Infusing Engineering into Secondary Level Classes

Projects INFUSE & INSPIRES

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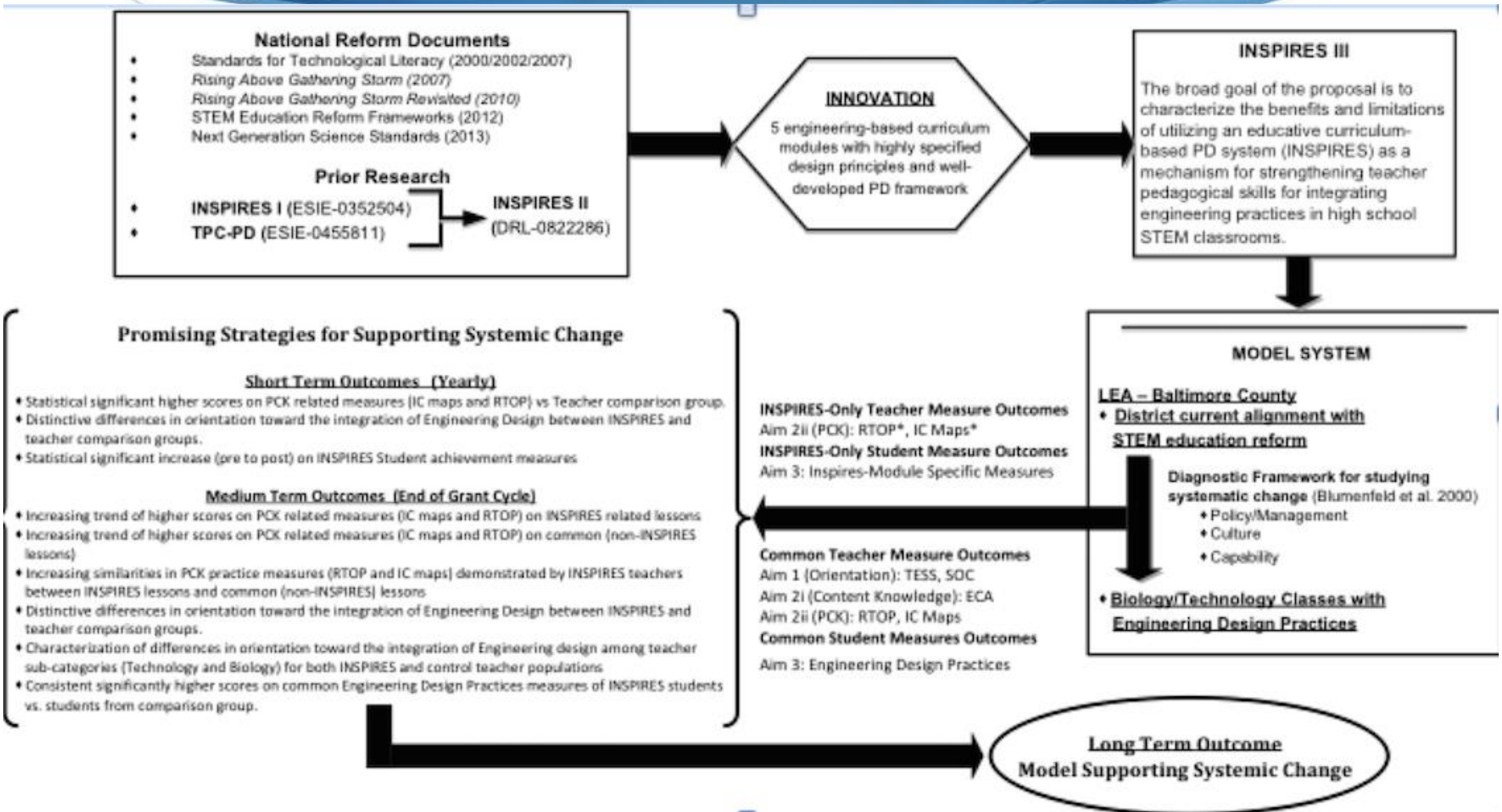
Context & Background
INFUSE

- Experience with National Center for Engineering and Technology Education
- Interest and background with the engineering component of the NGSS
- Examine possibilities of synergizing engineering and science
- Desire to develop a concept-based approach to engineering in science
- Other Project Team Members:
  - Julia Ross, University of Maryland, Baltimore County
  - Arthur Eisenkraft, University of Mass, Boston
  - Kathy Kennedy, Stevens Institute of Technology
  - Karen Peterman, evaluator

Context & Background INSPIRES



Overview

- Both projects have same goal*: to enable teachers to infuse engineering into science*
- Project Infuse goal:
  - To understand how science teachers learn engineering concepts through a **concept-based** professional development program.
- Inspires goal:
  - To characterize the benefits and limitations of utilizing an educative curriculum-based PD system (INSPIRES) as a mechanism for strengthening teacher pedagogical skills for integrating engineering practices in high school STEM classrooms.

INFUSE Selected Research Questions

- What gains can be achieved in **science teachers' understandings of engineering concepts** as a result of using the Project Infuse professional development model?
- What **core components are effective** for improving science teachers' understanding of engineering concepts through the professional development process?
- Is there a relationship between teachers' understandings of engineering concepts and their **willingness and perceived ability to infuse engineering** into science lessons?
- What are the **differences and similarities in life science and physical science teachers'** understandings of engineering concepts, their ability to infuse engineering concepts into their science lessons, and progress through the stages of concern?

INSPIRES Research Questions

Aim 1. To characterize teacher attitudes, beliefs and concerns associated with integrating engineering practices and core ideas in high school Biology and Technology Education.

Aim 2. To assess teacher content knowledge and pedagogical skills associated with integrating engineering practices and core ideas in high school Biology and Technology Education.

Aim 3. To correlate teacher knowledge of engineering and pedagogical skill level with student learning of engineering practices and core ideas and foundational science concepts as a function of STEM learning environment.

Project INFUSE PD Strategies

- Core engineering concepts:
  - **Design** (constraints, tradeoffs, optimization, prototyping)
  - **Analysis** (life-cycle, cost-benefit, risk)
  - **Modeling** (visualization, prototyping, mathematical models)
  - **Systems** (structure, functions, interrelationships)
    - *(Inspires is not including an explicit focus on systems.)*

Project INFUSE PD Core Components

- Hands-on Design Challenges
- Group-based Infused Lesson Development
- Reflections on Video-recordings
- NextGen Science Standards discussion
- Assessment Discussion
- Reflection Discussions
- Implementation issues analyses
- Pre-post Administration of the ECA, Stages of Concern Instrument, and effectiveness surveys

INSPIRES PD Strategies

Use of an Educative Curriculum (INSPIRES: ***Engineering in Healthcare: A Hemodialysis Case Study)***

- Summer Professional Development Institutes
  - STEM Content Practices
  - Experienced materials as "students"
  - Reflection on lesson design and instructional strategies
  - Logistical support
- Enactment of the Curricular materials
  - First month of academic year
  - Video tape targeted lessons used in monthly "lesson study"
- Monthly "lesson study" sessions
  - Video segment reflective critique
  - Plan - Do-Study-Act (Collaboration-Enactment-Extended Reflection)

INSPIRES Curriculum

Design Principle	Example Strategies
Context:	▪ Initial video ▪ Design Challenge ▪ “Just in time” content
Standards Based:	▪ Alignment charts ▪ Pre/Post achievement measures
STEM Practices:	▪ Inquiry- and Design- based activities ▪ Argumentation ▪ Models/Simulations
Collaboration:	▪ Inter and intra student group sharing ▪ Think, Pair, Share
Public Artifacts:	▪ Daily artifacts of key ideas ▪ Design Loop ▪ KWL posters, Target Poster
Metacognitive:	▪ Design Notebook set-up ▪ Targeted discussions emphasizing rationale for design decisions

Overlap Between the Projects

- Both included Biology Teachers
  - Infuse: biology and physics teachers
  - Inspires: biology and technology teachers
- Engineering Concept Assessment
  - Pre and posttest to measure understanding of engineering
- Engineering Lesson Rubric (IC Map)
  - Professional development tool
  - Video assessment instrument

Engineering Concept Assessment (ECA)

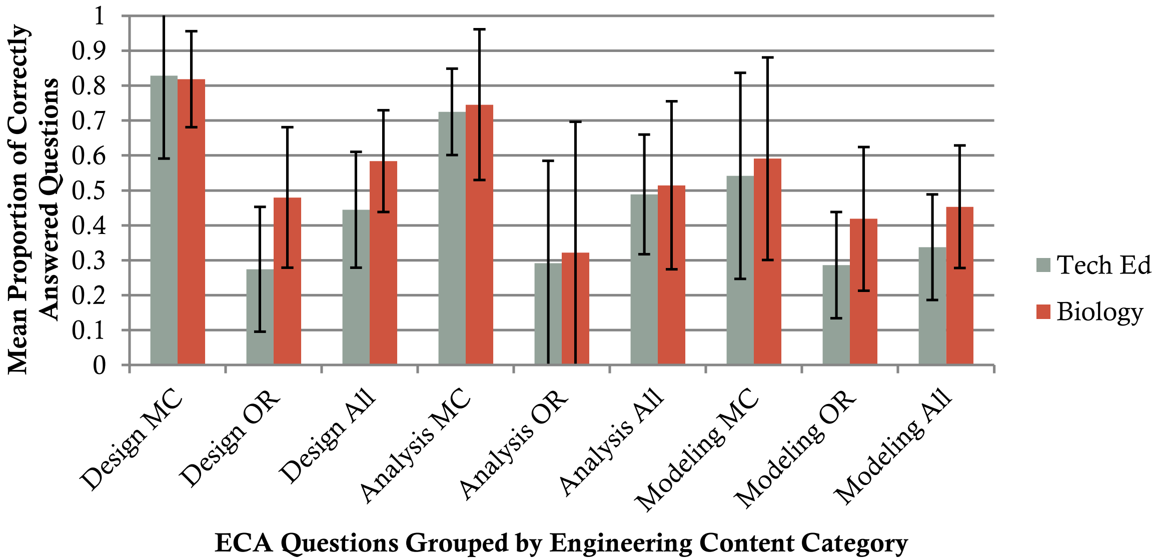
- Background and Goal
- Major development steps:
  - First a test framework was developed, grounded in definitions and specifications of engineering concepts.
  - Item development followed an iterative process beginning by developing 50% more items than will be needed for the final version. The goal was to have 6 items for each of the 4 engineering concepts that range across Bloom's taxonomy levels.
  - A pilot test version was administered to the pilot test teachers during the institutes. Item discrimination values were computed which led to extensive revisions to the instrument.

ECA - INFUSE

- Teachers scored higher on the Multiple Choice items than on the Constructed Response items
- Modest gains from year 1 to year 2
- Physics group tended to score somewhat higher, but differences were modest and not statistically significant
- Of the 4 concepts (design, analysis, modeling, systems), the scores for design were significantly higher than for the other concepts

ECA: Inspires

- Piloted via online survey with NSTA listserv members
- Base-line conducted during day 1 of initial summer PD
- Post-test data to be collected during day 1 of summer PD #2



Engineering Lesson Rubric

- Background and Goal
- Process:
  - Generated a list of major components representing engineering infusion including design-based curriculum materials and teacher practices.
  - Developed sub-components and descriptions across a spectrum of ideal implementation to marginal implementation.
  - Collectively, this process yielded a set of thick descriptions structured within a well-developed conceptual implementation framework.

ELR: INFUSE

- Professional Development tool
  - Was used to guide critique of existing lessons as an activity in the PD
  - Was used to inform observation protocol to capture snapshots of the components that happen in the classroom

- Lesson study (in progress)
  - The purpose of the study was to investigate the utility of the rubric to document the quality of engineering lessons for high school students.
  - A total of 171 lessons (63 Biology and 108 Physics) have been identified online using a set of criteria that are in the process of being evaluated and coded using the rubric

ELR: INSPIRES

- Assessment Tool measuring changes in classroom practices
- Used in conjunction with RTOP
- 4 lessons observed and coded per teacher participant
  - Baseline, 2 INSPIRES, Transfer
  - Repeated during years 2 and 3
- Comparisons to be made both among sub-populations (Bio and Technology) and with “control” population

Reflections INFUSE Preliminary Findings

- Importance of Curriculum and Lessons
- Value of ELR/IC Map
- Overall strong support for an engineering-based approach for both biology and physics teachers
- Value of including engineering-technology teachers in the process
- Difficult to develop valid and reliable direct assessment measures of engineering concept understanding

Reflections INSPIRES Year 1 Accomplishments

Accomplishment	**Description**
Participant Recruitment	39 Teachers (23 bio, 16 tech) in 13 HS 46%female, 54%male and 77%white, 23% persons of color.
Baseline Data	Teachers were provided a uniform prompt to enact a 90 minute lesson that targets an aspect of NGSS ETS-1 Engineering Design. In addition, teacher were also given the *Stages of Concern* (SOC) and *Teaching Engineering Self-Efficacy Scale* (TESS) surveys and the *Engineering Concept Assessment* (ECA). Data and video analysis are underway.
Enactment Data	Classroom video collected and assessed using *Reformed Teaching Observation Protocol* (RTOP) and *Innovation Configuration (*IC) map tools for baseline and 2 distinct INSPIRES lessons. "Transfer task" (non-INSPIRES lesson similar to baseline) is currently being collected.
Student Data	Student achievement (INSPIRES Pre/Post data has been collected – analysis are underway

Reflections INFUSE Preliminary Findings

- Identifying appropriate and engaging lesson ideas for the biology area
- Developing a valid and reliable content-based assessment tool for the engineering concepts (ECA)
- Aligning professional development with the ECA assessment tool
- Maintaining a focus on engineering concepts throughout the PD (rather than allowing activities to drive the process)
- Helping science teachers understand how to engage students in open-ended, multi-solution activities (what design process looks like)
- How to use engineering design-focused lessons to deliver and reinforce science content (rather than an engaging add-on)

Reflections INSPIRES

- Navigating the System
  - Commercial vender vs. University research
  - Recruitment and Permissions
  - Communication between and among stakeholders
  - Enactment placement
  - Time vs. Standardized testing
- Messaging
  - Curriculum vs. Professional Development
  - Curriculum vs. Transfer