CATALYZING CREATIVITY AND SUSTAINABLE INNOVATION IN TEACHING
ACTIVE LEARNING INITIATIVE

Call for Proposals to Departments
College of Arts & Sciences
September 2016

The dean invites departments across the College of Arts & Sciences to submit proposals for funds to substantially improve teaching and learning across significant dimensions of their undergraduate curriculum, particularly in large service courses. Grants are available to encourage and facilitate high-impact learning practices, technology enhanced learning, and a culture of educational excellence at the departmental and college levels.

This is the second iteration of a project launched by the college four years ago in response to calls from the White House,[1] the National Academies,[2] the Association of American Universities,[3] and an array of professional societies to improve college-level teaching in science and mathematics. These organizations were motivated by a growing body of new research, from both cognitive psychology and college classrooms, identifying a variety of pedagogical approaches that are significantly more effective than the traditional lecture-based format still used in most college teaching today.[4] The college's initial project has delivered impressive results. This new round is an opportunity to broaden that effort within the sciences and mathematics, but also now to include the social sciences and the humanities — placing the college and Cornell in the vanguard of an emerging national movement.

FUNDING
Funding is available to departments in two grant categories.

1) **LARGE GRANTS**
   Large, 3-6 year proposals involving a team of faculty and with the explicit purpose of affecting a sequence of important courses in a department's curriculum. There is funding for one or two large projects.
   Funding range: $500K - $1M.
   - This one-time investment is likely to be spent largely on people who help the faculty research, develop and test new materials and approaches, and/or free them from other teaching obligations for the project's duration.
   - Departments should consider employing teaching post-docs, or other disciplinary based education specialists with term appointments. There is considerable evidence, from many disciplines, that post-docs assigned to work closely with the faculty on course transformation greatly facilitate contributions from the faculty. Evidence also suggests that there is a good applicant pool for such positions in most disciplines, and that applicants will have good employment opportunities after Cornell. The college will help recruit and train teaching post-docs.
   - Funds can be used to help faculty develop research projects and publish on their teaching innovations, thereby extending the project's impact beyond Cornell.

2) **SEED GRANTS**

Seed grant proposals intended to allow departments to explore options that might lead to large-scale proposals. There is funding for several seed grants.

Funding range: $50K-$150K.

- These grants may be used for testing new pedagogical approaches.
- Grants may fund research projects that identify issues related to desired learning outcomes and to design, but not implement, new strategies to address them.

DESIGN OPPORTUNITIES

Proposals are encouraged from all areas of study, and may, for example, build upon design opportunities such as:

- Technology to facilitate and encourage students' active participation and collaboration in large courses, both inside and outside the classroom;
- Problem solving projects or case studies;
- Capstone projects;
- Experiential learning components;
- Synchronous online courses utilizing active-learning pedagogies.

Departments designing a proposal are also encouraged to consider connections with the current college-wide discussion of curriculum and graduation requirements.[5] New concepts for introductory courses within a department (or across more than one department) might connect with ideas for a college-wide set of foundational courses in a time-stamped scenario[6] or course design might employ experiential and problem-solving pedagogies[7] to support the a cross-disciplinary college-wide curriculum.

Other creative scenarios are welcomed. Please consult Section 1 and Appendices A + B for research and resources that can support department creativity and visions of scale.

DEADLINES AND PROCESS

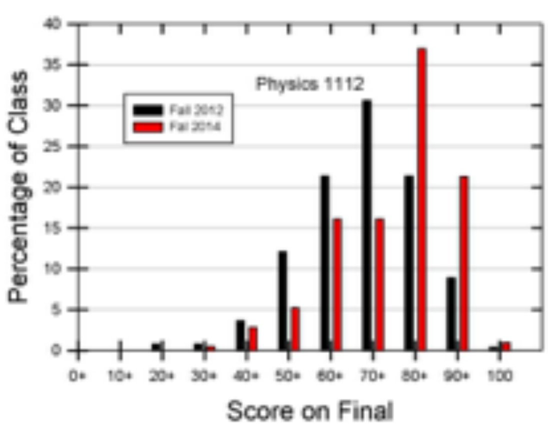
- November 1. Pre-proposal due. Two-five pages outlining major ideas, relevance of proposed changes and naming faculty members leading the proposed work.
- September-November. Pre-proposal discussions and development. Departments and/or faculty teams should meet with Peter Lepage (Director of Education Innovation) to discuss and develop proposed innovations, implementation plans, and strategy for sustaining change. Amy Godert (ama36) from the Center for Teaching Excellence is also available to consult on pedagogical strategies, assessment design, and faculty and staff training.
- January 10. Proposals due. Five-ten pages describing innovations and rationale, a schedule for faculty involvement and implementation, a plan for assessment of efficacy and outcomes, and a plan for sustaining the changes beyond the end of the project (without additional college funding). Seed-grant proposals will likely be shorter.
- Pre-proposals and proposals should be sent electronically to Peter Lepage (gpl3) and Amanda Kittelberger (abk36).
- February 3. Proposal awards will be announced by Friday, February 3, 2016.

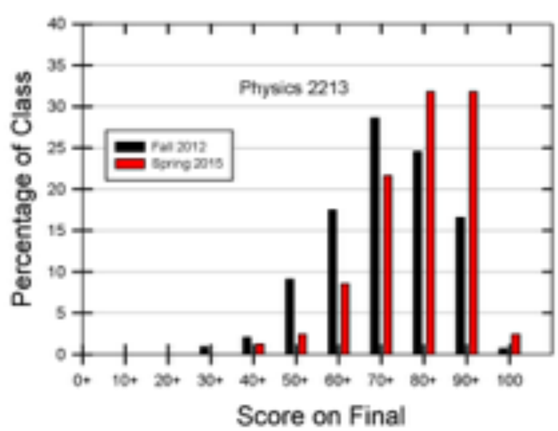
SECTION 1. CONTEXT AND RATIONALE

For four years, the College of Arts and Sciences has supported a donor-funded initiative to design and implement new active-learning pedagogies in STEM course sequences, informed by extensive research from the last two decades and experience with active learning elsewhere. These pedagogies emphasize:

- Deeper and more frequent student-student and student-instructor interaction (for half the class period or more) even when applied to large classes in traditional lecture halls.
- Structured out-of-class learning, for example, through pre-class readings or short videos, with online pre-class quizzes before every lecture to keep students up-to-date.
- Building a course backwards from carefully articulated learning goals for the course as a whole and by sub-goals for every class.
- Re-visioning course goals as less about the acquisition of particular facts, and more about imparting an expert's facility with the subject through deliberate practice of expert thinking/performance—an emphasis on what we want students to be able to do.[8]
- Use of fine-grained, real-time assessment of student learning in relation to the learning goals—information that that helps us improve courses but is also essential to students as they grapple with the course material and practice strategies for expert thinking.

Cornell is finding that teaching with active pedagogies can improve student achievement. Cornell's physics department introduced active learning in an extensive revision of its large introductory physics sequence for engineers and physical scientists. Student performance in the new courses has exceeded expectations.





The figures above show the distributions of student grades on (matched) final exams before (2012, black) and after (2014, red) introducing active learning. In each case *the entire grade distribution, covering everyone from the weakest to the strongest students, moved up by more than half a letter grade.* The number of students with failing or marginal grades was cut in half or more. Student evaluations from these courses were also significantly higher.

Cornell finds that teaching with active pedagogies helps close achievement gaps. In addition to the pedagogical revision of Cornell's introductory physics course sequence, two biology departments made substantial changes to selected large introductory biology courses. Based on final exam grades and a diagnostic test administered before and after BioEE1780 in 2014 and 2015, grades and learning gains increased for all students in the new course, but that the increase was much larger for students from under-represented minority groups, *completely eliminating a performance gap between white and URM students apparent in the results from the pre-active-learning class*. These data were collected by a post-doc and faculty members involved in the course redesign, and have been submitted for publication.

Across disciplines, experience here and elsewhere indicates that teaching with active pedagogies increases students' critical thinking and reasoning skills. While the college's first large-scale and heavily funded innovations focused on physics and biology teaching, the College of Arts and Sciences is fully committed to exploring and funding new pedagogies in disciplines in the humanities and social sciences as well as in STEM-related fields. The college is already funding a small-scale project in anthropology.

The college's initial efforts were grounded in extensive research about how people learn.[9] This research is not specific to STEM subjects. Liberal arts education, for example, is particularly adaptable to active pedagogies given the priorities placed on learning outcomes like critical thinking, integrative and synthetic thinking, intercultural knowledge, and persuasive expression. What we teach is, of course, highly discipline specific. Indeed, the growing research emphasis on teaching expert thinking/performance gives an essential role to the disciplinary expert (and the research university).[10]

During her tenure at UT Austin, Dean Ritter directed the Course Transformation Program (CTP) which explored active learning efforts in the social sciences and humanities. For instance, a CTP project in psychology was used to develop TOWER (Texas Online World of Educational Research), a learning platform developed by Professors James Pennebaker and Samuel Gosling for use in the large introductory psychology course. The TOWER system allows for personalized online quizzes, daily chat and survey exercises, and provides free online readings. Early analysis indicated that teaching the class with the TOWER system improved attendance and learning outcomes, especially for students from lower socioeconomic backgrounds: with active learning, grades shifted upwards by half a letter grade and achievement gaps shrank by half.[11]

In another innovative Course Transformation Program project in English, Professors Philip Barrish and Evan Carton led a team of faculty in developing CRIT (Close Reading Interpretive Tool) a web based application that supports the development of critical reading skills among undergraduate students in the sophomore level comparative literature course (E316K) which is the largest undergraduate humanities course taught at UT Austin with annual enrollments of over 5,000 students.[12] Early assessments indicated that teaching with CRIT substantially improved the critical reading abilities of students in the course.

These examples suggest that discipline appropriate approaches can be developed that employ active learning techniques and educational technologies to improve student-learning outcomes in lower division foundational courses in any field.

SECTION 2. PRE-PROPOSAL SUBMISSION

Deadline: Tuesday, November 1, 2016

The pre-proposal process is meant to provide departments feedback that helps them develop successful proposals. Department chairs are strongly encouraged to meet with Peter Lepage before submitting their pre-proposals. Further meetings will be scheduled after the pre-proposals have been reviewed.

Departments may also want to consult Amy Godert, from the Center for Teaching Excellence, for advice on design, assessment and training. The college has (limited) funds available for departments to bring other consultants to campus or to send faculty to visit programs elsewhere. Chairs should contact Peter Lepage with requests.

Pre-proposals should be two to five pages long and should include:

- Identification of the targeted courses or course sequence.
- An outline of major ideas for new, creative change(s) in the pedagogy of a foundation or distribution course or course sequence.
- Discussion of relevance and/or importance of proposed changes to departmental curriculum, majors, and minors.
- The names of faculty members leading the proposed work and the role(s) they've agreed to fill.
- Identification of new staff positions, such as term-appointed teaching post-docs or other disciplinary based education specialists.
- Description of the process by which the department faculty as a whole will discuss and approve the proposal. A significant part of this discussion should precede the pre-proposal.

SECTON 3. PROPOSAL SUBMISSION

Deadline: Tuesday, January 10, 2016

Teaching with new pedagogies should be no more expensive than traditional teaching, but the cost of converting from old to new can be considerable. The grants in this competition are meant to cover this cost.

FACULTY SUPPORT

Proposals should include clear and concrete information regarding faculty support and incentives that recognize their substantial work as innovators and also for their collective responsibility to sustain effective innovations. To make it feasible for active faculty to participate, departments are encouraged to considered options and incentives, even those typically viewed as too costly, in the fundamental project design. Some examples might be:

- Teaching post-docs
- Teaching relief
- Summer salary
- Faculty bonus awards
- External evaluation or collaborations
- Cross-department partnership

DEPARTMENTAL SUPPORT AND SUSTAINABILITY

Proposals should emphasize projects that are promoted by entire departments. Where large-scale teaching innovation has worked well, it has almost always involved a team of professors working with the active support of their department chair and the positive encouragement of their colleagues. Change that enjoys this level of support is far more likely to survive into the future, as teaching teams and departmental management change.

ASSESSMENT AND EVALUATION

The departments running projects in the existing program have developed various strategies for evaluating the impact of their projects on student learning. The results from such assessments are highly rewarding for the faculty involved, and often useful for informing further changes. Such results also tend to capture the attention of the other faculty in a department, stimulating broader discussions about the department's curriculum and pedagogy. The college, with help from CTE, is eager to help departments develop such strategies for their own projects; these should be discussed in proposals.

Proposals should be five to ten pages long and should include:

- A leadership/oversight plan for the entire project.
- Discussion of proposed pedagogical innovation. What is different? Why? What is the significance of the project to the curriculum and to the department's student learning outcomes? For courses fulfilling a distribution requirement, what is the significance for the college's student learning outcomes?
- Outline of the scope of expected pedagogical changes: numbers/levels of students affected, numbers of cross-college student enrollments or cross-departmental enrollments, inter-connection with existing college or university initiatives, impact on majors/minors, etc.

- Plan for assessing and evaluating the proposed pedagogical changes in terms of student learning outcomes.
- Plans for faculty support and incentives. Incentives work best when they come after the project has been completed.
- Discussion of the long-term sustainability of the proposed change(s) and succession plans that will allow innovations to out-live the original team of innovators.

Seed-grant proposals will be shorter but cover much of the same material.

Additional pages accompanying the proposal:

- *Budget request*: Format to be provided by the college.
- *Detailed work plan*: Project timeline for changing/creating courses that identifies specific courses, critical milestones, and participating faculty names, roles, and schedules.
- *Department process* used for department-wide review and approval of the proposal.

APPENDIX A. RESOURCES TO GROUND PRE-PROPOSAL DISCUSSIONS

Cornell's Center for Teaching Excellence (CTE) is working with the college to support departments as they prepare proposals. They offer reference materials on many aspects of teaching, including active learning: see, https://www.cte.cornell.edu/teaching-ideas/engaging-students/active-learning.html.

The college's program was inspired by and to some extent modeled after the science education initiatives at the University of British Columbia (CWSEI) and at the University of Colorado at Boulder (SEI): see, http://www.cwsei.ubc.ca/ and http://www.colorado.edu/sei.[13] Having helped more than 250 faculty members introduce active learning into their teaching across several disciplines, the CWSEI and SEI have created rich online resources to help departments and faculty members redesign courses. While targeted at STEM teaching, much of this material should be applicable in other disciplines. Useful links include:

- http://www.cwsei.ubc.ca/resources/course_transformation.htm: a collection of documents offering detailed advice for departments and faculty members on how to redesign courses.
- http://www.cwsei.ubc.ca/resources/instructor_guidance.htm : a collection of short guides for instructors—on assessment, clicker use, student engagement, etc., etc.—that illustrates in concrete terms the pedagogical philosophy (active engagement of students) underlying these initiatives. The advice is highly practical.
- http://www.cwsei.ubc.ca/resources/SEI_video.html: a collection of videos that show, among other things, what active learning looks like.
- http://www.cwsei.ubc.ca/resources/papers.htm: an annotated bibliography of papers on the research behind many aspects of active learning.

APPENDIX B.   A Research Sampler on STEM Teaching

What follows is a small sample from the thousand plus research papers on active learning and STEM teaching. For the most part these are written by faculty from the disciplines being taught. The references themselves are links: click on them to read the articles.

S. Freeman et al, *Active Learning Increases Student Performance in Science, Engineering and Mathematics,* PNAS 111 (2014) 8410: Following meta-analysis practices from medicine, these authors examined more than 200 articles, from 8 disciplines, on the impact of active learning. They find among other things that grades increased by half a letter grade with active learning (Fig. 2), and failure rates decreased by a third (Fig. 1B). They note that current standards for medical research would make it unethical to use conventional lecturing as a control in education research because of the damage it inflicts on students in the control group. Carl Wieman's commentary on this article provides an accessible and interesting summary of the paper's results and their implications: PNAS 111 (2014) 8319.

L. Deslauriers et al, *Improved Learning in a Large-Enrollment Physics Class,* Science 332 (2011) 862: This paper describes an experiment where a large introductory physics class was split in two for a week in mid-semester, with one group taught conventionally and the other using active learning. Student learning was assessed with an in-class test given after the intervention, but designed beforehand. The entire grade distribution was shifted up two letter grades in the active-learning group (Fig. 1). The authors also measured student attention levels during class (using a standard protocol) and showed it doubled in the new format. This kind of improvement has long been apparent in introductory physics courses: see R.R. Hake, Am. J. Phys. 66 (1998) 64, for a famous early study of 62 introductory courses at 62 institutions (see Fig. 2).

M.K. Smith et al, *Combining Peer Discussion with Lecturer Explanation Increases Student Learning for In-Class Concept Questions,* CBE—Life Sci. Ed. 10 (2011) 55: This semester-long controlled study, in two biology courses, compared the relative impacts of peer discussions (student-student) and instructor explanations on students' ability to absorb new concepts in class. They found that peer discussion followed by an explanation from the instructor was twice as effective as either peer instruction or an instructor explanation alone (Fig. 4A). By itself, peer discussion was slightly more effective than instructor explanation, but the difference was not statistically significant except for the *strongest* students in the class—peer discussion was twice as beneficial for them as instructor explanation (Fig. 5A). These results indicate that lecturing can be very powerful provided the students are first engaged; and strong students benefit even more than the others from peer discussion. Lead author, Michelle Smith, will be on sabbatical at Cornell (in EEB) in 2017-18.

N.G. Holmes et al, *Teaching Critical Thinking,* PNAS 112 (2015) 11199: This controlled study, in a freshman-level physics lab, shows how directed practice taught students to make expert-like decisions about data: Do the data prove anything? How should the experiment be changed to improve the data? Do the data disprove the model? How must the model be changed? And so on. The directed practice was phased out during the semester. By the end, students in the experimental group were outperforming the control group by factors of 5-10, and they continued to outperform in a subsequent course (Figs. 1 and 2). Lead author, Natasha Holmes, will be joining Cornell's physics department, as an assistant professor, in January.

R.E. Mayer et al, *Increased Interestingness of Extraneous Details in a Multimedia Science Presentation Leads to Decreased Learning*, J. Exp. Psych. Applied 14 (2008) 329: These authors show that including high-interest anecdotes or other appealing but extraneous material in a presentation damages learning. This surprising result is thought to reflect students' limited processing capacity for new knowledge: cognitive overload interferes with learning. This interpretation is supported by a completely different study: L. McDonnell et al, *Concepts First, Jargon Second Improves Student Articulation of Understanding,* Biochem. Mol. Bio. Ed. 44 (2016) 12. This study shows that removing jargon words from pre-class readings in a biology course doubled students' retention of the concepts covered by the reading (Fig. 2), without damaging their knowledge of the jargon (which was introduced in class).

H. Pashler et al, *Learning Styles–Concepts and Evidence,* PSPI 9 (2008) 105: This survey shows that there is essentially no evidence for the widely held belief that students learn more when teaching is tailored to their preferred learning styles. A shorter, more accessible account of these findings can be found in the Wired article by C. Jarrett (Jan 2015). This work suggests it is not worthwhile worrying about learning styles. In particular, there is no evidence that video is generally more effective than text for out-of-class study—it depends upon what is being taught. Bror Saxberg, Kaplan's Chief Learning Officer, spoke recently at Stanford (2015) about a Kaplan study, involving about 500 students, of Kaplan's professionally produced interactive training video on LSAT logic problems. They compared the impact of the video with that of 8 PowerPoint slides of text covering the same material. The 8 PowerPoint slides were significantly more effective; indeed, the video was slightly less effective than doing no training at all.

[1] https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf. Peter Lepage was a co-chair of the working group involved in this report. See also https://www.whitehouse.gov/blog/2016/08/17/call-action-incorporating-active-stem-learning-strategies-k-12-and-higher-education.

[2] http://www.nap.edu/catalog/13362/discipline-based-education-research-understanding-and-improving-learning-in-undergraduate.

[3] https://stemedhub.org/groups/aau. Peter Lepage is on their Technical Advisory Committee.

[4] For an overview see the articles by Carl Wieman and Sarah Gilbert in Microbe, Vol. 10(4), 152 (2015) and 203 (2015). Download copies from: http://www.cwsei.ubc.ca/SEI_research/files/Wieman-Gilbert_ScienceEd-pt1_Microbe_2015.pdf and http://www.cwsei.ubc.ca/SEI_research/files/Wieman-Gilbert_ScienceEd-pt2_Microbe_2015.pdf.

[5] Managed by the Curriculum Committee: http://as.cornell.edu/curriculum.

[6] http://as.cornell.edu/scenario-two

[7] http://as.cornell.edu/scenario-three

[8] The emphasis on deliberate practice stems from recent research indicating that the extent to which students engage in such practice is more important to their ultimate success than their a priori proclivity for the subject. This is contrary to conventional wisdom about STEM teaching, much of which has functioned in the past as a filter for selecting people who are "good at science." For a popular account of the research see the article by P. E. Ross in the August 2006 *Scientific American*, (vol. 295, 64-71); this has references to the scholarly literature.

[9] See, for example, Susan Ambrose and collaborators, *How Learning Works* (Jossey-Bass, 2010). A more technical survey is given by John Bransford and collaborators, *How People Learn* (National Academy of Sciences, 2000).

[10] See footnote 6. For a primer on expert learning from STEM fields, see Adams, Wieman, Schwartz, "Teaching Expert Thinking," July 2008.

[11] http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0079774.

[12] https://laits.utexas.edu/crit/home.

[13] These initiatives were created by Carl Wieman who won the 2001 Nobel Prize for his research on fundamental physics. Wieman has also worked on science education research for decades.