Development Engineering: Actionable Research and Global Impact

Alice M. Agogino
Professor of Mechanical Engineering
Chair, Development Engineering Graduate Group
Education Director, Blum Center for Developing Economies
University of California at Berkeley

Tata Center (Technology+Design),
November 10, 2016

Development Engineering: fields & goals

A new interdisciplinary **research** field that integrates:

- Engineering, physical sciences, energy & resource development
- Economics, business & social sciences

to develop, implement, evaluate & scale technologies to benefit people living in poverty in developing regions and low-income areas of the U.S.

Development Engineering: Tools & Models

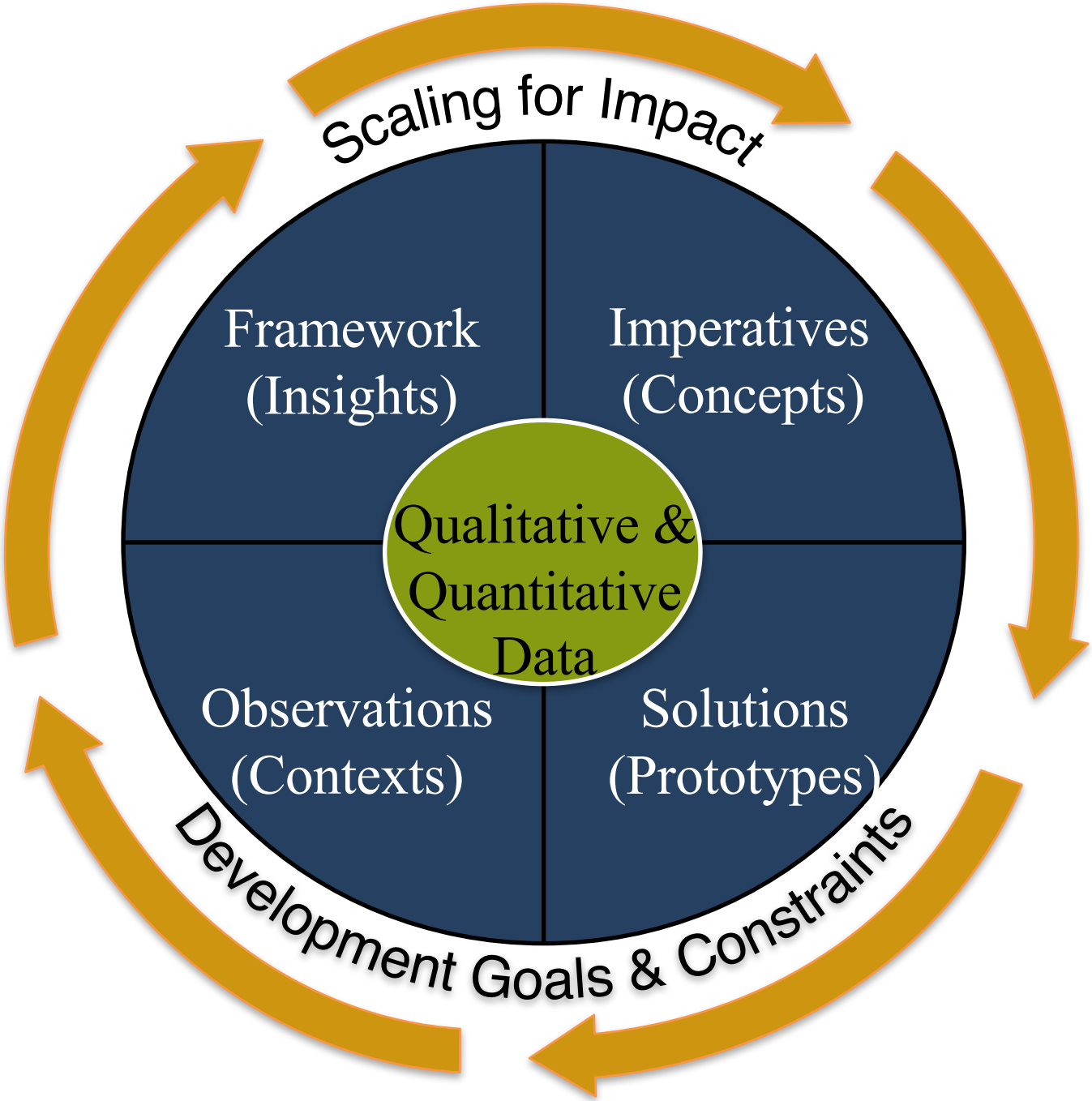
Uses a **human-centered design** approach and **technological advances** with an interdisciplinary framework of development that includes:

- innovative business models,
- continual impact analysis,
- cross-cultural learning, prototyping and scaling, and
- new models for productive multi-stakeholder collaboration.

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

Development Engineering: Designing products and services that improve poor people's lives at scale

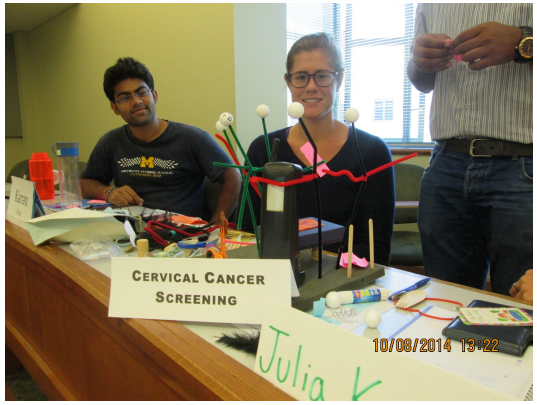
Development Engineering Research Model



PhD Minor at UC Berkeley

- Fall Semester: Dev Eng 200 (MBA 290T, ME 200): Design, Evaluate & Scale Development Technologies

Midwife Education



Black Carbon Meters

- Spring Dev Eng 210: Theory & Practice Seminar
- Choice of 3 elective courses, only one of which can be from the student's home department.

Development Engineering Minor

Must also take 3 electives from at least 2 of the following categories:

- Problem Identification & project design
- Evaluation techniques and methods for measuring social impact
- Development technologies

- Only 1 course can be in the major

Core competencies that development engineers must have as next generation development practitioners?

Ability to
Look Beyond Technology
and apply *relevant technology*

Flexibility

Communication Skills

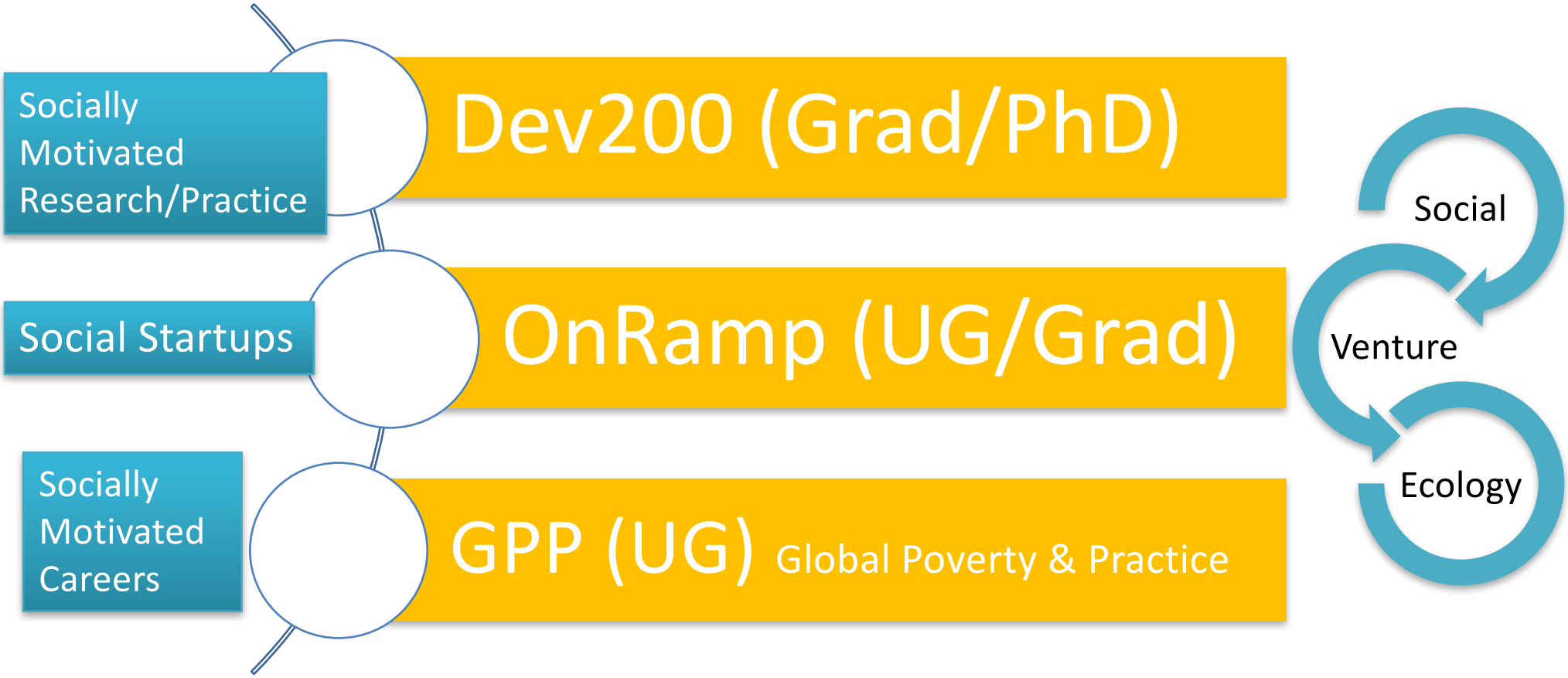
Cross-Cultural Skills

Ability to understand complexity &
Think in Systems

Humility
& listening & learning from others

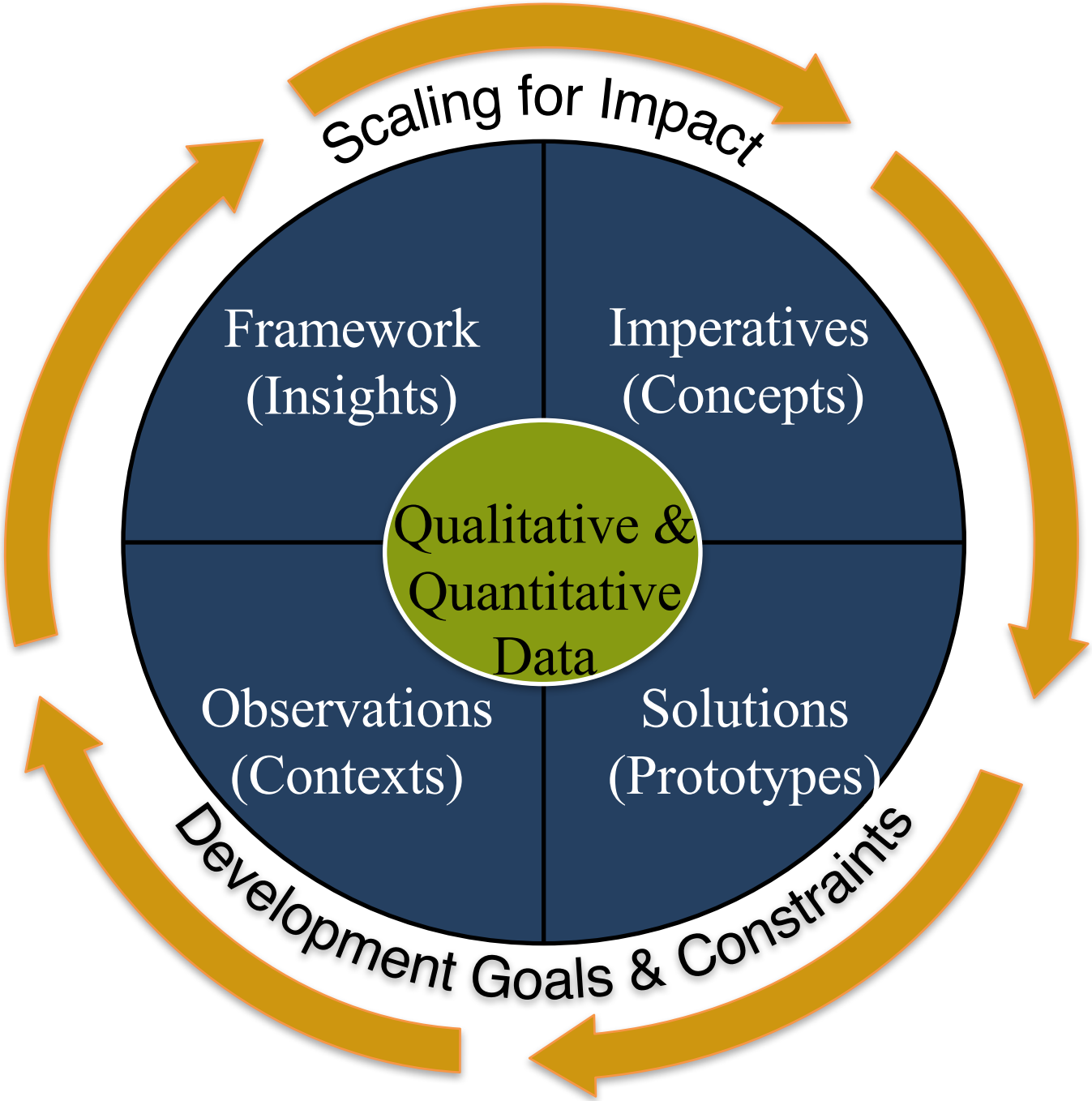
BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

Theory, Methods & Practice Ecology



BLUM CENTER FOR DEVELOPING ECONOMIES

Development Engineering Pedagogy



DevEng Ideation & Reframing Cards

- The Role of Gender
- Mobile phones/ Smartphones
- Community Groups and NGOs
- Complex household structures
- Groups facing discrimination
- Isolation
- Seasons
- Donors, government & diaspora
- Liquidity constraints
- Social norms
- Pollutions

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

DevEng Ideation & Reframing Cards

The Role of Gender

Motivation:

Gender roles affect almost every facet of life, and in turn affect almost every product and service

Illustration:

Individual pay-per-use for public toilets appears perfectly fair at first glance. However, it often requires women to pay more than men (due to menstruation, pregnancy, and taboos against women exposing themselves in public). A possible solution is family membership.

What stage are you in?

Just beginning (pre-prototype):

Ideation Questions:

1) Make a projection: What would happen if women and men used the same product?
2) Are there any roles or customs your product could take advantage of to empower women *in ways the community understands and accepts*?
3) Can you design a solution just for women? Just for men?

Intermediate (post-prototype):

Reframing Questions:

1) How do existing gender roles affect what your product needs to do? How it will be used? Barriers it will face?
2) Will your product or service interact with existing gender roles in harmful ways?
3) Can your product advance desirable norms?

Research & Teaching Example: cooking over biomass fires kills 4 million people per year

(Lim, 2014) http://blogs.civicus.org/worldassembly/2012/07/14/wood-fuel-destroying-the-environment-and-harming-the-african-woman/.

Example: Development issues & stoves

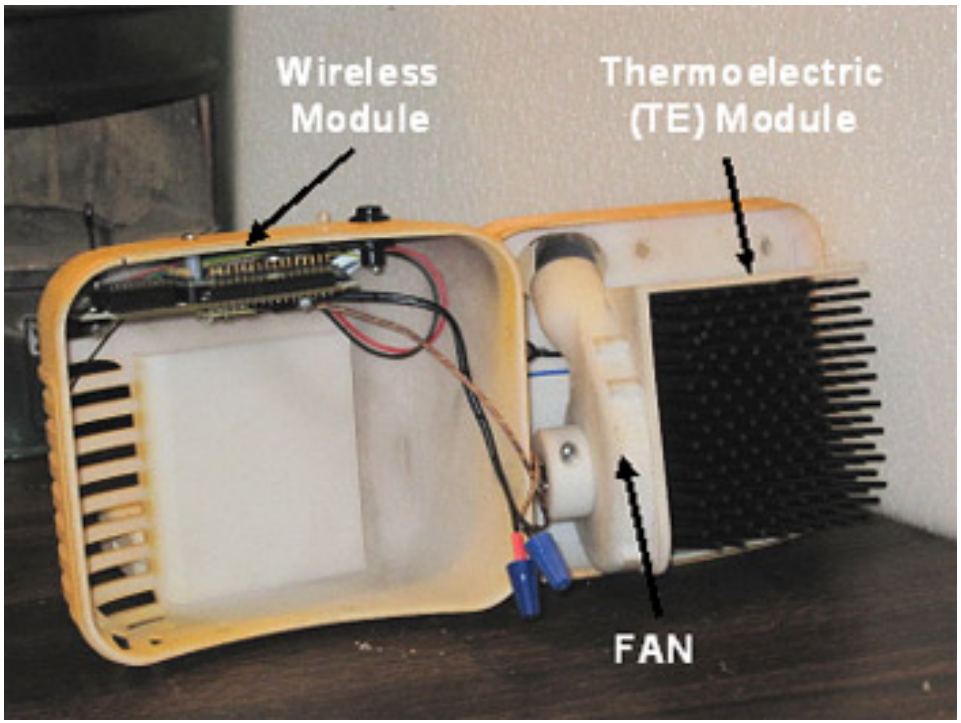
	Needs assess	Creativity	Improvement
Social goals to improve people's lives at scale	Who breathes the most smoke?	How can we reduce smoke exposure?	Are we reducing smoke exposure?
Barriers to design from geographic and cultural distance	How can we learn when far?		How to learn problems with out solutions?
Constraints of poverty, remoteness, liquidity constraints, gender roles,…	How to sell when liquidity constraints?	Find 20 solutions to liquidity constraints	Test our solutions
Opportunities of donors, mobile phones, microfinance,…	What role for mobile phones?	How to use mobile banking?	How collect data via phone?
Tools for impact evaluations	What impacts do donors care about?	How to roll out our product to build in learning? Role of sensors?	Low-cost RCT (randomized controlled trials)

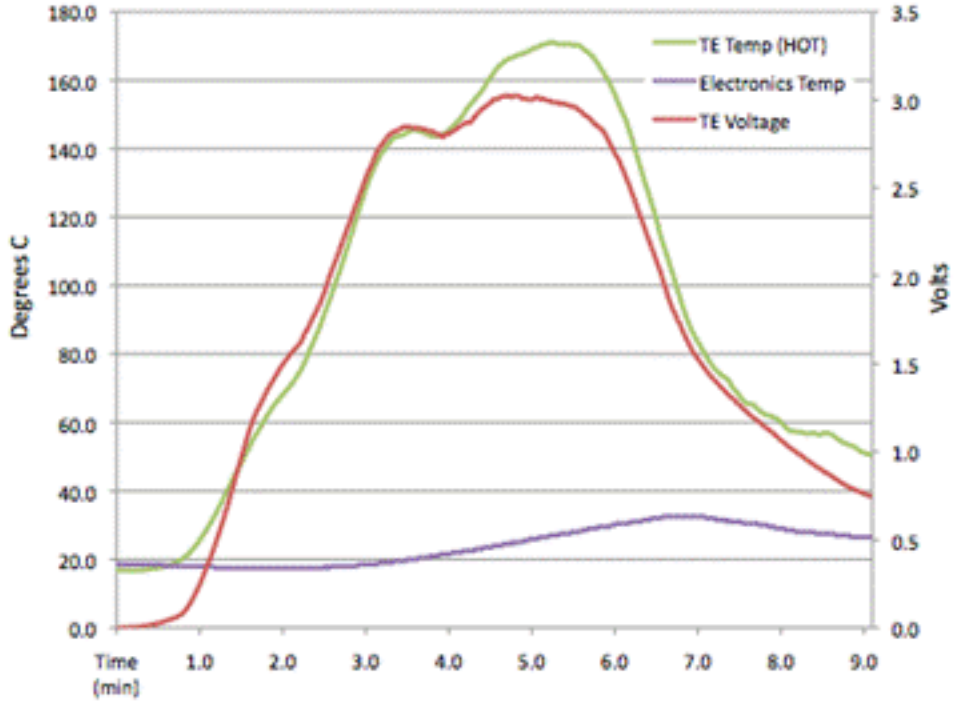
Cook Stove Workshop

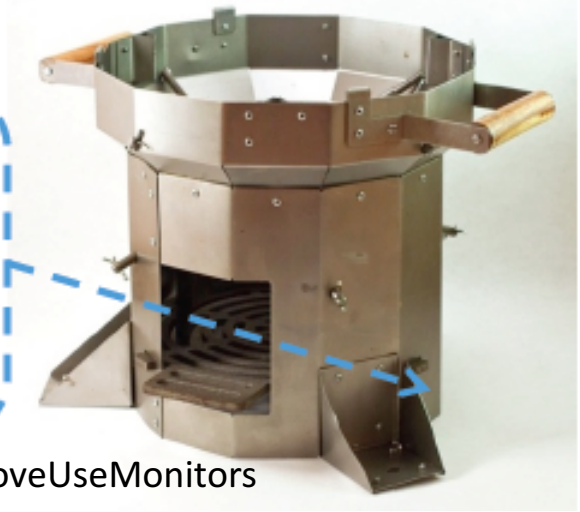
http://bit.ly/deveng-cookstove

Sensor Data

UCB-SUMS Stove Use Monitoring System



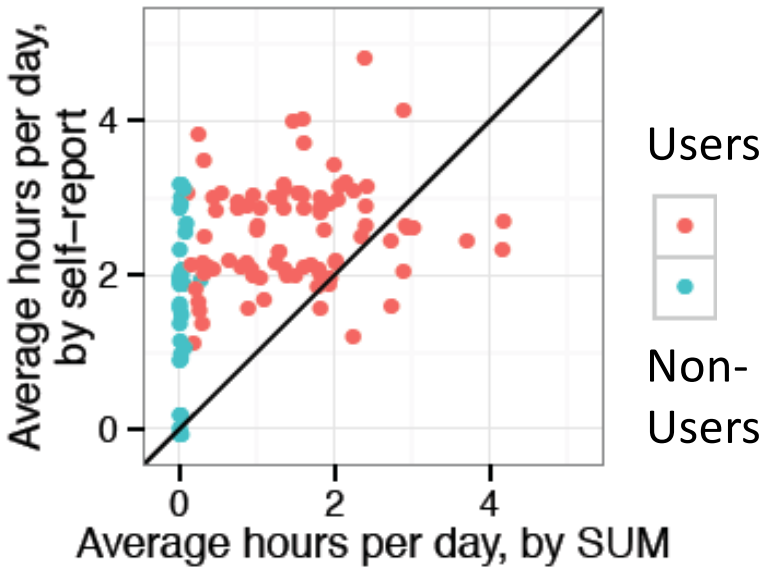




Maxim iButton: http://www.hedon.info/BP55:Low-costTemperatureLoggersAsStoveUseMonitors

Research: What is Said – What is Done

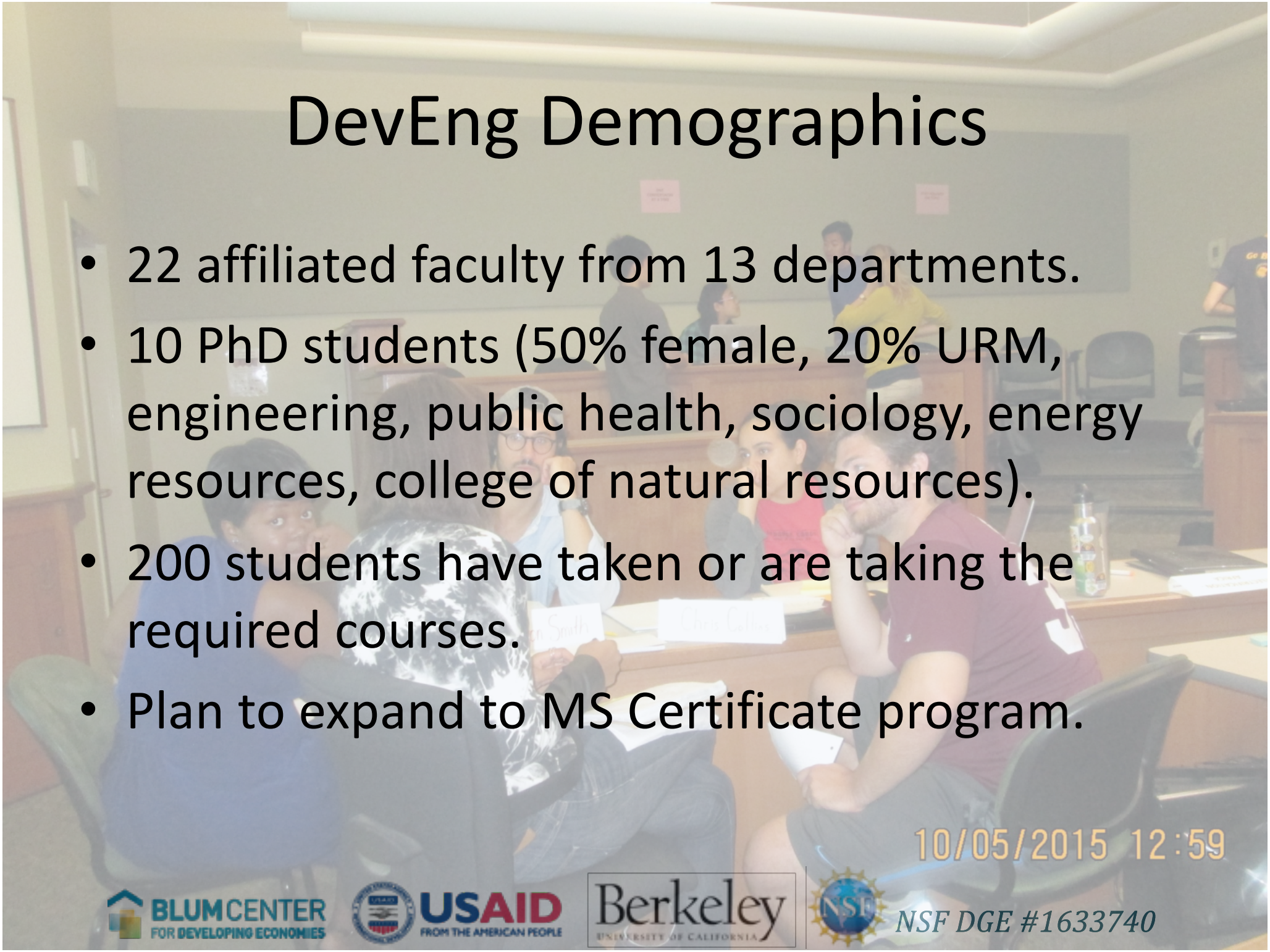
- Comparison between ODK survey data and sensor data
- 85% over-estimated cooking hours & events
  - – Users over-reported time spent cooking by 1.2 hours (almost double)
  - – Non-Users over-reported by 1.7 hours.



Daniel Wilson, PhD Dissertation, 2016, *Quantifying the Crisis of Cooking: Next-Generation Monitoring and Evaluation of a Global Health and Environmental Disaster*

DevEng Demographics

- 22 affiliated faculty from 13 departments.
- 10 PhD students (50% female, 20% URM, engineering, public health, sociology, energy resources, college of natural resources).
- 200 students have taken or are taking the required courses.
- Plan to expand to MS Certificate program.



BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF DGE #1633740

Student Profiles: Julia Kramer

- PhD 2019, Mechanical Engineering
- Research on cervical cancer detection & training in Ghana & world-wide.
- 275,000 women die each year from cervical cancer with 80% of these in the developing world.
- Collaboration with Kathleen Sienko Univ of Michigan.

1st place 2014 Big Ideas winner, global health ("Visualize an end to Cervical Cancer") . Crowd funding.

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

Student Profiles: Katya Cherukumilli

- PhD 2017, Environmental Engineering with Ashok Gadgil
- Research on using low-cost bauxite ore to eliminate flouride poisoning from drinking water in India, and globally.
- 2015 Big Ideas 2nd place winner
- DOW Sustainability Innovation Student Challenge Award winner in 2015

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

Research Profile: Nitrogen Cycle

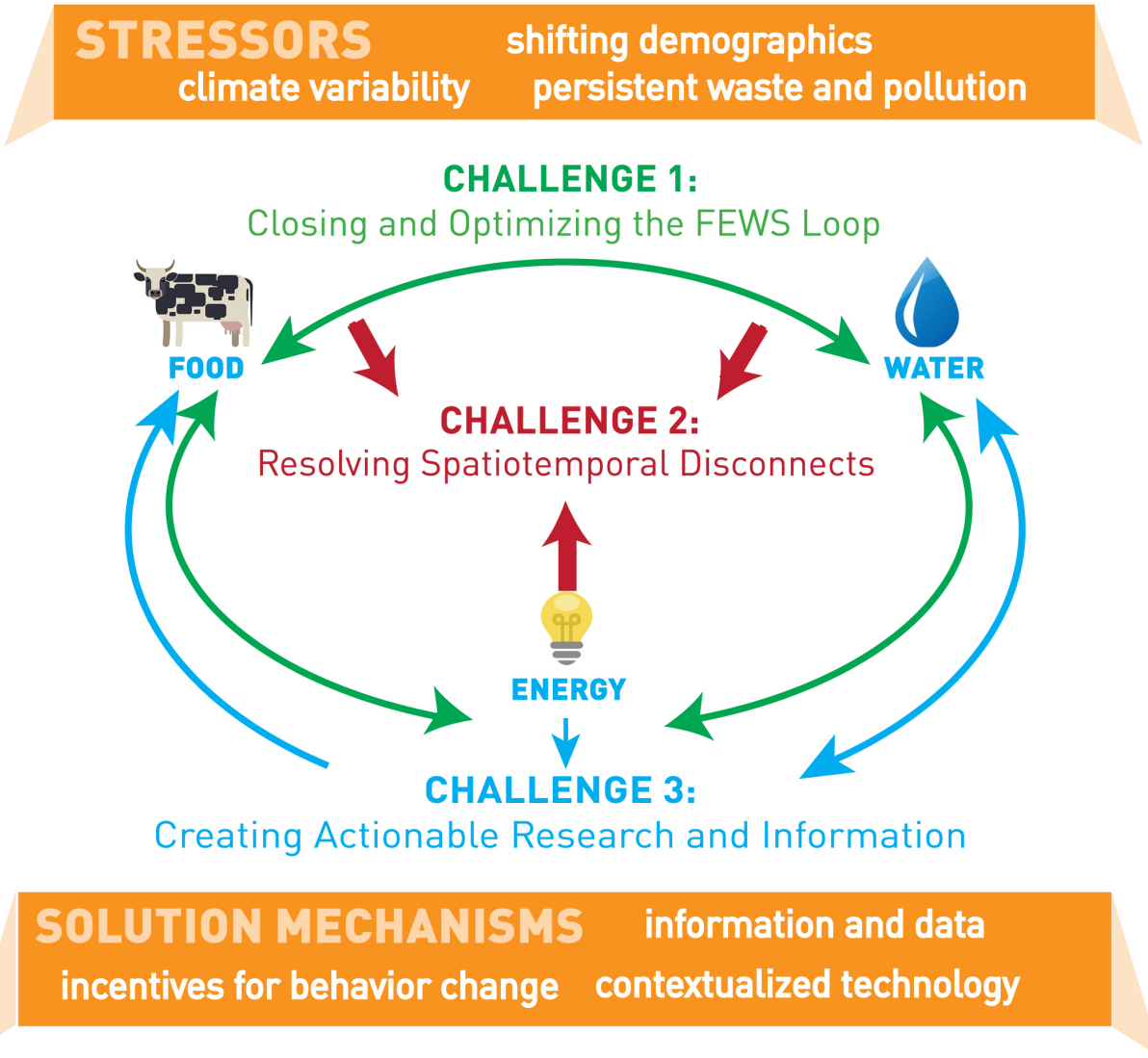
- Will Tarpeh, PhD 2017, Environmental Engineering
- Research on electrochemical cells to recover nitrogen from human urine and to disinfect feces, bringing affordable sanitation & fertilizer for agriculture to poverty-stricken communities in Kenya.
- Prof. Kara Nelson, advisor
- 1st place 2014 Big Ideas winner, poverty alleviation ("ElectroSan")

Just a touch of nitrogen hikes yields in depleted soil, common in Africa. But fertilizer is scarce and costly for small farmers.

The Nitrogen Fix, *Science*, **353** (6305) Sep. 2016.

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF DGE #1633740

Food, Energy, Water Systems (FEWS) Grand Challenges & Interconnections



BLUM CENTER FOR DEVELOPING ECONOMIES

USAID FROM THE AMERICAN PEOPLE

Berkeley UNIVERSITY OF CALIFORNIA

NSF DGE #1633740

Example Research

1. DISTRIBUTED FEWS SYSTEMS: Distributed generation & storage technologies for communities in transition that support energy services, water quality and access, and healthy food systems.

2. CONVERTING URBAN WASTE TO ENERGY, FOOD AND WATER: Production of fertilizer and energy from high-strength residential, municipal, and agricultural wastes.

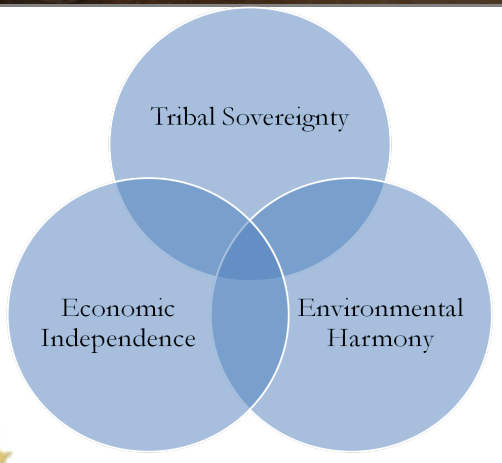
3. THE INTERNET OF FOOD: Tracking, analyzing and managing food supply chains with embedded energy, water and greenhouse gases.

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF
NSF DGE #1633740

Tribal InFEWS

Enabling information-rich sustainable community development

Culturally-sensitive sustainable buildings, energy, water systems and native plants, Pinoleville Pomo Nation



BLUM CENTER FOR DEVELOPING ECONOMIES

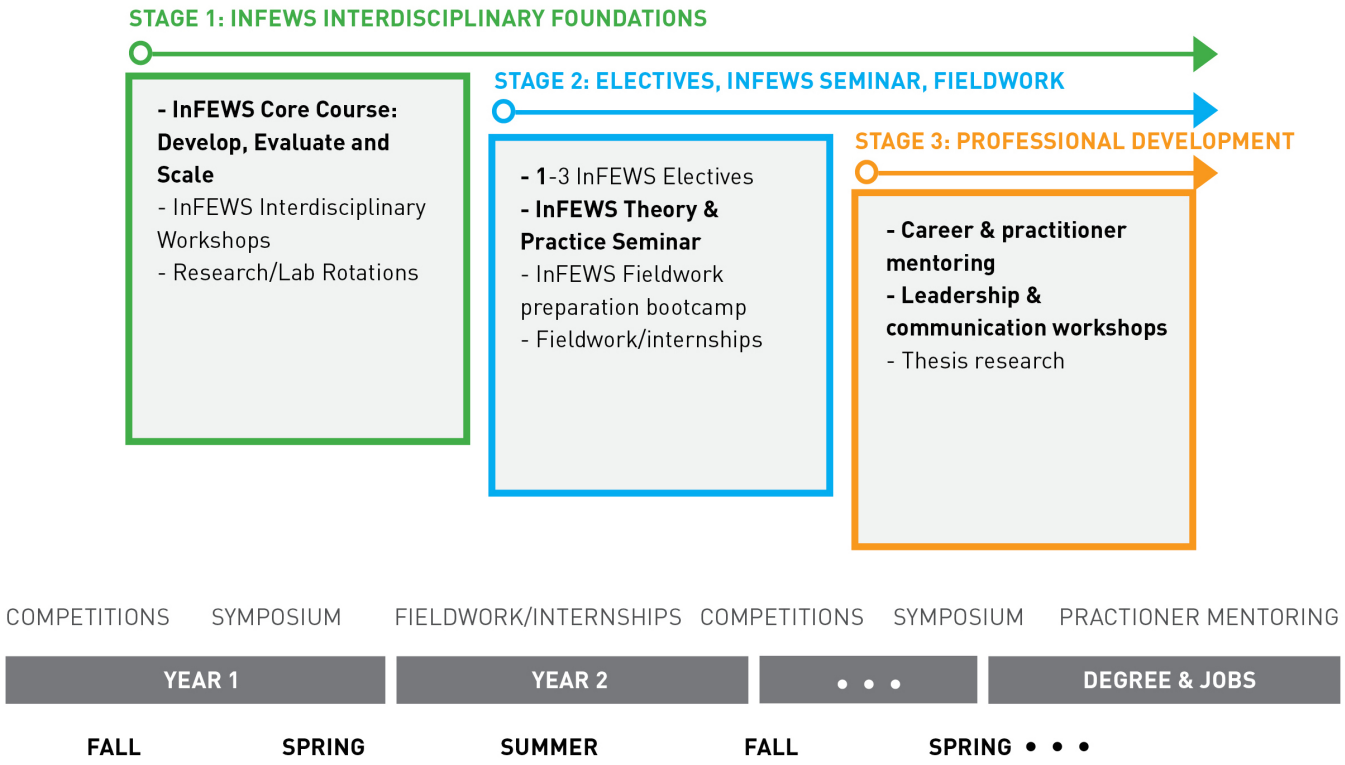
USAID FROM THE AMERICAN PEOPLE

Berkeley UNIVERSITY OF CALIFORNIA

NSF

NSF DGE #1633740

Program Timeline for FEWS Research Trainees



Bold designates required elements for both the FEWS MS certificate program and the PhD minor. 20 trainees per year over four years. Over 100 additional STEM students (non-trainees) per year will participate in one or more training elements.

BLUM CENTER FOR DEVELOPING ECONOMIES
USAID FROM THE AMERICAN PEOPLE
Berkeley UNIVERSITY OF CALIFORNIA
NSF DGE #1633740

Expand Global Collaborative

USAID
Higher Education
Solutions Network

BLUM CENTER FOR DEVELOPING ECONOMIES

USAID FROM THE AMERICAN PEOPLE

Berkeley UNIVERSITY OF CALIFORNIA

NSF DGE #1633740

Development Engineering Journal

- Engineering research in response to unique constraints imposed by poverty.
- Novel technologies or tools for measuring behavioral, economic and social outcomes in low-resource settings.
- Technology markets and the role of innovation in economic development.
- Assessment of technology solutions, including field performance, consumer adoption and end-user impacts.

BLUM CENTER FOR DEVELOPING ECONOMIES

USAID FROM THE AMERICAN PEOPLE

Berkeley UNIVERSITY OF CALIFORNIA

NSF DGE #1633740

DESIGNEXCHANGE

Where designers and researchers share methods and best practices.

JOIN

Learn

Browse methods and case studies to improve your design skills. Learn what to do and what not to do to successfully complete your next design task.

Invite

Invite your friends to join theDesignExchange community!

Methods

Learn about the methods you could use on your next design.

Cultural Probes

Gain insight into and inspirational responses about the daily life and habits of communities

Case Studies

Read about how real design problems were solved.

Adapting Usability Testing for Oral, Rural Users

Read about a study conducted in Ghanaian villages that evaluated an audio computer desgined for people living in oral cultures

DESIGNEXCHANGE

Where designers and researchers share methods and best practices.

Featured Case Studies

+ Add Case Study

Filter by Design Process

- Research
- Analyze
- Ideate
- Build
- Communicate

Computer Gamers in the Developing World: The value

Central Asia has a resource constrained environment, particularly political and economic constraints. In such a scenario, it is important to understand how the public nature of gaming affects players' what gaming is and what purpose gaming serves

Analyze Research 9

Requirements for the Design of Advanced Driver

As more people populate the earth and the number of vehicles on the road increases, traffic accidents are a rising problem. In an effort to combat this problem, today's vehicles are equipped with Advanced Driver Assistance Systems (ADAS). The

Build Analyze Ideate 77

A Trust Model for E-Commerce in South Africa

Electronic commerce has grown exponentially over the past few years in South Africa, but research still indicates that many web e-commerce web sites are still poorly designed. There is little evidence that [guidelines] are used in the design process. As a

Build Analyze Ideate 90

Using a Design Led Disruptive Innovation

In 2008, [Hwang and Christensen] (https://scholar.google.com/hl=en&q=Hwang%2C+J.%21335.+&btnG=&as_sdt=1%2 provided a critique of the US health care system, demonstrating that [healthcare remains] expensive and inaccessible to a large

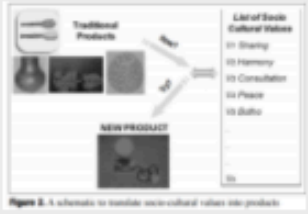
Build Analyze Ideate 56

Older adults with multi-morbidity: medication

Medication self-management is essential to drug safety but remains a challenging issue for older adults who have problems understanding and remembering [medication]. Personal health applications (PHAs) exists today, but

Analyze Research 52

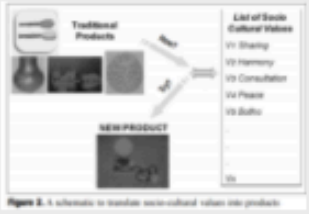
Mobile phone users in Kyrgyzstan: A



Mobile phones have been a potentially transformative techn[ology] platform for developing

Build Analyze Ideate 18

Designing for Learning Effectiveness



In Westernized nations information and Communication Technologies are readily

Analyze Research Commu 45

Adapting Usability Testing for Oral, Rural Users

The growing efforts to utilize technology in order to assist with poverty alleviation efforts reveal

Build Analyze Ideate 70

Development Engineering

dev.eng@berkeley.edu

Infews.berkeley.edu

BLUM CENTER FOR DEVELOPING ECONOMIES

USAID FROM THE AMERICAN PEOPLE

Berkeley UNIVERSITY OF CALIFORNIA

NSF DGE #1633740