1. PROJECT TITLE AND PRINCIPLE INVESTIGATORS
Transforming GEEN 1400: *First-Year Engineering Projects* to Enhance Climate of Inclusivity *TRESTLE Proposal, February 2018, submitted by Derek Reamon, PhD and Janet Tsai, PhD.*

2. PROJECT LEADERS AND EXPERTISE
Derek Reamon, PhD, Teaching Professor, Engineering Plus. reamon@colorado.edu, 303-735-0484, ITLL 1B42, UCB 522, 1045 Regent Dr, Boulder, CO, 80309.

Derek completed one of the first dissertations in the nascent field of engineering education and has been transforming courses in the College of Engineering and Applied Science (CEAS) for more than 15 years. Early in his career, the transformations were primarily converting conventional, lecture-style courses into active-learning courses with heavy emphasis on hands-on learning, labs and design projects. Derek won a course development award from the LEAP program in 2006 to transform *System Dynamics* from a highly-theoretical, math-heavy traditional lecture course into a lab-based, applications-heavy active learning experience, culminating in a team-based, design-build project where students created functional, advanced feedback control systems. In 2013, Derek became the founding co-director of the new Engineering Plus degree program. As Program Director, Derek laid out an entirely new curriculum, including development of several entirely new courses with heavy emphasis on hands-on learning and design. Derek also coordinated the inaugural ABET review for the new Engineering Plus program in 2017.

The proposed project is focused more on transforming climate and culture, which is a more difficult change to achieve than course format or learning modality. Derek and Engineering Plus faculty member Janet Tsai will lead the course transformation process through the existing community of scholars within the first-year projects faculty meetings.

Janet Tsai, PhD, Instructor, Engineering Plus. janet.tsai@colorado.edu, 303-492-6950, DLC180, UCB 522, 1045 Regent Dr, Boulder, CO, 80309.

Janet completed her engineering education dissertation in 2015, investigating durability and curricular reform efforts along the required undergraduate engineering mathematics curricular pathway in the CEAS. Since joining the Engineering Plus faculty in 2016, Janet's research has continued to investigate the effects of local and global historical structures and curricula on contemporary students. Her work seeks to identify the social and cultural impacts of technological choices made by engineers in the process of designing and creating new devices and systems. Her research considers the intentional and unintentional consequences of legacy structures, products, architectures, and standards in engineering education, to pinpoint areas for transformative change.

Janet has worked with Discovery Learn Apprentice (DLA) students to perform engineering education research over the last two academic years, with one collaboration resulting in a

peer-reviewed journal publication [1] and another in a forthcoming peer-reviewed conference publication [2]. Moreover, the current DLA project specifically studies the climate for women in active-learning, hands-on courses like GEEN 1400, *First-Year Engineering Projects,* wherein students work collaboratively in mixed-sex teams to design and build engineering projects.

3. COMPELLING PROJECT RATIONALE

GEEN 1400, *First-Year Engineering Projects,* is a hands-on, team-based introduction to engineering projects that approximately 60% of the admitted first-year cohort of engineering students takes each academic year in the College of Engineering and Applied Science (CEAS). Students work collaboratively in teams of four to six to dream, design, build, program, and create a tangible project over the course of the semester that they present to industry judges and the general public at a culminating Design Expo event at the end of each semester. As the first engineering design project class along the undergraduate engineering degree pathway, the experience of students in the course is consequential for their feelings of belonging in engineering, desires to persist in engineering, and identity development as engineers.

The course has been shown to improve overall retention in engineering, but we want to do even better - particularly for our women and minority students [3]. While caring instructors monitor inter-team dynamics as challenges inevitably arise during semesters together, many of the activities and interactions occurring among team members are invisible to instructors until most of the formal instruction and assessment are completed. For example, in end-of-semester peer assessments and college-wide surveys of the first-year experience, women frequently report feeling overlooked, underappreciated, and relegated to non-technical tasks by their male peers on their project teams. While many women have positive experiences on their teams, many more describe experiences in which they or their suggestions are ignored during brainstorming or fabrication sessions. Women also report doing more documentation, decoration, and project planning tasks rather than technical design, build, or programming tasks.

As the first engineering projects class along each student's degree pathway, GEEN 1400 sets the tone and expectations for future collaborative work in engineering projects and courses in the CEAS. Transforming the course to create a baseline climate of equity and inclusion will provide a positive trajectory for subsequent engineering courses to continue, as we hope students will become more and more understanding and appreciative of diversity rather than less tolerant during their undergraduate careers at CU. Several factors make us believe this to be an opportune time for this transformation. CEAS seems to be approaching a 'tipping point,' where representation of women has crossed the 33% threshold, creating a more comfortable environment and easing further growth in representation. The national discourse relating to the very public culture wars at tech firms including Google, Twitter, and Apple, as well as the #MeToo movement are bringing these issues to the forefront of students' awareness as never before.

4. REALISTIC AND SPECIFIC COURSE DEVELOPMENT PLAN

A. Course(s).

The central course for this transformation project is GEEN 1400, *First-Year Engineering Projects*. The project will also affect classes that follow GEEN 1400 in the curriculum, GEEN 2400, *Engineering for the Community*, and GEEN 3400, *Invention and Innovatio*n. Faculty from ASEN 1400, *Gateway to Space*, are also involved in regular faculty meetings, so this course will be impacted as well. The transformation will involve a fundamental change in the way faculty approach team dynamics, team roles, and student responsibility in all of these courses, encompassing more 30 sections of design projects courses each academic year. A specific workshop and intervention activity will be developed and delivered to all GEEN 1400 sections. This is the crux of the transformation and must be done well, as the most current research and best-practices in this area indicate there is a very real threat of doing harm with this intervention. The intervention activity will be followed by team and class discussions and a required individual student reflection paper.

B. Timeline.

- Summer 2018: Development of workshop and intervention activity with Derek, Janet and other members of Engineering Plus faculty. Derek and Janet will also lead an in-depth redesign of the GEEN 1400 pre- and post-surveys to include items related to climate, culture and inclusivity.
- Fall 2018: Delivery of new workshop and activity in all (~12) sections of GEEN 1400 with real-time assessment as well as course-long data gathering. At the end of the semester, the Engineering Plus faculty will analyze the data together and develop a plan for further changes for the spring semester.
- Spring 2019: Delivery of improved workshop and activity in all (~10) sections. Real-time and course-end assessment and analysis continues.
- Summer 2019: Engineering Plus faculty will analyze the data together and determine efficacy of program and transformation and make the decision to continue the intervention or not.

C. Assessment plan.

Each intervention will be observed by Derek, Janet or other involved Engineering Plus faculty, using a modified version of the Teaching Dimensions Observation Protocol (TDOP) to assess signs of student engagement during the intervention workshop [4]. Short, anonymous student responses will also be collected after each session. The redesigned pre/post course survey will also capture changes in attitudes towards diversity and inclusion from the start of the term to the completion of the semester. Many such items exist in the current surveys, so changes correlating with the curricular transformation can also explored in comparison to data from prior years of the course.

D. Faculty and instructor involvement.

GEEN 1400 sections are taught by all Engineering Plus faculty, as well as faculty from Computer Science, and Aerospace, Civil, Electrical, Environmental and Mechanical Engineering. The new intervention will be taught by the section instructor and a facilitator from Engineering Plus. All of the faculty meet on a weekly basis to discuss the course, and the

transformation will be a major discussion point and focus during the process. Instructors will be trained on the delivery of the new intervention and its goals. Faculty will be debriefed each semester with attitudinal survey results from pre/post instruments. The instructors of these sections are already established as a learning community focused on bringing research to practice. They are also already aware of the climate and culture issues our students face, and they are struggling to address these issues in a meaningful and productive way. In short, instructors are eager for this transformation and will buy-in readily.

E. Sustainability.
The instructor community for these design courses is already established, cohesive and dedicated. This existing community of scholars provides a great advantage for our transformation. It has taken years of weekly meetings to establish this community and create a culture where instructors are supported and feel safe to ask questions and express their opinions. With Derek and Janet leading the meetings and the discussions of the intervention, and all of the interested Engineering Plus faculty involved in the design and execution of it, we feel that we have a significant advantage in ensuring sustainability of the transformation, should it prove effective. We are also data-driven, and open to the possibility that the assessment will not indicate that the transformation has been effective. New faculty join the community every year, and the culture is established to welcome and aid them. With the critical mass of consistently involved faculty, some instructor turnover will not change the community or their dedication to improving the culture and climate of CEAS.

F. Coordination across the department.
The changes proposed in this transformation project will promulgate through the subsequent projects courses in the program, with continued attention to team dynamics, roles and inclusivity in GEEN 2400 and 3400. The Engineering Plus faculty who teach GEEN 2400 and 3400 also teach GEEN 1400, so they will know the intervention and will have delivered it themselves. This will enable them to be attentive to student cues and provide productive interventions in the extended curriculum. A letter of support from the program co-Directors is attached.

5. IMPACTS ON OTHER FACULTY OR DEPARTMENTS (BROADER IMPACTS)
The GEEN 1400 instructor community, comprised of faculty from Engineering Plus as well as faculty from numerous other departments in the CEAS (Computer Science, and Aerospace, Civil, Electrical, Environmental and Mechanical Engineering) will benefit from the direct experience of administering an evidence-based educational intervention in their sections through this course transformation process. By exposing these faculty to the process of designing the intervention, testing, administering, assessing, redesigning, and re-deploying, their home departments will additionally benefit by having these instructor-ambassadors to share their personal experiences of the process of implementing an evidence-based educational intervention.

As the CEAS has identified improving undergraduate retention as a strategic priority, continued renovation and transformation of required, large-enrollment undergraduate engineering courses

is one academic means of making a difference for our undergraduate engineering students. The more engineering instructors experienced in evidence-based course redesign and development processes, the more awareness of new pedagogies and assessment techniques will be spread through the CEAS, with potential for more and more curricular adjustments spreading and positively impacting the overall educational experience for our students. If we wish to truly inculcate an environment of educational expertise and remain at the forefront of national evidence-based movements in engineering education, we need more instructors involved in course transformations like the one proposed and experienced in various stages of the transformation process.

Furthermore - if the proposed transformation does lead to measurable changes in student attitudes, beliefs, and feelings of belonging, while improving interactions with peers in collaborative team settings, the results will be shared widely within the CEAS, broadly across the CU campus, and nationally at engineering education research meetings. As many engineering faculty within the CEAS and elsewhere are unfamiliar with engineering education research, explaining the process and the results of this course transformation is one step towards demonstrating the value of evidence-based curricular reform and the power of educational research techniques and methods. This curricular transformation proposal thus has potential for changing the climate of our undergraduate educational programs to be more supportive of inclusion and diversity while also expanding the acceptance and understanding of engineering education research and evidence-based teaching practices in the CEAS.

6. RESOURCES REQUESTED

A. Budget:

Salaries and Wages

Derek Reamon, Co-Director Engineering Plus Program	
100% time, 0.40 mo, summer	$4,367
Janet Tsai, Engineering Plus Instructor	
100% time, 0.50 mo summer	$3,648
Undergraduate student: Discovery Learn Apprentice	
2 semesters: 150 hours total, $12/hr	$1,800
Total Salaries and Wages	*$9,815*
Total Direct Costs	**$9,815**

B. Other/Non-financial resources

Consultations with CSL educational advisors, particularly those experienced with the TDOP instrument, would be helpful for training the Engineering Plus faculty who will conduct the formal observations of the workshop interventions as they are administered in Fall 2018 and Spring 2019. In addition, Derek has already reached out to the Office of Institutional Equity and Compliance at CU Boulder, inviting the Director of Education and Prevention and Deputy Title IX Coordinator, Teresa Wroe, to speak to the community of GEEN 1400 instructors in Spring 2018. We plan to continue working with Teresa and learning from her experience to design (and redesign) a successful workshop intervention as a primary component of this course transformation.

7. AGREEMENT TO EXPECTATIONS

Derek and Janet agree to all expectations for successful awardees, including documentation, evaluation, and presentation of course development and transformation activities. In prior semesters, Janet has presented to DBER as a past winner of a Chancellor's Graduate Award for Excellence in STEM Education and thus she is already familiar with the DBER format and community, and eager to discuss the proposed course transformation with the group. Derek would be pleased to attend the national meeting at KU in October.

8. REFERENCES

1. M. Zarske, M. Vadeen, J. Tsai, J. Sullivan, and D. Carlson, "Undergraduate Engineers and Teachers: Can Students Be Both?," *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 7, no. 1, Jun. 2017.

2. M. R. Keogh, K. Waugaman, M. Zarske, and J. Y. Tsai, "Active Learning Group Work: Helpful or Harmful for Women in Engineering?," in *ASEE Conference Proceedings*, Salt Lake City, UT, 2018 (forthcoming).

3. N. L. Fortenberry, J. F. Sullivan, P. N. Jordan, and D. W. Knight, "Engineering Education Research Aids Instruction," *Science*, vol. 317, no. 5842, pp. 1175–1176, Aug. 2007.

4. E. Osthoff, W. Clune, J. Ferrare, K. Kretchmar, and P. White, "Implementing immersion: Design, professional development, classroom enactment and learning effects of an extended science inquiry unit in an urban district," University of Wisconsin–Madison, Wisconsin Center for Educational Research, Madison, 2009.