Pathways of Interdisciplinary Cognition

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Abstract:

In this paper I explore the cognitive processes in which the mind is engaged at the juncture of several disciplines. These processes include overcoming monodisciplinarity, attaining provisional integration, and questioning the integration as necessarily partial. These processes are captured here with the help of the empirical data collected through interviews with students and faculty involved in exemplary interdisciplinary programs at the University of Pennsylvania (Center for Bioethics), Swarthmore College (Interpretation Theory), and San Francisco State University (NEXA Program). I hypothesize that interdisciplinary thinking reflects at a higher level the fundamental tendency of our cognition to creatively blend ideas, use metaphor, and think dialogically. The description of interdisciplinary cognitive processes is informed conceptually by Bakhtin’s insights into dialogic thinking as well as recent writings by cognitive scientists. The study urges an opening of the conversation among designers of interdisciplinary programs and curricula about the ways by which integrative thinking can be achieved and supported.

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Introduction
Interdisciplinarity is for unquiet minds. Putting together a sociological survey and a piece of legislation, a poem and a theory of evolution, requires risky leaps of faith that defy cognitive stability. The epiphany of things coming seamlessly together in one perfect click is far from the reality of daily efforts to make many disciplinary ends meet. What are the cognitive operations in which an interdisciplinary mind engages on the path towards the integration of different disciplinary ideas? What is the cognitive challenge of interdisciplinary work? These are questions that guide this inquiry.

I see interdisciplinary cognition as involved in three core activities: activities aimed at overcoming monodisciplinarity; efforts to achieve a provisional synthesis of ideas; and the critical probing and questioning of such a synthesis. The proposed parsing of an interdisciplinary process questions a linear developmental sequence of events. I want to show that the interdisciplinary process is not internally homogeneous, but involves a series of distinct cognitive steps that get represented in different forms. I also suggest that perhaps interdisciplinary thought is a reflection of the fundamental tendency of human cognition for “dialogic” thinking (Bakhtin (1981) and blending of multiple voices and perspectives.

Three types of activities of an interdisciplinary mind – overcoming monodisciplinarity, provisional integration, and sustaining disciplinary dialogue – are presented with the help of an extended opening vignette. In this vignette I show how a physics professor’s understanding of the concept of color evolved as a result of interdisciplinary thinking and collaboration with a philosopher. Each section of the paper – Overcoming Monodisciplinarity; Provisional Integration; and Questioning Integration - refers to a portion of the vignette representing a particular cognitive process described in that section and uses other examples from interviews to describe and empirically ground that process.

Research Study and Data Collection

The study of interdisciplinary cognition is part of a larger 3-year project carried out by the Harvard Interdisciplinary Study. Its goal is to examine exemplary practices of interdisciplinary work at the collegiate, pre-collegiate, and professional levels. The present inquiry into interdisciplinary cognition relies primarily on data in our collegiate sample - specifically on the interviews with faculty and students at Swarthmore College (Interpretation Theory), the University of Pennsylvania (Center for Bioethics), and San-Francisco State University (NEXA Program). On top of demonstrating their sustained commitment to interdisciplinary work in their program design and mission, these programs also in different ways promoted critical reflection on the goals and impacts of the program among participants. One way or another, these programs posed difficult questions that get at the heart of the participants’ identity: What does it mean to be a scientist? How is philosophical discourse valuable? What kinds of questions is history equipped to answer that science cannot? In different ways, all three programs attempted to construct a bridge connecting the human and the natural sciences, which is one of the most challenging projects in interdisciplinary work. The epistemological difficulty of this undertaking gave both students and instructors a reflective pause, which is exactly the moment this study tries to capture. Many interviews from these sites supply rich descriptions of figuring out how to
make the next cognitive move towards an integration of the humanistic and scientific positions, thus providing a rich and consistent problem space for the analysis.

All three programs have been to some extent designed to bridge the sciences and the humanities. The central mission of the NEXA Program from inception has been to promote dialogue between the “two cultures” (Snow, 1959) of the sciences and the humanities. With a few exceptions, it is implemented through a series of courses team-taught by a scientist and a humanist. Interpretation Theory’s capstone courses at Swarthmore College are also team taught by representatives of the two disciplines (not always science and the humanities), and have the general goal of considering different interpretive traditions inherent in different disciplines. Courses at the Center for Bioethics at University of Pennsylvania are typically taught by one instructor (a sociologist or a philosopher), but the subject matter of human cloning, organ transplantation, and genetic engineering makes it imperative to bring the social and the scientific aspects of biological research together as well.

The fact that all of these programs are based on either explicit or implicit collaboration among scholars from different fields makes the individual cognitive moves more transparent and accessible for study. The most useful portions of the data have been descriptions of an intensive collaboration with a colleague on the interdisciplinary course design, in which bridges were first attempted, first crumbled, tried again, were tested and reinforced in front of the students, and the new way of thinking and teaching of the subject emerged. It was also helpful that collaborations in most cases lasted several months to several years, so that thinking about them had a chance to mature and gain perspective. In some cases, professors’ interdisciplinary efforts were commented on and triangulated by students who were on the receiving end of the collaborative instruction.

Data collection in all sites took place mainly during a research visit by Harvard researchers in the fall of 2002. Research instruments for the study were interviews with faculty and students, classroom observations, and faculty publications. Interviews were semi-structured, and guided by open-ended questions about the challenges and impacts of the integrative curriculum, interdisciplinary pedagogy employed in the classroom, and the nature of faculty collaboration. Open structure of the interviews allowed for a deep reflection on the complexity of the cognitive processes and provided in some cases a thick description of the cognitive moves that participants made.

Theoretical Foundations

My definition of interdisciplinary work is rooted in the conceptualization by Boix Mansilla, Miller, & Gardner (2000), Gardner (1999, 2000), Klein (1990), and Newell (1998). This particular body of scholarship proposes that what constitutes interdisciplinary work is not a simple aggregation of disciplines in a classroom or in research, but rather active and transformative interaction of disciplines. Boix Mansilla et al. (2000) define interdisciplinary efforts as "geared towards deep forms of understanding” that can “make use of both [disciplinary and interdisciplinary] perspectives" in order to “illuminate issues that cannot be adequately tested through one discipline.” Thus, solid, not cursory, knowledge of the
integrated disciplines is the prerequisite for such “deep forms” of interdisciplinary understanding. Two elements are crucial for the interdisciplinary efforts in general and for the understanding of interdisciplinary cognition in particular: 1) deep disciplinary knowledge is foundational for interdisciplinary work; and 2) disciplinary knowledge undergoes substantive transformation and exchange in the course of interdisciplinary efforts.

In both of these aspects, the interdisciplinary efforts are very similar to what Mikhail Bakhtin (1981) describes as the workings of “a dialogic” mind, which also combines respect to the individuality of voices with their active molding in the course of a dialogue. A dialogic mind, in his view, is the mind that attains “close exchange” between several “unmerged consciousnesses” (Bakhtin, 1981). Bakhtin, however, does not concern himself with interdisciplinary cognition, and “voices” in dialogue, or “words” colliding with each other in the literary text (the source of Bakhtin’s theory), are not disciplines with their epistemological depth and sophisticated methodological instrumentation. Integration of disciplinary viewpoints requires not just mental agility, but mental preparation, which takes years of study.

Nevertheless, I find this parallel between Bakhtinian voices, representing different worldviews, and disciplines in the interdisciplinary dialogue insightful in crystallizing the underlying cognitive foundation for interdisciplinary transfers and mergers. It provides an essential framework for describing the core processes (monological-dialogical, “monoglossia”- “heteroglossia”), which may underlie the interdisciplinary exchanges.

It is in this broad sense (with reference to general cognition) that I borrow elements and terminology (“dialogue,” “dialogic,” “dialogicity”) from Bakhtin’s universal framework. The distinction he draws between the monological and dialogical thinking, his description of the tenuous balance in which voices find themselves in a dialogue, helps me chart the path of the interdisciplinary mind from monodisciplinary positions to a provisional synthesis that is constantly in the process of becoming. Using Bakhtin’s insight, I see interdisciplinary work as the path of unfolding dialogicity, a growing ability of the mind to overcome monologic tendencies, and strive to sustain several ideas (or disciplinary inputs) in a dialectic, and non-relativistic way. Overcoming monodisciplinarity is thus similar to overcoming “monologic thinking”, or “achieving heteroglossia,” in Bakhtin’s terminology, and his “dialogue” is parallel to the process of interdisciplinary integration, which involves finding a balance among several perspectives without abandoning one’s core disciplinary beliefs. I use Bakhtin’s insight about complex and dialogical nature of cognition with an awareness that its specific application to interdisciplinary cognition may take it further and in a new direction. Bakhtin is not specific, for example, about the different paths that can be taken towards integration and harmonization. He often describes monologic and dialogic cognition as distributed in historic time and linked to the evolution of European languages from being “closed and deaf to each other” in ancient Greece and Rome, to their active and irreversible mixing in Renaissance Europe. In the transition from mythological absolutes and hierarchies, the cognition of modern humans, in Bakhtin’s view, becomes incomplete and unstable, and ultimately dialogic.
The existing literature on interdisciplinarity has so far mostly explored the issue of interdisciplinary cognition in a conceptual way, and produced lists of thinking dispositions of individual interdisciplinary thinkers, such as “flexibility, patience, resilience, sensitivity to others, risk-taking,” (Klein, 1990). Summarizing her analysis of such studies, Klein (1990) observes that the empirical studies and thick descriptions of “the complex actuality of doing interdisciplinary work” are generally under-represented. An exception is William Newell’s study (Klein & Doty, 1993) of interdisciplinary pedagogy, which attempts to describe the interdisciplinary process itself, leading from “an appreciation for perspectives other than one’s own; an ability to evaluate the testimony of experts” to “tolerance of ambiguity; increased sensitivity to ethical issues,” and other changes. While very useful for this study, it still is not rooted in the empirical study of interdisciplinary thinkers. The present investigation is a step in that direction. Its findings are based on participant observations, in-depth interviews, review of curriculum materials and student work.

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**Opening vignette: Color as a psychophysical unity**

The following vignette is gleaned from the interview with John Burke, Physics and Astronomy Professor in the interdisciplinary NEXA Program at San Francisco State University. In it, Professor Burke describes the evolution in his thinking about color, which occurred as a result of integrating physics and philosophy perspectives in the context of co-teaching the *Reality and the New Physics* course with the philosophy professor Don Province:

*My five-year experience of teaching *Reality and the New Physics* with Don is an example of having the two minds approach the same subject from different directions. It was a marvelous experience for me of finding out how good philosophers are at pinning weak arguments. Being a physicist, I’ve got lots of things in my head that are obvious, except of course they aren’t. Don and I would get to this question of reality, which philosophers basically don’t want to talk about, the reality of the universe. So I would come on and just without thinking proceed as if something were obvious. What is mass? Isn’t energy the real stuff? Don was picking up on how does the physicist actually look at these things and he was quite properly flummoxed by the inconsistency of these terms’ usage. The most cogent example in the class was “mass.” Newtonian "mass” is precisely what gets measured if you ask a butcher to "weigh" a cut of meat. When Einstein first wrote \( E=mc^2 \), he was seeing the explanation for the enormous energies of particles that result from radioactive decay, thus resolving a major mystery of the time. Thus, we were treated to "mass" as dependent on the speed of a particle, and a divorce of the "mass" concept from its Newtonian roots. Of course, photons of light possess energy but are "massless" How can that be? So, we, physicists, use terms like “mass” and “color,” for example, in a very sloppy way. We talk about red shifts and blue shifts, red and blue as if color were identical with the wavelength of light. You can probably see why Don was flummoxed, and why he pursued this point relentlessly.*
We ended up after five years telling the class that "real stuff is energy-momentum four vector."

It took Don three years to get me to see the sense of the conclusion [of the book on color] that color is an illusion, albeit a well-founded illusion. And then after he did, he said, “Yeah, but I don’t accept that!” Had another two years of that. After those two years we finally agreed that color is a binary relation between the world and the nervous system wiring of the species Homo-Sapiens. Why do philosophers care about color? And the historical answer is, it seems to be a given truth about the world.

We found out pretty quickly that philosophy has really ceased in large measure to be informed by the physical sciences. So, Don was learning the physics, and I was realizing that a direct empirical correlation between color and wavelength turns out to be a falsehood about the world. I was exposed to these experiments that show instances of the two wildly different spectra of light producing precisely the same color experience. That basically smashes the idea that color is directly connected to the physical attributes of what is coming in. It was to be viewed as some sort of cooperative things between brains and the world. We went for the ferment. The color perception is a combination of the light that enters the eye and what the brain does with it. We found at the end of the five years we could bring the students a lot further along toward the goals of the class, because we had come further along.

In order to hope for a melding of the ways of thinking, you just sort of have to put it out a bit explicitly what constitutes the way a philosopher approaches a problem? What constitutes the way a physicist approaches a problem? Then, humanists and scientists need to ask together: What is color? What’s real stuff? What is time? What is consciousness? Consciousness isn’t physics, it’s not philosophy, but it’s something we can both say what we think about it. So you actually see the two methods, the two approaches coming together and fermenting, neither one being definitive.

This vignette captures how a scientist’s view on color and light flows from a monodisciplinary (physics-based) understanding via a sense of dissatisfaction with it, to the admission of value of the two distinct pathways of inquiry into the nature of light, and eventually to attempting a provisional merger of these two perspectives.

In a short spell of time, Burke and Province traveled a long epistemological distance that took many centuries of scientific research to span. In his book Catching the Light, Arthur Zajonc (1993) captures the history of the crossing of scientific and the philosophical paths in inquiry into the nature of light. This tenuous crossing of epistemologies eventually lead to a current view that light can only be accounted for as the interface of the mental and the physical phenomena, and that neither the science nor perceptual experiences alone can explain the nature of it. Zajonc (1993) ends his thorough investigation in a similar vein as Burke finishes his story of collaborative inquiry into color with Don Province, claiming that integration of physical and psychological perspectives is the only way to go, even though it does not bring to a full reconciliation of views or obliteration of disciplinary differences. Zajonc writes,
…light … has been treated scientifically by physicists, symbolically by religious thinkers, and practically by artists and technicians. Each gives voice to a part of our experience of light. When heard together, all speak of one thing whose nature and meaning has been the object of human attention for millennia. During the last three centuries, the artistic and religious dimensions of light have been kept severely apart from its scientific study… the time has come to welcome them back, and to craft a fuller image of light than any one discipline can offer.

The goal of this paper is to suggest a mental process, by which one comes to such a realization in the course of interdisciplinary work.

I. Overcoming Monodisciplinarity

The road to dialogical thinking is paved with realizations that one disciplinary frame of reference is simply not enough. At some point of thinking about the physics of light, John Burke saw that the physics experiments were simply inadequate, because of “two wildly different spectra of light that produce precisely the same color experience.” Such realizations take different forms: the subject may develop an appreciative investigative interest in another discipline, he or she may express tolerance to the alternative methods of inquiry, or he or she might carefully estimate the degree of usefulness of one disciplinary tool versus another. In John Burke’s example, his first step was to realize “how good philosophers are at pinning weak arguments” and how inadequate the physicists’ paradigm is to account for the phenomenon of color. Through sensitizing himself to Don Province’s philosophical arguments and admission that his own disciplinary periscope did not afford a full view of the phenomenon of color, he was able to reach some provisional syntheses of ideas on light and color.

The move to overcome one’s monodisciplinary orientation and open up to alternative disciplinary perspectives takes three basic steps. These steps include: 1) appreciation of alternative disciplinary views; 2) identifying strengths and weaknesses inherent in one’s disciplinary position; and 3) making a decision to accept or reject a given disciplinary tool or method as useful or relevant.

1) Appreciating alternative disciplinary views

In his NEXA seminar, Burke appreciated having “the two minds approach the same subject from different directions,” and talks about how much he learned about structuring an argument and questioning one’s disciplinary assumptions from his philosopher colleague. This appreciative stance helped Burke to see the point and the value of the philosophical perspective on the nature of light and color and integrate it with his physics perspective. Zajonc (1993) describes how the same appreciative and attentive stance to philosophical and psychological arguments naturally evolved in the history of scientific exploration into the nature of light waves. It became increasingly clear to people like Faraday, Planck, and Einstein that “our every perception is literally colored by context, prior experience, indeed, by every aspect of our inner world. These are all active in producing color” (Zajonc, 1993).
John Burke came to a similar realization in the context of a close interdisciplinary encounter.

Burke’s colleague at NEXA, geology professor Ray Pestrong, showed the same intellectual appreciation of what could be described as an almost opposite belief system, student’s faith-based view on the origins of the Earth. Without sacrificing his own scientific convictions, he was able to recognize and give value to the student’s mythological or religious viewpoint. In his own words, he stopped “to consider what that must feel like to know, to feel at such a profound level that no data could change my view of the world, and I’m so at peace with that view.” By granting the student room to consider both arguments, Pestrong gave himself room to realize that perhaps there is a different kind of value inherent in mythological or religious explanation. Scientist John Maynard Smith, writing in *Natural History* (1984), shares his conviction that myths do in fact inform scientific thinking and are indispensable to it both in the history of civilization and in current scientific research. “We need both myths and scientific theories… that “values do not derive from science but are necessary for the practice of science… Scientific theories tell us what is possible, myths tell us what is desirable. Both are needed to guide proper action.” Pestrong appreciates myth as another valuable interpretive tradition, informing science of its deeper assumptions, pointing to its foundational values, and reminding it of its blindspots. He feels uncomfortable when his teaching partners in the humanities “capitulate” to him in the class, claiming that he, the scientist, holds the true and only answer. In Pestrong’s view, such “capitulation” displays a dangerous monologic or monodisciplinary tendency.

Ray Pestrong, Scott Gilbert (a biology professor at Swarthmore College) and many other professors in our sample see it as part of their teaching mission in interdisciplinary courses to convey to the students that the world can be told in many disciplinary “stories.” According to Gilbert, for example, the body may be defined by an immunologist, and also by a politician, each telling their own important story. Gilbert goes even further in his appreciation of myth, when he makes myth an explicit part of the story of biological theory and points out to students that “the sperm [is] following essentially the pathway of Odysseus and Aeneus.” Making a connection between Greek mythology and biology, between the human genome project and the oracle at Delphi Gilbert is actively soliciting the help of myth to teach science.

Becoming respectful and receptive of another disciplinary account or “story” also involves, in the testimonies of many participants, overcoming of disciplinary chauvinism - the “smugness” typical of some people “who are trained in science” (Pestrong), and other forms of disciplinary close-mindedness. Michael Gregory of NEXA points out that a joint interdisciplinary inquiry, in which NEXA faculty participate, puts “tolerance for cognitive dissonance” at a premium.

Charitable regard for alternative views and a broad curiosity about other positions are general thinking dispositions not specific to interdisciplinary work alone. There are many ways to be broad and open-minded. One can be broad in a dilettantish way, reading widely, accumulating a vast but thin knowledge database. One can be broad in a non-adventurous way, putting a predictable collection of intellectual resources to a predictable use.
Interdisciplinary breadth and appreciativeness, I argue, are of a special nature. It involves intellectual generosity, but also a critical judgment. Burke and Province, Pestrong and Gilbert have carefully considered alternative disciplinary arguments, extended their respect for their contributions, and, in the end, made a choice among the contending positions.

2) Identifying strengths and weaknesses in disciplinary perspectives

Knowledge can be as limiting as ignorance when it comes to interdisciplinary work. Working side by side with a philosopher, John Burke began to see the filters that his disciplinary assumptions as a physicist impose on his approach to the understanding of color. A lot of broad concepts such as “mass,” “energy” and “material reality” have never been questioned by him, because they seemed “obvious” to him as a physicist. It took philosopher Don Province to point out to him how “sloppy” and “grubby-hands-on-whatever-works” his answers to these fundamental questions were.

Zajonc (1993) describes a similar realization achieved by scientists before him, when the quantum theorists failed to account for the nature of light and color: “Quantum theory can deepen the mystery [of light and color], but it cannot relieve it. Light is not substantial, at least not in the form of a massive particle a la Newton, nor even in the form of undulations through a material medium a la Euler or Maxwell. … The nature of light cannot be reduced to matter or its motions…” Working side by side with the humanities faculty, Burke and Pestrong come to realize that physics’ answers to the question of color, mass and energy are not powerful enough. Philosophy or psychology, on the other hand, have other powers to tackle such questions that physics and geology don’t have, but their tools, too, can only take them so far in their investigation.

Overcoming monodisciplinarity involves more than just an appreciation of different disciplinary inputs and an acceptance of the contributions from different interpretive traditions. At some point, an interdisciplinary thinker starts to search actively for the missing disciplinary tools to address the question at hand. The problems with both the mythological, the psychological and the scientific perspectives become clearer, and, in response, a plan to compensate for them is drawn. Burke realized that “philosophy has really ceased in large measure to be informed by the physical sciences,” and that physics is weak in its definitions of mass, energy, and reality. Both he and Province had to roll up their sleeves and try to bridge those gaps in knowledge.

On his own, Scott Gilbert exposed the weaknesses and strengths of science and critical theory by bringing them into close contact. He used science “to limit interpretations” with experimental data, while at the same time turning to the humanities to prevent simplification of an issue and to remind science of its social responsibility. Appreciation of the alternative discipline goes hand in hand in his case with the critical review and comparison of different disciplinary toolkits. This process of identification of the potential of different disciplines to contribute to the solution of the problems is another step on the path away from monodisciplinarity towards provisional integration.
3). Accepting or rejecting disciplinary perspectives

Appreciation of different approaches, and analysis of the strengths and weaknesses of different disciplines can very well leave one at a point of relativistic acceptance of all positions and convictions, if the interdisciplinary process were to end there. But it generally did not in this research sample. Interdisciplinary thinkers in this study typically took an extra step to choose which set of arguments and tools they found more convincing. After a long study and appreciative consideration of the scientific data, which pointed to the elusive (at the very least) physical properties of light and color, Don Province came to reject that argument as unsupported by human experience. Color, in his view, does convey “a given truth about the world,” despite the fact that science is unable to quantify it. Burke, on the other hand, refused to buy into the view science “is just another story” about the world, with the same explanatory power as myth or subjective experience.

Burke, Pestrong and Gilbert ended up regarding the mythological “story” or explanation of the world’s origins as valuable, but unequal to science. “The creationist story”, Gilbert asserts, “is not as equal a story as the evolution story. One is supported by a hundred years’ worth of research and data and the other is not. And one is based on certain rules of evidence and the other is not.” For most participants, science is not just another story. While most of the interviewed scientists agreed that Newton is not the last word in physics, it is a weighty word, indeed. “Newton’s story did put men on the moon,” while “many, many stories are unable to produce an automobile,” Burke points out.

The interdisciplinary Interpretation Theory concentration, where Scott Gilbert teaches capstone seminars, historically has been under a strong influence of postmodernist and deconstructionist thought that rejects certainty or any kind of the hierarchy of knowledge. Teaching there, Gilbert finds himself countering relativistic arguments all the time. He draws a clear line between postmodernist assertions that science is no more than a social construction, or “product of the mind,” and his own view of science and society as co-dependent, with science ultimately capable to assert certain limited truths.

Overcoming monodisciplinary thinking takes many mental moves. It involves appreciation and critical evaluation of disciplinary tools, mental flexibility and clear judgment. These activities push the interdisciplinary mind beyond the confines of one disciplinary frame and force it to interface with other alternative disciplinary inputs in a deliberate and critical way.

II. Provisional Integration

Integration of disciplinary ideas is typically seen as the ultimate goal of interdisciplinary work. John Burke describes how he and Don Province “went for the ferment” and eventually came to see color “as some sort of cooperative thing between brains and the world.” They arrived at a view of color as a psychophysical unity, informed both by physics and by individual perception, with neither perspective being “definitive.” While Burke and Province merged ideas from different disciplines, other subjects took a different path in their
integrative efforts by focusing more on extending and complexifying their disciplinary toolkits by incorporating some practices from other disciplines. Both of these pathways towards integration – hybridization and complexification - are described here in more detail. And both of these pathways lead to the integration that represents, on the one hand, a positive moment of creative synthesis, and, on the other hand, - a moment of reflection on the differences among disciplines that are not obliterated in the deep interaction. There is always a sense – at least among participants in this study – that integration is provisional in its nature, open to other disciplinary inputs and in need of refinement.

Bakhtin describes the integration of different voices and worldviews as the point of tenuous yet compelling “dialogue,” in which both the external (other people’s) voices and colliding internal views of the subject or character become cognizant of and informed by each other. “Dialogue” and “polyglot consciousness” are inevitable and omnipresent in our language and culture. “The living utterance… cannot fail to brush up against thousands of living dialogic threads, woven by socio-ideological consciousness around the given object of an utterance; it cannot fail to become an active participant in social dialogue” (Bakhtin, 1981). At the same time, dialogue, in Bakhtin’s view, is not something static or easy to maintain. It involves different kinds of adaptation, active borrowing, and dynamic reconciliation of differing positions: “The word enters a dialogically agitated and tension-filled environment of alien words, value judgments and accents, weaves in and out of complex interrelationships, merges with some, recoils from others, intersects with yet a third group.” In the words of education researcher and Bakhtinian scholar Alexander Sidorkin (1992), dialogue for Bakhtin is achieved not just by “averaging the two ideas,” but rather “it is revealed when one can hear and comprehend both or all voices simultaneously” – “when one’s own voice joins in and creates something similar to a musical chord. In a chord, voices remain different, but they form a different type of music, which is a principle unachievable by a single voice.” (Sidorkin, 1992). Both the idea of our internal tendency for dialogic and multi-voiced thought and the idea that dialogue is continually being crafted provide a powerful parallel to what happens at the interface of disciplines.

Bakhtin’s ideas need to be taken further in order to account for a variety of ways in which interdisciplinary balance or integration are achieved, or for what specifically is being exchanged between disciplines (methods, practices, theories, and not just words or personal views) in the process of new knowledge production or product development. In other words, Bakhtin provides a basic framework that needs to be probed and elaborated with specific interdisciplinary content in mind.

1) Emergence of hybrid understanding

In the case of Burke and Province, getting to the “ferment” in their understanding of color meant reaching a hybrid view of color informed both by the material (physics) and subjective (psychology of perception) perspectives. Hybridization involves the melding of the disciplinary views, in which the positions of the two disciplines become inseparable. Scott Gilbert talks of a similar process of hybridization of his historical (critical theory) and biological perspectives, which produces his view that “science is co-constructed with
society,” being neither the product of social forces, nor being completely independent of them.

Cognitively, hybridization of disciplinary views may manifest itself both as the easing of tensions and differences among distant epistemologies, and as their exaggeration for the sake of finding a better fit. In this interview, John Burke demonstrates both tendencies, which I call here assimilative and contrapuntal. He first describes how he used play one discipline in counterpoint another by “dumbfounding the position A (philosophy) with the position B (physics)” in front of the students. Then, he and Province moved to the harmonization (assimilation) of the two perspectives in their psychophysical conception of color.

In their integrative thinking, some interview participants showed a clear predisposition to either the contrapuntal or the assimilative approach. Scott Gilbert, for example, generally does not seem disposed to exacerbate differences between biology and the humanities. He prefers to go straight “for the ferment,” or melding of views, downplaying disciplinary differences. His colleague at Swarthmore, philosophy professor Rick Eldridge, on the other hand, would like to see more of the contrapuntal encounters among disciplines, at least in educational practice. He sees positive value in clearer demarcation of disciplinary lines, as a productive strategy for achieving complex understanding of phenomena. “I would love to teach interdisciplinary classes that were framed in terms of a fundamental disciplinary debate,” he stresses. “I think the students, as long as they have mastered some home disciplinary paradigms, would benefit immensely from …an all semester long examination of how different disciplinary paradigms engage divergently with common objects of study.”

Interdisciplinary programs explored by the Harvard Interdisciplinary Study showed a general predisposition to either the assimilative or contrapuntal approach to integrating knowledge in their classrooms. This may be linked to their core mission to promote dialogue among members of the “two cultures,” or, by contrast, to prepare students for public debate and taking a stand on divisive issues. The NEXA program at SFSU may be a good example of an assimilative type of program. Most of the faculty and students who were interviewed went “for the ferment” or the “convergence” of disciplinary views. “The point of convergence,” describes the founder of NEXA Michael Gregory,

…is first of all to give an exercise to a scientist and a humanist in getting to know each other in terms of a common investigation. In convergence, there is no new discipline, but the application of two existing disciplines and their protocols upon an object of attention that lies outside and beyond these disciplines as such.

Other interdisciplinary programs, such as the Center for Bioethics at the University of Pennsylvania, bring out the counterpoint in different disciplinary ideas on complex bioethical issues. Although the goal, too, is to ultimately reach a “consensus” and propose a policy solution that integrates voices of many constituents, instruction often takes the form of a public debate or “performative” disagreement among different parties to the issue. Professors build their curriculum around combustible issues, such as a patient’s right to die, human cloning, the discussion of which purposefully polarizes students and pushes them to
take a stand before any kind of a consensus of thinking can occur. In addition to instruction, research done at the Center is also very much conscious of the unique contribution of philosophers and sociologists, and their differing disciplinary inputs. Sociologist Paul Wolpe is keenly aware of what he as a sociologist brings to bioethical debates and how his contribution helps to keep philosophers on their toes:

The philosophers and the theologians see it as their business to make those ethical recommendations. The social scientists do not. So when you're really wearing that sociological hat squarely on your head, your job is to refute or support philosophical or theological points not because you can agree or disagree with them ethically, but because you can support or not support them empirically or culturally. I think the clear contribution of the social scientist is grounding ideas in the actual experience of people. A kind of inductive rather than deductive understanding of ethics. The critique of some philosophical perspective by sociologists is not just a critique based on data, but is also a critique based on what is sometimes disembodied intellectual and logical thought leading to a conclusion, which is entirely disconnected from the lived experience of the people who actually make ethical decisions.

In other words, Wolpe sees it as his role to be a vigilant critic of philosophers’ claims that are not thoroughly grounded in empirical data.

*Assimilative* and *contrapuntal* approaches should be viewed on a continuum, rather than as exclusive of each other. Burke, for example, starts his move towards an integrated understanding of color, by first considering how his and Province’s disciplinary approaches clash, or address different aspects of a phenomenon. Gilbert uses a similar strategy. Before he gets to an integrated view of biology as “the queen of liberal arts,” he exposes how disconnected the different sub-disciplines of biology are:

- Biologists interpret a cell or a plant very differently depending on their training… you take say a heart cell, that’s an appropriate example - and the way a physiologist looks at that cell, the way a developmental biologist looks at that cell, the way a gerontologist looks at that cell, it could be a different cell!

While individual or circumstantial factors might lean towards *assimilation* or *counterpoint*, the mixing of the two approaches goes on in interdisciplinary work continually.

This short outline of hybridization of disciplinary inputs, shows that the interdisciplinary mind at this point goes beyond mere appreciation for other disciplinary perspectives, comparing and contrasting the capacity to address the problem, or even assess their relevance. The crucial and challenging as those steps are, they are only the budding of an interdisciplinary dialogue. The real dialogue begins when the mind attempts to actively fuse those understandings together into some coherent whole. When John Burke and Don Province go beyond finding out from each other how the philosopher and the physicist look at color, and how their respective lenses are deficient, they enter into a realm of interdisciplinary dialogue leading to an understanding of color as a unity of how things interact with light, its physical nature, and “what the mind does with it.” Attaining hybrid understanding, however, is just one way to engage in an interdisciplinary dialogue.
2) Emergence of complex disciplinarity

After their interdisciplinary adventure, Burke and Province did not return unchanged to physics and philosophy. Don Province, in Burke’s account, came to view “reality” in a new and more material light. Burke, following five years of co-teaching an interdisciplinary course called *Reality and The New Physics*, reported that he came to realize the crucial need to be more consistent and precise in speaking about the core tenets of his discipline, such as “energy,” “mass,” “light” and “color.” Burke’s teaching of physics changed “to include a tremendous amount of writing as compared to calculation,” and to demand a lot more clarity of thinking and argumentation than he ever expected of students. He came to see “clarity in the language” as something that is “crucially important to their understanding of what’s happening in physics.” He acquired a new appreciation for the Einsteinian equations as the expression of profound truth about matter. “After about five years I finally decided, OK, I’ve got to say it. Real stuff is energy-momentum four-vector density.” He came to see that hidden in this formula was “the best thing that one has going in physics for the answer to that question [about the nature of reality].” In other words, a philosopher and a physicist did not only forge a hybrid understanding of light and color; they also complexified their respective fields and took them beyond what they thought they were about.

Emergence of a complexified view of the discipline means astretching of the core concepts and theories to respond to the challenge or alternative methodologies offered by another discipline. Complexification is another manifestation of an interdisciplinary dialogue, in which the mind does not try to stake a new ground outside the disciplines or on the borders of disciplines, but rather takes the dialogue into the interior of the field and changes it from within.

Another example of stretching and complexifying the disciplinary views is the work and teaching of Scott Gilbert at Swarthmore. His history background and collaborative teaching in the Interpretation Theory program helped him realize how much biology actually relies on interpretation, and that “there’s no such thing as an uninterpreted cell.” This realization dispelled for him the simplistic view of biology, shared by many biologists, that it, like any science, is all about certainty and objectivity. Biology in the hands of Scott Gilbert becomes a more complex field, involving a lot of “story telling” and metaphorical thinking, as well as hypothesis testing and “getting rid of false interpretations” that the science does. Gilbert does not want his students to leave his class with a narrow view of biology as “mere interpretation,” nor does he want students to see biology as purely factual. He is always challenging the discipline of biology to incorporate both scientific and interpretive traditions.

Complexification can build upon a hybrid understanding (as in the case of Burke and Province), or it can occur independent of it, as a result of a transforming encounter with another field. A case of this in our data revolves around sociologist Robin Wagner-Pacifici, who, after co-teaching an Interpretation Theory course with professor of literature Phil Weinstein, got more deeply “re-attached” to her home field of sociology. But what she got
“re-attached” to was not the same old sociology she used to practice, but a sociology aware of its larger humanistic roots and issues, and a sociology reminded of the importance of the individual in the social fabric. Wagner-Pacifici reported being reconfirmed as a sociologist, because she realized sociology’s larger role in the humanities and social sciences as the revealer of the “social embeddedness” of subjective experiences.

Complexification of disciplinary views may also turn the practitioner of that discipline into a gadfly in his or her own field, who points to the limitations and shortcomings of his field for the sake of enriching it with other disciplinary methodologies. A good case in point among the participants in this study is Swarthmore anthropologist Timothy Burke. Burke found himself disputing some of the presentations at a professional conference regarding the impacts of hypertext and new media, on the grounds that they were not well informed by the knowledge of technology. He had been exposed to these ideas while co-teaching an Interpretation Theory course with computer scientist Bruce Maxwell.

Hybridization of disciplinary views and their complexification are by no means the only ways to engage in an interdisciplinary dialogue. Integration or disciplinary heteroglossia, to use Bakhtin’s term, is the primary goal of interdisciplinary discourse and is reached via different routes. The two paths towards integration discussed here – hybridization and complexification – are not exclusive of each other, nor are they lineally connected in time. They can build on each other, or manifest themselves separately, and only careful longitudinal research can reveal if there is a reliable sequence to the mental events in interdisciplinary efforts. While integration of disciplines is a defining moment of interdisciplinary work, it is by no means the point of closure.

III. Revising Integration

In interdisciplinary endeavors synthesis and integration is never finished business. All forms of hybrid or of complexified knowledge are necessarily partial, often unsatisfying, and open for further questioning. Following Bakhtin (1981), I regard this openness of an integrative idea or dialogue for revision as a positive and fundamental feature of cognition, which ensures that integrative work continues beyond the point of provisional integration. Bakhtin views dialogue as a state of unsettlement, irresolution, where “every event, every phenomenon, every thing loses its completeness, its hopelessly finished quality and its immutability… and significance of any one voice or position is constantly “renewed and grow[s] as the context continues to unfold.”

Much as Burke and Province reached a synthetic psychophysical understanding of color, they admittedly did not achieve a perfect fusion of ideas or disciplines. They felt that their breakthrough insight needed a lot of refinement and a continuation of dialogue between scientists and humanists. Thus, rejection of integration as complete and final, and a search for a better fit of ideas become a crucial step in the interdisciplinary process.

**Rejection of integration as final and complete**
If, in Burke’s view, “consciousness isn’t physics, it’s not philosophy,” it is but a bit of both, then physics and philosophy need to continue their conversation, even though a “definitive” answer may not be found in any individual or blended field. There is no expectation or desire on Burke’s part that physics will one day completely subsume philosophy or that the differences between these two disciplines will ever be reconciled. Neither do biology and Interpretation Theory in Scott Gilbert’s classes come together in a way that resolves all differences among them. Balancing the two perspectives in the Interpretation Theory classes involves, at some points, bringing out the interpretive nature of science, and, at others, strongly claiming science’s power to limit and weed out weak interpretations. Often in interdisciplinary classes, Gilbert finds himself balancing a “very thin line” between these two positions. He states:

I don’t want the students to go away thinking a) that science is mere interpretation to — every cell is interpretation, before you know DNA is an interpretation, sperm is an interpretation; and b) I don’t want them going away thinking science is completely out of the realm of interpretation theory because it’s all about facts and numbers. Those are the two things I don’t want them to come away with.”

He treads this “thin line” not to deliberately baffle or confuse students, but rather to put them on the path of questioning the nature of science and the humanities and finding complex integrative answers for themselves. His student, Sophia Accord, takes up the challenge when she in turn treads the same “thin line,” weighing the arguments of gender studies against the arguments of science. She does not end up rejecting either perspective, nor does she relativistically accept them both as equal. After considering “gender as merely a performance,” she catches herself to notice that this is not biologically or predominantly the case. She realizes, “Everything is not a social construct. We have to acknowledge physical realities.” In other words, she, as her professor Scott Gilbert, is held in a dialogical space between seeing science as a “social construct” and seeing it totally independent of social discourse.

Many reasons have been cited by our subjects for continuing to question the integration and rejecting the existing integrative solution as definitive. These include: missing data, constraints on how much disciplinary knowledge can be acquired; and core methodological and epistemological differences among disciplines. Claire Robertson-Kraft, a bioethics student at UPenn, describes consensus as “one of the most difficult obstacles faced by bioethicists.” In some cases, the problem is that the general public lacks biological understanding to influence policy-makers. She points out: “When you’re dealing with something as complex as human cloning, you can’t really expect the general public to understand the science behind what it means to clone a human being. You can only hope that they understand that there’s a difference between therapeutic cloning and reproductive cloning.” In other cases, according to Claire, the problem lies in the fundamental difficulty in reconciling different agendas and different belief systems: “In some cases, consensus may be impossible because those coming from a religious perspective are never going to be of the same mind as those coming from a scientific perspective, who will never understand the anti-abortion protesters who fail to see eye to eye with pro-choice supporters.” Generally speaking, the harmonization of different views appears to be a tenuous task.
Rejection of integration as final and complete is a natural step towards finding better bridges between disciplinary ideas, or towards the inclusion of a wider scope of disciplines. Improving the integration may mean extending the bridges further, finding the missing links to support it, or reaching out to include additional disciplines. At the same time, a complete merger of disciplines may actually be antithetical to an interdisciplinary “convergence” ideal, pursued by the NEXA program. The whole point of “convergence,” in the view of the program founder, Michael Gregory, is that the participants both maintain “fidelity” to the disciplines and at the same time substantively inform and transform them by bringing them into close contact with each other. The dialectical unity of disciplinary integrity and disciplinary transformation, stabilizing and destabilizing forces acting on the integrative idea propel the participants to defy cognitive closure and continue their interdisciplinary efforts.

Summary

Interview data reveal that interdisciplinary thinking is not a uniform process, but consists of a series of mental activities, each complex in itself. Overcoming disciplinary monism may involve the development of an appreciative attitude towards other “stories” and disciplinary frames of reference, defining and defying of limits imposed by one discipline, and making decisions to reject or accept different disciplinary theories based on their relevance and credibility. The stance of an appreciation and openness to alternative disciplinary inputs may be countered by the stance of critical review and adaptive transformation of alternative disciplinary inputs aimed at forging a more cohesive understanding of the topic. Integration may also take many forms. An interdisciplinary mind may end up revising his or her own disciplinary positions in response to challenges posed by another discipline. Or, an interdisciplinary thinker may place different disciplinary methodologies within a larger philosophical framework, questioning the different ways of knowing as well as the validation and proof inherent in that discipline. The result of this could be either a complexification of a disciplinary perspective or generation of a hybrid third position, which melds several disciplinary views. None of these forms of integrating knowledge seem to reach a point of complete settlement or full reconciliation of disciplinary differences. This ensures that the dialogue among different disciplines continues beyond provisional integration, pushing interdisciplinarians to find better bridges, wider frameworks, and a tighter fit of ideas.

This account of different mental activities is by no means exhaustive, but rather meant to set the organizing framework to be fleshed out in future research. Careful longitudinal study of interdisciplinary thinkers engaged in the creative synthesis of ideas may be especially helpful in illuminating the question of whether there is a certain developmental sequence to mental operations in interdisciplinary work. Such a study can also help to determine whether different pathways or strategies of integration are available to people at different educational and professional levels. Challenging as this research might be, due to its reliance on individual self-reporting and significant observational data, it may be crucial for educators who try to support interdisciplinary thinking of students in their classrooms.
Study of interdisciplinary cognition may also hold special importance for the understanding of the basic cognitive processes involved in any creative thinking. It may help validate or challenge some cognitive theories (on metaphoric thinking or conceptual blending) that have been put forth in the recent years, and were preceded by an intuitive insight into the dialogic nature of thought proposed by Mikhail Bakhtin. Only further development of the cognitive theories beyond the linguistic stage and more empirical studies of the interdisciplinary cognition can substantiate this parallel between higher order interdisciplinary thinking and basic cognition, or point up possible differences of significance.
**Bibliography**


