Disciplines and Interdisciplinarity in Research Universities

Presentation at the National Research Council

Meetings on Team Science October 24, 2013

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September 2013

DRAFT

I was pleased to receive the invitation to participate in this workshop, but I confess that I was concerned about responding to Henry Bienen, President Emeritus of Northwestern University. Given his stature and many accomplishments, I expected that he would be a tough act to follow.

In reviewing a preliminary draft of his remarks, however, I was relieved to find that we agree on many important points, particularly with respect to the openness of disciplines and the role that university-based research centers play in promoting cross-disciplinary conversations. President Bienen reviewed his leadership positions at Northwestern and Princeton, noting efforts to promote interdisciplinarity in both settings. I plan to draw on examples from these distinguished institutions to illustrate several points discussed below.

The question of how to make interdisciplinary teams work as effectively as possible quickly spills over into questions of how university degrees and departments should be organized. My view is that the disciplinary arrangements that have dominated US colleges and universities since the Second World War have been remarkably successful, and that we would embark on a wholesale reorganization of this system at our peril.

My research on disciplines and interdisciplinarity is presented in my forthcoming book, *In Defense of Disciplines*, which will be released within the next few weeks by the University of Chicago Press (Jacobs, 2013). In the short amount of time I have today, I'd like to make six main points.

1. Interdisciplinary research teams represent a small subset of scholarly collaborations and also a small subset of interdisciplinary communication.
2. Interdisciplinary communication is routine.
3. The overwhelming volume and growth of research and scholarship make specialization inevitable.
4. Disciplines are broad and dynamic.
5. Ironically, interdisciplinary domains are often quite narrow and specialized.
6. Research universities based on interdisciplinary principles are likely to be more centralized, less creative, and more balkanized than are the great research universities with which we are familiar.

While some of my remarks may run a bit against the grain, I'd like to emphasize the fact that we share the same goal, namely a vibrant and dynamic university system that advances scholarship while addressing the daunting practical challenges facing contemporary societies.

1. Teamwork and Interdisciplinarity

Research teams are typically comprised of researchers who share a disciplinary background. This pattern is evident in an ongoing study I am conducting on authorship patterns of review articles. While many of these literature reviews are written collaboratively, the co-authorship teams are typically comprised of scholars in the same field and often from the same university. So it is safe to say that interdisciplinary co-authorship probably represents only a small subset of all co-authorships.

It is also the case that interdisciplinary collaborations represent a small portion of interdisciplinary communication. Researchers and scholars in every field draw on ideas, methods and techniques developed in other fields. The set of interdisciplinary collaborations is no doubt an interesting and important topic, but it may be helpful to remember that this type of connection is only one of many mechanisms by which information flows across fields.

The relationships between these sets are depicted in a simple Venn diagram (see Figure 1). Interdisciplinary research teams are located at the intersection between interdisciplinary communication and collaboration, but this subset is not coextensive with either of these larger sets.

A specific set of examples returns us to President Bienen's two favorite universities. One aspect of these distinguished institutions that was not mentioned was the many Nobel prizes received by leading members of the faculty. In recent years, the accomplishments of Princeton and Northwestern in the field of economics are particularly noteworthy. Princeton and Northwestern have a total of 9 Nobel prizes in economics to their credit. Indeed, during the span of 2002 to 2011, at least one of the

economics Nobel prize winners had a Northwestern or Princeton tie in more than half (6 of 10) of the years (see Table 1).

While this partial list of Nobel Prizes indicates the growing prevalence of joint Nobel Prize awards in economics, not all of the joint winners were involved in collaborative research. By my count, the most cited paper of these nine laureates was jointly authored in only 3 of these nine cases. Furthermore, teamwork is not coextensive with interdisciplinarity. With one exception, the teams involve two economists who often shared a specialty and who worked within the same framework. There is really only one clear-cut case of interdisciplinary on this list, and that is Daniel Kahneman's work on behavioral economics. A little probing, however, reinforces the conclusion that cross-field collaboration is only one facet of interdisciplinarity

First, Kahneman and his most enduring collaborator, Amos Tversky, were both psychologists. Any funding rule that restricts interdisciplinary grants to scholars from different disciplines would exclude future teams like Kahneman and Tversky from consideration. In terms of published papers, there are several important papers which co-authored by psychologist Kahneman and economist Richard Thaler. But Kahneman's ten most cited papers do not have interdisciplinary co-authorship teams, nor do 17 of his top 20 papers.[1]

How interdisciplinary is behavioral economics at present? Let's take a set of articles published in the *Journal of Behavioral Finance* as an example. This publication, formerly the *Journal of Psychology and Financial Markets*, is published by the Institute of Behavioral Finance. It claims to be interdisciplinary in scope, and is particularly interested in the influence of "…individual and group emotion, cognition and action" for the behavior of markets (Journal of Behavioral Finance, 2013). If we define this journal as interdisciplinary, then the simple act of publishing in this outlet might make research interdisciplinary because the author(s) seek to reach an interdisciplinary audience. On the other hand, if we define interdisciplinarity in terms of cross-field co-authorship, 51 percent of these behavioral economics papers are interdisciplinary (67 percent of papers in these two journals were co-authored, and 77 percent of these co-authorships crossed disciplinary lines). Finally, if we define interdisciplinarity in terms of bibliographic entries that span economics and psychology, then 71 percent of papers published in 2012 are interdisciplinary in this sense. Cross-field co-authorships represent a smaller interdisciplinary domain than the set of papers with cross-field citations (51 percent versus 71 percent). Thus, even in the justly celebrated interdisciplinary case of

[1] This patter is based on the author's analysis of Google Scholar citation data as compiled by the Publish or Perish software (Publish or Perish, 2013).

behavioral economics, an exclusive focus on co-authorship would miss a substantial volume of cross-field connections.[2]

2. Interdisciplinary Communication is Routine

As I have already mentioned, President Bienen has made my work to substantiate this assertion much easier by citing wonderful examples of interdisciplinary communication and collaboration at Northwestern and Princeton. While I do not have the time or space here to fully document this large and important topic, I will instead try to illustrate this idea in several ways.

Using citation data, bibliometricians and others have shown that scholarship is comprised of a web in which various discipline and research groups represent nodes or clusters, not isolated silos. Moreover, it is easy to track the diffusion of particular ideas across diverse fields of study. For example, statistical innovations such as "event history" or "survival analysis" are used extensively by scholars in fields as diverse as demography, oncology, and engineering.

Finally, the flow of ideas is quite rapid. In my book, I track the timing of ideas flowing into the field of educational research from psychology, sociology and economics. The delay between the reception of ideas in their field of origin and their entry into the field of educational research is remarkably brief and often hard to detect at all, with the partial exception of economics.[3]

Cross-field communication can be seen in many facets of university life. Interdisciplinary classes are surprisingly common. Data from the UCLA higher education research institute indicate that many faculty (approximately 2 in 5) report having taught an interdisciplinary course within the last two years. Team-teaching is also more widespread than is often recognized, with approximately one third of faculty reporting recent experience of this type (Higher Education Research Institute, 1990-2011). Cross-listed classes are also common in many fields. In the spring 2013 semester at the University of Pennsylvania, just over one-third of undergraduate courses were cross listed, including 80 percent of sociology classes.

At major research universities, faculty members often secure secondary appointments with other departments and appointments in interdisciplinary programs. For example,

[2] This analysis is based on 45 papers published in the *Journal of Behavioral Finance* in 2012 and 2013. The same approach was applied to 142 papers published in 2013 in the *Journal of Economic Behavior & Organization* (2013). While the level of inter-disciplinarity is lower, the patterns for co-authorship and cross-field citation for this journal resemble those in the Journal of Behavioral Finance.

[3] The rapid diffusion of information does not mean that all researchers are fully aware of every possible idea and technique that might ultimately prove useful to them. Rather, the evidence supports the more modest claim that a broad set of ideas and techniques make their way into diverse disciplines.

among full-professors in the top 10 sociology departments, over 80 percent listed a secondary and often a tertiary affiliation on their home page. These affiliations were often with interdisciplinary centers and programs rather than other academic disciplines.

Finally, research centers are a particularly common feature of major research universities. Interdisciplinary research units have long been present and serve to channel applied research funds. President Bienen is justifiably proud of the interdisciplinary research centers at Princeton and Northwestern Universities, but these institutions are by no means unique in this respect. A count obtained from their websites indicates that 140 research centers can be found at Northwestern, while Princeton has 77.[4] These counts are in line with other major research universities. Data I reviewed from the Gale Research group indicated that the top 25 research universities in the U. S. have an average of over 100 research centers, most of which claim to be interdisciplinary in one manner or another (Jacobs, 2013; Gale Cengage Learning, 2012). The boundaries between academic fields that are ostensibly fixed and rigid are in fact remarkably porous. The research university thus has a hybrid form, with discipline-based departments complemented by more flexible and more interdisciplinary research centers.

3. <u>The overwhelming volume and growth of research means that specialization is inevitable</u>.

The modern research system since World War II has been so productive and innovative that more research is produced than anyone can possibly follow by themselves. Complaints about the difficulty of keeping up with one's field of research are common among faculty.[5]

A couple of years ago, when I began to explore the subject, 28,000 active, peer-reviewed academic journals were included in the Ulrich Periodical data base (Ulrich Periodical Directory, 2011). Given a 3 percent growth rate, we are probably about to reach the 30,000 threshold. At this rate, approximately five new scholarly journals will be founded during the course of our meetings today and tomorrow. And of course academic journals are just one of many sources that researchers consult. The contemporary scholarly system operates on so vast a scale that some form of an academic division of labor is inevitable.

The goal of bringing together disparate lines of research and theoretical insights is of course a laudable one, but the scale of the system yields some unanticipated conclusions. For example, let us examine the assumption that interdisciplinary journals

[4] These figures are both higher than that reported in my book, which were obtained from the Gale directory. An exact count depends on whether centers that are part of institutes are counted separately.
[5] Author's analysis of data from the National Survey of Post-Secondary Faculty, discussed at greater length in Jacobs, 2013. For more information on this survey, see US Department of Education, 2011.

are established in order to integrate knowledge. While the presence of a small number of high-status broadly-based journals such as *Science* and *Nature* no doubt advance this goal, the proliferation of interdisciplinary journals may well have the opposite effect. If five percent of research journals were interdisciplinary, then researchers would have to comb through as many as 1,500 journals to find the unexpected insight that will aid their investigation. Since attempting to follow this strategy for so many journals would consume all of their time and sources, researchers might be forgiven if they stay closer to home and spend the bulk of their reading time closely following a small number of specialty journals in their field.[6]

The premise of an interdisciplinary journal is that, by putting disparate findings under the same journal cover, researchers will be unable to avoid seeing papers on diverse topics. But as the number of journals increases, this effect is likely to diminish if not reverse itself. The emergence of search engines means that the paper title rather than the table of contents of a journal issue is likely to become a primary research strategy.

The effect of open-access repositories is likely to be similar. In other words, open-access repositories may be viewed as one big interdisciplinary journal. The consequence of scale, however, is that researchers will search for papers on a particular topic rather than stumble upon intriguing titles while perusing a journal's table of contents.

4. Disciplines are broad and dynamic.

When presented with evidence on the openness of disciplines, supporters of interdisciplinary reforms sometimes respond by saying "OK, you have shown that disciplines are not always as bad as their harshest critics suggest. But disciplines nonetheless stifle innovation, and more interdisciplinarity will make universities more dynamic." The debate in this area rests, then, not just on the empirical data on cross-field communication but on our understanding of the role of disciplines in promoting intellectual advances.

While disciplines each have unique histories and may have emerged for a wide variety of reasons, I maintain that a common organizational structure makes them particularly-well suited for the role of promoting the cumulative growth of knowledge. Indeed, I would posit that over the long term any thriving field of research will have to adopt many of the elements of a disciplinary structure.

Before we can ascertain whether disciplines play a positive or negative role in the advancement of knowledge, we need to take a moment to define what we mean by

[6] This conclusion assumes that each of these 1500 journals were truly comprehensive in nature. In fact, as is noted at greater length below, most interdisciplinary journals are quite specialized in their focus.

disciplines. A number of university-based academic disciplines are familiar to most people, such as biology, economics, mathematics, and psychology. What these fields have in common is that they are simultaneously many things: fields of research, academic departments, undergraduate majors, and doctoral degree fields. Disciplines typically restrict the pool of candidates for an academic position to those with a degree in the field. There is a loop which links disciplines, departments, and majors.

The principal disciplines are constitutive of universities – it is difficult to think of a college or a university which does not have a biology department, an economics department and a mathematics department. Disciplines and departments spread from school to school in part through diffusion and mimicry, but at the end of the day, without sufficient students, research support, and institutional and public legitimacy, a field of research is more likely to become a niche field that is not represented on all campuses rather than a ubiquitous discipline.

Disciplines to a great degree control their hiring of new faculty. This definition of disciplines results in only a small number of fields qualifying as disciplines. This definition also de-emphasizes the intellectual structure of a field and instead focuses on its social resources and organization. An example from languages will help to make this point clear. I take it as a given that all languages have the same intellectual standing, yet some constitute a discipline in the sense used here. Spanish, French, Italian and perhaps German are languages that are associated with academic disciplines in U. S. universities. Each has sufficient number of faculty across colleges and universities to generate demand for PhDs in these fields. Spanish constitutes a discipline because departments of Spanish staffed by professors with degrees in Spanish teach undergraduates and graduate students who will receive degrees in Spanish. Chinese, Arabic, Hindi, Swahili and numerous other languages have equal standing as valid and valuable areas of research and scholarship, but these have not attained the status of disciplines in the U. S. because teachers in these fields do not possess doctoral degrees, and students who study these languages rarely are awarded degrees.

Disciplines offer a degree of shelter from open competition by limiting openings to those with degrees in the field. This shelter facilitates extensive investments in specialized knowledge and techniques, and the long time horizons needed for speculative lines of research and training of graduate students.

Disciplines are never fully insulated from the world, however, because they depend on various publics for legitimacy: they depend on a steady stream of undergraduates, bright graduate students eager to commit to a career, research funds, the support of deans, and some degree of acceptance from the public at large.

Disciplines attain the right balance of shelter from external forces and competition that drives innovation. While critics complain of the insularity and complacency of academic fields, the sources of disciplinary dynamism are too often ignored. Researchers and scholars operating within a disciplinary context face competition. They compete with each other for fame and fortune; their specialty areas compete with each other for students, faculty positions and other resources; they compete with friends and colleagues in other disciplines, and they must constantly compete for the interest and support of various publics – students, deans, funding agencies, and for disciplinary authority in the realm of popular opinion.

Only a small number of liberal arts fields are represented in the vast majority of colleges and universities in the US: biology, chemistry, English, history, mathematics, political science, psychology, sociology. A number of other fields are nearly universal: economics, physics and philosophy. Less common but not represented on all campuses are fields such as anthropology, art history, classics and computer science. Finally, fields that are commonly found in research universities but rare in liberal arts colleges are astronomy and linguistics. Among language studies, Spanish and French are commonly degree granting subjects in US colleges and universities, while Italian and German are less commonly taught.[7]

This definition of disciplines immediately leads to two conclusions. Disciplines have to be broad enough to justify academic departments and faculty positions in school after school. Yet this very breadth in turn generates many specialty areas within these disciplines.

To return to the case of behavioral economics discussed earlier, this exciting area of research is not (yet) listed by the American Economic Association as one of the 20 major domains of economic research, nor is it one of the 134 specialty areas. Behavioral economics is not on either of these lists, but instead appears on the more detailed list of 891 sub-specialties of economics. The related area of neuro-economics also appears on this longer list, as does network analysis, an import from sociology. The jostling of all of these specialty areas for intellectual status, academic positions, recognition and resources contributes to the vitality and dynamism of disciplines. The breadth of disciplines and their internal differentiation into specialty fields helps to keep faculty meetings lively and academic politics endlessly intriguing.

A contrast between sociology and demography may help to further underscore the breadth of disciplines. Sociology is a broad field with many specialty areas of scholarship. There are currently 55 specialty groups (called “sections”) within the

[7] This discussion leaves out applied fields from business to education to engineering to medicine. Calls for greater interdiscipinarity tend to emphasize liberal arts disciplines more than they do applied or pre-professional units on campus.

American Sociological Association, and many more nodes of research. One can obtain a bachelor's degree in sociology in most colleges and universities, and faculty positions in the field are generally filled by those with doctoral degrees in sociology.

In contrast, demography is an academic specialty that has not attained the status of a discipline. Almost no undergraduates obtain degrees in demography; very few schools feature demography departments. While the field is increasingly interdisciplinary, demographers in the US are principally seek academic positions in departments of sociology. This is not to criticize the intellectual standing of the field, which has many distinguished scholars, its own national and international scholarly associations, journals, professional association, methods, textbooks, and so on. But the fact of the matter is that there is no closed loop between departments, majors, and doctoral degrees that is characteristic of liberal arts disciplines. Demography is an interdisciplinary field with a focus which, although quite substantial in scope, is much narrower than its disciplinary parent, sociology.

A final point to be made about disciplines is that the boundaries between them are typically quite fuzzy. The contrast between academic disciplines and professions may be instructive. While one can be arrested for practicing medicine without a license, there is no penalty for practicing anthropology, sociology or history without a license.

Since there are no formal boundaries between fields, scholars invade each other's domains with impunity. Economists such as Gary Becker claim family life as an area of economic decision making, while literary scholars analyze cultural phenomenon that anthropologists and sociologists have long considered their territory.

Liberal arts disciplines then are broad intellectual domains well ensconced in the university setting. Disciplines are fuzzy on the outside and internally differentiated on the inside. Their dynamism comes from many levels of competition, at the level of individuals, specialties, and disciplines. Their partially sheltered labor markets allow for long time horizons needed to pursue risky lines of research without immediate prospects for practical utility. Disciplines balance dynamism and stability in a way that has made them remarkably successful. It should not be assumed that alternative arrangements will be as successful in nurturing scholarly activity.[8]

5. <u>Ironically, interdisciplinary research is often quite specialized.</u>

While disciplines are criticized for being narrow, it is also assumed to be the case that interdisciplinarity must be broad. But, in fact, many interdisciplinary fields represent

[8] Disciplines also form the basis for research communities, and are needed to evaluate and certify scholarship. This aspect of disciplines is also hard to replicate in interdisciplinary contexts.

specialized niches of research and scholarship. In this way, they resemble the many specialized areas of research that spring up within disciplines.

Say a university recruits a philosopher of education who receives a joint appointment in a school of education and in a philosophy department. Will this result in the "integration" of philosophy and education? Perhaps, but a more likely outcome is that this new professor will have her greatest impact in the domain of educational philosophy, a long-standing specialty area within the field of educational research and also within the discipline of philosophy. The point is that the presence of a faculty member whose research interests happens to lie at the border of two or more fields may contribute more to advancing a particular specialized niche than to fully connect two disparate bodies of knowledge.

The notion of "specialized interdisciplinarity" may seem to be an oxymoron, but closer scrutiny suggests that interdisciplinarity domains are typically quite specialized. As part of my study of research on this issue, I conducted an analysis of 789 research journals founded in 2008. Based on a content analysis of their mission statements, I found that roughly one quarter professed to be interdisciplinary in orientation. These journals, however, varied a great deal in what they meant by interdisicplinarity. In many cases, these journals focus on what outsiders may well view as a limited domain.

Table 2 presents the mission statements of eight new journals that have been founded within the past few years. Each journal's mission statement or statement of "aims and goals" makes the interdisciplinary orientation clear. While the first two journals are "comprehensive" in the sense of having very broad agendas, the rest of the journals employ a much narrower, more "targeted" sense of the concept of interdisiplinarity. It is appropriate to classify these as "specialized interdisciplinarity." There is likely to be little if any overlap between these six journals. Each addresses a particular and often specialized topic or domain. And, since scholarly journals tend to broader than specialized research groups, interdisciplinary research nodes are typically far narrower in scope than are these journals.

The more general point about the specialized nature of interdisciplinarity is that there are many nodes to connect. To keep things simple, let's start with the number of two-way ties between 20 academic fields, and then factor in specialties within fields as well as three-way ties. The number of bridges needed to make all two-way connections among 20 fields of study would be 196, and 1,140 would be needed to cover all of the 3-way ties. If each field in turn has 20 specialties, it would take 79,800 links to cover all of the 2-way ties between these 400 units, and over 10 million connections to cover all of the 3-way links. Since there are more than 20 fields, and more than 20 specialties in each, covering even a small fraction of the possible interdisciplinary connections is beyond the reach of even the richest or largest universities. And each of the

interdisciplinary units containing links between two or three fields would be smaller than the 20 disciplines we started out with. To return to the list in Table 1, an interdisciplinary outlet that focuses on the holocaust such as the *Prism Journal* might well be narrower in scope than a discipline-based journal such as the *International Journal of European History* or even the *Journal of Modern European History*. The equation of interdisciplinarity with broad and disciplinarity with narrow, while appealing on the surface, does not hold up under closer scrutiny.

6. Research universities based on interdisciplinary principles are likely to be more centralized, less creative, and more balkanized than are the great research universities with which we are familiar.

Whether or not disciplines are currently hardened silos or nodes in a complex network, advocates of interdisciplinarity maintain that there is more to be done in this area; in short, the more interdisciplinarity the better. But there are good reasons to demur before reaching this conclusion.

We have seen that research universities are remarkably open to cross-field units when they take the form of interdisciplinary research centers. These offer the flexibility needed to respond to practical concerns and funding opoportunities without the long-term commitment inherent in the creation of new departments. Consequently, there need be no debate about this form of interdisciplinarity. Similarly, few would object to efforts to facilitate cross-field communication. While the overwhelming volume of scholarship makes it impossible for everyone to be fully aware of developments in all academic fields, various ways to promote communication may be useful when there is sufficient demand. In order to facilitate cross-field communication in my area, I have recently worked with colleagues to establish an interdisciplinary scholarly association, the Work and Family Researchers Network (WFRN, 2013).

The real question has to do with whether training, degrees and departments need to be reorganized on interdisciplinary axes. While there are many organizational variants for promoting interdisciplinarity, some broad conclusions may nonetheless be offered.

In a world with stable or declining research budgets, funds devoted to interdisciplinary pursuits must at some point detract from disciplinary budgets. Interdisciplinary faculty appointments will eventually substitute for disciplinary appointments. If the success of interdisciplinarity depends on strong and vibrant disciplines, then there will be some price to pay in terms of foregone disciplinary growth.[9]

[9] The tight research budgets expected in coming years may lead review committees to avoid risky projects. This would be most unfortunate if scarcity produces both fewer and more conservative grant awards.

In addition, the disciplinary system currently in place is decentralized to a remarkable degree. Faculty at major research universities have considerable say in hiring decisions. This influence derives from their specialized expertise. The more that a university emphasizes interdisciplinarity, the greater the power of central administrations and the smaller the role for faculty in making key decisions. Once the unit in question involves multiple departments, the dean's role increases and the faculty's declines; once the unit crosses schools, the deans' role declines and the central administration (president, provost, or chancellor) increases. It follows that if the dynamism and creativity of the modern university is due in part to the decentralized decision making, then a system that enhances the role of central players runs the risk of less creativity and inventiveness.

While deans and presidents are generally smart people who care about the well-being of their institutions, the fact is that they have a much shorter time horizon than do faculty. A five year time horizon is typical for a dean, while developing and nurturing a program of research takes much longer, and developing a successful graduate program longer still.

Evidence suggests that interdisciplinary initiatives have much shorter life-spans than disciplines and departments. For example, Roger Geiger and Creso Sa (2009) report that the majority of interdisciplinary initiatives launched at Duke University were not renewed after 5 years. While this may seem to be an exemplary case of administrative discipline, the fact is that this is too short a time horizon for assessing basic research and especially graduate education. Few if any graduate students could be selected, recruited and graduated within that time frame. The department- and discipline-based training of graduate students thus require longer time horizons that are not in synch with the short term, often grant-driven activities that are currently based in research centers.

Balkanization might seem like an odd charge to levy against interdisciplinary since a main aspiration of this approach is to promote greater connectivity. But this conclusion is supported by several reasons.

First, if we maintain the current structure of disciplinary departments and add another set of interdisciplinary units on campus, the number of domains that need to be connected has just increased. Second, as we have seen, interdisplinary fields are often quite narrow in scope. There are certainly dozens and probably hundreds of possible interdisciplinary possibilities.

Third, new fields that burst forth with great promise and enthusiasm often generate a series of institutional structures that resemble established disciplines.

They form new scholarly societies, hold conferences, establish new journals, write textbooks and develop related curricula, create special interest groups within

established fields of research, and compete for dedicated streams of research funding. In this way, interdisciplinary fields often revert to forms that resemble disciplines in many ways. Those interdisciplinary fields that succeed in establishing academic departments over time become increasingly closed in their hiring practices. In other words, the more established the field, the more likely it will restrict hires to those with specialized degrees in the field. In this sense, interdisciplinarity is a transitional form which continues until established techniques and bodies of knowledge are begun to be taught to graduate students.

An important element of this reversion to disciplinary form is the proliferation of sub-specialty areas. The most successful interdisciplinary fields are most subject to this tendency because their growth makes it impossible to keep everything in focus. Thus, when there were a handful of nanotechnology journals, one could legitimately hope that this would emerge as a single interdisciplinary field. But now that there are more than 75 nanotechnology journals, it becomes harder and harder to follow each of these areas. Some bibliometricians have suggested that nanotechnology, which is still a very young and vibrant field, is dividing into at least four fields; biological nano, materials nano, computer nano and physics nano.[10]

Finally, the track record of interdisciplinary research centers is often one of balkanization rather than coordination. A case in point is the area of homeland research. At Pennsylvania State University, enterprising deans and scholars succeeded in securing funds for a number of research centers in this area. No, there was not a single center for the study of homeland security but rather the remarkable total of 21 homeland security researcher centers, most of which claimed to be interdisciplinary in orientation (Pennsylvania State Universtiy, 2011). (See Table 3 for a partial list.) While these are no doubt legitimate and worthy enterprises, attacking real issues (cyber security, bio-terrorism, and so on), it is difficult if not impossible to bring all of these units together under a single meaningful umbrella because the range of issues in this area is so wide. If universities tried to build interdisciplinary training programs along the lines of interdisciplinary research centers, there would be no end to unique, specialized configurations.

[10] Compare Meyer and Persson (1998) and Schummer (2004) in order to see the growing specialization in this field of research.

Conclusion

Implicit in these comments is the premise that an institutional and historical context is helpful in understanding the pro's and con's of disciplines and interdisciplinarity. In other words, analysis and evaluation of interdisciplinary benefit by going beyond the individual team or collaboration and consider the underlying organizational arrangements.

In terms of specific reforms, my comments have raised questions about faculty joint appointments, requiring cross-field collaboration for research proposals, and the role of interdisciplinary degree programs. More broadly, the question is whether inter-disciplinarity would serve as a useful organizing principle for 21st century research universities. I do hope that movement in this area is incremental, and that the numerous virtues of the current organization of academia will not be lost as universities seek to adapt in the face of the many pressures they are confronted with.

Bibliography

Gale Cengage Learning. 2012. Research Centers Directory. 42nd Edition. www.gale.cengage.com

Geiger, Roger L., and Creso M. Sa. 2009. *Tapping the Riches of Science*. Cambridge, MA: Harvard University Press.

Higher Education Research Institute (HERI). 1990-2011. Faculty Surveys. Los Angeles: Higher Education Research Institute (UCLA). http://www.heri.ucla.edu/facPublications.php

International Journal of European History. 2013.

International Journal of Interdisciplinary Research https://www.facebook.com/PSAKUIJIR

International Journal of Surface Engineering and Interdisciplinary Materials Science (IJSEIMS) 2013. http://www.igi-global.com/journal/international-journal-surface-engineering-interdisciplinary/59713

Jacobs, Jerry A. 2013. *In Defense of Disciplines: Interdisciplinarity and Specializationin the Research University*. Chicago, IL: Chicago University Press.

Journal of Behavioral Finance. 2013. http://www.tandfonline.com/action/journalInformation?show=aimsScope&journalCode=hbhf20

Journal of Innovation and Entrepreneurship. 2013.
http://www.springer.com/business+%26+management/entrepreneurship/journal/13731

Journal of Modern European History. 2013.
http://www.chbeck.de/themenseite.aspx?toc=4079

Meyer, M., and O. Persson. 1998. “Nanotechnology —Interdisciplinarity, Patterns of Collaboration and Differences in Application.” *Scientometrics* 42(2):195 – 205.

Multidisciplinary Respiratory Medicine. 2013. http://www.mrmjournal.com/

Source: Nobel Prize Website. 2013. Nobelprize.org
http://www.nobelprize.org/nobel_prizes/economic-sciences/

Pennsylvania State University. 2011. “Homeland Security Initiative: Research Centers, Institutes and Labs.” http://homelandsecurity.psu.edu /discovery/centers /index.html.

Prism Journal. 2013. http://www.yu.edu/azrieli/research/prism-journal/

Schummer, J. 2004. “Multidisciplinarity, Interdisciplinarity, and Patterns of Research Collaboration in Nanoscience and Nanotechnology.” *Scientometrics* 59(3):425 – 65.

Solutions. 2013. http://www.thesolutionsjournal.com/

Tourism Management Perspectives. 2013.
http://www.journals.elsevier.com/tourism-management-perspectives/

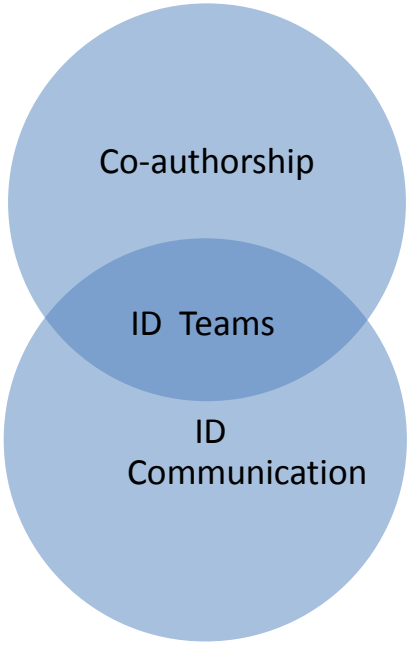
Transgender Studies Quarterly. 2013.
http://www.dukeupress.edu/Catalog/ViewProduct.php?viewby=journal&productid=45648

Ulrich’s Periodical Directory. 2011. http://ulrichsweb.serialssolutions.com/.

US Department of Education. National Center for Education Statistics. 2011.
National Survey of Postsecondary Faculty: Overview. http://nces.ed.gov.surveys/nsopf

Work and Family Researchers Network. 2013. http://workfamily.sas.upenn.edu/

Figure 1. Diagram of the Relationship Between Co-authorship, Interdisciplinary Research Teams and Interdisciplinary Communication



Note: Interdisciplinary is abbreviated here as “ID”

Table 1. Nobel Prizes in Economics from Princeton and Northwestern

Northwestern

	Name	Date	Solo/Joint	Topic
1.	Dale Mortensen	2010	joint	markets with search frictions
2.	Roger Myerson	2007	joint	game theory
3.	Edward Prescott	2004	joint	technology and the business cycle

Princeton

	Name	Date	Solo/Joint	Topic
1.	Christopher Sims	2011	joint	macroeconomic research
2.	Thomas J. Sargent	2011	joint	macroeconomic research
3.	Paul R. Krugman	2008	solo	trade theory, new economy geography
4.	Daniel Kahneman	2002	solo	behavioral economics
5.	John Forbes Nash	1994	solo	mathematician, Nash equilibrium
6.	Sir William Arthur Lewis	1979	solo	development economics

Source: Nobel Prize Website. 2013. Nobelprize.org

http://www.nobelprize.org/nobel_prizes/economic-sciences/

Table 2. Mission Statements of Selected, Recently Founded Interdisciplinary Journals

A. Broadly-Focused Interdisciplinary Journals

1. International Journal of Interdisciplinary Research

PSAKU International Journal of Interdisciplinary Research (PSAKUIJIR) is an international double blind peer reviewed journal published yearly by the Political Science Association of Kasetsart University, Thailand. This Southeast Asian base...d journal aims to promote new discoveries in the various disciplines of knowledge, within and across sciences and technologies and humanities and social sciences, which are contributed by researchers and experts from all over the world. Therefore, the editors dedicated to providing a venue for both academics and practitioners to publish their original research articles and reviews in English.

2. SOLUTIONS

Solutions is a nonprofit print and online publication devoted to showcasing bold and innovative ideas for solving the world's integrated ecological, social, and economic problems. Our mission is to provide a forum for developing and discussing seriously creative ideas to solve society's most pressing problems in an integrated way.

B. Targeted or Specialized Interdisciplinary Journals

1. Transgender Studies Quarterly

Over the past two decades, transgender studies has become fertile ground for new approaches to cultural analysis. *TSQ: Transgender Studies Quarterly* offers a high-profile venue for innovative research and scholarship that contest the objectification, pathologization, and exoticization of transgender lives. It will publish interdisciplinary work that explores the diversity of gender, sex, sexuality, embodiment, and identity in ways that have not been adequately addressed by feminist and queer scholarship. Its mission is to foster a vigorous conversation among scholars, artists, activists, and others that examines how “transgender” comes into play as a category, a process, a social assemblage, an increasingly intelligible gender identity, an identifiable threat to gender normativity, and a rubric for understanding the variability and contingency of gender across time, space, and cultures…

2. Tourism Management Perspectives

Tourism Management Perspectives is concerned with the planning and management of travel and tourism, including tourist experiences and the consequences of those experiences for communities, economies and environments. It is also concerned with the creation of image, the shaping of tourist experiences and tourist perceptions, and the ways in which tourist organizations manage themselves and destinations… The journal takes an interdisciplinary approach and includes planning and policy aspects of international, national and regional tourism as well as specific management studies. It publishes articles that range from quantitatively based empirical papers to those embedded in critical analysis via those using constructionist approaches and ethnographic research. Articles are relevant to both academics and practitioners.

3. Journal of Innovation and Entrepreneurship

The *Journal of Innovation and Entrepreneurship* is dedicated to exchanging the latest academic research and practical findings on all aspects of innovation and entrepreneurship in spatial context and over time. The central theme of the journal is to explore why some areas grow and others regions stagnate, and to measure the effects and implications in a transdisciplinary context that takes both historical evolution and geographical location into account. The journal addresses such issues as: How does technological advance occur, and what are the strategic processes and institutions involved? How are new businesses created? To what extent is intellectual property protected? Which cultural characteristics serve to promote or impede innovation? In what ways is wealth distributed or concentrated? …Contributions from researchers in a wide variety of fields will connect and relate the relationships and inter-dependencies among (1) Innovation, (2) Political Regime, and (3) Economic and Social Development.

4. Prism Journal

PRISM: An Interdisciplinary Journal for Holocaust Educators… offers educators a practical, scholarly resource on teaching the Holocaust at the high school, college and graduate school levels. The first issue of this peer-reviewed journal was published in fall 2009… Each issue examines a specific topic through a variety of lenses, including education, history, literature, poetry, psychology and art.

5. The International Journal of Surface Engineering and Interdisciplinary Materials Science (IJSEIMS)

The *International Journal of Surface Engineering and Interdisciplinary Materials Science (IJSEIMS)* is a refereed, interdisciplinary journal that publishes high quality articles on materials science with special emphasis in aspects related to surface engineering. The journal covers all surface engineering topics, including tribology, coatings, and surface treatments. In addition, the journal serves as a forum for the discussion and exchange of information on all aspects of the science of classical and advanced materials, namely, nano and biomaterials.

6. Multidisciplinary Respiratory Medicine

Multidisciplinary Respiratory Medicine is a peer-reviewed, open access journal encompassing all aspects of respiratory medicine. It has a particular focus on interdisciplinary and translational research. *Multidisciplinary Respiratory Medicine* is the official journal of the Italian scientific society AIMAR.

Source: Mission statements were culled from each journal's website. The URS's for these journal homepages are included in the bibliography.

Table 3. Pennsylvania State University Homeland Security Centers (Partial List)

Anechoic Chamber and Laboratory Facility

- communication systems interoperability

Center for Information Assurance

- research on information and cybersecurity

Center for Network Centric Cognition and Information Fusion

Indoor Environment Center

- securing buildings from chemical & biological weapons

International Center for the Study of Terrorism

- understanding and responding to terrorism

North-East Visualization and Analytics Center

- early warning systems

Protective Technology Center

- protecting people and infrastructure against attacks

User Science and Engineering Laboratory

- emergency crisis management

Source: Pennsylvania State University website, 2011.