EVERYTHING OLD IS NEW AGAIN: CIRCULARITY AND SINGULARITY IN THE PURSUIT OF SCIENCE AS A LIBERAL ART

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Historical Trends: Science as an Insider and an Outsider in Liberal Arts

As far back as two millennia, the prototypical scientist Aristotle offered a compelling definition of liberal learning: "In education it makes all the difference *why* a man does or learns anything; if he studies it for the sake of his own development or with a view to excellence, it is liberal" (cited in Gould). Yet, it is not uncommon to hear today's students and faculty refer to "science and the liberal arts," rather than "science and the other liberal arts." Why does this compartmentalization of science persist, and how can we move toward a more encompassing view of a liberal education? It is defined as the unity of knowledge the Greeks sought, the belief that everything is worth knowing, free from justification through technical application.

Humankind has spiraled through centuries of alternately valuing the creation of knowledge for its own sake and viewing such endeavors as frivolous. A brief overview of the patterns in science education over the last 150 years reveals how perspectives on science are closely linked to our societal milieu (for an historical overview, see Matthews). When Benjamin Silliman set up the first chemistry lab at Yale in 1847, he not only purchased his own equipment and supplies, but also rented his lab space from Yale (Whitman, 201). Science was not recognized as a rigorous intellectual pursuit worthy of inclusion in higher education. The gradual acceptance of science took numerous forms in both high schools and higher education. Debates about content coverage versus in-depth investigations, including laboratory experiences, were as lively at the beginning of the twentieth century as they are today. Science emerged as a set of practical goals having a benefit to everyday life. By the 1940s, the significant contributions of science to World War II efforts highlighted the societal benefit of scientific pursuits. Discussions in the 1940s about the role of science in the curriculum focused on practical applications, liberal education, and the preparation of future scientists.

The launch of Sputnik by the Union of Soviet Socialist Republics brought the training of future discipline-specific scientists to the top of the priority list (for a review of this era, refer to Rudolph). From 1950 to 1975, science was rarely viewed as one of the liberal arts. Rather, science education often favored the academic elite who showed substantial promise for careers in specific scientific disciplines. Not only was science set apart from other pursuits of knowledge, but within the sciences the separation and hierarchy among the disciplines was exacerbated.

The space race culminated with the moon landing, and science education lost its dominant position in education. The Education Division of the National Science Foundation was abolished and later resurrected as the Division of Education and Human Resources. A new agenda emerged with the report from the American Association for the Advancement of Science titled *Science for All.* Science was welcomed back as a liberal art, an essential part of everyone's education. The definition of "everyone" was also broadened and continues to be broadened to include women and underrepresented groups, although achieving this inclusive goal still remains a challenge. The National Science Board currently has two priorities for science education. The first is scientific literacy for all citizens, and the second is preparation of a scientific and technical workforce (National Science Foundation). The door is once again open to ensure that undergraduates develop an understanding of science as part of a liberal education.

Barriers to Creating an Inclusive Liberal Arts Community

If science is to truly be one of the liberal arts, we need more than science distribution requirements. The development of scientific knowledge must be understood in a broader, comparative epistemological context. The long tradition of disciplinary departments and divisions, even within liberal arts colleges, is an impediment to providing students with a liberal education. Within science divisions, faculty struggle to build multidisciplinary and interdisciplinary learning environments. Reaching beyond the sciences requires exploration of uncharted territory and often confrontation of misconceptions about other disciplines on the parts of both humanists and scientists. This essay explores the ups and downs of reaching across campus to create a scholarly community for faculty and students. The emphasis is on liberal arts colleges and, in particular, curricular experiments at Carleton College. The small size of schools like Carleton enables human connections across disciplinary boundaries for both faculty and students. These institutions have maintained a strong emphasis on liberal education despite historical societal swings in the perception and valuing of science. They serve as incubators for curricular development that have the potential for scale up at larger institutions. That said, many larger universities also have liberal arts at the core and a long tradition of providing a liberal education.

At a time when society as a whole saw science as a means to achieving practical goals, Laurence McKinley Gould took the helm as president of Carleton College. In his 1945 inaugural speech, this geologist and internationally renowned polar explorer claimed that, "…the true spirit of liberal or humane studies is not inherent in any special or sacred field. There are quite as great cultural values to be derived from the study of chemistry or geology as from that of Latin and

Greek if inspired teaching guides the students." Gould's leadership through 1962 laid a strong foundation for the genuine inclusion of science in the liberal arts at Carleton. Yet, we have gone around the carousel many times, inventing and reinventing curricula that reflect this commitment to liberal arts education.
Why does the carousel keep spinning? Certainly the scientists have a tremendous amount of responsibility here. Rapid progress in the sciences made possible through ever changing, ever exciting technological advances, as well as conceptual changes on the order of Kuhnian revolutions, can entice one down a rich but narrow path and overwhelm another with surface-level detail. T.S. Elliot (cited in Gould) described these intellectual traps far more eloquently:

> Where is the wisdom we have lost in knowledge;
> Where is the knowledge we have lost in information?

The academic community as a whole assumes additional responsibility. Misunderstandings lead to unnecessary barriers. Departmental entrenchment arises from concern over resources, fueled by lab space needs and funding opportunities. Creative thinking and cooperation are replaced with a perceived zero sum game. The amazing potential of integrating curricula can become diluted to superficial survey courses, with all sense of wonder lost. We conflate multidisciplinary and interdisciplinary. Too great a focus on surface connections can lead to ignoring or failing to value epistemological differences. What "counts" as evidence and knowledge in different fields is something to be explored and celebrated. Sadly there are times when lack of understanding leads to denigration of other ways of knowing the world.

Integrated Academic Experiences as a Solution

One potential solution to bringing science back into the fold of the other liberal arts is to create integrated academic experiences for students that build intellectual bridges among the sciences, humanities, and social sciences. Integrated learning to create a scholarly community of faculty and scholars is not a new idea. From 1965 to 1969, the University of California at Berkeley created learning communities with academic and residential components for a group of students during their first two years of college (Trow). Tussman, the originator of the program, intended to provide moral education and encourage students to develop a "political vocation." The program was organized around the theme of "Culture in Crisis." An historical perspective was taken with examples that included Greece during the Peloponnesian wars. Thirty years later, Katherine Trow did a retrospective analysis of the program through interviews with forty former participants. The interviews attest to the lifelong value of the experience as perceived by the participants and also include a critical analysis of the experimental program.
Evergreen College has built its entire program around linked course experiences. The word "department" is not in the Evergreen vocabulary, and students benefit from rich interdisciplinary experiences each term. Unlike Evergreen, most institutions face a long history of strong departmentalization that at times creates a strong barrier to true interdisciplinary learning for both students and faculty.

We offer a model for linked courses that has worked within a departmentalized culture with minimal disruption to colleagues within our departments.

Linked course goals

At Carleton we have developed optional dyads and triads for first term students. Students who opt for this introduction to college learning simultaneously enroll in two or three linked courses that cross divisional boundaries and are united thematically. Syllabi for the linked courses are aligned so students are asking the same questions simultaneously but framed in different disciplinary contexts. One recent dyad taught linked introductory geology and English courses with a focus on the American Midwest. Our own involvement with the triad program has focused on an Origins and Mind theme and linked introductory biology, philosophy, and psychology courses. The overarching goals for dyads and triads are:

- To foster deeper understanding of connections among diverse disciplines for both faculty and students.
- To provide a context for students to understand and appreciate distribution requirements.
- To create an especially strong learning community for first term students.
- To use a thematic approach to learning across disciplines.

Different dyads and triads have additional goals. Several linked-course programs, including our own, are designed to help students work towards their college writing requirement in a multidisciplinary way. Our triad has the additional goal of assessing this integrated academic learning experience for first-term student learning.

Structuring an integrated academic experience

We have found that a weekly common session that brings all faculty participants and students together for an intentionally designed interdisciplinary activity is essential for the success of the program. Faculty model cross-disciplinary discourse and at times discover the hidden depths of epistemological differences. Our students challenge each other and the faculty to push beyond disciplinary boundaries. Discussions and activities vary widely. By way of example, Cartesian dualism becomes a fascinating and challenging topic for discussion when students closely examine the implications and conclusions of biologists, philosophers, and psychologists. Exploring evolution in biology and philosophy class provides a forum for a deeper and richer understanding of the theory. In our triad, students were able to synthesize their own views of development by considering the perspectives of two of their faculty members who have expertise in developmental biology and developmental psychology.

The schematic in Figure 1 models both the structural and intellectual intersections of the three linked courses. Keep in mind that these are three individual courses rather than a single course taught by multiple instructors. We see two primary advantages to linking rather than team teaching a single interdisciplinary course. Pedagogically our students can delve deeply into a single discipline to have sufficient resources to engage in meaningful discussions crossing disciplinary

boarders. On a more pragmatic note, linked courses are a subversive means of teaching across disciplines without creating staffing challenges within departments. Each course fulfills the same requirement for the home department as a standalone introductory course within that department. A key to our success has been to start with courses that count toward the major. For example, a student enrolled in introductory biology in the Origins and Mind triad is as well prepared to go on to the second introductory course as a student in the traditional introductory course. None of the courses are taught as non-majors courses, and this has been important in terms of both credibility and departmental contributions.

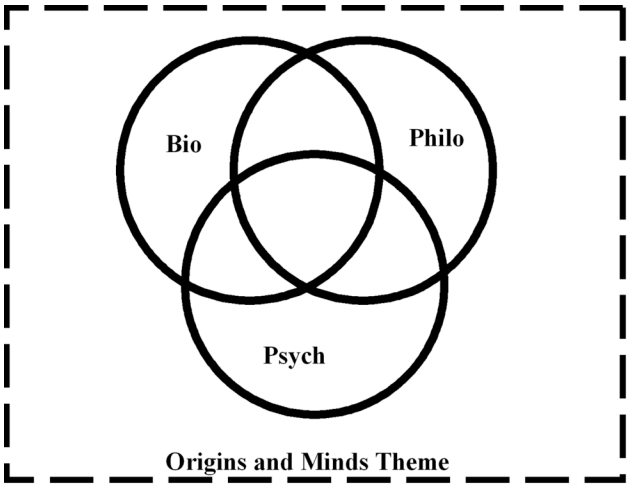

Figure 1. Schematic of Origins and Mind triad. Note the intersection of all three courses represents both the common time experience and the true interdisciplinary understandings our students integrate from all three courses. The other three intersections represent the connections students make between course pairs. The unifying theme forms a common thread for the entire experience.

Assessment of the Origins and Mind triad

To avoid a impressionistic analysis on the parts of the faculty members, we compared survey responses from our students and those enrolled in a parallel biology course with the same learning goals that were also taught by Susan Singer. Students in this control group independently enrolled in two other courses (we have a three course trimester system). Kathleen Galotti, our psychology faculty member, analyzed the results, which are published (Elveton et al.). What follows is a brief summary of some of the key differences and similarities in the survey responses of the two groups. All differences are statistically significant.

Students in the Origins and Mind triad were more likely to agree with the following statements:

- Classes offered a reasonable and broad view of intellectual inquiry.
- My ability to grasp important theoretical issues has been improved this term.
- My courses gave me a good sense of what liberal arts is all about.
- My classes allowed me to see why science courses are considered liberal arts.
- My classes complemented each other this term.
- My written assignments (exams, papers, projects, reports) were well coordinated this term.
- My workload fluctuated a great deal, ranging from heavy to light (less fluctuation for triad group).
- If advising a good friend, I would recommend classes I took this term.

While the balanced workload was appreciated by the student, from a faculty perspective, the increased confidence in grasping theoretical issues, perceiving science as a liberal art, and understanding what liberal education involves are particularly exciting.
We found no differences in the following categories:

- I feel I have been honestly challenged in my classes this term.
- My courses have been far too easy.
- I feel my writing improved this term.
- I feel I am making good progress this term toward fulfilling my distribution requirements.
- Open-ended responses on educational goals, which included such intents as intellectual breadth, growth, exploration, well-roundedness, broadening horizons, finding a major, survival, identity, thinking skills, and writing skills.
- Average hours per week reported spent on all homework (about 24 hours per week).

Of particular significance in this second category is the similarity in educational goals in both groups. Students, whether enrolled in the triad or not, were motivated to attain intellectual breadth during their time at Carleton. Thus our triad group was not self-selecting for that critical factor.

Lessons learned

Based on our experience, we have several suggestions for others who might consider linked courses as a way to teach science as one of the liberal arts. There are social aspects of class size that play out when students spend all of their academic time together over the course of a term. We have offered the triad to a group of 25 students and also to 48 students. Student evaluations indicate that a group of 25 may be a bit limiting in terms of the social dynamics. We have shifted back to 48 students and divide them into two groups for the biology lab and for philosophy class, which is discussion based.
The courses need to be truly integrated and not simply parallel. With first year students, faculty guidance in making connections explicit helps students begin to build an interdisciplinary frame. These connections are enhanced by common sessions, as discussed previously, where all instructors are present and engage with the students in a thoughtfully constructed activity. In some of our very best

common sessions, we have had a difficult time getting the students to stop discussing long after the allotted time for class has passed. Implicit in both these suggestions is the essentialness of engagement among faculty.

Finding a great common book makes a substantial difference in the empowering students to build connections among the courses. We chose Pinker's *How the Mind Works* one year and found numerous confluences among the courses. Dennett's *Darwin's Dangerous Idea* was first used in a faculty reading group, and our students also found the text to be a compelling doorway to entertaining multiple perspectives and epistemological approaches. The advantage of choosing new books each time is that it keeps the faculty interactions fresh and vital.

Increasing numbers of colleagues are choosing to offer dyads and triads. The concerns we have heard among other faculty are focused on sequencing of language courses, as we have a foreign language requirement at Carleton. This becomes purely a scheduling issue, and the dyad offers a solution for students who want to begin their language study their first term at Carleton. On a semester system, there might be more flexibility in the number of courses that are linked as students take four or more courses.

As with most endeavors, the option rather than the requirement to develop or take a triad or dyad course appears preferable in our environs to a college-wide requirement. The opportunity for faculty to take ownership of a dyad or triad with colleagues and create their own unique version is more likely to lead to sustainability and vitality than a formulaic approach.

Multiple course case studies as an alternative to fully linked courses

As a slight aside, an intermediate step between independent courses and linked courses is a shared case study that involves two or more classes for a portion of a term. This approach is less time intensive and brings together two or more different groups of students with unique expertise to offer each other. By way of example, my colleagues Debby Walser-Kuntz (immunologist) and Heather Rissler (biochemist) and I devised an edible vaccine case study that involved our students in Immunology, Bioinformatics, and Plant Biology. We plan to add Microeconomics in the next round. In brief, students were assigned to teams that were to develop business plans for either plant-based or tradition vaccine production for malaria. Each class was responsible for preparing a set of frequently asked questions to provide other classes with relevant background needed to answer an integrated set of study questions and prepare a business plan during a lunch for all three courses. A final individual project focused on writing a letter to the CEO of a mock foundation that was going to provide funding for the development phase of one of the vaccines. While the case had a strong biological foundation, the social, economic, and ethical issues loomed large, and students tackled those issues with zeal. The cross-class case study is a prototype we hope to extend across disciplines to involve more students and faculty in meaningful experiences with science as one of the liberal arts.

Linked courses can be win-win for both faculty and students

While a quantitative analysis of the effects of teaching science as a liberal art is difficult, faculty report that participation in linked courses is a valuable faculty development activity that has stretched and broadened them intellectually. While we each teach our own courses, we need to be cognizant of our colleagues' approaches and able to fully engage in the common sessions. In fairness we are compelled to note that this type of teaching does take more time. In particular, the front end preparation requiring careful coordination among faculty participants can be quite intensive. The reward is the growth of the students and our own personal growth from rich interactions with colleagues. We hope that linking courses is not a singular point in the circle or spiral of science education, but rather one of many efforts to explicitly celebrate science as one of the liberal arts.

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