Based upon comparisons of more successful and less successful transformation educational innovations:

a. What were the critical (human, organizational, resource, etc.) factors that led to success?

Factors for consideration:
- Implementation Fidelity
- Context of Understanding
- Coordination of efforts
- Sense of community is helpful
- Pedagogy – Application based on how to use it...
- Curriculum Development
- Inquiry –based learning
- Critical Elements are not optional, (e.g. safety, ethics)

How do we define success?
- Success of an innovation – needs to be defined...
- Innovation and Success are not the same thing...
- Innovation attracts Donors

Degree of diffusion – Leave this for the other group

Elements and/or Factors that led to Success
1. Transformative Impact - Degree of Change or Impact
2. How big the Change – Size and Scope
3. Charismatic Leaders
4. Sustainability
5. Institutionalization
6. Desirability – will engineers
7. Degree of Impact - Educational Impact - Effectiveness of Creating Learning
   a. Specific Skills
   b. Persistence
   c. Professional Skills
8. Employability (Student)
9. Extent to which serve the workforce (Industry)
11. Citizenship
12. Stakeholder Impact
   a. More efficient
13. Determining if is doable?
14. Curriculum Requirements Reform

Common Characteristics:
- Ease vs. Difficulty
- Appeal to the way engineers are comfortable functioning and thinking
- Pervasive – how well know is it ...
- Broad vs. specificity
• Relevance and authentic
• Challenging the norms vs. logistics
• Institutional and Organizational Constraints
• Threatening the Status Quo
• Curriculum with no calculator – estimate with your mind utilize your conceptual understanding
• Engaging Students
• Knowledge of Student of Learning

Inhibiting Factors /Barriers:
• Getting Faculty to work together (Consensus building)
• Faculty Resistance to Change
• Resources/ Funding
• Curriculum Rigor - Pressure to cover content
• Relevance of materials, courses, and pedagogy
• Student Resistance – Resistance to Change, receptacle of knowledge,
• Engineering Cultural - Institutionalization of the field –
• Pride in being in a program that is more rigorous than the other
• Reputation of Faculty – underrepresented groups, (e.g. women, racial diversity, etc.)
• Incentive/Reward System or Structure, within and outside of the institution for innovation
• Eng. Faculty need to understand the value of integrating the Humanities

Typology of Motivation Factors:
• Economic Constraints
• Global Economy – Changing Job Market
• Diversify Population of Engineers
• Limited Resources
• Need for Innovative Engineers
• Use new Tools/Methods to Improve Education
• Continuous Improvements
• Connection of Faculty to the Profession

b. What intermediate metrics provide indication of short-, mid-, and long-range success (educational impact)?

Operational

▪ Process Metrics – Engagement
▪ Outcomes Metrics – Formative and Summative
▪ Unobtrusive data to track adoption,
  ▪ e.g. hits on websites, purchase materials, race, gender
  ▪ “n-grams” via google
  ▪ #papers
  ▪ # workshops
▪ Alignment of Intentions and Outcomes of Innovation
▪ Alignment of Faculty Attributes with Attributes desired of graduation
Study more and less successful teams in transforming STEM
  o What effects does team composition have?

Potential METHODS

- Survey Research
- Participatory Research (Naturalistic Inquiry)
- Expert Inquiry
- Tracking or Exploring “Culture Change”
- Comparative Measures among methods – effectiveness of enhanced teaching and learning

STUDENT

- Short –term (Course)
  o Learning Outcomes/Grades
    ▪ Track what students do in the workforce overtime
    ▪ Portfolio
    ▪ Self-Assessment in Meta-Cognition
  o Engagement
    ▪ Integration of Technology (Tools)
    ▪ Student Satisfaction
  o Minimization of Negative Consequences
  o Awareness
  o Diversity of Students Entering and graduating
  o Data from ABET Documents
  o Authentic Tasks
    ▪ Student
    ▪ Faculty
  o Direct Measures
    ▪ Science Reasoning, Problem Solving, Analysis, Valuing

- Mid- term (Program)
  o Achievement in Later Classes
  o Persistence
  o Engagement
  o Leadership

- Long – term (Workforce)
  o Graduates are better prepared for the workforce, better contributors
    ▪ Become Professor
    ▪ CEO
    ▪ Entrepreneurship / Intra-preneurship
  o International Impact
  o Creativity
  o Citizenship
• Local
• Regional
• Global

FACULTY
• Short –term (Course)
  o Learning Outcomes/Grades
  o Engagement
    ▪ Integration of Technology (Tools)
    ▪ Student Satisfaction
  o Proportion of Adjunct Faculty
  o Use of Innovation
  o Belief Scales
  o Number of Instructors using a particular innovation
  o Examining belief systems

• Mid- term (Emerging Career)
  o Achievement in Later Classes
  o Persistence
  o Engagement
  o Leadership
  o # of Doctorates Awarded

• Long – term (Career Success)
  o Career Success in Profession
    ▪ P & T Documents; Assistant, Associate, Full Professor
    ▪ Awards, Prestige,
  o Total Endowment
    ▪ Nobel aureate
  o International Impact
  o Creativity
  o # of National Academy Members
  o # of Faculty Awards
  o Citizenship
    ▪ Local
    ▪ Regional
    ▪ Global

ORGANIZATIONAL / INSTITUTION
• Short-term
  o Awareness
  o Efficiency / Resource Savings
• Mid- term (Program)
  o Innovation
- Sustainability
- Institutionalization
  - Persistence
  - Status and Prestige (e.g. Home of ...)
  - Attractive to Diverse Population (Faculty and Student)
- Learning Factory
- Olin College Approach
- Studio Physics

- Long – term
  - Endowed Positions
  - Alumni Giving (for targeted projects)
  - Center Creation
  - Changing Norms/Culture/Incentive Structure
  - International Impact

**c. What broad strategies emerge by which to pursue transformative educational innovations?**

**Strategies**

**Institutional Level**
- Change Promotion and Tenure Criteria
- Scholarship of Teaching and Learning (SOTL) Awards – could be beyond the institutional level
- Support and/or fund projects on curriculum reform

**Disciplinary societies can take more active role**

**Engage ‘traditional’ faculty members**

**Assemble “the right team” for innovation**

**Provide Resources and Support to implement known successful innovations**
- Team should be prompted to reflect on and be supported in the change process
- Provide “How to” workshops organized around specific innovations in a timely efficient manner
- Five minute Youtube videos as an example
- Formation of consortia around specific innovation / desired change
- Influence graduate students in eng’g to have bias toward innovation / continuous improvement (C&I) in Teaching and Learning (T&L)
- Implement X-Prizes

**Consistent targets for change from NSF and other agencies and foundations involved in supporting the change process**

**Items:**

**CBL = Challenge/Problem/Question/Context-based Learning (curricular, co-curricular, and non-curricular) including + case-based learning (including cases in failure, ethics, etc.) + project/service learning including EPICS (Service Learning) , EWB (Engineering without Borders), ESW (Engineering Sev, etc. + engineering design courses and clinics, particularly when they include lower-level students.**

**SCBL = Student Cohort-based Learning (e.g., learning communities) often with other innovations**
CL = Cooperative/Team-based Learning

FA = Use of Formative Assessment tied to Course Objectives including + minute papers, + concept inventories + personal response systems—clickers, + question driven instruction

*The candidate instructional activities judged to be less innovative and less diffused were*

ETH = Engineering Ethics courses and modules, particularly when earlier in the curriculum

SVS = Spatial Visualization Skills courses

ITS = Integrated theory, skills, and practice spaces (e.g., Learning Factory, Ideas to Innovation Lab, etc.)

IME = Introductory Mathematics for Engineering Applications -

STT = Systematic topical spine/thread/context learning throughout undergraduate curriculum – Spiral curriculum - extended

ENTR = Engineering Entrepreneurship courses (Business Plan for Life) Bridge between Engineering and Business

*The candidate instructional activity judged highly innovative but not well diffused was:*

HIASS = Holistic Integration of Arts, Humanities, and Social Sciences into Engineering Curricula spanning programs to make engineers better writers to programs leading to the bachelor of arts in engineering –