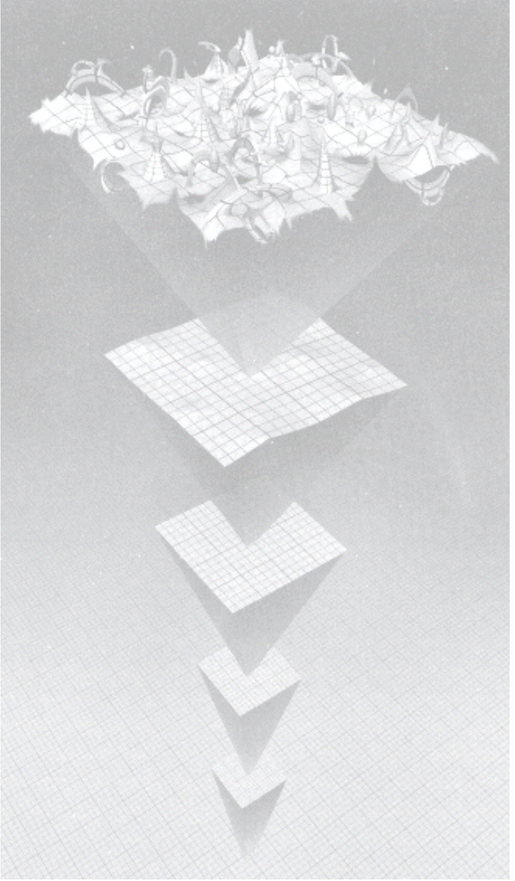
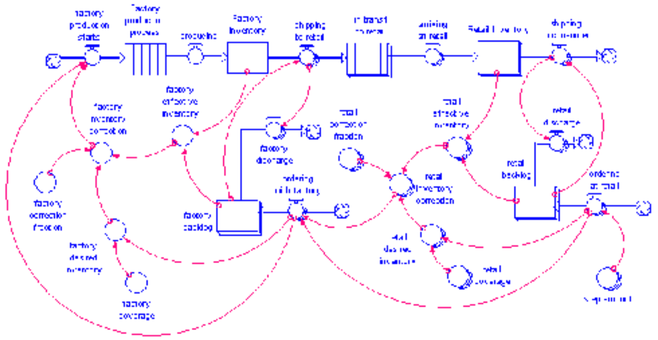
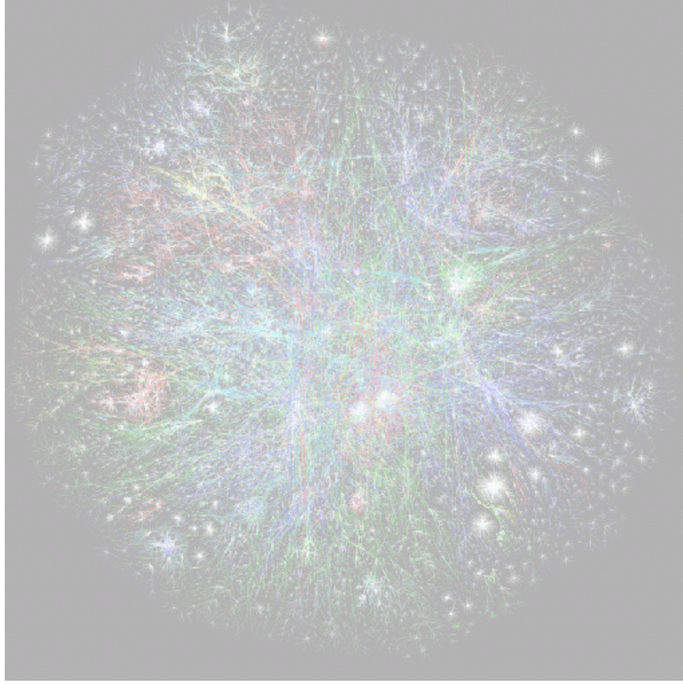


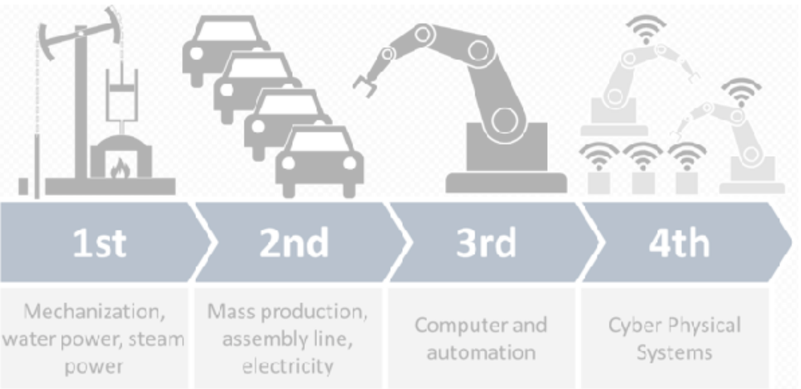


ICONS 22 - Keynote Speech

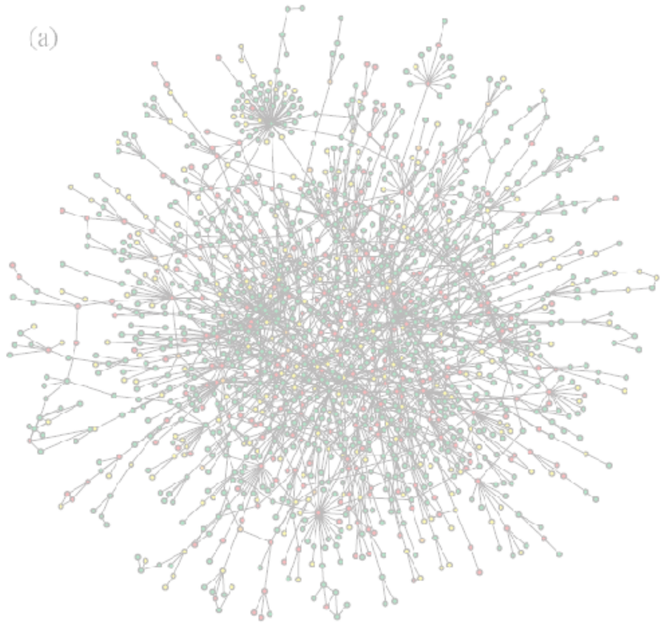


Approaches on Systems Governance and Policy

Case of the U.S. STEM-H

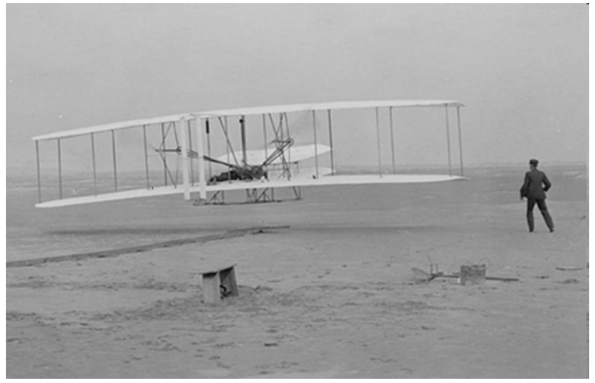


Mo Mansouri



Change is the name of the game!

From a technological metamorphosis towards a methodological paradigm shift

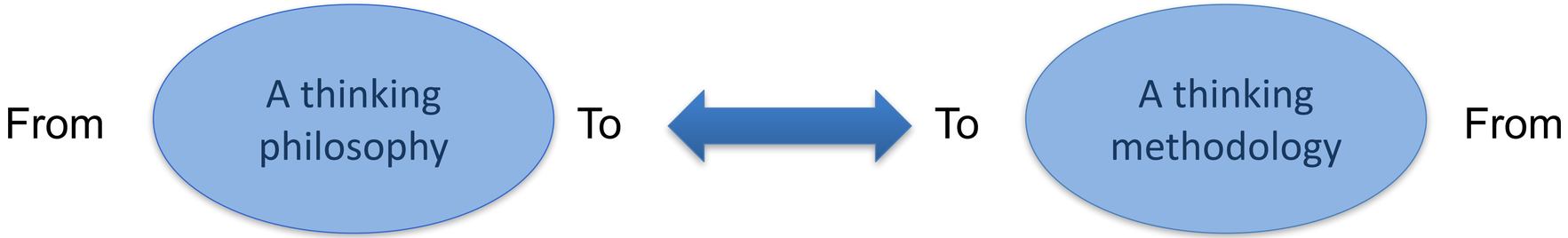


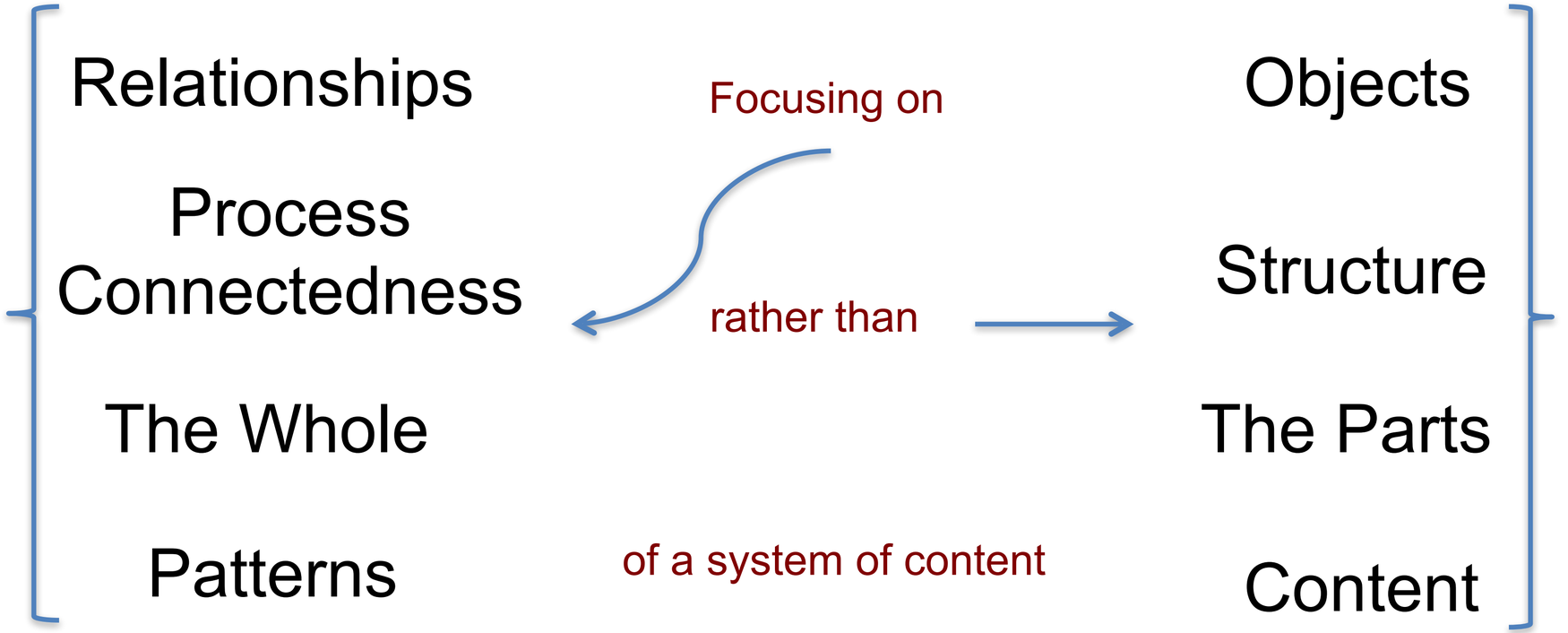
Human-Machine interaction era:

New challenges needs new problem solving approaches

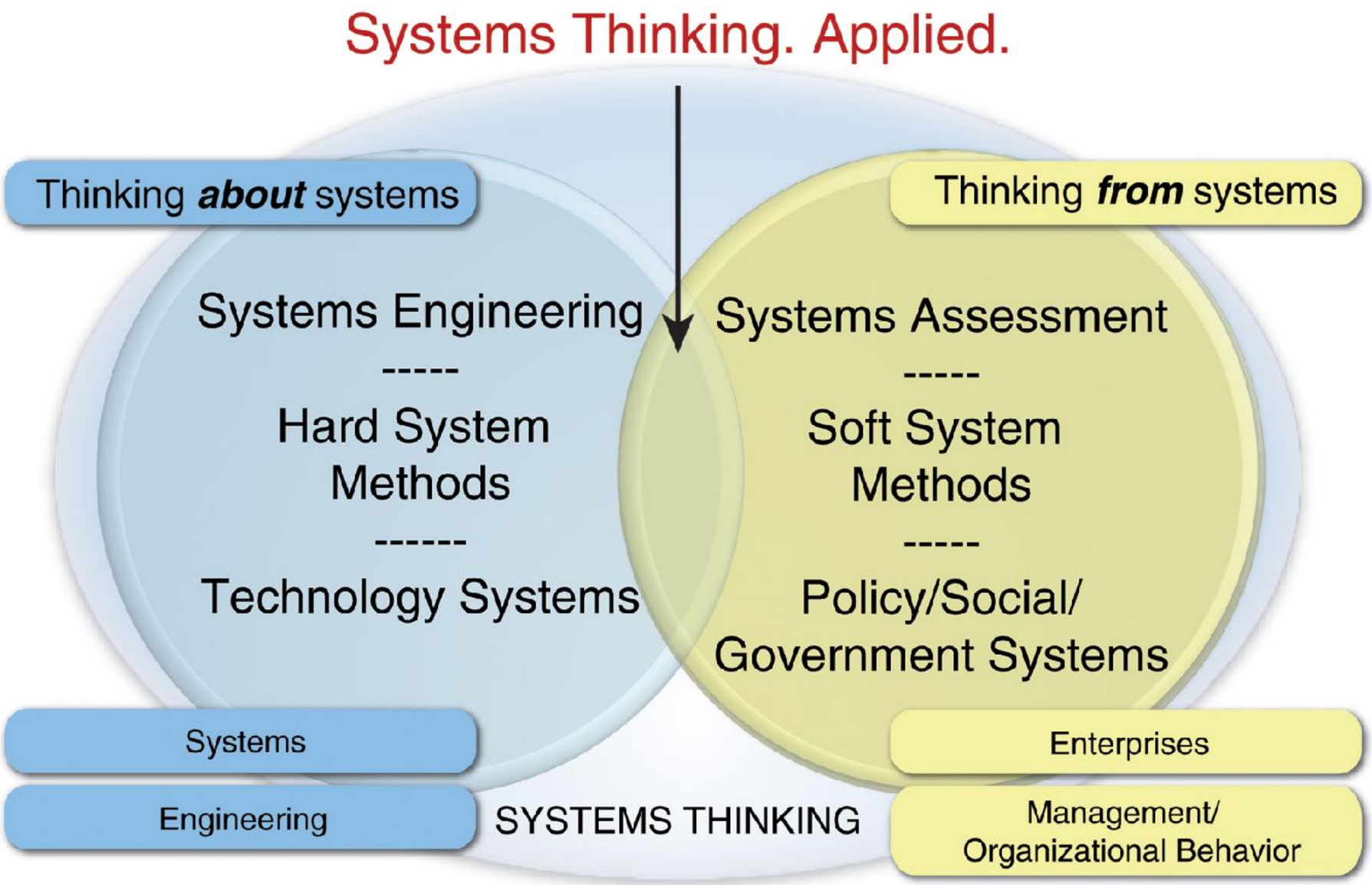
- Emerging Technology Breakthroughs are taking over:
  - Robotics
  - Internet of things
  - Autonomous vehicles
  - 3D Printing
  - Quantum computing
  - Nanotechnology
  - Fintechology
  - Biotechnology
  - Decentralized consensus, decision-making, design, governance, etc.
  - Artificial Intelligence (AI) and machine learning, deep learning, etc.

“Systems Thinking” is a methodic approach and a cognitive paradigm most needed in governance and policy making



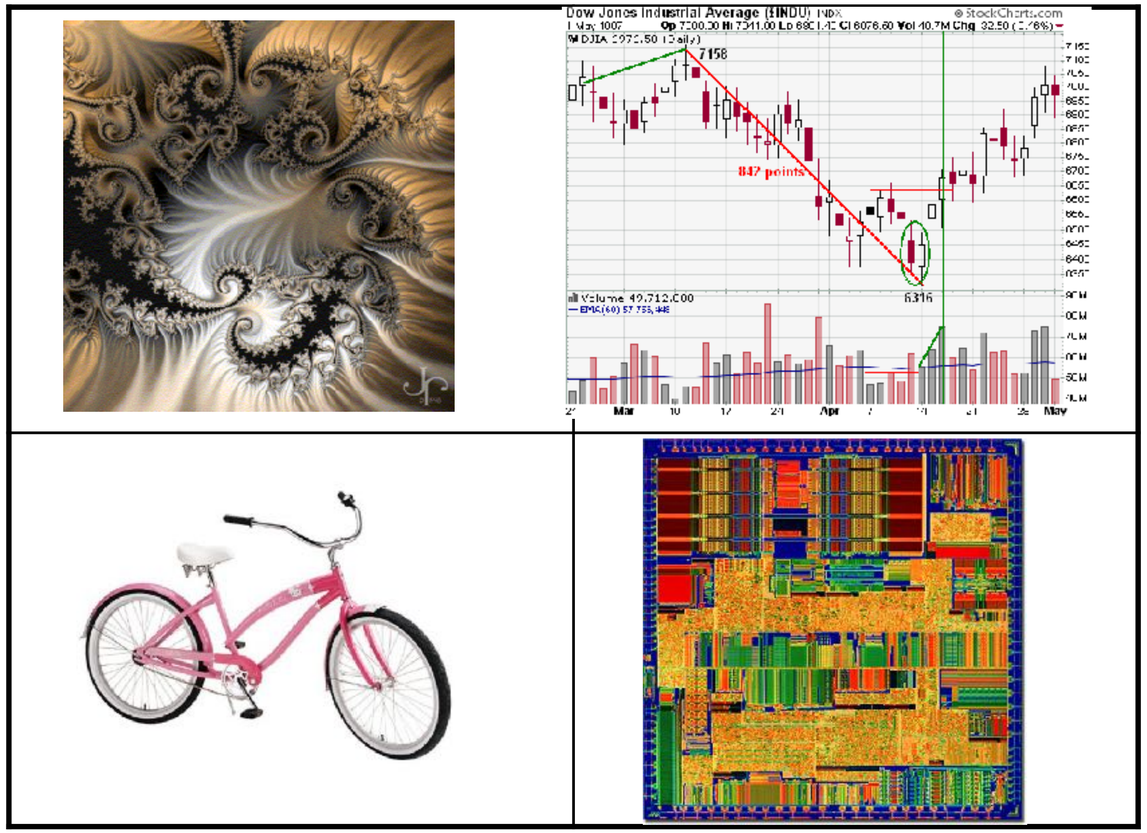


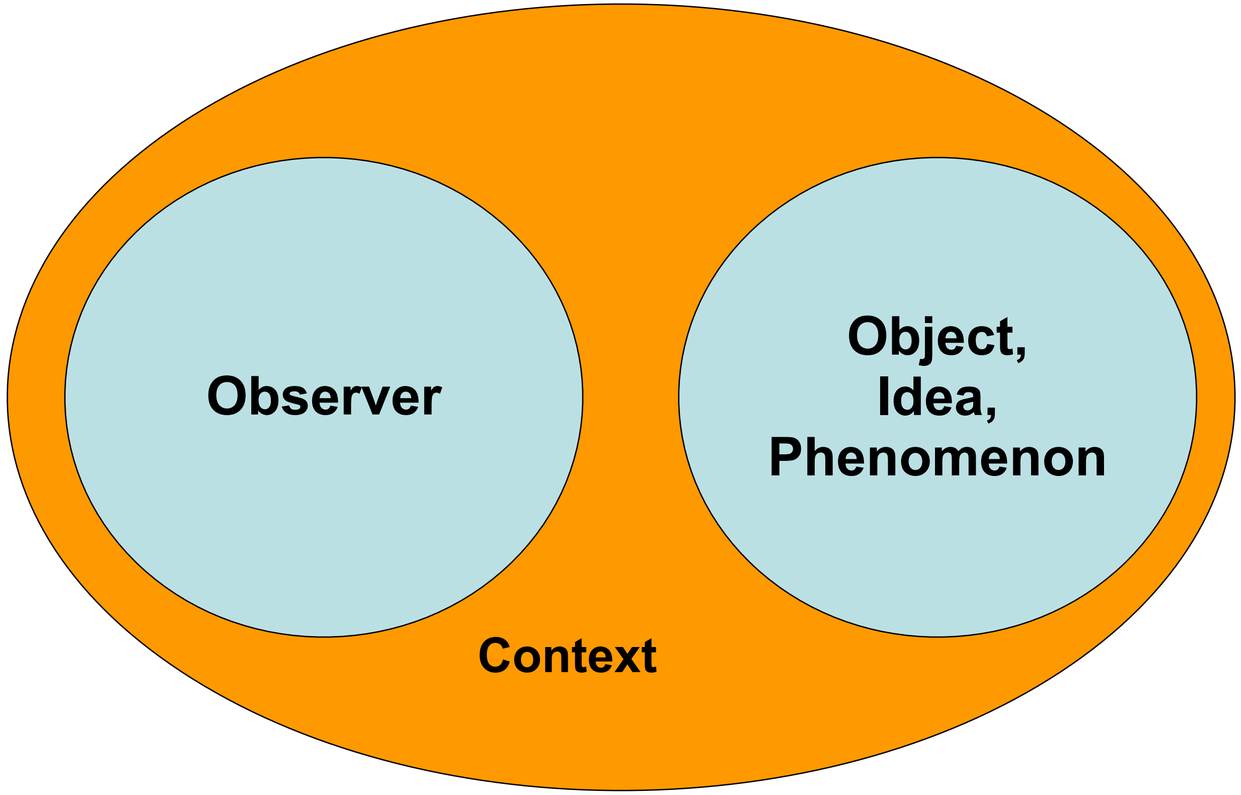
Two ways in one shot: hard vs. soft



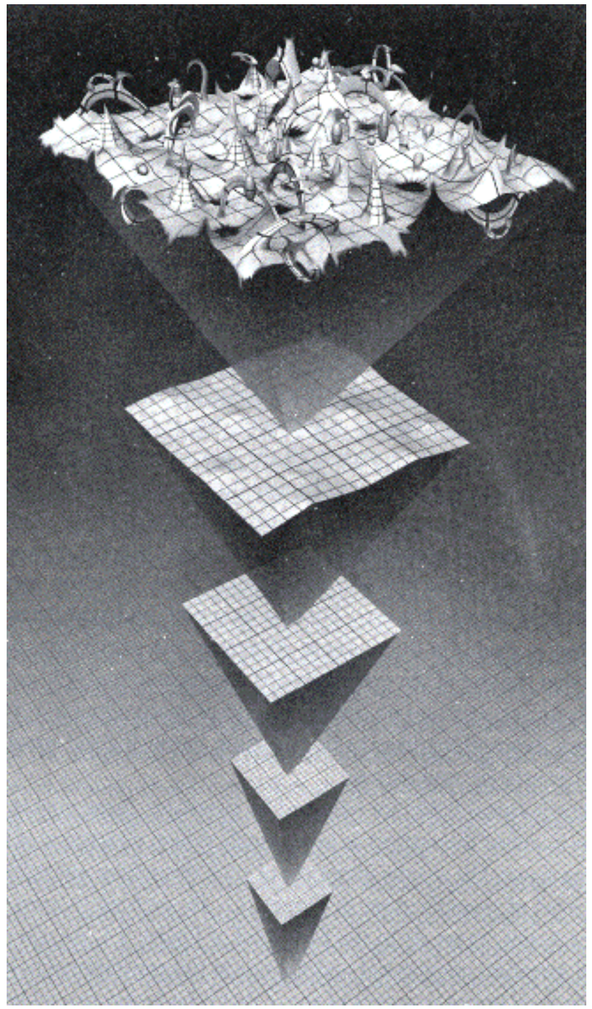
Developing governance structures to hedge impact of complexity?

"The degree of difficulty in accurately predicting behavior over time."





Taxonomy of Complexity



Prediction Quality:

- Precision
- Time scale
- Context

Prediction Difficulty:

- Relationships
- Current state
- Computation

Simplification Framework

Abstraction

- schematic modeling

Transformation

- graphical modeling

Reduction

- structural modeling

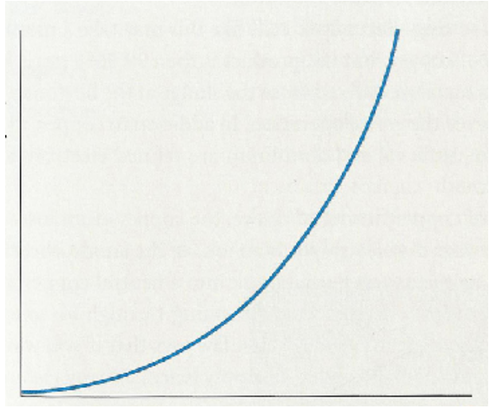
Homogenization

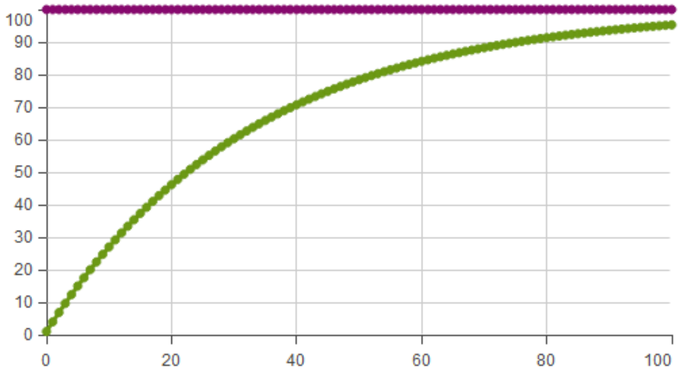
- mathematical modeling

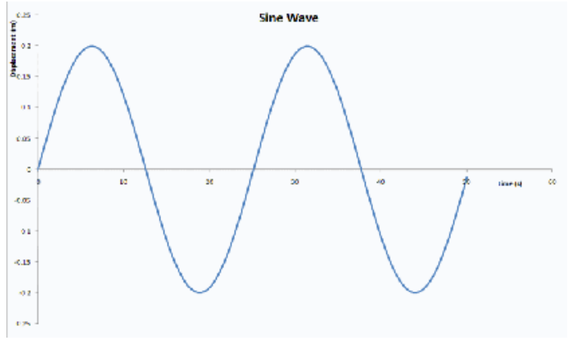
Systems modeling approach: behavior pattern recognition

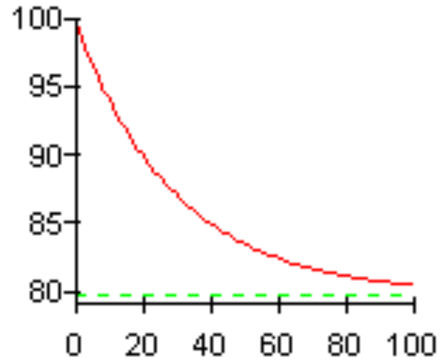
Simplification Functions

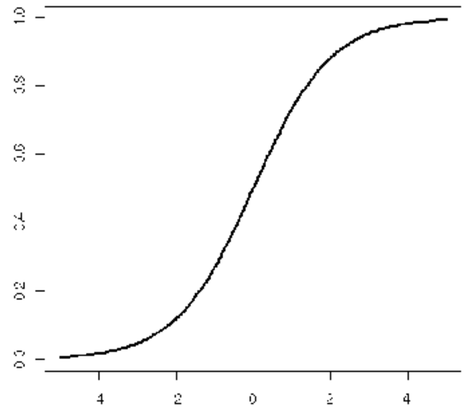
- Exponential growth
- Goal seeking
- Oscillation
  - S-shaped growth
  - Growth with overshoot
  - Overshoot and collapse

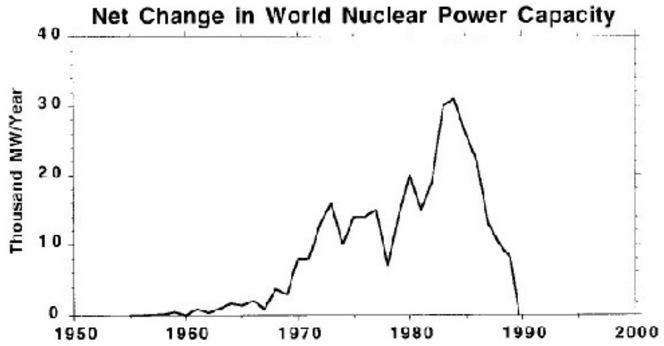












Systems governance approach to policy design and improvement planning

Case of the U.S. STEM-H Education

- A novel framework for understanding the STEM-H educational outreach ecosystem
- A model-based approach to analytical optimization intervention policies

Research doctoral journey of two graduate students in my research team:

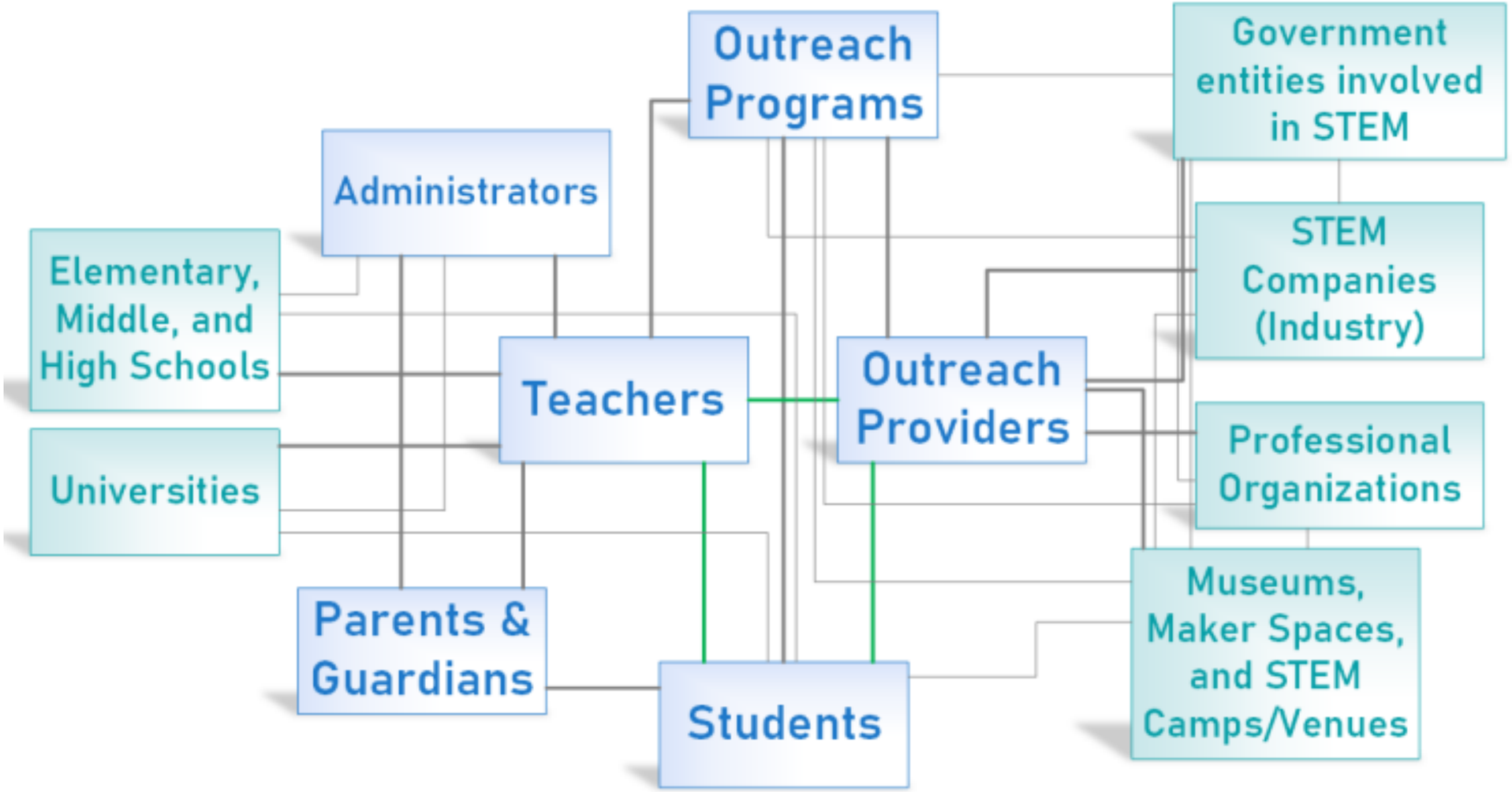
Dr. Ralph C. Tillinghast and Dr. Daniel C. Appel

Research pathway

- Definition
  - Identify and address lack of formalized definition for STEM-H Education Outreach
- Stakeholders
  - Identify and conduct analysis of stakeholders identified across literature
- STEM-H Education Ecosystem Model
  - Develop careerization pipeline model and causal loop modeling architecture to represent the broader STEM-H education ecosystem
- Survey Data & Analysis
  - Conduct analysis of STEM-H professional survey to identify positive catalysts, trends, and validate careerization pipeline model
- Functional Modeling & Simulation
  - Develop Vensim system dynamics model to functionalize STEM-H education ecosystem model and conduct analysis of model
  - Implement
- Verification and Validation of Modeling & Simulation
  - Conduct sensitivity analysis of Vensim model, comparing groups of surveyed STEM-H professionals to simulated instantiations of these groups to validate model
- Develop STEM Education Improvement Strategies
  - Perform optimization of intervention strategies across student cohorts

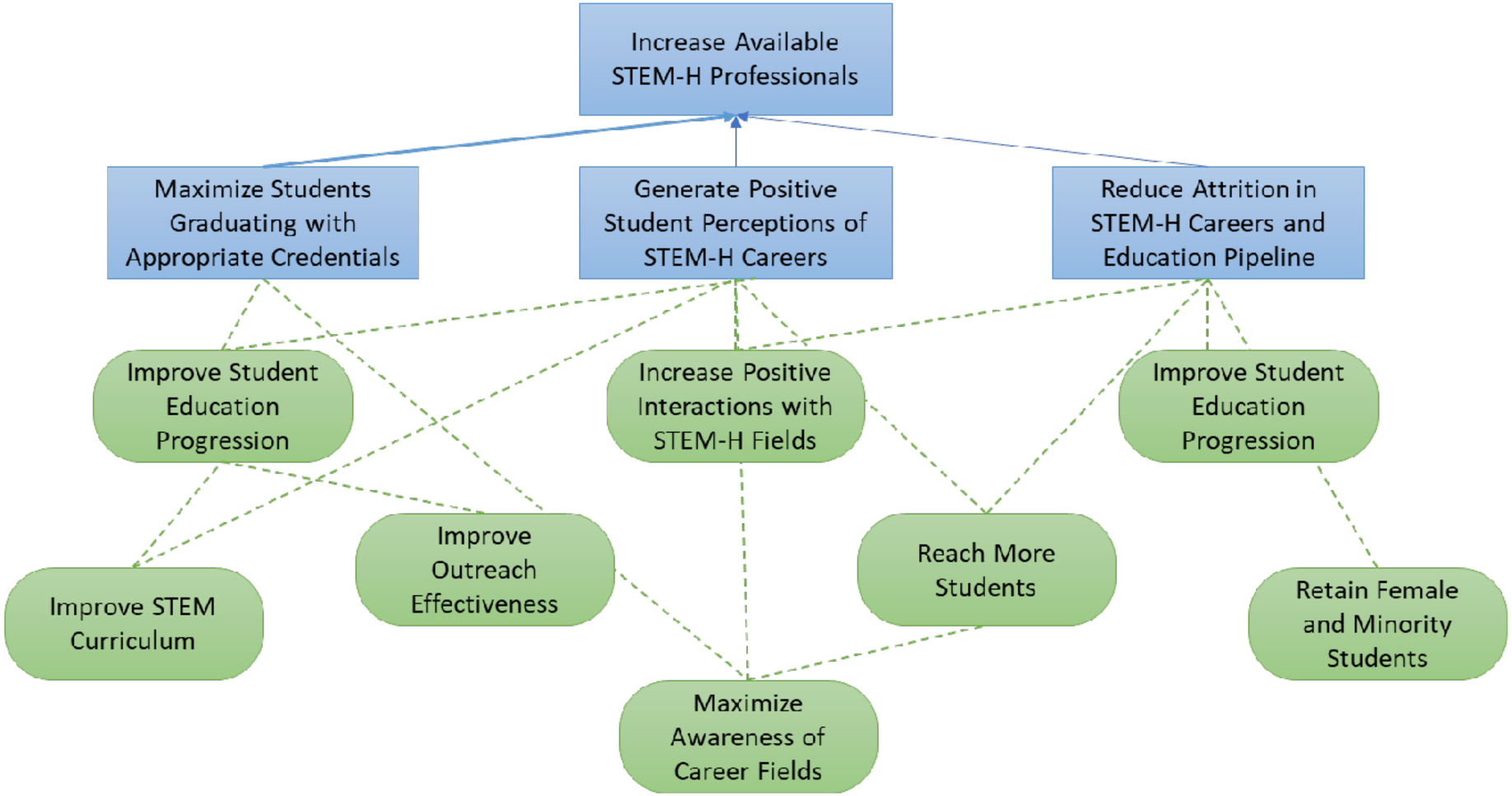
A systems approach:

Stakeholders analysis and establish relationships



STEM-H Outreach

Leveraging Scaled Agile Framework Epic Hypothesis, Fundamental Objectives Hierarchy, and Means Objectives Networks



Combined Fundamental Objectives Hierarchy (Blue) and Means Objectives Network

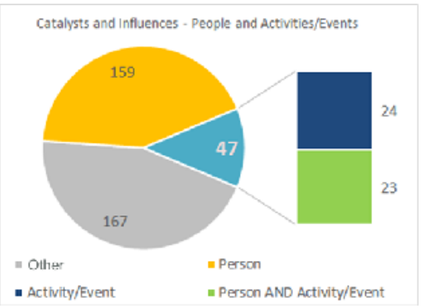
Used to identify how educational outreach initiatives can meet stakeholder goals

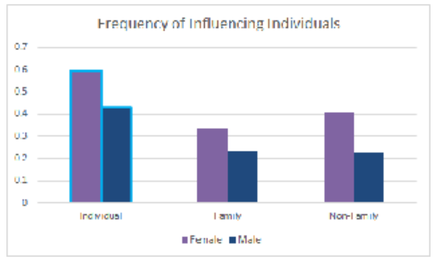
STEM-H Career Pipeline Model

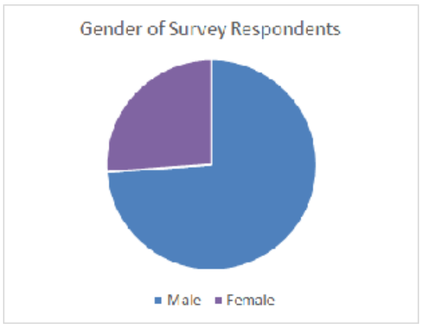
- Career Pipeline is modeled as:
  - Students developing an interest in STEM-H areas
  - Considering STEM-H fields as potential careers
  - Selecting careers in STEM-H areas
  - Proceeding with education and career goals
- Survey responses captured the grade at which students reached these points

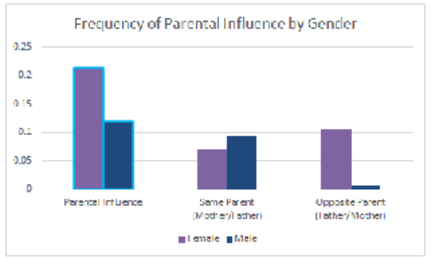
Final result of testing heuristic pipeline models, such as Introduce, Promote, Nurture, Recruit and Retain

Analyzing STEM-H Professional Survey

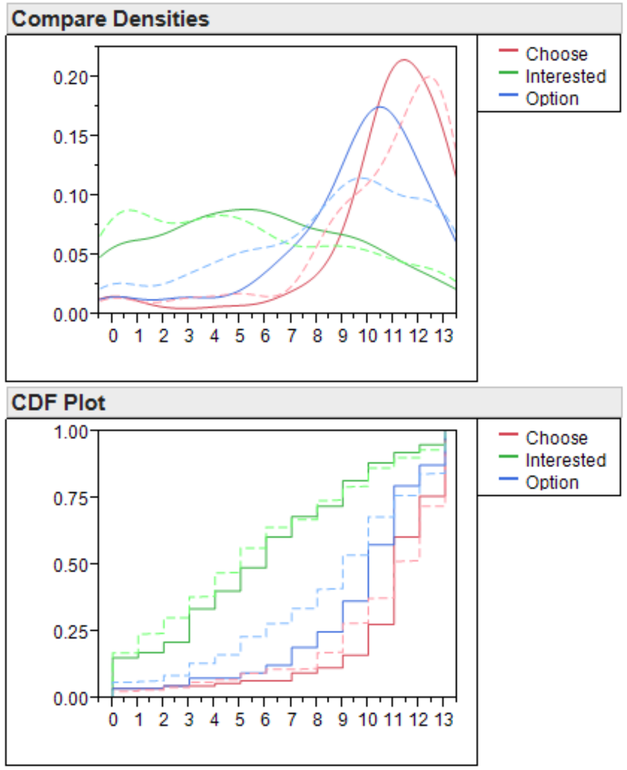








- Conducted analysis of 376 complete survey responses
  - 97% of responses indicated a positive catalyst or influence
- Catalysts and influences were categorized using character regex searches of survey responses
  - Subcategories for individuals and types of activities/ events were also generated
  - Additional markers were tested, such as Space Exploration, Camps, and Outreach
- Analysis performed in JMP, analyzing waveforms of grades where each pipeline transition occurs



Female respondents influenced by individuals outside the family (Solid)
Other respondents (Dotted)

Sequential Layered Markov Decision Chain & Systems Dynamics Models

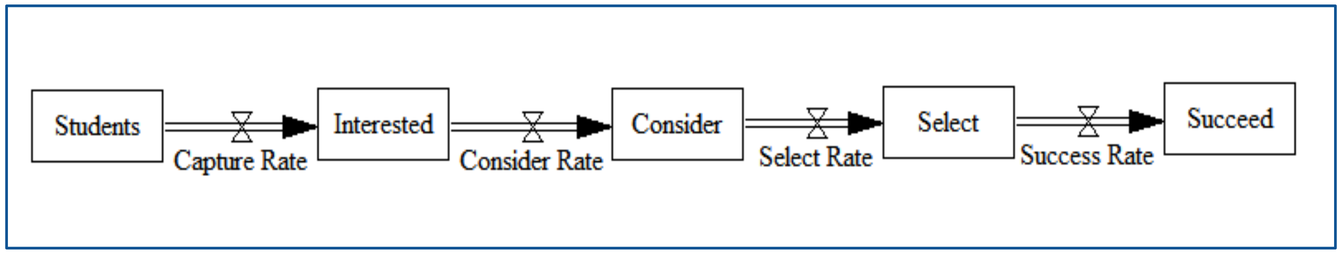
$$r_{i,j}^{(n)} = \sum_{k} r_{i,k}^{(n-1)} p_{k,j} \rightarrow r_{entry,succeed}^{(gradeN)} = \sum_{k} r_{i,k}^{(gradeN-1)} p_{k,succeed}$$

$$r_{entry,\,succeed}^{(n)} = \left(\sum_{k=lostSetb.}^{consider} \left[\sum_{k=lostCons.}^{interest} \left(\sum_{k=lostInt.}^{entry} r_{entry,k}^{(n-4)} p_{k,interested} \right) p_{k,consider} \right] p_{k,choose} \right) p_{choose,succeed}$$

Layered Markov Decision chain representations of the education to career pipeline through successive phases

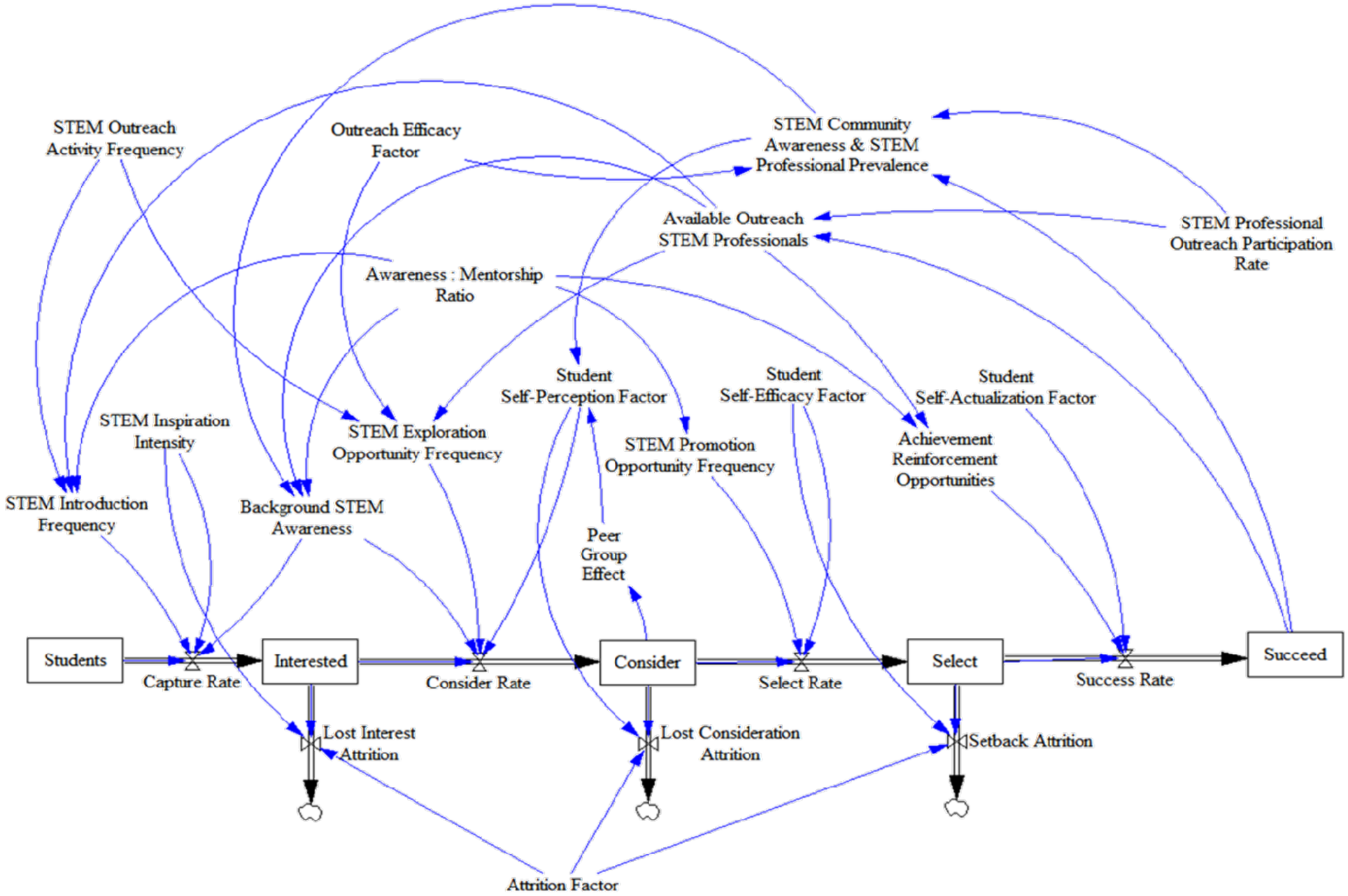
Students pass through the Entry, Interested, Considering, Choose, and Succeed phases with STEM-H Career Goals

- Core Career Pipeline remains modeled as:
  - Students developing an interest in STEM-H areas
  - Considering STEM-H fields as potential careers
  - Selecting careers in STEM-H areas
  - Proceeding with education and career goals
- Attritional losses, and causal loops added to ecosystem model for simulation in Vensim

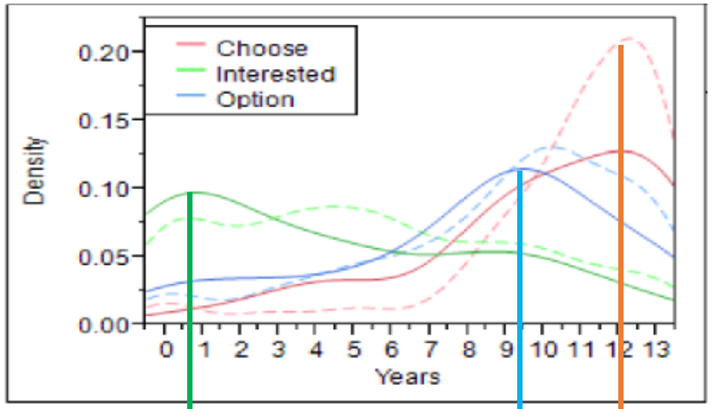


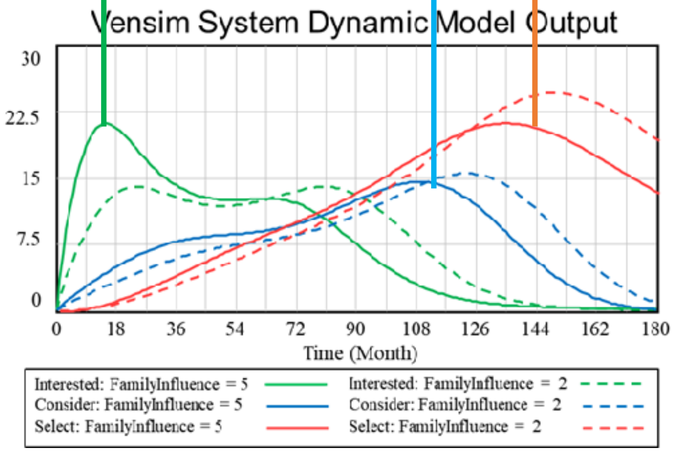
System Dynamics Model

- *Vensim* modeling and simulation framework emerging from 23 architectural revisions
  - Conducted extensive sensitivity analysis for verification and validation for each architecture revision
  - Leveraged *SynTheSim* capability to approximate JMP output waveforms from every identified student cohort
  - Unified modeling framework successfully represented every student group



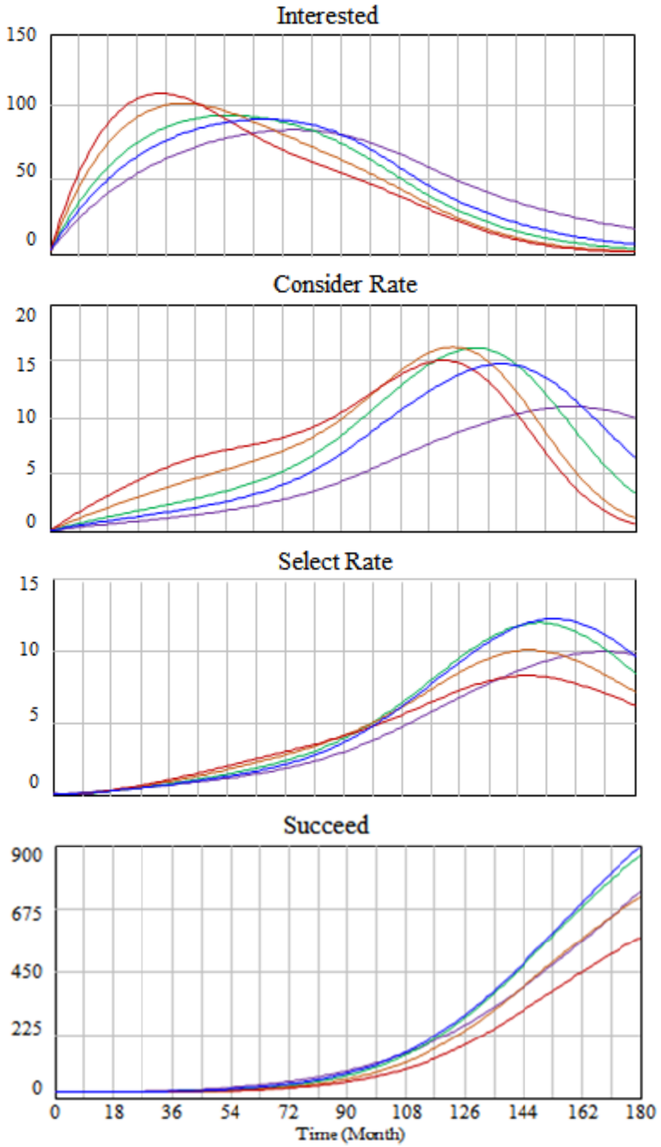
V&V



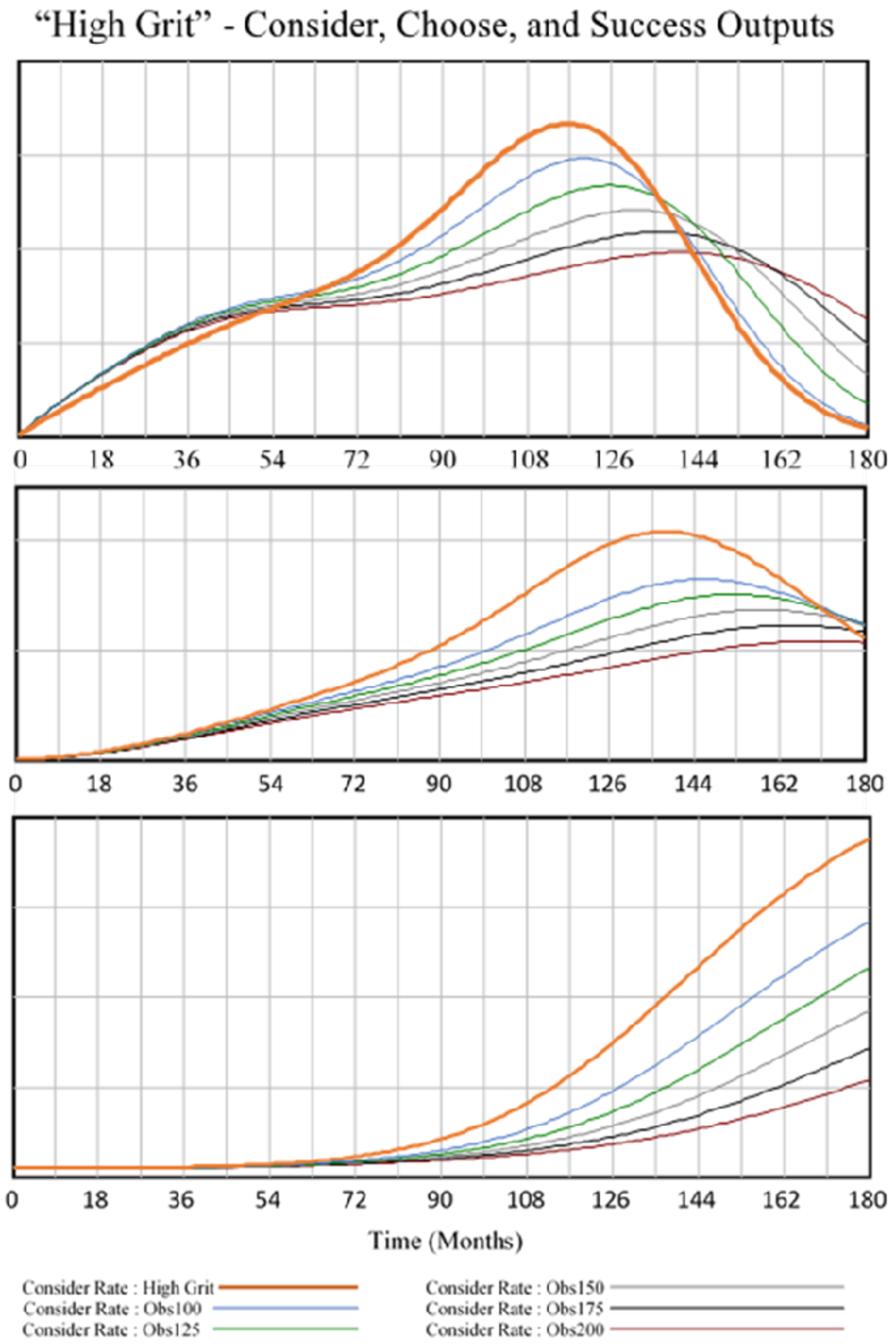


Vensim system dynamic model sensitivity analysis of background STEM awareness factors on career progression comparing Family Influence factor

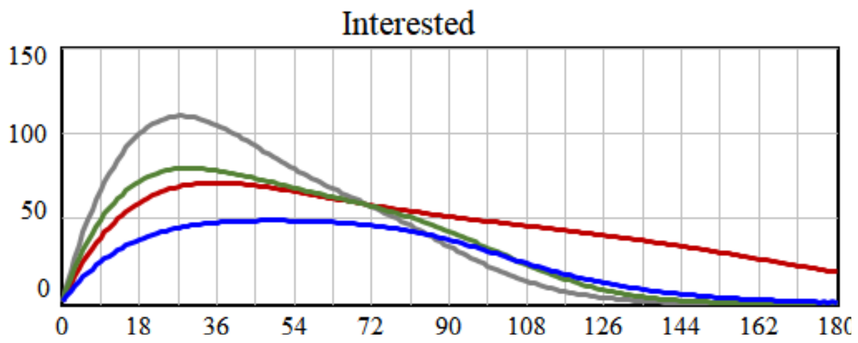
Sensitivity Analysis

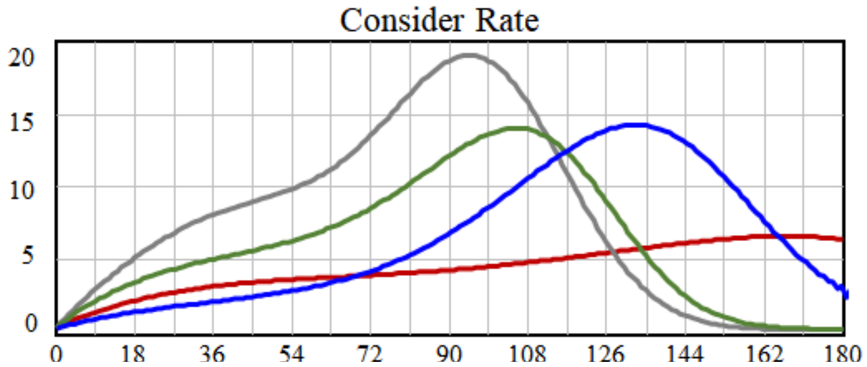


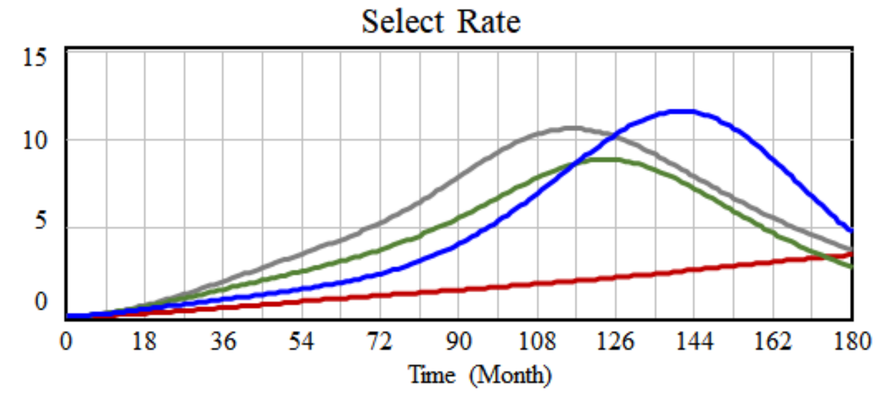
Vensim Sensitivity Analysis of the Awareness to Mentorship Ratio Variable

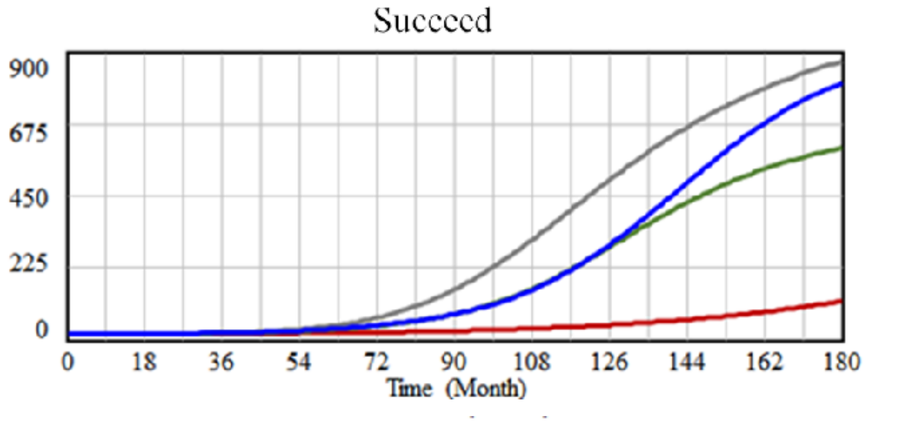


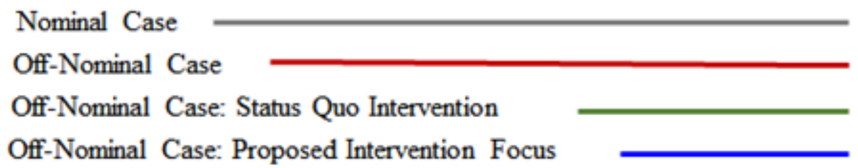
Intervention strategies: governance through policy making











Focusing almost exclusively on mentorship and near-peer outreach emerges as most promising strategy for students in underrepresented demographics

Comparison of the nominal pipeline progression, emulation of underrepresented groups (Off-Nominal) Default Intervention strategy, and Proposed Intervention cases from the system dynamics model

Off-Nominal case generated by reducing initial community awareness and prevalence factors, reducing attrition resilience factors, and increasing self-reinforcing aspects of peer group and self-efficacy factors