Transforming STEM Education through Teacher Training

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If improving STEM education is our end goal -

How do you get there?

What does teacher training have to do with it?
Where we are going...

- Unpacking Baggage
- Building Frameworks
- Project Specifics
- Putting Them Together
- A Strong Undergraduate STEM Foundation
Unpacking Baggage - STEM

These are our STEM foci for these projects. What are yours?

- Disciplinary Sciences
- Information Technologies
- Engineering
- Mathematics
- Student engagement
- Teacher training
- Pedagogical Strategies

STEM Education
Unpacking - Teacher Training

Direct Experiences

- Professional Development
- Curriculum Development
- Pre-service preparation
- Mentoring & Support

Indirect Experiences

- Outreach, Dissemination
- Curriculum Materials
- Curriculum Modeling
- Experiences for Students

These are our primary routes for teacher training. Are there others you include in your projects?
Frameworks

Teacher Learning
- New learning
- Testing new ideas
- Student results
- Changing beliefs
- Continued use and sharing

Pedagogical Strategy
- Design - Refine strategy as it fits with a specific discipline

- Identify and Define
- Gather Information
- Identify Alternatives
- Refine
- Communicate
- Select Solutions
- Communicate Solution
- Evaluate Solution
- Implement Solution

Modified from Guskey 2002
Three Specific NSF-Supported Projects

• **CEEMS** – Cincinnati Engineering Enhanced Math and Science Partnership

• **DITLE** – Design-based Information Technology Learning Experiences

• **ECBTE** – Expert Clinically-Based Teacher Educators
Specific Project Components

**CEEMS**
- Teacher PD
- Curriculum Units/Modeling
- Mentoring
- Outreach Activities
- Pre-service preparation

**DITLE**
- Student Experiences
- Pre-service Preparation
- Outreach Activities
- Curriculum Development

**ECBTE**
- Teacher PD
- Curriculum Development
- Mentor Development
- Pre-service preparation
- Curriculum Modeling
- Outreach
Three distinct efforts with different emphases but a common goal.

Improving Undergraduate STEM Education

ECBTE

DITLE

CEEMS
What is CEEMS?
Math & Science Partnership grant from National Science Foundation

Enhances STEM education through *teacher training* with:

- UC as a higher education partner with 14 school districts - urban, rural, & suburban
- Five inter-related STEM education goals
Five CEEMS Goals

Goal 1:
Improve 7-12 student knowledge of engineering design process and STEM careers and increase interest in college study of engineering or other STEM careers.
Goal 2: Increase 7-12 student knowledge of math and science content when taught using engineering as a context for learning
Goal 3:
Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
Goal 4: Create a sustainable track for engineering undergraduates to simultaneously obtain secondary teacher licensure and provide teacher experiences for engineering students with younger college students and in 7-12 schools.
Goal 5:
Promote broader application and impact of challenge-based learning and engineering design-based learning across region by exposing pre-service teachers to the pedagogies and developing sustainable propagation strategies to in-service teachers not directly participating in the grant.
Primary Pathways to Achieving these Goals

1. Summer Institute for Teachers (SIT) for in-service and pre-service teachers

2. ACCEND (ACCelerated ENgineering Degrees) for engineering undergraduate students

3. Regional conferences for sharing CEEMS units
Summer Institute Courses

Engineering Courses:
• Engineering Foundations
• Applications of Technology
• Engineering Applications of Mathematics
• Engineering Models – elective
• Engineering Energy Systems - elective

Science Courses:
• Modeling & Applications in Physical Sciences
• Modeling & Applications in Biological Sciences - elective
• Modeling & Applications in Earth Systems – elective
Summer Institute
Professional Workshops

Professional workshops focused on:
- Integrating CBL and EDP into State standards
- Designing high quality CBL learning units and assessments
- Deepening engineering knowledge as used in local industry
- Support for presentation skills and strategies
CEEMS Expectations for Teachers

Two year commitment including:

• 2 SIT programs - 7 weeks each summer
• Create 5 CBL units to be implemented, documented, and revised during the academic years
• Conduct 4 Professional Development sessions about CBL or EDP
Teaching Using CBL

- **Academic Standards**
- **Big Idea**
- **Essential Questions**
- **State Challenge**
- **Formulate Guiding Questions**

- **Select One Question**

- **Real world: global or local relevance**

- **Unit Addresses the Challenge**

**Guiding Activities**: At least one activity will require students to use the engineering design process to solve the challenge.

(CBL is challenged based learning)
Engineering Design Process
Some Examples of CBL Units

- **Stunt Design** in a physics classroom
- Explore [Genetic Engineering](#) in a middle school science or biology class
- Design a de-icing compound in chemistry class: [Melt Away](http://ceas.uc.edu/special_programs/ceems/CEEMS_Pathways/SIT/CEEMS_InstructionalMaterials.html)
- Students use their knowledge of [slope](#) to design a wheelchair ramp
- Algebra 2 students design a working seismograph in [Measuring the Shaking of the Earth](http://ceas.uc.edu/special_programs/ceems/CEEMS_Pathways/SIT/CEEMS_InstructionalMaterials.html)
- Calculus students design a belay device in [Falling Safely](http://ceas.uc.edu/special_programs/ceems/CEEMS_Pathways/SIT/CEEMS_InstructionalMaterials.html)
Teacher Outcomes

By the numbers:

• 80 SIT participants
• 200 plus distinct CBL units publicly available
• Approximately 800 students participating in CBL units
• 68% of teachers used CBL as an instructional strategy beyond CEEMS

Quality Outcomes

“[CEEMS] taught me a new way of teaching as far as how to make my project seem to matter to the students...They had ownership in it...they had a part in [creating] it.”
Changes in Teachers’ Beliefs

Teaching Engineering:
Shift from engineering is ‘problem solving’ to engineering is a way to organize thinking and manage problem solving tasks which:
• Helps students master ambiguity through formal processes and documentation
• Pushes students beyond their comfort zones
• Requires supporting students to connect and draw on content/evidence, across a wide range of sources

Learning Engineering:
• Requires team work and accountability Understanding processes for decision making
• Monitoring your work and outcomes
• Being able to communicate, in writing and orally, what you did and why
ACCEND Program

Purpose – to create a direct pathway and support engineering students toward dual degrees:

• Bachelor’s degree in engineering plus master’s in education plus teaching licensure
• To enhance 7-12 students knowledge of engineering during their mathematics and science instruction
STEM Conference

• Approximately 1200 attendees in 4 years
• CEEMS teachers featured as they present innovative units in break-out sessions

And next two quite different efforts…
DITLE (Design-based Information Technology Learning Experiences)

Goals:

1. Increase secondary students’ interest in, awareness of, and preparation for IT career opportunities

1. Prepare a cadre of STEM educators to integrate IT skills, processes and career information into their science and mathematics instruction

1. Expand and strengthen the current regional technology infrastructure by harnessing and sharing essential IT resources
DITLE Partners

UC
School of Information Technology
School of Education

Schools
5 Urban high poverty, high minority population
1 suburban, high income, low minority
1 urban academic magnet, mixed income

Industry
Members of “Interalliance” 26 regional IT groups
Program Structure

• Summer Experiences for 9-11 students and pre-service teachers
• Academic year experiences
• Advanced student experiences
• Teacher Graduate Certificate in IT
Summer Camp

Students and Pre-service teachers attend a 3 week foundations of IT summer camp

- Competency- Based Approach to Instruction
- Assessments through competency aligned design projects
- Pre-service teachers serve as group coordinators for camp long design project
**Outcomes**

- 42 student completed summer camp in 2015
- 10 pre-service teachers completed summer camp
- 4 students participated in paid IT internships
- 5 schools initiated or extended IT clubs at their schools
- 5 schools held two community computer nights lead by club members
- Foundations of IT course curriculum redesigned for camp and under graduates
- 1 student is enrolled at UC in the IT program for fall
**ECBTE (Expert Clinically-based Teacher Educators)**

Goals:

- To retain and provide continuous professional development to experienced, expert secondary STEM teachers in CPS.

- To enhance the preparation and support available to pre-, novice, and mid-career secondary STEM teachers in CPS.

- To provide access to high quality STEM instruction for all secondary students in CPS.
Specific Program Components Addressing Improving Undergraduate STEM

1. Advanced content training experiences for teachers
2. Enhanced STEM pedagogies – CBL, Design Learning
3. Preparation for HS teachers to teach dual credit college courses
   1. Orientation to college teaching
   2. Mentoring and support to HS teachers
   3. Learning communities for HS teacher
Improving Pre-Service Teacher Preparation

1. Collaborative pre-service curriculum development with school of education faculty
2. Developing a mentoring curriculum to support pre-service teachers learning in urban schools
3. Co-teaching of methods courses
Who are the ECBTEs?

• Cohort 1 – 9 teachers selected in April
  – 5 African Americans; 8 women
  – 7 science; 2 math
  – Average of 22 years of urban teaching experience
  – All have a masters degree or higher
  – 6 graduates of the CEEMS program
  – 2 working with DITLE school clubs
  – All demonstrated success in student learning
Putting All of the above efforts Together ....

Some Common Outcomes--

– School and Partnerships Developed
– Learning at all points in the education system
  • Teachers – practicing and pre-service
  • 7th-12th grade Students
  • College Faculty
– Outreach and curriculum materials to last past grant activities
– Advanced certifications and degrees
How does this impact undergraduate STEM education?

We have created a multilayered STEM foundation.

STEM experienced and knowledgeable students entering college

Knowledgeable and prepared teachers to guide students to STEM options

Pre-service teachers learning through STEM pedagogies

Responsive and knowledgeable STEM faculty

Available curriculum and outreach materials for other schools and teachers

Responsive and knowledgeable STEM faculty