



COLLEGE OF LIBERAL ARTS & SCIENCES INTERDISCIPLINARY SIGNATURE AREA PROPOSAL

T.R.U.E. Learning: A Model for Teaching through Research in Undergraduate Education

Theme: The goal of this signature program is to promote, mentor, and support high-quality undergraduate (UG) research across disciplines on the UCDHSC Downtown Denver Campus. The program provides opportunities for students to engage in experiential learning in the form of intensive scholarship and faculty-mentored multidisciplinary research leading to dissemination to a larger external audience (e.g., publication or other scholarly presentation). Although we emphasize the sciences, experiential learning comprises any of a variety of activities that engage students in the process of "learning-by-doing." It is hands-on and participatory, typically occurring outside the traditional classroom. Experiential learning provides opportunities for practical application of coursework, intellectual development, professional exploration, and personal growth. We propose a program of experiential learning in the sciences that will serve as a model for other disciplinary and interdisciplinary academic programs which incorporate an experiential learning component.

Why CLAS should support it: The education literature reveals that undergraduate research experiences enrich student learning by producing students with higher levels of academic and cognitive skill and confidence — students who begin to “think like scientists” (Hunter, et al. 2006). However, benefits extend beyond professional development; for example, there is evidence to suggest that participation in faculty mentored undergraduate research can result in increased retention of “at risk” students (Nagda et al. 1998). However, these benefits are not restricted to the sciences, but extend to other disciplines in the social sciences and humanities, as well (Ishiyama 2002). Although metropolitan Denver colleges and Universities variously support undergraduate research, no comprehensive programs or curricula in this area are currently available in the state; as such, UCDHSC is poised to take advantage of this opportunity to further distinguish our institution. Students will choose our campus for the prospect of participating in an educational environment that is stimulating, fosters creativity and generates authentic knowledge through faculty mentored undergraduate research.

The multidisciplinary program proposed here builds on existing strengths to explore the challenges and requisites of building interdisciplinary research programs. By design, it does not include a wide variety of disciplines at the outset, but seeks to develop a model based in fields where a strong tradition of research already exists and, among which significant interdisciplinary research is already taking place. Our endeavors will thus mirror the blurring of boundaries that is already apparent among the sciences, although clearly, similar movements are taking place in many other disciplines (note the creative approach taken by Professor York in his signature proposal melding poetry and publication). Boundary blurring in the sciences is a natural outgrowth of the discovery of mutual interests and complementary strengths among scientists who work in disciplines once thought to be distinct and even disparate. Furthermore, there is a growing realization that a significant proportion of “cutting edge” research is located in these areas of overlap, e.g., Environome Science. Interestingly, this development is hardly new in the sciences; biochemistry, materials science, and neurobiology, which have now emerged as disciplines in their own right, began as ‘interdisciplinary’ research. The

difference is the pace at which interdisciplinary research is growing, and its increasing centrality in the research arena. The American Chemical Society, for example, is growing in numbers of identified sub-disciplines to the extent that there are now open debates about whether an identifiable core discipline will continue to exist. In sum, the nature and shape of research in the sciences, and many other disciplines, is changing rapidly. It is fitting and necessary that our students, especially our undergraduates, participate in and appreciate this exciting evolution of our knowledge base.

Benefits to CLAS and the University: Implementation of this program of student engagement will provide a highly distinctive educational experience for students completing it, one which integrates well with the strategic goals of the Academic Master Plan Educational Approach and Engagement Signature Area. There are a number of specific benefits that will come to the college and institution as a result of expanding and institutionalizing undergraduate research:

- Research resonates with a wide range of undergraduates from diverse academic and social backgrounds. This includes many who have significant creative potential, but who may not have flourished in traditional classroom settings. More so than graduate programs, these programs bond students to the institution.
- Undergraduates who engage in research are more likely to stay focused academically, which will translate into increased retention and graduation rates for our campus.
- Assessment of undergraduate research experiences provides data for educational research measuring how UG research affects student learning and engagement. We are already involved with the Center for Ethnography and Evaluation Research (UCB) to plan assessment of these programs on our campus.
- Undergraduate research programs are more flexible and less expensive to initiate. They can serve as a way to explore and develop more advanced research programs as merited by results.
- Interdisciplinary research brings together the strengths of faculty from diverse departments, permitting us to develop innovative programs (e.g., Biophysics, Public Health).
- There are numerous opportunities for external funding for programs focusing on undergraduate research for which the University is already very competitive, and faculty are already writing grant proposals to support this work, often in conjunction with CASMIC.
- Undergraduate research provides an avenue for connecting with existing (e.g., CASMIC, CU-Succeed) and proposed programs (e.g., P-20 Education Signature Area) to develop pipelines from K-12 into UCDHSC and CLAS.
- Research connects the University to the community by addressing local concerns and by providing a steady stream of better educated, more socially, culturally and intellectually aware graduates.

How we can initiate it: We propose a new curricular program, a grants-in-aid program to support undergraduate research, and a seminar course focused on training undergraduates in and fostering multidisciplinary research on campus. In addition, we propose, as a longer-term goal, the establishment of a Director of Undergraduate Research to expand and apply the model described here across other undergraduate disciplines on campus.

I: Undergraduate Course Sequence in Multidisciplinary Research

Course 1: Methodology in Multidisciplinary Research: We propose a team-taught course sequence that will introduce the challenges, methods, and successes of multidisciplinary research in addressing real-world problems and give students hands-on experience in conducting such research. These courses would have a CLAS prefix, indicating that they are housed in the college

and across departments, rather than residing within a single department. Although the first semester can be taken as a stand-alone course, participation in the second and third semesters requires completion of the first course. Teams of two or more faculty from different departments will present real-world problems that demand multidisciplinary solutions. Cases will include the problem, the variables that need to be examined and tested, the experimental approach(es), techniques, and methods from various fields employed to address the problem, the outcome(s), and the implications of the research. A variety of types of cases could be presented that bridge the different departments; furthermore, the focus of the course will change with each offering depending on the faculty involved.

Example: Stress-related Disparities in Pregnancy Outcome. An example of a case that addresses the areas of community and health psychology might be the role of stress induced by poverty and racism on the incidence of premature birth. In this case, faculty from Psychology and Health and Behavioral Sciences would present the case and the types of multidisciplinary efforts that are ongoing to solve this real-world problem. In the later part of the semester, students will identify a problem they wish to address, form a research team, and work with at least two faculty members to research the problem, develop a detailed multidisciplinary approach to addressing it, and produce a research proposal. The proposals will be presented in a series of oral/poster presentations by student teams and graded based on both the faculty members' evaluations and those of the peer group.

Course 2: Laboratory Practicum: In the semester immediately following completion of Course 1, students may enroll in this second course. Participating students will receive hands-on research training in the methodologies relevant to the research project proposed in Course 1 by completing a laboratory rotation supervised closely by a faculty member. Students will function as research assistants, assisting faculty with their ongoing research while attaining the necessary skills to continue their own research projects. During this semester, the students, in conjunction with the faculty member, will revise and expand the research proposal from Course 1 into a full grant proposal that will be submitted to the grants-in-aid program upon mutual agreement of the faculty mentor(s) and students. Again, students may end their participation in the sequence here or, pending funding of their grant proposal, move into Course 3.

Example: Effects of Environmental Estrogens on Hormonal Modulation of the Menstrual Cycle. Faculty from the Departments of Biology, Chemistry, and Health and Behavioral Sciences would work with a group of students to examine the effects of exposure to environmental estrogens on serum levels of estrogen and progesterone in women of reproductive age and how these patterns are related to variability in the menstrual cycle. Implications for overall reproductive health and rates of infertility would be discussed from the community health standpoint.

Course 3: Independent Study/Honors Thesis in Multidisciplinary Research: Grant proposals submitted as an outcome of Course 2 will be reviewed for funding by a panel of faculty and students. Successful proposals will lead to Course 3 in which students work very closely with the faculty mentors to conduct, analyze, and report their research project. The student team will then produce a journal-quality manuscript and will present their scholarly activity at Research and Creative Activities Day. The goal will be to produce manuscripts that would be competitive for publication in peer-reviewed professional journals that students can then put on their CVs and graduate school applications.

Example: Randall Tagg and Arlen Meyers (SOM) have already created a model for this aspect of the curriculum in the the Auraria Emerging Technologies Prototyping Lab (AETPL). More than two dozen students from several science and engineering disciplines have worked on focused projects prototyping medical instrumentation and related technologies. Under a three-year grant from the National Collegiate Inventors & Innovators Alliance (NCIIA), student teams are working on eight research clusters in the medical technology arena. Many of these projects are undertaken with faculty "clients" and, thus, faculty from biology, engineering, and math have a stake in the outcome of this program.

II. Grants-in-Aid of Multidisciplinary Undergraduate Research. A competitive grants-in-aid program will be established to fund the aforementioned student research proposals following review as described above. Although these projects will be conducted in the laboratories of research active faculty, additional funding is necessary to support these projects independently of the faculty member's own research program. Funding provided by program fees, for example, would be used to offset these laboratory expenses. Up to one month of summer salary may also be provided as part of the grant package to both encourage faculty to take on these projects and to assure that they have sufficient time and support to mentor the student teams throughout the year.

III. CLAS 4990: Undergraduate Research Seminar (NOTE: Seminar to be cross-listed, e.g., GEOL 4990 and BIOL 4990). The Undergraduate Research Seminar will introduce students to a timely topic of broad interest through the primary and secondary literature that is state-of-the-field. This course will be cross-listed across disciplines (depending upon topic) and appeal to a diversity of students. Prerequisites may vary, but will reflect minimum expectations for intelligent discourse. Moderated group discussion will be supplemented by a modicum of lecture. The seminar will be coordinated by one faculty member, but will require the commitment of three or more contributing faculty members and the one-time participation of an expert in the field. While the coordinator will be compensated through a yet-to-be-determined load reduction, contributing faculty members will be compensated monetarily at a competitive rate.

Example: On the Origin of Life. This seminar will address the scientific discourse that is taking place with respect to the origin of life on earth. It will build on the founding principles of a variety of disciplines including geology (e.g., deep sea vents), chemistry (e.g., redox equations), biochemistry (e.g., chirality of organic molecules), cell biology (e.g., endosymbiosis, membrane theory), genetics and molecular biology (e.g., central dogma), microbiology (e.g., microbial diversity), evolutionary biology (e.g., Darwinian theory), and phylogenetics (e.g., cladistics).

IV. Director of Undergraduate Research. Finally, we propose establishing a Director of Undergraduate Research (DUR) who will provide the nexus for undergraduate research, creative, and entrepreneurial activities on the Downtown Denver Campus. The DUR's primary mission will be to identify, articulate and promote the unique nature and benefits of undergraduate research, thereby fostering a rich, distinctive culture of experiential learning that will attract outstanding students and faculty to study and learn together. To define a final shape for the signature program is oxymoronic, because it will emerge as vision forged jointly by the faculty and student body under the leadership of the DUR. New opportunities will continuously arise from the Program, and be incorporated into it. In short it will reflect the dynamism that lies at the heart of a vital university.

Five-Year Implementation Plan, including stages and goals: In the first two years, the program will build upon established research programs in the disciplines previously identified (biology, chemistry, physics, psychology, geography, environmental sciences and math. This will involve:

- (1) establishment of Undergraduate Research Seminars (CLAS 4990); discussions led by students and faculty will be accessible to participants in all these disciplines;
- (2) implementation of Course 1: Methodology in Multidisciplinary Research;
- (3) implementation of follow-up Course 2: Laboratory Practicum
- (4) implementation of grants-in-aid program, beginning with an interdisciplinary Summer Undergraduate Research program, developed with CASMIC;
- (5) focused efforts to overcome barriers to interdisciplinary research, such as (a) the requirement of major or minor declaration in a degree program for approval of independent study (2840/3840/4840), (b) ambiguities surrounding how excellence in such research will be measured and (c) how consequent faculty rewards will be distributed;
- (6) assessment of progress toward the goals of this signature program, especially the quality of student experiences and their impact on student competencies, will be conducted in collaboration with CEER at UC Boulder. Formal educational research and the development of appropriate participant demographics are essential tools in such assessments.

During the second two-year period, the summer undergraduate research program will be implemented, and the multidisciplinary research course will be entering its second and third cycles. Outcomes assessments for these programs will be ongoing, and analysis of these results and their application to program improvement will be in full swing. New investigators, programs, and departments will be invited to become involved and will be incorporated as the program moves forward. We will lay the groundwork for an Office of Undergraduate Research and the appointment of a Director.

In the fifth year and thereafter the Signature Program in research will move beyond being a model housed in the sciences. In conjunction with the Director of Undergraduate Research we will apply the model to support similar efforts in disciplines across the University. The experiences gained from the science model will help groups establish similar programs and sustain these activities. At the same time we will be looking toward ways to promote even broader interdisciplinary interactions. We do not intend to stop at the establishment of multidisciplinary work only among those fields that appear to have 'natural' affinities. As the acceptance of such interactions grows, and our experience of how to promote them deepens, we will look toward the discovery of multidisciplinary opportunities in unexpected places, too. Ultimately, these new areas of interaction and collaboration may be the ones that give our Signature Program its truly distinctive character. But finding these, and knowing how to nurture them, depends on the experience and support structures built in the early years, established and extrapolated from more familiar models.

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