# Active Learning Initiative Postdoctoral Fellowship
# 2023 Department Grant Competition

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## Call for proposals from departments

The Provost's office, together with college Deans, are inviting applications for the Active Learning Postdoctoral Fellowship. Building on the success of the Active Learning Initiative, which funded departmental proposals from 2012-2022, the Active Learning Initiative Fellowship program invites departments to apply for grants that support a teaching postdoc to work with a team of faculty members who want to introduce active learning into their courses. These grants provide a unique opportunity for faculty who are new to active learning and want to learn more or for those who want to expand upon initial efforts in implementing these teaching strategies. This ALI competition is open to undergraduate and graduate departments across the university.

Previous ALI projects have delivered impressive results in nineteen departments encompassing humanities, social sciences, and STEM courses. So far more than 100 Cornell faculty have worked with an ALI postdoc to improve their courses. Department chairs report that ALI projects have been transformative for the teaching cultures within their departments.

Teaching postdocs work closely with the faculty on course transformations and greatly facilitate improvements in student learning by helping faculty research, develop, and implement new teaching materials and approaches. The postdocs have PhDs in the appropriate discipline and a strong interest in teaching. The Center for Teaching Innovation (CTI) trains teaching postdocs to be education specialists embedded within their departments. Experience at Cornell and elsewhere indicates that there is a large supply of capable and interested candidates for such jobs in most disciplines, and good jobs for them afterwards.

The grant will cover the postdoc's salary[1] for three years, recruitment and setup costs for the postdoc, and some funding to cover the postdoc's research and travel. The grant will also provide $30K per year to be shared among the faculty involved in the project. This is to facilitate and encourage faculty participation through teaching relief, summer salary, or other mechanisms. Project support is also provided by a central ALI team within the Center for Teaching Innovation.

[1] Benefits will also be provided where they are not normally covered by the colleges.

## Funding and schedule

This competition is funded by the University Provost and the college deans. The grants are for $384K spread over three years (see table below) and are available to departments for projects starting in the summer/fall of 2024. Grants typically support the redesign or design of 3–5 courses and involve teams of faculty who are scheduled to teach these courses in the next three years. Proposals may include courses of all sizes and level from large introductory courses to smaller senior capstone courses and graduate courses.

Grant applications are submitted by department chairs after projects have been reviewed and endorsed by the departments' faculty. Department chairs and their faculty teams should meet with Peter Lepage, Director of the ALI (g.p.lepage@cornell.edu), early in the process of developing their proposals. We also recommend that department chairs discuss their plans with their college. They can also consult teaching specialists from the Center for Teaching Innovation (CTI) for advice on pedagogical strategies, assessment design, and approaches to teaching with technology; contact Carolyn Aslan, Associate Director of the ALI, in CTI for more information (crc1@cornell.edu).

*Three-year budget (supporting one postdoc)*

**Grant Budget (starting Fall 2024)**

| | FY25 | FY26 | FY27 | Total |
|---|---|---|---|---|
| **Postdoc salary** | $65,000 | $66,950 | $68,959 | $200,909 |
| **Benefits** | $24,050 | $24,772 | $25,515 | $74,337 |
| **Office + computer** | $5,000 | | | $5,000 |
| **Moving** | $5,000 | | | $5,000 |
| **Conference travel/research** | $3,000 | $3,000 | $3,000 | $9,000 |
| **Recruitment** | $500 | | | $500 |
| **Faculty support** | $30,000 | $30,000 | $30,000 | $90,000 |
| **Total** | **$132,550** | **$124,722** | **$127,474** | **$384,746** |
| **From ALI** | **$66,275** | **$62,361** | **$63,737** | **$192,373** |
| **From College** | **$66,275** | **$62,361** | **$63,737** | **$192,373** |

Important dates for this competition are:

> ***October 20: Optional*** **Draft proposals are due.** Departments can submit a draft proposal for initial review and discussion. Although this step is optional, we strongly recommend it.

***October – November*: Department team meetings.** Peter Lepage and Carolyn Aslan would like to meet with each department team planning to submit a proposal to discuss and help develop the proposed innovations, implementation plans, and strategies for sustaining changes. This meeting should include all the instructors who are interested in teaching a transformed active learning course and participating in the project.

***Dec 1, 2023:* Final proposals are due.** These should be five–ten pages long, 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 funding). See discussion below for more information.

***January 2024:* Proposal awards will be announced.** Winning proposals will be selected by the Vice Provost for Academic Innovation, with input from internal reviewers and in consultation with the college deans. Departments can begin the hiring process for postdocs, who typically start in the summer to begin work on fall courses.

Proposals should be submitted electronically to Carolyn Aslan at ali-admin@cornell.edu. If you would like to see examples of previous successful proposals, please e-mail us.

## Context and rationale

Extensive research from the last 20–30 years, much of it "discipline-based education research" in college classrooms, has led to new, highly effective pedagogies that are quite different from conventional lecturing. The new pedagogies emphasize active learning, with much more interaction among students, and between students and instructors than in the traditional format, even when applied to large classes in lecture halls.

These methods emphasize building a course backwards from carefully articulated learning outcome goals for both the course as a whole and also broken down into specific sub-goals for every lecture. The goals are 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. These methods generally incorporate time in class for students to process what they are learning, discuss it with others, and practice or apply their knowledge. Opportunities are provided for fine-grained, real-time assessment and feedback (multiple times in every class) — information that is essential to the students themselves as they grapple with the course material.

A large and growing research literature (many hundreds of papers), from both cognitive psychology and college classrooms, shows that these new pedagogical approaches are significantly more effective than the traditional lecture-based format still used in much college

teaching today (see Appendix D for examples). And faculty who have tried these approaches report that they are far more engaging for both instructor and student.

Since 2012, the Active Learning Initiative has supported successful course transformations in 19 departments. Early successful results in Biology and Physics motivated the expansion of the initiative to the humanities, social sciences as well as other STEM disciplines. Students now use active learning strategies to debate the impact of social inequality (Sociology), explore ancient societies through hands-on experience of their material cultures (Classics), probe the structure of music using electronic keyboards in class (Music), and practice modeling dynamic systems in the life sciences (Math).

In addition to common and effective active learning strategies (classroom polling, think-pair-share, structured worksheets, small-group discussions), ALI instructors at Cornell have been designing innovative projects and assignments that give students more agency over their learning through student-directed lab experiments (Physics), semester-long projects (Natural Resources, Economics, Engineering, Classics), video assignments (Plant Sciences, Engineering), and at-home lab kits (Engineering, Classics). More information about the variety of previous grant projects can be found on our website.

## Faculty collaborations with postdocs on course transformations

Creating an active-learning course is time consuming. Faculty need to develop clear learning goals for the course, absorb often large amounts of research on how to teach their topics, design large amounts of new pedagogical material (for example, the in-class questions, problems, or activities), and create or revise tools for assessing the impact of the new instructional methods. The major cost of the current and earlier ALI projects has been in hiring teaching postdocs who make it possible for the faculty to do this work.

The Center for Teaching Innovation (CTI) trains teaching postdocs to be education specialists. Funding supports a postdoc for three years, so they can work on multiple iterations of courses through several semesters. Postdocs are expected to work in-person in Ithaca and attend and assist faculty during the in-person classes (unless circumstances require a return to remote teaching). Part of the responsibility of the lead faculty member on the grant is to help supervise and mentor the postdoc.

More information about the roles of teaching postdocs can be found in Appendix C. We also recommend a handbook developed for similar initiatives at UC Boulder and the University of British Columbia https://open.ubc.ca/the-science-education-initiative-handbook/, which guides faculty on starting a course transformation project and effectively collaborating with embedded teaching specialists (postdocs).

Active learning course transformation projects work best when instructors are both enthusiastic about transforming their course and also realistic about the time commitment that is needed to

effectively collaborate with a teaching postdoc. We recommend that department chairs draft a letter to each participating faculty member outlining the expectations and incentives in detail for faculty to sign to signal their commitment. All of the involved faculty should be willing to commit to the following within the time period of the project.

- Spending at least two semesters implementing significant revisions to an existing course or designing a new course. Preparatory work needs to happen in the summer or semester before teaching.
- Collaborating with a postdoc in clarifying learning outcomes, identifying where students are struggling, designing learning activities and assignments, and assessing student learning and experiences in their course. Usually this involves meeting on a weekly basis.
- Being open to trying new teaching strategies.
- Getting feedback about their course by inviting an observer from the central ALI team to visit their class a few times a semester, meeting with the ALI team consultant before classes begin and at least once during the semester, and collecting student feedback through a mid-semester survey.

## Proposal submission (deadline Dec 1, 2023)

Department chairs and project lead(s) are strongly encouraged to submit a draft proposal (deadline Oct. 20, 2023) and meet with Peter Lepage and Carolyn Aslan before submitting their final proposals. Departments may also want to consult Carolyn Aslan and other CTI consultants for advice on design, assessment, and teaching strategies.

Before the proposal is submitted, a meeting that includes the department chair, the project lead(s), and all the faculty who will be working on a course redesign project should be arranged with Peter Lepage or Carolyn Aslan. Proposals should be sent electronically by department chairs to Carolyn Aslan (ali-admin@cornell.edu) by December 1, 2023. They should be five to ten pages long and address:

> ***Courses:*** Identify the targeted courses or course sequence. Include information about the courses and their context, such as: course numbers and titles, 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, relation to distribution requirements and/or department/college learning goals and curriculum, etc.
>
> ***Changes and rationale:*** Describe the changes being made to the courses and the rationale for those changes. List any specific learning challenges that are being addressed.

*Faculty:* Identify the faculty lead(s) for the project, and the other faculty who will be working on courses in the project. Discuss any plans for department meetings or workshops to discuss progress and share teaching ideas.

*Timeline:* Create a timeline similar to the one below (see table) indicating which course and faculty member(s) the postdoc will be working with each semester. It can be beneficial to include two iterations of a course in the grant timeline to allow time to revise and improve the course. In our experience, a postdoc can effectively work with one, sometimes two, courses each semester depending on the size of the teaching team and the extent of the transformation. The postdoc should be assigned to work with at least *one course* each semester.

| Semester | Course number and name | Faculty member (s) |
|---|---|---|
| Fall 2024 | | |
| Spring 2025 | | |
| Fall 2025 | | |
| Spring 2026 | | |
| Fall 2026 | | |
| Spring 2027 | | |

*Backup faculty and courses:* Sometimes plans need to change if faculty go on leave or course schedules are altered. Please indicate two back-up courses and faculty members that could be substituted for the primary courses listed in the timeline.

*Assessment:* Describe plans for assessing the proposed pedagogical changes and their impact on students (and faculty). An assessment plan is essential for improving and refining initial instructional designs, and also for convincing students, faculty, and others that the project is/was worthwhile; see Appendix B for some ideas. If you are uncertain about the best ways to assess impacts, we are happy to meet with you and help develop a plan.

*Sustainability:* Discuss the long-term sustainability of the proposed changes, such as archives of course materials, and faculty succession plans that will allow innovations to out-live the original team of innovators.

*Department review process:* Proposals must be submitted by the department chair, after review by the department faculty. Describe the process used for departmental review. This typically involves discussion at one or two faculty meetings, followed by a vote.

Proposals will be reviewed by internal reviewers with experience in active learning and higher education initiatives. These reviews will be shared with the college deans, who will review and prioritize projects from their colleges. Final funding decisions will be made by the Vice Provost

for Academic Innovation based on information from the reviewers and the colleges, as well as university priorities.

## Project support from CTI

The ALI's support services are provided by the Center for Teaching Innovation (CTI). A central ALI team within the CTI consults with ALI departments on proposal development, course design, research-based teaching methods, and strategies for assessment and sustainability. They help train ALI faculty and, especially, teaching postdocs, and provide education technology support, as needed. CTI organizes ongoing activities that encourage faculty and postdocs from different ALI projects to interact with each other and share ideas. CTI helps departments measure their progress, and the impact of their redesigned courses on student learning and experiences, through methods such as class observations, mid-semester student surveys, and data from student learning assessments.

## Project reporting and dissemination

Chairs of ALI departments submit annual (in June) progress reports to the ALI, for review by the Vice Provost for Academic Innovation and the relevant college deans. Reports detail changes that have been made to courses, assessments of their effectiveness, and plans for further improvement, as well as impacts on teaching and discussions within the department as a whole. Postdocs also submit end-of-semester progress reports on their work to the ALI director and associate director. Department chairs submit a final report after their projects conclude.

ALI faculty are invited to discuss and explain their course redesign projects to other Cornell faculty at university events hosted by the Provost or CTI, or college events such as the CALS Learning Experience. ALI faculty also meet together at least once a semester to discuss their projects and share ideas and resources. ALI faculty and postdocs are encouraged to disseminate teaching resources and research results from their projects through publications, and presentations at disciplinary conferences. Presentations and teaching workshops within your department are also highly encouraged.

## Appendix A. Resources to ground pre-proposal discussions

The ALI was inspired by Carl Wieman's 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, as well as Wieman's book Improving How Universities Teach Science (Harvard, 2017). 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 is directly applicable in other disciplines. Useful links include:

- https://open.ubc.ca/the-science-education-initiative-handbook/: this handbook guides faculty on starting a course transformation project and effectively collaborating with embedded teaching specialists (postdocs)
- 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.—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. Creating a course assessment plan

Structured assessment is essential when redesigning a course. It provides information about what is working well and what could be improved. Assessment methods can help to target the development of teaching materials and methods by identifying which topics or skills student struggle to learn well. Assessment data is also essential for a department to document its progress for their dean and for the ALI.

The Center for Teaching Innovation (CTI) can work with each department to develop a customized assessment plan. CTI can also assist departments through the process of obtaining permissions for human research studies from the Institutional Research Board.

Possible assessment strategies include:

> ***Grades, scores, tracker questions, and concept inventories:*** Direct measures of learning are important when evaluating a new pedagogy. This data might include final grades, scores on exams or assignments, scores on components of a rubric, or points given to individual exam questions (such as tracker questions reused, in disguise, from one semester to another). Tests, often called concept inventories, can be given to students at the beginning of a course or a unit, and the same questions asked again at the end of the course or unit to measure how much students have learned.
>
> ***Mid-semester feedback:*** Mid-semester feedback from students allows instructors to address and resolve issues with a course before the semester ends. CTI administers a mid-semester feedback program and can distribute survey questions to students and

then report and discuss the information with faculty. Other options for mid-semester feedback include minute papers or polling questions asking for anonymous responses to questions.

*Class observations using COPUS (Course Observation Protocol for Undergraduate STEM):* With the COPUS protocol for class observations, a trained observer from CTI comes to class several times a semester and records the type of activity happening during two-minute intervals (for example: lecturing, group work, class discussion, polling question, students writing etc.). COPUS observations can help instructors find the right balance between time spent on different activities. They also document changes in the course over time.

*Student attitudes, motivation, confidence, and sense of belonging:* Surveys, focus groups, or interviews can assess factors such as student mindset, motivation, confidence, and attitudes towards the subject material and learning experiences in your course. For example, some initial findings indicate that Cornell ALI courses improve students' sense of self-efficacy and confidence in science. Other ALI departments are researching student motivation and attitudes towards the discipline. Awareness of metacognitive strategies has been another area of interest for some departments in the initiative. Some departments are also using structured interviews to learn more about student misconceptions about course material and their experiences in learning.

*Long-term studies (various options):* 1) A longitudinal study can be designed to retest students and assess how much knowledge they retain after six months, a year, or in upper level courses; 2) one could survey or interview faculty and TAs teaching upper level courses within the major to ask them about the level of student preparation for their courses; 3) one could also examine trends in enrollment numbers, students majoring or minoring in the department, or taking a second or third class in the department.

*Student reflections about their own learning:* Reflection can take the form of "minute papers" (short responses to a prompt, for example "what was the most interesting concept you learned today?"). Other options include reflective responses on an online class forum after a discussion, or a reflective essay at the end of the semester. Instructors can also ask students the same reflection question at the beginning of the course and the end of the course (for example: "what relevance do you think this course will have for your life outside of this class?").

*Faculty development and engagement with active learning:* Faculty can measure and document changes in their teaching practices by completing the Teaching Practices Inventory survey before and after a project. Other options include documenting faculty perceptions and experiences implementing active learning, how their attitudes towards teaching have changed, and what changes they have noticed in their classes and with students. Surveys, interviews, and focus groups with faculty and TAs are possible.

## Appendix C. Working with an Active Learning Initiative fellow

Active Learning Initiative department grants give you the opportunity to work with an ALI fellow (postdoc) to improve your course and develop active learning questions, activities, assignments, and other materials. Based on many conversations with previous ALI faculty, we've distilled the following advice.

**Five tips to make it a positive experience:**

- ***Set up regular weekly meetings*** with the ALI fellow.
- ***Identify the trouble spots*** in the course – i.e., which topics or assignments do students struggle with the most? Focus on improving these areas.
- ***Enjoy the intellectual and creative process.*** In the best collaborations, ALI faculty and fellows bounce ideas off each other to develop engaging, innovative, and enjoyable activities that foster interaction and create a positive learning experience for students.
- ***Choose one or two active learning strategies*** and become comfortable with incorporating them into each class. Set up a routine in class so students become accustomed to what is expected.
- ***Allow enough time for activities in class.*** Be willing to shorten parts of your lecture and let go of some content. Consider asking students to read ahead of time or complete other pre-class work to learn some of the basics so that there is more time for them to practice, discuss, and get feedback during the class time.

**A few things that can cause difficulties:**

- ***Don't wait until the last minute*** to make changes and design activities with the ALI fellow. Start planning and meeting during the summer or the semester before you are teaching the course.
- ***Design learning activities that can be easily implemented*** and updated by yourself and other instructors in the future. Remember that the ALI fellow will eventually leave, and the changes should be sustainable.
- ***Take time to involve and train TA's*** if they are expected to implement or help with active learning activities. TA's can also help design and give feedback on learning activities.

**Generally, within a department, ALI fellows will:**

- ***Collaborate with faculty*** on course transformation projects to implement active learning. Typically, an ALI fellow will focus on one course each semester, with secondary work for one or two other courses.
- ***Serve as a resource*** within their departments (consult with faculty, organize seminars or workshops about teaching)
- ***Collect and analyze evidence*** of student learning and experiences to guide course improvements

**Typical timeline for a course transformation project:**

*Before the semester starts, an ALI postdoc can collaborate with faculty to:*

- Refine or develop learning outcomes.
- Identify aspects of the course that most need improvement: i.e., areas where students tend to struggle.
- Decide on one or two main types of active learning strategies to implement throughout the semester (e.g., polling questions, think-pair-share, worksheet activities, group work, problem-solving etc.).
- Design learning materials (i.e., activities, worksheets, polling questions, assignments etc.)
- Develop assessments of student learning and experiences (pre/post quizzes, surveys, rubrics, revise prelims etc.)
- Review educational literature to identify best practices to implement
- Develop TA instructions and training materials

*While the course is being taught the ALI fellow can:*

- Sit in and observe the classes, take notes on student engagement, length of activities, reflections on how things are going, troubleshoot technology.
- Move around the class to help students during activities.
- Co-teach: some ALI fellows lead activities or teach parts of class sessions.
- Help train and mentor TAs in implementing active learning in sections, labs etc.

*After the semester ends:*

- Analyze student data to inform educational changes and course revisions.
- Make improvements to activities, assignments, assessments etc.
- Develop new materials for the next iteration of the course.
- Archive curricular materials for use in upcoming semesters.
- Author or co-author publications and/or presentations.

## Appendix D. A short research sampler on teaching

What follows is a small sample from the thousand plus research papers on active learning and teaching. Research in Cornell classes both confirms and extends these findings (selected ALI research publications). Books that offer more systematic surveys include: D. Schwartz et al, The ABCs of How We Learn (Norton, 2016); S. Ambrose et al, How Learning Works (Wiley, 2010); and J. Bransford et al, How People Learn, (National Academies Press, 2000).

S. Freeman et al, Active Learning Increases Student Performance in Science, Engineering and Mathematics, PNAS 111 (2014) 8410: Following meta-analysis practices familiar 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 in the paper), and failure rates decreased by a third (Fig. 1B). They question

whether, in light of these results, it is ethical to use conventional lecturing as a control in education research given 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.

Theobald et al. Active Learning Narrows Achievement Gaps for Underrepresented Students in Undergraduate Science, Technology, Engineering, and Math, PNAS 117 (2020) 6476. This is another recent meta-analysis study that shows that classes in which students spend a high proportion of time in active learning activities reduced the exam and grade performance gaps of underrepresented minority and low-income students when compared with traditional lecture classes. The authors argue that courses that combine opportunities for deliberate practice within an intentionally inclusive environment can increase equity in higher education attainment by improving the learning and retention of minority students.

S. Wineburg et al, What is Learned in College History Classes?, Journal of American History 104 (2018) 983: Much discipline-based education research is in STEM fields, but similar research is available in other disciplines. This paper is part of a multi-year study of differences between novice and expert historians in their evaluations and interpretations of historical sources. The study identifies analysis skills central to the discipline that are reflexive for experts but almost nonexistent for novices (i.e., undergraduates); and it provides tools for addressing these shortcomings through repeated deliberate practice, with immediate feedback, in history courses. For information about how this research is done (and another interesting example) see: S. Wineburg, Cognitive Science 22 (2010) 319. For a similar study, about reading poetry, see: J. Peskin, Cognition and Instruction 16 (1998) 235.

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 in the paper). 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 by 62 different instructors 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 in the paper). 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 even strong students benefit from peer discussion. The benefits of having students struggle with a problem before they hear the expert solution (i.e., the lecture) is a theme in many other studies from a variety of disciplines: for example, D.L. Schwartz et al, A Time for Telling, Cognition and Instruction 16 (1999) 475 shows how having students analyze "contrasting cases" and then hear a lecture substantially improved their learning in psychology (Fig. 5). Lead author of the biology paper, Michelle Smith, is a professor at Cornell in Ecology and Evolutionary Biology, and the Senior Associate Dean for undergraduate education in the College of Arts&Sciences. Smith also provides advice on writing effective questions for student learning through peer discussion (ch. 10 in Active Learning in College Science).

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 in the paper). Lead author, Natasha Holmes, joined the Physics faculty at Cornell and has been redesigning Physics laboratory classes as part of an ALI project. The redesigned labs provide students with more authentic experiences in scientific inquiry and discovery where they have agency to make decisions about their experiments (ch. 18 in Active Learning in College Science).