreciate "the heuristic limits that constrained their habits and practices of thinking." (70). For these reasons and more, STEAM, SEAD and THEMAS projects are fundamentally exciting. Nowhere does this have more potential than in applied projects that offer specific material goals linked to technology and education.

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