2014-2015 Annual Report

for the

CU Science Education Initiative

Covering periods August 2014-July 2-15

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2013-2014 Executive Summary of CU's
Science Education Initiative

The goal of CU's Science Education Initiative (SEI) is to improve undergraduate education in the sciences. For each course, this process involves a three-part process:

1) establishing well-defined learning goals through faculty consensus,
2) creating valid assessment tools for measuring attainment of these learning goals,
3) creating and using pedagogically effective materials and teaching approaches that are:
    - aligned with the learning goals,
    - based on and aligned with established research on how people learn,
    - based on research into student thinking about and learning of the content, and
    - improved through research (assessment and iteration).

Achieving this goal requires substantial changes to the standard university departmental and faculty culture surrounding undergraduate education. The funding provided to departments through the SEI has enabled the hiring of 2 or 3 Science Teaching Fellows (STFs) within each department. The STFs facilitate, guide, and support faculty as they learn about research on learning and engage in transforming their own and the departments approach to teaching. The STFs also investigate student thinking and measure student learning, and by doing so, provide faculty with the data they need to make informed choices about teaching approaches.

After 7 years, a significant number of faculty in 7 departments over the lifetime of the SEI (APS, CHEM, EBIO, GEOL, IPHY, MCDB, PHYS) have been impacted by the SEI, modifying their teaching, creating and using learning goals, and using information on student thinking to guide their teaching. Faculty are engaging in research-based teaching methods and educational issues. The SEI project has also impacted a large number of courses, through in-depth interaction with faculty teaching those courses, developing learning goals in collaboration with faculty, and developing and administering validated assessments of student learning. These changes have impacted over 10,000 students per year, considering courses in which STFs have been both fully and partially involved. The SEI has also impacted departmental culture, affecting the frequency of discussions about teaching and learning in departments, and leading to numerous grants to continue the work begun by the project.

In summary, faculty, current and future students, individual departments, and the university as a whole are substantially benefitting from the investment CU has made in the SEI project. The learning environments and structures are overall more effective; the faculty have defined their learning goals and the curricular materials focuses on achieving those goals; the faculty are better educated in research on teaching and learning, particularly as they apply to the specific content of their courses and how students think about that content; and the faculty engage in and value research on their own student's learning – e.g. through the use of formative assessment tools such as clickers to probe and immediately respond to their students' thinking.

See later reports for more detailed numerical impacts of the SEI.

I. Overview of the Science Education Initiative

The CU Science Education Initiative is designed to implement and coordinate departmental-wide improvement of undergraduate science education. The major goal of the SEI is to bring about the sustainable transformation of the teaching of science on a department-wide basis to employ the research-based methods that have been shown to be highly effective in achieving faculty-defined learning goals.

While it is essential to improve science education at major research universities, the task is formidable. These science departments are large entities with established practices and are subject to a variety of economic and external constraints, providing barriers to change. The approach of the SEI is two-fold: 1) to have the faculty and the department initiate their involvement in and commit to participation in the SEI, and 2) to lower the time and money challenges by providing the funding needed to carry out these department-initiated activities.

The SEI operated at the department level. Departments submitted proposals to a small "SEI Central" unit for funding; this funding was used primarily to hire postdoctoral fellows (Science Teaching Fellows, STFs) to support course transformation. SEI Central acted as a highly-involved funding agency, providing advice, training, and administration. Funding was committed by the university higher-administration.

The main assumptions of the model are (a) that courses transformed by faculty collaborating with the STF will be "departmentally owned," with shared and sustained expectations for how these courses are taught; and (b) that changing faculty practices will lead to a shift in departmental norms favoring the use of active-learning techniques. If these assumptions hold, then we should see improvements in student learning, faculty capacity, and departmental and institutional norms and practice. This model is shown graphically in Figure 1 below.

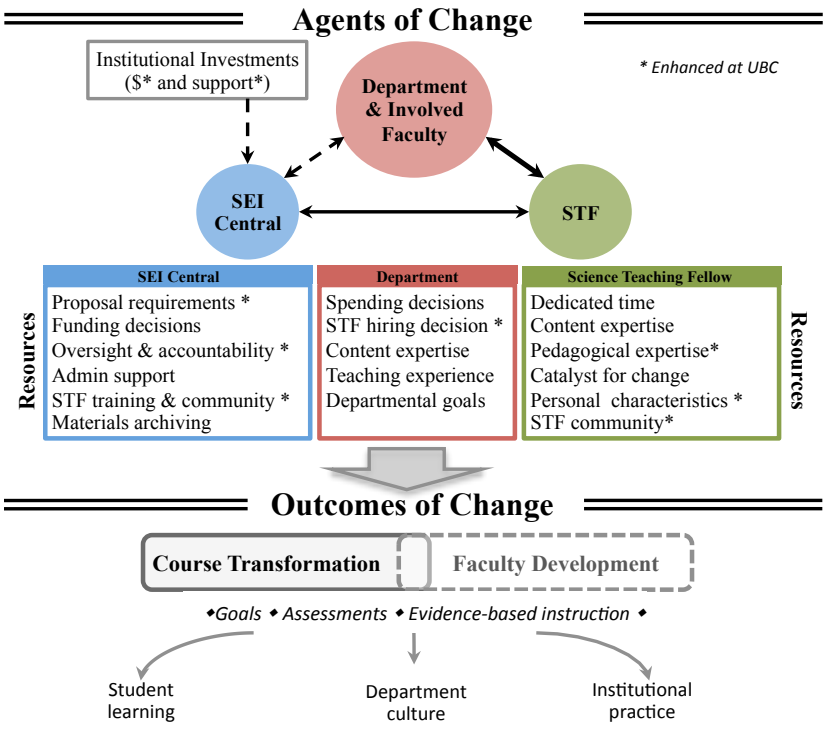

Figure 1. The SEI Model and its intended impacts. The strength of interactions between players is indicated by the weight of the connecting arrow. Course transformation was the explicit focus of the program; faculty development was equally important as a program goal, but implicit in the model. Areas which were enhanced at UBC are indicated with *.

The SEI was implemented at two institutions: the University of Colorado Boulder (CU)[1] and the University of British Columbia (UBC)[2]: See Table 1.

Table 1
Key Aspects of the SEI Programs

	CU	**UBC**
Period of operation	2005-2014	2006-2016 (projected)
Total funding amount	$5.3 M (USD)	$12 M (CAD)
Funding per department	$150-$860 K (Ave $650 K[3])	$300 K-$1.75 M (CAD) (Ave 1.45 M[3])
Funding source	University	University and private donors
Number of departments	6 + 1 small pilot	6 + 1 small pilot
Total number of STFs	24	50+

The SEI efforts in each department are focusing on sequentially targeting courses for improvement, often beginning with the large introductory courses. Working in conjunction with the participating department, the major elements of the SEI-department efforts for each targeted course include:

1) establishing well defined learning goals,
2) creating valid tools for diagnostic assessment of attainment of learning goals,
3) identifying student thinking,
4) creating and using pedagogically effective materials and teaching approaches, and
5) developing faculty knowledge and practices.

Below, we provide details on the central SEI activities that are being conducted in support of the project. In the last sections, the participating departments summarize the structure of the SEI project within their department, the course-related activities, faculty involvement in the SEI, and departmental goals for 2014-2015.

[1] http://colorado.edu/sei
[2] http://cwsei.ubc.ca
<fn>[3] Averaged among the 6 fully-funded departments at each institution respectively.

II. Central SEI Activities

A. Update on central staffing

Dr. Chasteen has served as Associate Director since September 2011, and undertook additional responsibilities related to the SEI such as reporting, STF training, and other duties.

Dr. Kathy Perkins continues to serve as director of the program, and Oliver Nix continues to spend a portion of his time assisting with administrative tasks for the SEI.

B. Funding departmental-based efforts

Most departments have completed their SEI programs. In 2011, CHEM, GEOL, IPHY completed their programs, with PHYS, MCDB, and APS completing their programs in 2014. As of summer 2014, only EBIO has an active SEI program. Most of the activities in EBIO have concluded as of summer 2015, with a modest amount of funding remaining to complete final activities in this department. A summary of activities in EBIO is provided later in this report.

C. Activities to support departmental-based efforts

The SEI central staff (Kathy Perkins, Stephanie Chasteen, and Oliver Nix) support the departmental-based efforts in a variety of ways. Programmatic support from SEI Central has been gradually phased out as the SEI reaches maturity and activities are coming to a close. Current support mainly consists of providing periodic updates to the website to archive and document the outcomes of the SEI.

D. Resources for faculty

The central SEI staff currently provides and is creating additional central resources for faculty working on improving science education on campus. Workshops, pedagogical resources, and the SEI website, serve as resources to the campus and the national community.

E. Outcomes and evaluation

As the SEI is in its' final year, Chasteen and Perkins, along with Wieman and Gilbert from the program at UBC, have undertaken to document and analyze the outcomes from the program. This work is ongoing in 2014-2015, but has resulted in the following publications:

Change from Within: The Science Education Initiative
Stephanie Chasteen and Katherine Perkins (CU SEI). Book Chapter, in McDaniel, M., Frey, R., Fitzpatrick, S., & Roediger, H.L. (Eds.), *Integrating Cognitive Science with Innovative Teaching in STEM Disciplines*. [e-reader version] (pp. 298-370

Educational transformation in upper-division physics: The Science Education Initiative model, outcomes, and lessons learned. S. Chasteen, B. Wilcox, M. D.

Caballero, K. K. Perkins, S. J. Pollock and C. E. Wieman, Physical Review Special Topics – PER (in press).

The Science Education Initiative: An Experiment in Scaling Up Educational Improvements at a Research University. S. Chasteen, K. Perkins, W. Code and W. Wieman, proceedings of the 2014 Transforming Institutions conference (in press).

We describe the major outcomes of the SEI below. Details of the evaluation methods, and more discussion of the outcomes, are available elsewhere (Chasteen et al., in press).

As shown in Table 2, a sizeable fraction of courses, faculty, and students were impacted by the SEI work. Our data indicate that most approaches did follow a backwards design model (though as we will discuss later, this wasn't necessarily the best way to get faculty involved in course transformation. The available publications (and unpublished data) show a positive effect on student learning, but data are limited. The challenge, of collecting baseline data for comparison, and of publishing data on student outcomes, is one of the lessons learned in the program. It was particularly challenging to administer assessments to traditionally-taught courses. There was often little incentive for faculty to devote time and energy to this activity, and an eagerness to begin work on the course. Often, assessments were not available until after the course approach had already changed. In some cases, collection of baseline data created tension in the department because faculty felt that they were being set up for failure.

Table 2
Courses, Students, and Faculty Impacted by the SEI

	CU	UBC
Courses impacted		
Number of courses with SEI involvement	103	167
Percent of undergraduate courses (in SEI departments) with SEI involvement	35%	~33%
Students impacted		
Total annual enrollment in courses with SEI involvement	18,000	43,000
Percent of annual enrollment (in SEI departments) in courses with SEI involvement	50%	67%, (78% without math)
Faculty impacted		
Number of faculty making some use of the STF	190	Not available
Percent of faculty (in SEI departments) making SEI supported changes	49%	48% (57% without math)

Note. Student enrollment represents the number of student seats, not unique students. Within any one department, the percent of courses ranged from 15-55%, the percent of student enrollments ranged from 30-85%, and the percent of faculty ranged from 10-93%. Mathematics at UBC is removed from some data were noted, as it is anomalous among SEI programs due to cultural approaches towards teaching in the department.

The impacts of the program on departmental norms—and the sustainability of changes made through the SEI—are still under evaluation. At CU, 77% of N=97 faculty surveyed indicated that the number of conversations they have with their colleagues about teaching has increased due to the SEI. Additionally, in interviews, many faculty have lamented the loss of the STF, and have

indicated that they would like the SEI to continue—in many cases indicating that this would be a worthwhile use of precious departmental funds.

The success in each department depended strongly on the timing of the proposal, the departmental culture and organizational structure, how teaching assignments are handled, the department chair, and the departmental director and STF. In one particular department case (Huber & Hutchings, 2014), however, these various factors conspired to generate a highly favorable environment for change, resulting in high rates of adoption of active-learning strategies and supportive infrastructure changes in the department (Huber & Hutchings, 2014). In other departments, change has not been quite so sweeping, and the SEI made varying levels of progress towards changing the culture of teaching. Across departments generally, when faculty participated in course transformations they showed faithful and sustained use of new teaching methods (Wieman, Deslauriers, & Gilley, 2013),

III. SEI in Ecology and Evolutionary Biology

A. Departmental Structure

Andrew Martin (AM) is the faculty supervisor for the EBIO-SEI program. Sarah Wise (SW) has continued as an STF at 60% time. Gabrielle Katz (GK) was hired as an STF in summer 2014 at 25% time. Cindy Buchenroth-Martin was hired part-time as an STF during fall 2014 and Joanna (Joey) Hubbard was hired part-time as an STF during spring-summer 2015. While it would seem that a team made entirely of part-time staff would be disjointed, this was a particularly synergistic arrangement. The group held very productive 1 hour meetings, twice a month. This year, in recognition of his leadership and innovative teaching transformations, APM was awarded a BFA award for teaching excellence.

B. Departmental Support Activities

EBIO 2014 Summer Teaching Retreat

On August 14 and 15, 2014, AM and SW implemented the second annual EBIO SEI Teaching Retreat, themed "Data Driven Instruction" and located in the interactive classroom in MCDB.

12 EBIO faculty and 8 postdocs/graduate students were in attendance, along with 2 staff members from the BSI program. The retreat progressed through four interactive modules: "Using pre-post assessment data", "Classroom observation data", "Student attitude survey data", and "Sustaining data-driven instruction in EBIO". In each of the first three modules, an EBIO faculty member gave examples of how they used that kind of data to revise their teaching. The retreat concluded with a potluck party at Andy's house. There was no retreat held in summer 2015, but the AAU organized a day-long retreat in May related to departmental visioning and organization around teaching initiatives.

EBIO Departmental Learning Goals

In September 2013, the EBIO Curriculum Committee (CC) decided to make Departmental Learning Goals a focal project. During summer and fall 2014, faculty working groups developed both process and content goals. From their work, 30 goals were compiled by Sarah Wise and discussed at a faculty meeting in March. Next, a faculty subcommittee led by Andrew Martin identified 8 central goals and produced two hub-and-spoke type diagrams illustrating the process and content goals, respectively. By early summer, a third set of four metacognitive goals had been added and faculty had annotated the process goals with the courses that include each as a learning goal. Future EBIO subcommittee ideas for the goals include elaborating on the course alignment, generating a Prezi format, and making a student-interactive version available on the EBIO website. While they are currently considered working drafts, and will continue to be living documents, the diagrams will be archived this summer on the SEI website.

Development of an EBIO Major's Assessment.

APM, SW, and John Basey continued work developing a process skills-oriented assessment tool that can be used to measure learning gains for EBIO majors. A presentation of the second pilot assessment's data was included in the 2014 summer retreat, and also prepared for faculty presentation in March 2015, but the latter did not occur due to time.

In spring 2015, the instrument was revised to be in a multiple true-false format, with 6 scenarios followed by 1-5 true false questions about that scenario, and a total of 30 items. A third pilot was conducted in May 2015 with one EBIO upper division class (Genetics 2070, n=153) and the General Biology laboratory classes. Results indicate that changes in performance from freshmen to seniors vary widely depending on the test item. Some items show little change. Overall, there is a small significant effect of years in major on performance. Future versions of this assessment will be aligned with EBIO Major's learning goals, once the learning goal development process is completed.

EBIO Website

The department is interested in highlighting innovative teaching on the EBIO website. Joey worked with Nolan Kane and Joe Workman to create a webpage featuring Nolan's plant genomics course. The webpage includes text describing what students did throughout the course and how they contributed to the larger scientific community as well as visualizations of the genomes the students constructed. This course feature webpage will launch when the new EBIO website goes live in July/August. This webpage can serve as a template for similar features on innovative courses in the department.

C. Course and Faculty Support Activities

a. Activities led by Andrew Martin; May 2014 – June 2015

Curriculum development

APM co-developed a course with Brett Melbourne called Introduction to Quantitative Thinking for Biologists (IQUIT). The main purpose for co-development of the course was for the two instructors to learn about teaching from each other and to share techniques and emphasis on particular learning goals. The course was designed with an emphasis on student-centered active learning curriculum and can be shared via Dropbox. The course was a remarkably successful model for developing the teaching community in the department.

Faculty observation and mentoring

APM observed courses for three professors (Nolan Kane, Brett Melbourne, Harrison Carpenter) and provided feedback and mentoring based on quantitative and qualitative data stemming from a standardized observational protocol (a modification of the SITAR). APM was also a workshop presenter for the CSL- sponsored event for Community College professors.

Educational Research

APM has been conducting research on the development of learning communities in large, active learning courses (Evolution and IQUIT) using network analysis. A manuscript summarizing the work was recently submitted to CBE Life Sciences for review. APM was awarded a Chancellor's fellowship to continue this work in the IQUIT class during the 2015-2016 academic year.

b. Activities led by Sarah Wise; June 2014-2015

Genetics (EBIO 2070)

In fall 2014, Sarah began working with David Stock to transform his Genetics course. In spring 2015, Sarah also began working with TA Abbey Paulson, who completed a portion of the Genetics development work. Significant changes were implemented in spring 2015, including:

- a resequenced syllabus putting molecular genetics first;
- new prelecture reading quizzes;
- recitation quiz questions considered TA input, weighting less on recall;
- inclusion of clicker questions in lecture; updating of lecture with examples and images from recent Genetics reviews and studies; inclusion of summary slides for some lectures
- TA assignments to certain sections of class and reminders to patrol those sections primarily asking questions
- all new recitation assignments emphasizing concepts and problems;
- recitations were sometimes case study based or involved genetic data analysis;
- exam questions selected/modified considering teaching fellow input, balance of exam questions weighted less on recall

David constructed most of the clicker and exam questions, while Sarah developed most of the recitations and summary slides and guided/trained TAs, and Abbey developed the pre-lecture quizzes. Feedback on course implementation was gathered using observational data via the SITAR (taken by both Sarah and Abbey), Sarah's specific suggestions incorporated into .ppts during class, post-class verbal check-ins, two SALG-style student surveys, and a pre-post assessment analysis of learning gains.

During summer 2015, SW coordinated the work of a student to analyze the pre-post assessment, analyze student student surveys, and compile SITAR data feedback and clicker data into David's lecture powerpoints. Work around David's SITAR led SW to update the SITAR archived on the SEI website. Results of survey analyses and discussions of David's and Sarah's reflections and priorities were consolidated into a bulleted revision plan subdivided by time scale. Specific initiatives that could be carried further by hiring graduate students were identified. The Genetics 2015 syllabus, learning goals, recitation assignments, and clicker questions have been archived at the SEI website.

Faculty Consults

Sarah consulted with Stephanie Mayer on including more active learning in her fall course, and coordinated the work of recent alum Matt Bitters to observe three classes and provide feedback to her. Sarah also provided input to Stacey Smith's design of writing assessments for her Plants and Society class. Lastly, Sarah met with Harrison Carpenter to brainstorm ways that his Writing in Sciences course could be structured to tie more closely to departmental content learning goals.

c. Activities led by Gabrielle Katz; September 2014-May 2015

Landscape Ecology (EBIO 4060)

During the fall semester (2014), GK supported Carol Wessman in her upper division course, *Landscape Ecology*. This work involved meeting with Carol weekly to discuss learning objectives for each unit, and to brainstorm ideas for active learning activities related to these objectives. GK collaborated with Carol on the development of active learning activities, and

reviewed her lecture materials before each class. One of the main science process goals of *Landscape Ecology* is for students to learn to read and analyze the primary scientific literature. Thus, a lot of effort was focused on designing targeted active learning activities around assigned journal article readings. The class was divided into discussion groups, which usually met for 20-30 minutes during class once a week. Groups were provided with worksheets that contained guiding questions for discussion, usually focused on key tables or figures. Carol facilitated whole class discussions using random call after students worked in groups. GK observed Carol's classes, and provided brief feedback after each session. Over the course of the semester, lecture content was refined and streamlined, and think-pair-share questions were added. GK assisted Carol in revising and implementing an in-depth forest management case study which occurred over the final weeks of the semester. GK also drafted an end-of-semester reflection survey for students, to provide Carol with feedback about the course and the changes she had made thus far. Carol compiled the responses and found them to be very helpful. GK also engaged Carol in an on-going conversation about the overall learning goals for the course, and presented those to Carol in a draft document at the end of the semester.

Plants and Society (EBIO 3590)

During the spring semester (2015), GK supported Stacey Smith in her junior level course, *Plants and Society*. This work involved assisting with the writing component of the course and consulting on the implementation of active learning in lectures. GK met with Stacey weekly during the semester, and attended Stacey's class approximately once per week, either to assist with activities or to observe and provide feedback. Plants and Society is a writing intensive course, and GK assisted Stacey in implementing student peer review for the three writing assignments in the class. For each assignment, peer review enabled students to obtain/provide timely feedback on draft assignments, before revised final versions were due. GK surveyed students at mid-semester and end-of-semester, and they reported very positive perceptions of the writing component of the course (and the course overall). The writing assignments provided them with an opportunity to write in new scientific formats, and to learn about biology topics more deeply. Further, they felt very strongly that engaging in the peer review process, as both authors and reviewers, helped them to improve their writing. GK and Stacey Smith will be presenting a conference poster on this aspect of the course (Earth Educator's Rendezvous, July 2015), exploring how participation in peer review promotes development of student self-assessment skills. GK also collaborated with Stacey to develop several in-depth active learning activities, including a jig-saw style debate on GMO's, a controversial case study on bioprospecting, and development of a funding announcement for research on impacts of climate change on plants.

Ecology (EBIO 2040)

During the spring semester (2015), GK occasionally consulted with Katherine Suding, a new faculty member (to CU) who was teaching *Ecology* (a core EBIO course) for the first time. One of Katie's key goals for the course was more effective integration of the lecture and lab components, which had historically been handled separately. Katie integrated several active learning pedagogies into her lectures, including daily clicker questions and frequent group problem solving activities using white boards. She also worked with her TA's to revise the labs, focusing on teaching the scientific method and building students' research capabilities. Support from GK included meeting with Katie individually on two occasions to discuss goals and needs

for the course, occasionally attending TA meetings, observing Katie's lecture and providing feedback on one occasion, creating a grading rubric for the research paper assignment, reviewing the three course exams, and creating an end-of-semester SALG survey. Exam reviews consisted of identifying the Bloom's level of draft exam questions, reviewing questions for alignment with lecture content, and offering suggestions to improve question clarity and effectiveness.

Katie's work on the *Ecology* course has led to broader engagement of a group of EBIO faculty and graduate students involved in the course. At the end of the spring semester, Katie submitted a proposal for EBIO summer support for two graduate students (*Ecology* TA's) to solidify and further develop *Ecology* lab materials that promote lecture-lab integration. This proposal prompted Carol Wessman (EBIO Associate Chair of Undergraduate Studies) to initiate a meeting of all ecology instructors, to make sure there was awareness and buy in. So far this summer there have been two meetings of this group, which has included graduate students, tenure line faculty members, and instructors involved in the course (and GK). This group appears to have good momentum, and shared interest in improving lecture-lab integration in the course, promoting science process skills (e.g., quantitative skills, research skills), and aligning with other courses within EBIO. Some longer term issues relate to developing content learning goals for the course (working from the 2012 learning goals as a starting point), and finding adequate classroom facilities that support active learning.

d. Activities led by Joanna Hubbard; March-June 2015

Joey designed several case studies for core courses in EBIO based on research by faculty in the department. She developed a case study based on Rebecca Safran's research on barn swallows; this case will be used in Evolutionary Biology (EBIO 3080) to teach sexual selection. This lesson can be adapted for a 50 minute or a 75 minute lesson, as well as pared down to a clicker case study for general biology. Joey will run this lesson during the summer term of Evolutionary Biology. Joey also developed a case for Ecology using data from Kendi Davies' work with the Wog Wog fragmentation experiment. This case is set up as a jigsaw in which students receive information about different families of beetles that have different responses to fragmentation and edges. Joey is also developing a brief (10-15 minute) lesson on Mendelian genetics for General Biology. This activity will use Nolan Kane's work on cannabis to cover Punnett squares and crossing plants (and animals) to yield offspring with desired traits.

D. Research and Scholarly Activities

CourseSource Publications

Joey is preparing the above case studies for publication in CourseSource, a peer-reviewed education journal that publishes case studies and background information for college-level instructors. After teaching the Evolutionary Biology case during the summer term, Joey will complete and submit the manuscript. There will not be an opportunity to test the case study for Ecology until the fall term. Joey will work with the instructor to complete the manuscript. During spring 2015, Sarah Wise prepared a case study on color variation and pigmentation genetics for the EBIO 2070 (genetics) recitation. Joey is putting together this activity for publication; the manuscript will be co-authored by Sarah and Helen McCreery, a TA for genetics during the spring 2015 semester that implemented the activity.

EBIO Graduate Educational Training Program.

Nichole Barger and SS received a Chancellor's iStem grant for $9,707 to expand the graduate *Science Education Seminar* into a multi-year training program (proposal title: "Transforming Graduate Training in STEM Education"). In the expanded program, students participated in a four day summer workshop on curriculum development, where they were matched with faculty partners. Faculty and graduate student teams developed active learning units for implementation in courses. During the fall semester, students provided feedback and revision on each other's curricula and tested their materials in the classrooms of their faculty partners. Students received feedback from their faculty mentor, from the instructor, and from their peers before, during, and after implementation of their materials. Nichole leveraged this grant to obtain funding lines from the Dean's office for two experienced graduate students to teach their own courses as GPTIs, implementing innovative teaching practices in a more intensive experience. The workshops will continue to be offered each summer and fall, and GPTI lines will continue depending on Dean's office priorities.

Group Sign-Up Experiment.

This project began in spring 2012 as a collaboration between Kendi Davies, Brett Melbourne, and Sarah Wise. Sarah Seiter was unable to complete the analysis as expected. The dataset, we now realize, is unexpectedly complex. This summer, graduate student Geoff Legault is generating a database that can be queried in order to ask questions much more readily of the data while minimizing useage errors. Brett and Kendi anticipate this experience will help them summarize in more general terms how to plan and manage complex educational data projects.

NSF TUES Clicker Discussion Experiment.

Sarah Wise, Jenny Knight, and Erin Furtak were awarded $150,000 in June 2012 to carry out "Investigating Instructional Influences on Clicker Discussions". Data analysis of both 2012 TUES data is complete, and the paper on the LA experiment carried out in MCDB is being re-submitted shortly. A second paper on the EBIO cues and modeling experiment should be submitted within the month. Analysis is ongoing for a third paper on two experiments involving random call, one in MCDB and one in EBIO. All three papers document modest shifts in student participation in discussion and features of discussion resulting from aspects of instructional design, including what instructors say about clicker discussions, what LAs say during clicker discussions, how large of a group is involved in discussion, and whether groups are called randomly after instruction.

Professional meetings

GK attended the 2015 Mountain Regional Summer Institute (HHMI). GK and Stacey Smith are presenting a poster this summer called "Exploring the relationship between peer review of scientific writing and student self-assessment skills," for the Earth Educator's Rendevous. Jenny Knight is presenting on Sarah's and her NSF TUES research work at a Gordon Conference and at this year's SABER meeting.