Introduction

Creative EDG2 is an initiative launched by Baskin School of Engineering leadership in partnership with the Institute for Science and Engineer Educators to facilitate changes that will cultivate an ethical and entrepreneurial mindset among engineering undergraduates. Creative EDG2 recognizes the need for a renewed focus on pedagogy to meet rising demands among engineering students for more hands-on experience during their undergraduate careers and that employers prefer to hire students who have already experienced the engineering design process as it is actually practiced. Two influential reports released in spring of 2018 - the ABET Brief and MIT State of the Art in Engineering Education - report on pedagogy and curricular features common among current and emerging global leaders in engineering education. We have prepared a table (see Appendix A) summarizing and comparing the major assertions of these two reports which were foundational to this initiative. Our overarching goal and strategy is to engage a coalition of faculty in learning from the successes achieved at other campuses while recognizing and leveraging Baskin Engineering's own unique strengths and assets. Actions we have taken towards these ends are summarized below.

Conducted Preliminary Case Study Research

Following the launch of Creative EDG2 in late Fall 2018, the leadership team set out to build case studies describing the unique strengths, assets and strategies of innovative engineering educational programs at institutions recognized as leaders in the MIT and ABET reports. Preliminary work quickly pointed to the need for a framework to guide the compilation of unique program details. We also became aware that information readily available online or in publications is largely limited to outcomes rather than the "backstory" describing how transformation was achieved. Online research would need to be supplemented by "live" interviews and discussions with representatives from selected programs.

Online and live case study research is ongoing and details about programs offered at approximately 20 different institutions (see **Appendix A**) are being compiled following the parameters of the Creative EDG2 framework (described below). Additionally, a set of "mini case study profiles" is being created to give snapshots of outstanding features (See **Appendix A** for an example). These mini profiles will be shared through the Creative EDG2 website.

Developed the Creative EDG2 Framework

The Creative EDG2 Framework is a conceptual tool that can be used to define and relate features of experiential learning ecosystems in engineering education ranging from implicit institutional norms, to course sequencing, to a specific performance assessment tool or fee structure. While the iterative development of the Creative EDG2 framework is derived from and closely informed by commensurate tenets of the MIT and ABET reports, for our purposes, we found that some features needed further articulation while other features important to the UC Santa Cruz campus were missing (e.g., inclusion). The full Framework including descriptions of major categories structuring the Creative EDG2 framework is available in **Appendix B** along with a link to a version that includes examples of each of the major and minor categories.

Engaged Faculty

From the outset, Creative EDG2 was intended to be a collaborative “bottom-up” effort, inclusive and responsive to faculty, staff and student participation. Early efforts focused on recruiting and engaging a committed coalition of faculty willing to invest in shaping the priorities and processes that will inform decisions and strategies. Continuing efforts will focus on expanding this faculty coalition, formalizing their role in program development and involving student representatives. Sustained engagement of those that initially express interest in joining Creative EDG2 will require reassurance by school leadership that their input and efforts are valued and given due-consideration in future decision-making.

Two impromptu meetings spurred by a visit from an engineering faculty member at the Technical University of Denmark (DTU) and founders of the CITRIS Invention Lab at UC Berkeley provided a glimpse into a promising group interview format that could be utilized simultaneously to advance case study research while bringing faculty participation to the fore. Formal recruitment efforts followed a letter from the dean announcing the initiative and inviting faculty to indicate interest by responding to a short survey. Interested faculty as well as faculty recognized for exemplary efforts already aligned with Creative EDG2 were interviewed and/or invited to participate in exchanges with invited guests and/or other Baskin Engineering faculty. Highlights from the impromptu session with our visitor from DTU, one-on-one interviews with individual Baskin Engineering faculty, a summary of the exchange during the CITRIS Berkeley visit on April 18 and notes on the June 4 faculty exchange are included in **Appendix C**.

Implemented Creative EDG2 Framework

We discovered multiple ways to implement the Creative EDG2 Framework for different purposes. The Framework provides selection criteria for content available online while tracking what is *not* readily available or requires a different information gathering strategy. True to an iterative design process, the details of strengths and assets from programs at exemplary campuses have informed and continue to inform development of the Framework even as it is used to gather those details.

The Framework has also been instrumental in engaging faculty. Two impromptu meetings conducted in Fall confirmed the utility of using the Framework to guide future discussion sessions with visitors from other campuses. The Fall meetings also provided insight into revisions that could increase the Framework’s adaptive value. For example one insight related to expanding the Framework to be more specific about program design and off-campus relations and to include more information about categories that help surface the “backstory” (internal politics, funding sources etc.) behind these success stories.

On April 18, the dean and the director of ISEE co-hosted a meeting with visitors from three UC Berkeley / CITRIS programs where we also introduced a small group of Baskin Engineering faculty to Creative EDG2 and a revised version of the Framework. The Framework also served as a protocol and repository for information gathered during one-on-one faculty interviews and was circulated in advance of the June 4 faculty exchange to guide and align the group as we collectively explored strengths and assets of existing BSOE curricula and teaching. Finally, as we

start to look across courses and departments, the Framework is being used to identify redundancies and simultaneously assess how contrasting assets can be leveraged to supplement or compliment others. Notes on faculty interviews and from the faculty exchange are being compiled using the Framework as a guide and summaries are being prepared. Notes on initial interviews will be available by June 24.

Launched Online Interactive Platform

Two urls have been established to host information about Creative EDG2. One site is hosted through ISEE where the initiative is listed as a current ISEE project. This site includes a homepage with graphics, descriptive information about the initiative, the principles behind it, our process and a link allowing viewers to contact our team. A second site for Baskin Engineering is in development. Currently it includes a similar homepage with a "contact us" link and a link to a quick survey designed to gauge faculty interest. After some delay, due to the loss of drupal-savy personnel, a student assistant was hired to continue building this site. She will continue work through June.

Next Steps

We will continue building the BSOE Creative EDG2 website. Specifically we are planning to incorporate an online faculty forum (google group), an interactive yet curated calendar of events, a resource library including links to selected literature, case study profiles and other resources. Preparations for a visit from a colleague representing the Integrated Teaching and Learning Laboratory at CU Boulder will involve: gauging the availability of invited faculty, introducing and familiarizing our guest with the Framework, and prepping participants to make use of the Framework during the Q & A. Tamara will follow up with Berkeley CITRIS personnel to fill in gaps in the information shared during their visit (see notes in appendix below). We will continue recruiting faculty to help plan and host two more faculty exchanges before the start of Fall quarter to identify strengths, assets and challenges at UC Santa Cruz. We will continue case study research, add literature and resources, and meet with leadership to determine how Creative EDG2 efforts align with other priorities and activities within Baskin Engineering, the UC Santa Cruz Strategic Academic Plan, and a new campus-wide effort from the Office of Research to integrate a focus on entrepreneurship into teaching and research efforts on our campus.

Appendix A: Comparison Table

Table 1. "State of the art" Educational approaches identified by 2018 ABET Brief and MIT State of the Art in Engineering Education report.

	MIT "current leaders"	MIT "emerging leaders" [1]	ABET Brief
Connected	Linking engagement with university's research activities with courses;	Industry / community informed curriculum and research agenda	Interdisciplinary, team based approach
Student-centered Active Learning	Technology-based, design-led curricula. integrated extra-curricular activities; often student-led	Non-conventional student entry; influential Student-led extra-curricular activities	Holistic approach to problem solving; real-world contexts,
Experiential and Authentic Practice	experiential, focused on problem identification and solution path	increasing integration of work-based learning	Project-based, problem-solving, teamwork
Outward-facing and Situated	User-centered design developing entrepreneurial skills of social responsibility	Shaped by regional needs and constraints, concerned with relevance, social impact	Industry informed
Adaptive, Blended Learning	Include online and blended learning	Online learning blended with intensive experiential learning	Customizable to meet changing industry needs
Reflective		Dual emphasis on engineering design and student self-reflection	Effective, timely assessment & self-assessment

[1] Typically newly established school of engineering or system wide overhaul.

Appendix B: Case Study Profiles

Case study profiles are being developed for each of the following programs:

1. Olin College
2. Iron Range Engineering
3. Singapore University of Technology and Design
4. Rose-Hulman Institute of Technology
5. Worcester Polytechnic Institute
6. Colorado School of Mines
7. California Polytechnic University - San Luis Obispo
8. Pennsylvania State College of Engineering
9. Stanford Engineering + D-School
10. Delft University of Technology
11. McMaster Faculty of Engineering
12. Villanova University
13. D-LAB, Massachusetts Institute of Technology
14. Aalborg University
15. DTU - Technical University of Denmark
16. CITRIS Banatao Institute and UC Berkeley Engineering
17. Integrated Teaching and Learning Laboratory, University of Colorado Boulder
18. College of Engineering, Purdue University
19. College of Engineering, UC Davis
20. ASU Arizona State Engineering

Box 1. Example Case Study Profile: Iron Range Engineering

Iron Range Engineering

Launched in 2010, Iron Range Engineering (IRE) is a bachelor's in engineering program offered as a collaboration between Itasca Community College in Grand Rapids, MN, Minnesota State University, Mankato (MSU) and the Iron Range industry in northeastern Minnesota. IRE has been recognized by the MIT Global State of the Art in Engineering Report as one of the top 5 global leaders. This faculty-conceived and faculty-driven program equips students to work closely with industry partners on design projects throughout their 3rd and 4th years. IRE undergraduates (<1,000) are enrolled through Minnesota State University, Mankato but are typically transfer students who have graduated from two year associate degree programs. An adaptation of the Aalborg model, upper division courses are delivered in two half-semester periods called "blocks" and students engage in semester-long design projects. Design projects are either proposed by industry partners (80%) or represent entrepreneurial ideas proposed by students (20%). Rather than bringing industry-sponsored projects to the students on-campus (the norm), this program embeds students in industry to work on-site. Accordingly, IRE is developing a "flipped classroom" model where a significant proportion of the learning and support will be supplied online. For example, after initial independent study students can engage with mentors in "learning conversations". The IRE capstone is roughly a 40 hour-per-week experience where students learn engineering practices while working side-by-side with industry clients. Instructors require students to describe competencies they have demonstrated in industry-based projects in a portfolio that includes evidence of their work and their reflections on it.

Appendix C: Creative EDG2 Full Framework

Creative Engineering Design for Global Good (Creative EDG2) Framework A resource to identify campus strengths and assets that promote entrepreneurial thinking for global good through experiential learning		
Theme	Category	Description
Type of Institution & General Situation	SIZE	Undergradute enrollment in SOE, faculty, staff
	HISTORY	Faith based, industrial roots, private donor, land grant, etc.
	CONTEXT	Urban, suburban, private, public, standalone SOE or embedded, URM serving, regional,
	THEMATIC FOCUS	Eco-sustainability, global exchange, aerospace, promoting women in engineering, etc.
	GEO-POLITICAL	USA or international, first world, geographic location, global politics, etc.
Organization & Infrastructure	CAMPUS ORGANIZATION	Postion of engineering within the institution
	SPACES & BUILT ENVIRONMENT	Dedicated project space, open space, maker spaces, etc.
	LEADERSHIP	Deans, directors and other leading administrators
	SUPPORT STAFF	Non-teaching personnel such as program managers, lab managers, technicians, etc
	INSTRUCTIONAL SUPPORT	Affordances and constraints shaping teaching activities, faculty, instructional support teams
	INCENTIVES	Incentives for teaching excellence, innovation, inclusion, etc.
	STUDENT SERVICES	Student advising, incentives, work-study programs etc.
	CAMPUS COMMUNITY	Fostering campus community in innovation, excellence, inclusion
Connections	RESEARCH & INSTRUCTION	Involvement of industry, philanthropy, non-profits, community organizations or goverment
	COMMUNITY - CAMPUS CONNECTIONS	Role of advisory boards & influence of industry, philanthropy, goverment, NGO partners
	EXTRAMURAL FUNDING	Corporate sponsorship, centers, government incentives, paid internships, hackathons, donations
	EXTERNAL ADVISORY FUNCTIONS	Corporate sponsorship, government incentives, paid internships, contests, donations, exterally funded centers, etc.
Equitable & Inclusive Culture	DEMOGRAPHICS & DIVERSITY	Monitors changes in student, faculty, and staff demographics
	INCLUSIVE TEACHING	Curriculum designed for inclusion
	PROGRAMS & PROFESSIONAL DEVELOPMENT	Programs or student activities aimed to promote inclusion, diversity, retention
	POLICIES & PRACTICE	Formal and informal policies regulating admissions, hiring, and conduct
Program Design & Learning Ecosystem	SEQUENCING / STRUCTURE	Degree requirements; pathways to degree; course structure
	ALTERNATIVE LEARNING FORMATS	Online, flipped-classroom, modular, mobile, distance, blended learning
	EXTRA / CO-CURRICULAR	Student-run clubs, chapters, societies, informal spaces
	FEE STRUCTURES	Course fees, membership fees, direct costs, supplies, materials
	NOTABLE FEATURES	Unique or outstanding features of a program

Creative Engineering Design for Global Good (Creative EDG2) Framework A resource to identify campus strengths and assets that promote entrepreneurial thinking for global good through experiential learning		
Theme	Category	Description
Experiential Pedagogy & Curriculum	STUDENT / CAREER CENTERED	Self-directed, active, valuing students' unique backgrounds and aspirations
	ENGINEERING PRACTICE	Explicitly teaching the practices of engineering (e.g. designing within requirements, etc.)
	HOLISTIC PROBLEM SOLVING & DESIGN	System level design incorporating social, economic, ecological, and technological lenses
	USER-DRIVEN DESIGN/ ENTREPREURISHIP	Outward facing engineering, customer discovery to create value and fulfill human needs.
	ENGINEERS AS GLOBAL CITIZENS	Ethics and social responsibility in the global arena
	VALUE & IMPACTS OF ENTPRENURSHIP	Social and planetary value of entreprenuership
	INTERDISCPLINARY	Collaborations across disciplines, working in interdicsplinary teams, coordinated coursework
	METACOGNITIVE / REFLECTIVE	Systemic student self-reflection and self-awareness
Assessment of Experiential Learning	Learner FORMATIVE	Ongoing, geared as feedback for learner
	Learner SUMMATIVE	Cognitive skill evaluation; performance assessment; authentic assessment
	Program Level	Measures taken to ensure that course-level learning outcomes are all working together

Appendix D: Meeting Notes

Summary of April 18 CITRIS Berkeley Visit

Creative EDG2
UC Santa Cruz Baskin School of Engineering
Institute for Scientist & Engineer Education

CITRIS Berkeley: UC Berkeley Foundry, Invention Lab, and Jacob's Institute of Design

April 18, 2019, UCSC Engineering 2 Room 599

Hosts

- Alexander Wolf, Dean, Baskin School of Engineering (article)
- Tamara Ball, R&D Manager, Institute for Scientist and Engineer Educators tball@ucsc.edu
- Lisa Hunter, Director, Institute for Scientist & Engineer Educators <lhunter@ucsc.edu>
- Abigail Kaun, Special Assistant to the Dean <akaun@ucsc.edu>

Attending Participants

UCSC

- Rebecca DuBois, Biomolecular Engineering rmdubois@ucsc.edu
- Richard Jullig, Computer Science and Engineering <rjullig@ucsc.edu> (one hour only)
- Narges Norouzi, Computer Science and Engineering <nanorouz@ucsc.edu>
- Gabe Elkaim, Electrical and Computer Engineering Department <elkaim@ucsc.edu>
- Michael John, Computational Media <mbjohn@ucsc.edu>
- David Lee, Computational Media <davidtlee@ucsc.edu>
- Steve Petersen, Electrical and Computer Engineering <petersen@soe.ucsc.edu>
- Marco Rolandi, Electrical and Computer Engineering <mrolandi@ucsc.edu>
-

CITRIS Berkeley

- Chris Myers, Senior Lab Manager, CITRIS Invention Lab

- Alic Chen, Co-Founder, CITRIS Foundry
- Maher Hakim, Executive Director, CITRIS Foundry
- Julie Sammons, Director of Knowledge Management, CITRIS
- Michael Matkin, Assistant Director, CITRIS at UC Santa Cruz

Program Summary

Circa 2014, responding to a growing demand among Berkeley students for design and digital prototyping design experience, faculty sought out space. Early efforts aligned with the Chancellor's call to guarantee all students an authentic "discovery experience"and inspired by the nationwide "maker movement," resulted in the retrofit of a single basement room. Over the ensuing five years with support from the CITRIS Bantano Institute, this rogue "maker-space" attracted investments funding staff positions and ultimately the establishment of the **Invention Lab**, **CITRIS Foundry** and the donor-funded **Jacob's Institute for Design Innovation.** Funds to build **Jacob's Hall** enabled all-hours access to authenticated members, opened up multi-use fabrication spaces and versatile classrooms which in turn inspired popular new engineering courses, and set the stage for a strategic alliance with the ***UC Berkeley Haas School of Business*.**

Distinguishing Features

Managed through the CITRIS Banatao Institute, the aforementioned entities are now recognized as wayshowers in preparing undergraduates to launch successful tech start-up businesses. Distinguishing features include:

- **Space & Built Environment:** 24 hr student access to open fab-lab workspaces supported by course or membership fees; also attractive tour stops for potential donors.
- **Space & Built Environment:** on-site supply store provides materials on demand, at cost.
- **Student services:** Students compete for annual seed funding to support original entrepreneurship through the Tech for Social Good (student project funding) and benefit from seed funding available for faculty research programs.
- **Personnel:** Super-users lower intimidation factors, provide oversight, mentorship, community and peer-peer support while keeping staffing costs down.
- **Personnel:** 20 + part and full time staff positions play critical role in support, project management and securing funding.

Greatest Accomplishments to Date

- **Funding models:** Popularity of Invention Lab was impetus for large private donation that established Jacob's institute and was used to build the 24,000 square foot **Jacob's Hall** with design studios and labs that serve academics and act as a community space.

- **Sequencing & Structure:** a new project-based data science major is now filling 800 seat courses; new courses such as “Re-imagining Mobility” were directly inspired by access (faculty petition for use) to versatile well-equipped classrooms
- **Funding models:** Over 400 students have been funded through annual funding competitions to work on original innovation and applied research projects for social good.
- **Interdisciplinary:** projects such as the DataCorps “Policy Lab” are bringing together students from over 100 disciplines to work collaboratively as design teams.

Salient Challenges

- **Spaces & Built Environment:** the process for adjudicating petitions for access (course instructors, individuals, student groups and community members) to desirable spaces has been in flux over the years.
- **Policies and Practice:** All Foundry and many Invention Lab Projects are 100% extra-curricular which could carry inequitable bias and limit participation of low income students.
- **Personnel / Student Services**: Initially only students enrolled in sponsored classes had access to the Invention lab. Strategic shift to key card access for members required payment of a full time lab manager to provide safety training and supervision. (Currently operates with two full time staff who manage 4-5 grad student “super-users” filling in).
- **Campus, Off-Campus Connections:** Managing relationships needed to support the experiential learning ecosystem is time consuming and challenging as unpredictable opportunities arise and dissipate spontaneously.
- **Interdisciplinary**: teaching skills for tech start-up requires more than engineering, which has been overcome by CITRIS leadership building strong relationships with several departments and the Haas School of Business.

Key Outtakes

The payback on dedicating and outfitting a relatively small space on a restricted budget ($100 - $200K) to serve as an multi-use digital prototyping/fabrication space more than justified the up-front costs. However, expansion and upkeep of the experiential learning ecosystem that grew out of this required a significant extramural investment in human resources in order to support new staff positions and/or the restructuring faculty roles to accommodate different sorts of responsibilities required to curate projects and manage relationships with outside stakeholders.

Follow Up communication plan

Tamara will schedule follow-up ZOOM talks with Chris Myers, Senior Lab Manager, CITRIS Invention Lab, Alic Chen, Co-Founder, CITRIS Foundry Maher Hakim, Executive Director, CITRIS Foundry to ask follow up questions listed in Column E of the appended Creative EDG2 CITRIS 4/18 Visit Framework. Follow up question will focus on:

- **External Advisory Boards:** What role do they play and what are Intricacies of relations with advisory boards
- **Experiential Learning Ecosystem** How have labs stimulated changes in formal degree requirements or course offerings, or classroom pedagogy?
- **Engineering practice:** Has the move to projects in labs stimulated new emphasis on teaching the practices and mindset of engineers?
- **Culture and Climate**: How are they serving students without discretionary time in their schedules; are they monitoring the demographics in formal and informal learning?
- **Funding models**: More details on funding models and allocations
- **Summative assessment:** How are extra-curricular projects assessed? Are different assessments used for course-related vs. extra-curricular projects?

Creative EDG2
UC Santa Cruz Baskin School of Engineering
Institute for Scientist & Engineer Education

BSOE Faculty Exchange

June 4, 2019 UCSC Engineering 2 Room 399

Hosts

- Tamara Ball, R&D Manager, Institute for Scientist and Engineer Educators tball@ucsc.edu
- Nicholas McConnell, Program Manager, Institute for Scientist and Engineer Educators njmcconn@ucsc.edu

Attending Participants

UCSC

- Rebecca DuBois, Biomolecular Engineering rmdubois@ucsc.edu
- David Lee, Computational Media <davidtlee@ucsc.edu>
- Steve Petersen, Electrical and Computer Engineering <petersen@soe.ucsc.edu>
- Yishu Chen, Technology Management in Sustainability, Electrical and Computer Engineering yihsuchen@ucsc.edu
- Narges Norouzi, Computer Science and Engineering <nanorouz@ucsc.edu>

Brief Summary

Creative EDG2 Framework was circulated in advance. Participating faculty met for 90 minutes to share aspects of their teaching and curriculum aligned with Creative EDG2 initiative. After a brief introduction by the hosts, approximately 50 minutes were devoted to discussion of select courses or extra-curricular projects championed by individual faculty. The last 30 minutes shifted to topics spanning courses and departments related to instructional support, course sequences, interdisciplinary teaching, fee structures, extra-mural funding models and community partnerships, faculty incentives (teaching credits) and connections between research and teaching. Participants expressed their interest in joining future Creative EDG2 faculty exchanges.