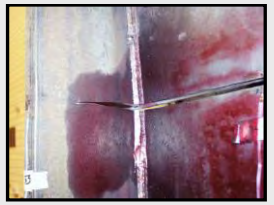
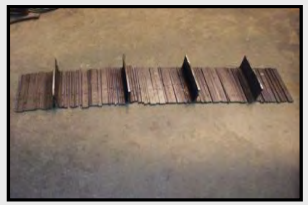
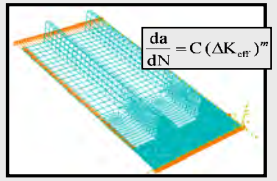
TRANSITIONING STEM STUDENTS INTO COLLEGE AND BEYOND

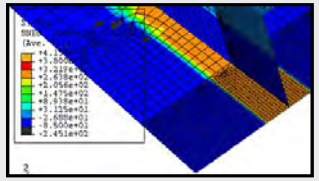
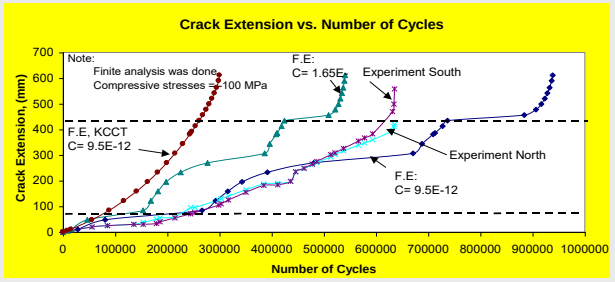
Hussam Mahmoud

Department of Civil and Environmental Engineering

Academic Experience – U. of Minnesota & Lehigh U.



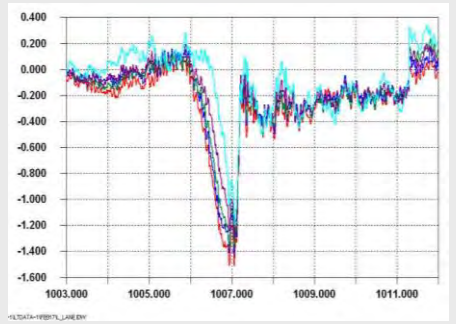



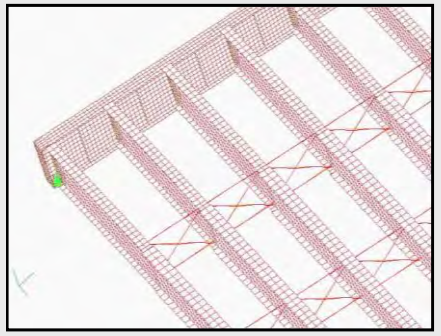
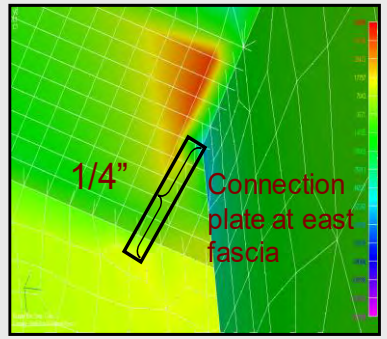
Crack Propagation Rate in Welded Stiffened Panels

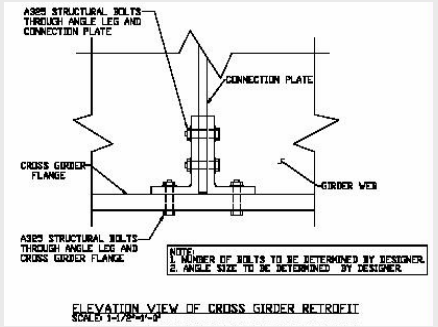
- Conducted other tests as an UGRA
- Column stiffener and panel zone behavior of SMRF
- Fatigue testing of expansion Joints

UNIVERSITY OF MINNESOTA

1999 - 2003



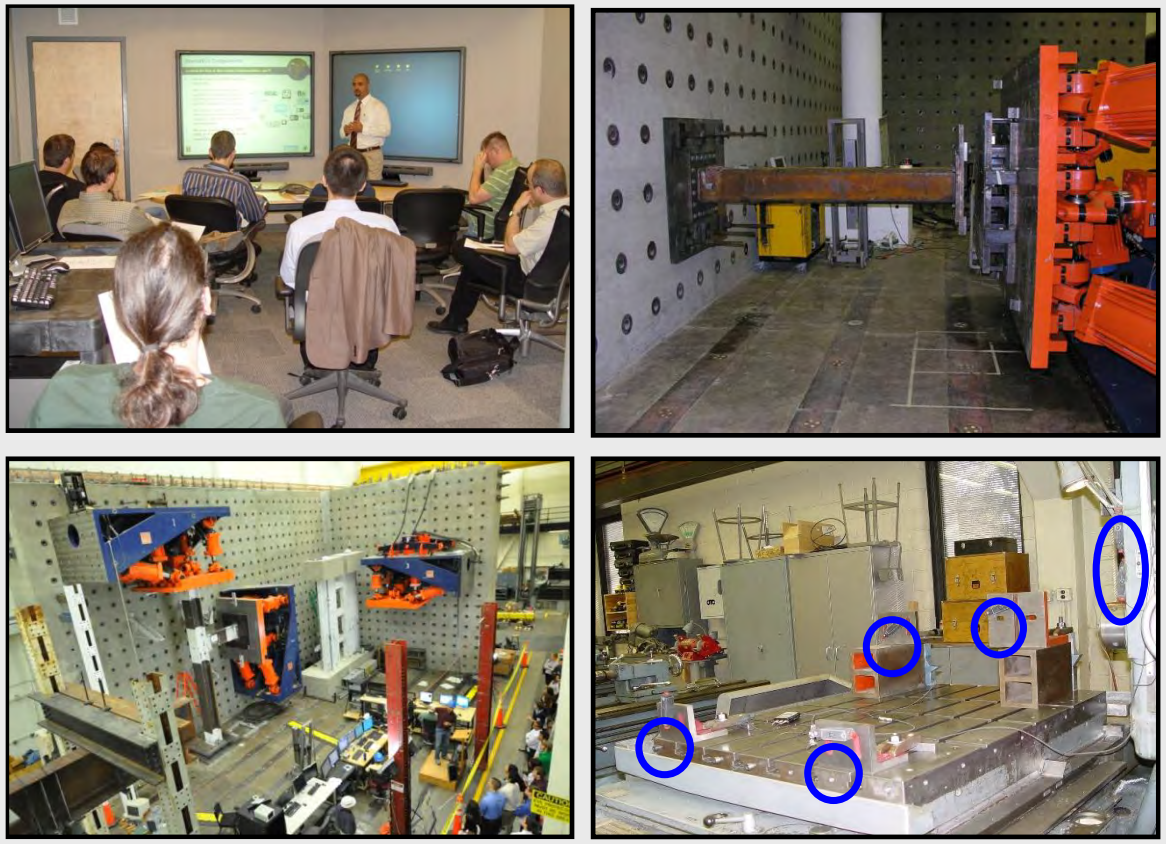
Health Monitoring, FEM and Retrofitting of the I-476 Bridge over the Schuylkill River

- Health monitoring of many bridges around the country
- Numerical simulations on key bridges
- Fatigue assessment of sign and ship structures

2003 - 2006

LEHIGH UNIVERSITY

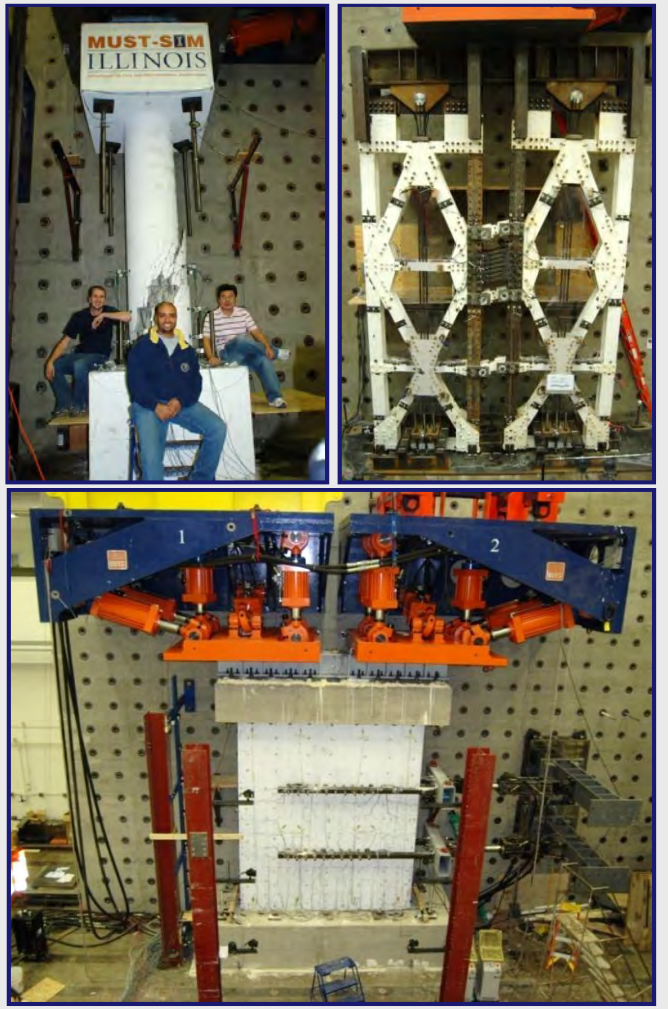
Academic Experience – U. of Illinois Urbana-Champaign



Manager of the NEES Laboratory

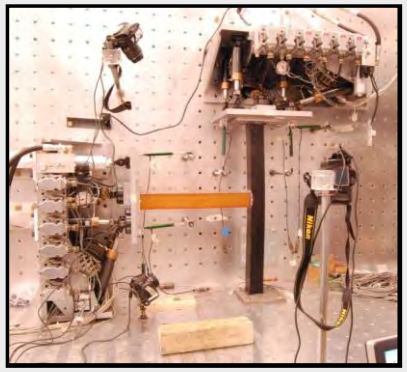
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

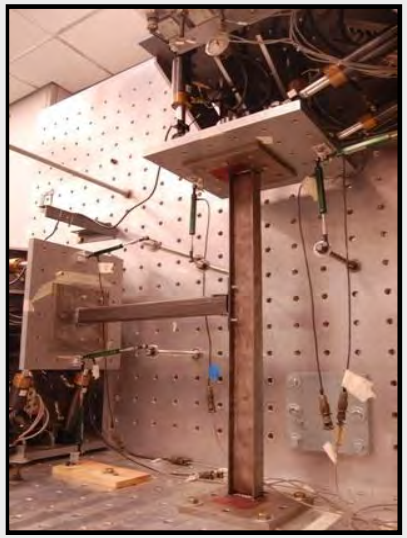
2006 - 2008

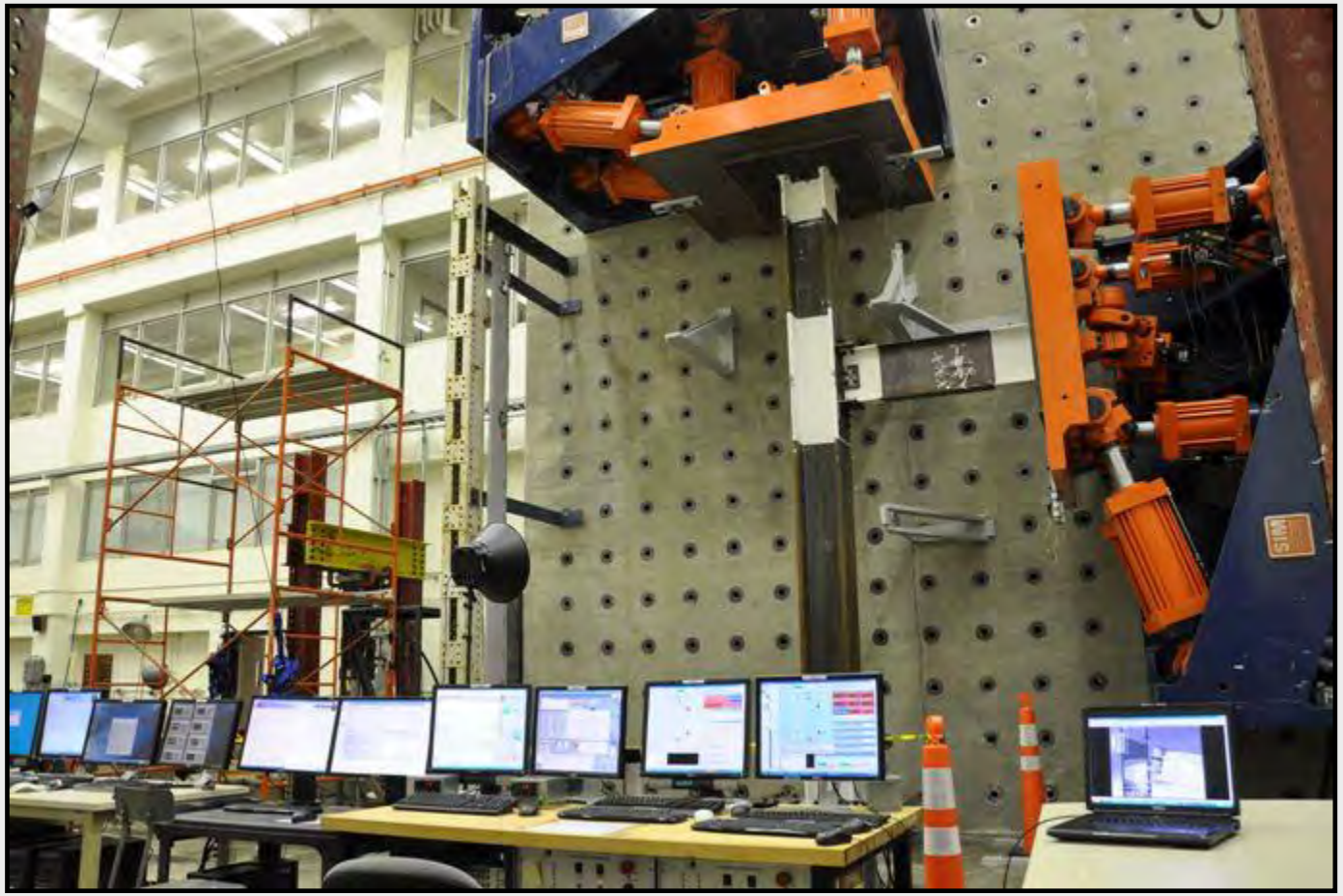


Various hybrid simulations

Academic Experience – U. of Illinois Urbana-Champaign





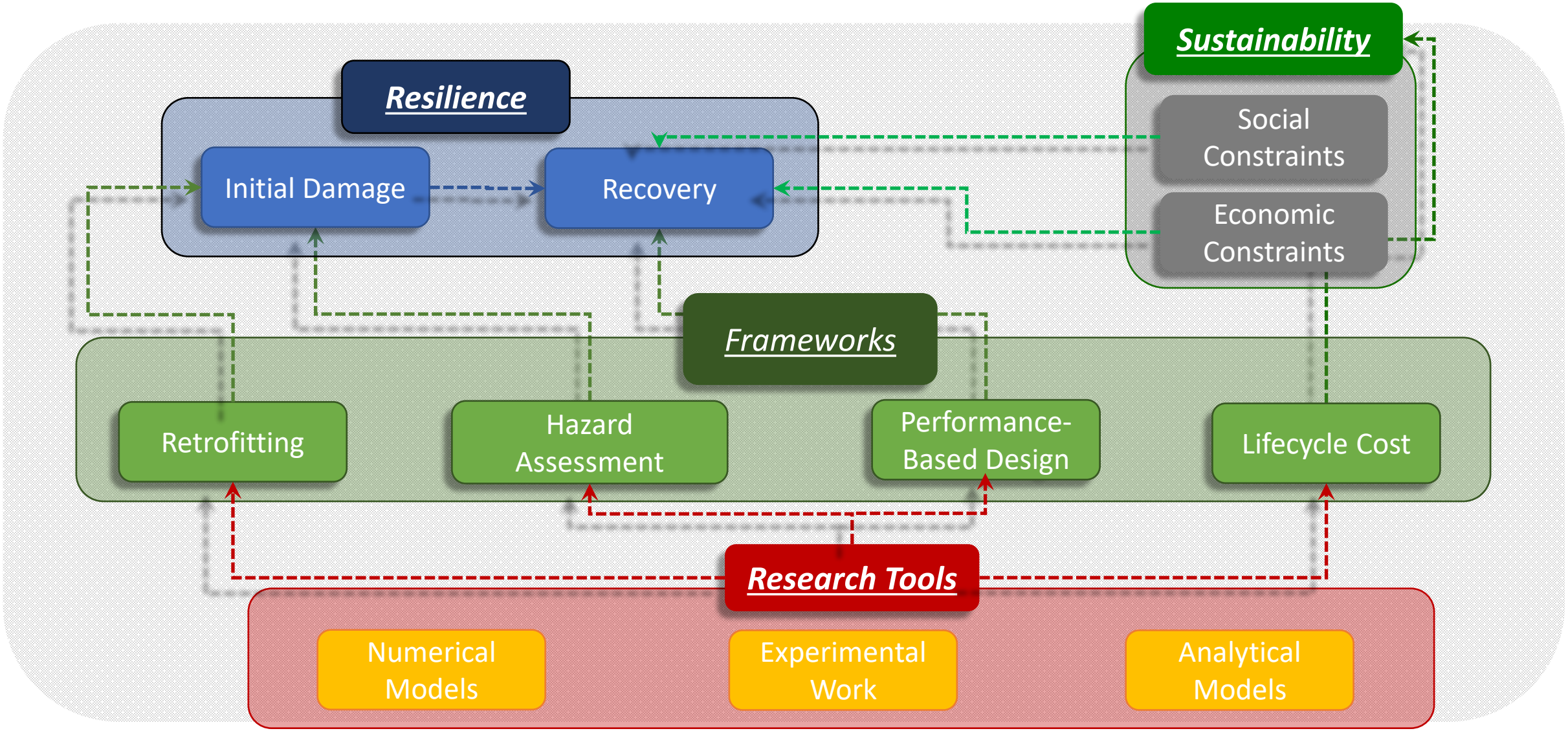


Ph.D. work

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

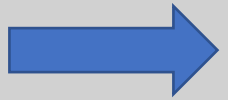
2008 - 2011

Research Direction – Colorado State University



Outline of the Presentation

1. Motivation for STEM Education
2. Trends in STEM Education
3. Utilizing STEM Education Trends in Research
   a) Vulnerability to Wildfires
   b) Recovering from Extreme Events



Integrating STEM Trends

4. Characteristics of Future Engineers
5. Questions

Motivation for STEM

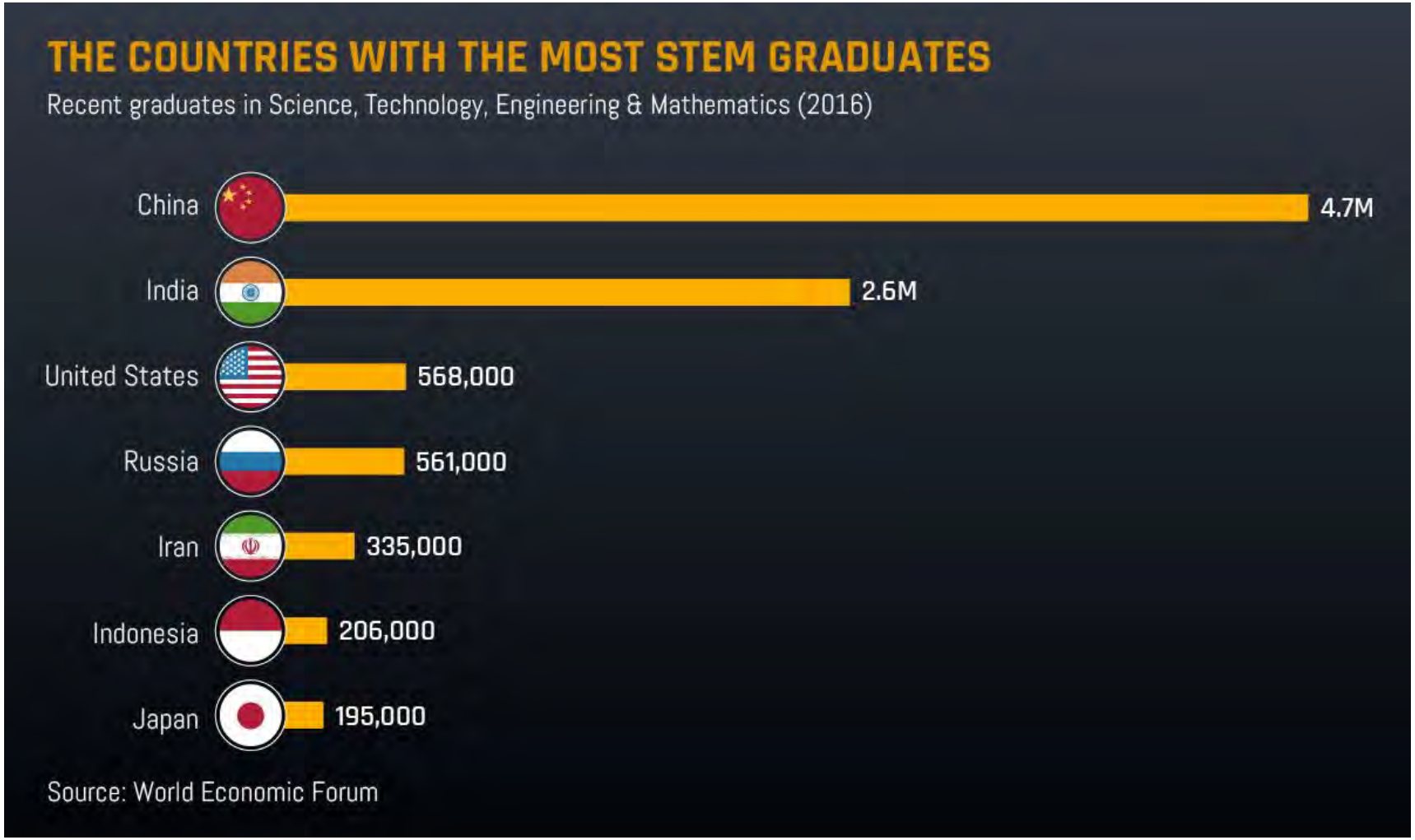
Enhance logical thinking, and increase economic competitiveness

Motivation for STEM Education – Improving Logic and Analysis Tools

- Provide hands-on experience through different lessons.
- Making math and science fun and engaging helps students do much more than just learn.
- STEM can improve collaboration skills.
- STEM focuses on *logical thought* processes and problem-solving.

Motivation for STEM Education – Economic Competitiveness

- The U.S. is falling behind other countries regarding the number of STEM graduates.
- Countries surpassing us will have the *opportunity to compete much more in global markets.*
- India is set to be the second-fastest growing economy in FY 2022-23.



Motivation for STEM Education – Addressing Complex Societal Problems

- Our society is faced with many challenges.
- The consequences are substantial and can last from a few years to decades.
- *We need engineers and scientists that can address these challenges.*

Natural Disasters – Infrastructure Damage

Market Collapse – Economic Downtime

Uncontrolled Immigration - Social Disruption

Pandemics – Social Disruption

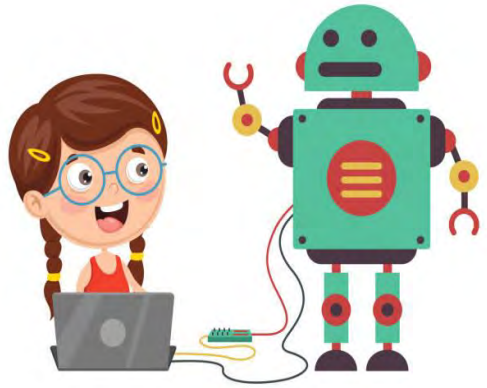
Trends in STEM Education

Current and future trends in STEM Education

Trends in STEM Education – Current

Hands-on Learning

STEM in all Subjects



Utilizing Robotics

Games in STEM

- Hands-on learning can help understand complex coding concepts.
- Utilizing STEM across subjects is essential for innovation and creativity.
- Utilizing robotics to support the expansion of learning tools in STEM learning.
- Integrating games in STEM can motivate students to learn and explore more.

Trends in STEM Education – Future

STEM to STEAM

Cross-Disciplinary

Adaptive Learning

Entrepreneurship

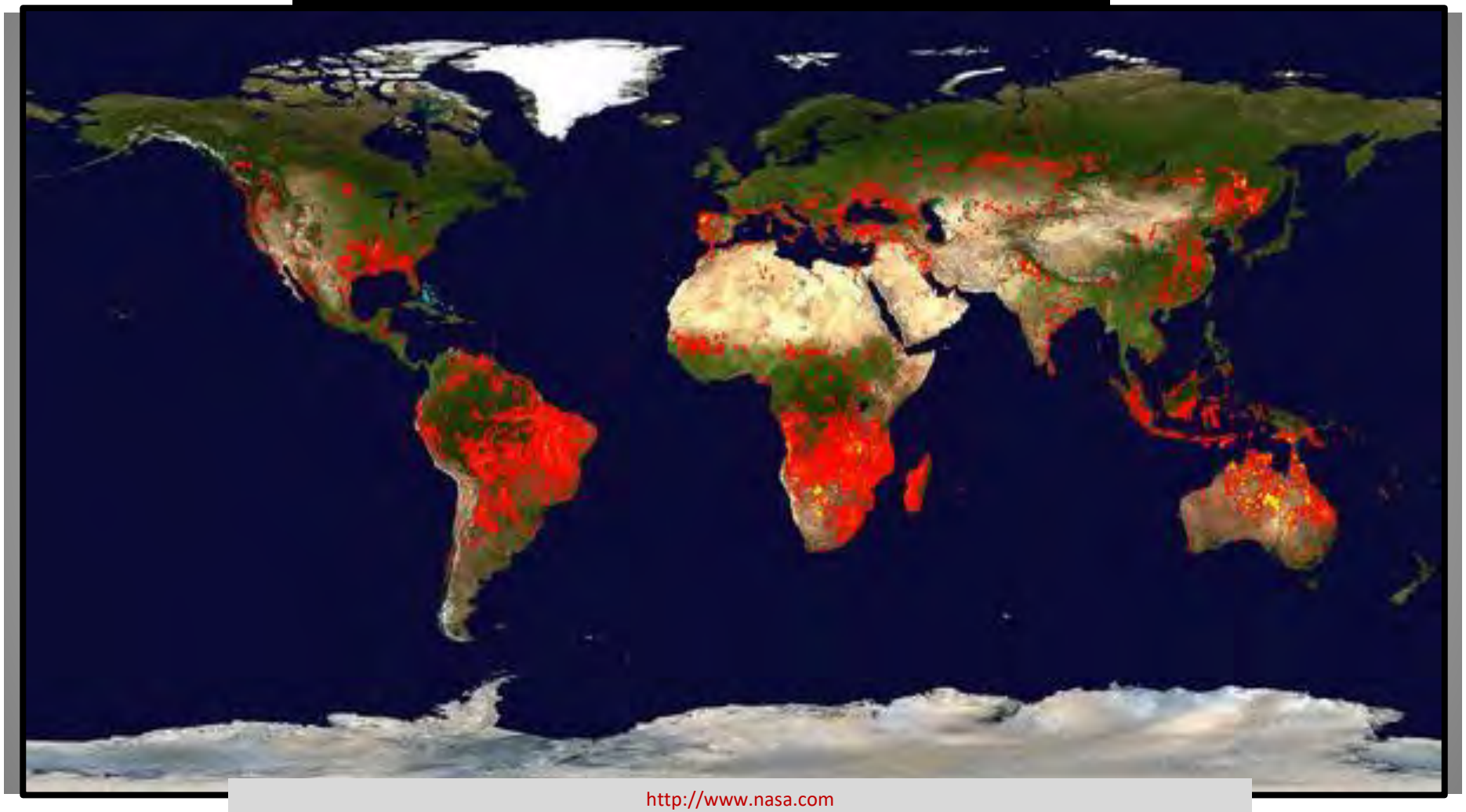
- STEM to STEAM enhances student's creativity and problem-solving skills.
- Cross-disciplinary helps improve creativity and problem-solving skills.
- Adaptive learning offers means for understanding data-driven topics.
- Entrepreneurship provides proper training in soft and hard skills.

Utilizing STEM Education Trends in Research

Vulnerability to wildfires

STEM Education Trends in Research – Wildfires as a Global Problem

Distribution of Wildfires Worldwide



http://www.nasa.com

STEM Education Trends in Research – Stages of a Wildfire Event

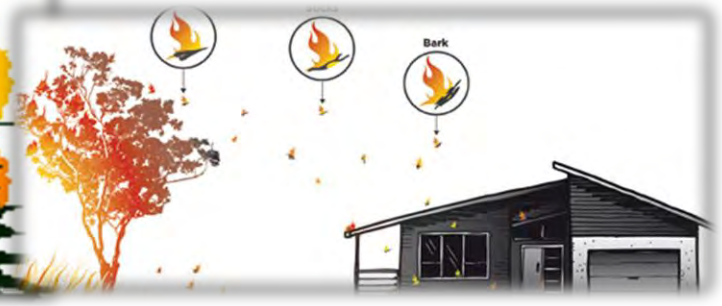
STAGE 1

Fire ignition
(Wildland Fire)

STAGE 2

Fire Propagation
(Wildland Fire)

STAGE 3



Ember Attack
(WUI Fire)

STAGE 4

Fire Propagation
(WUI Fire)

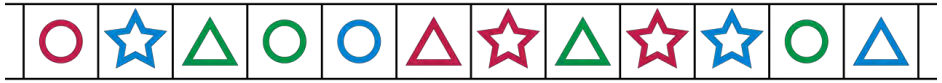
The framework in this study encapsulates the four stages of WUI fire to derive community risk

WUI = Wildland Urban Interface

STEM Education Trends in Research – Wildland Fire Propagation (1)

Game Theory – Using Cellular Automata to Model Wildlands Fire

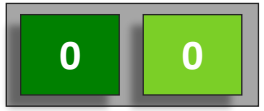
Initial state:



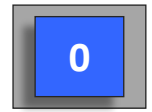
After 1 step: forward dynamics: shape color

Cellular Automata – rules-based Simulations

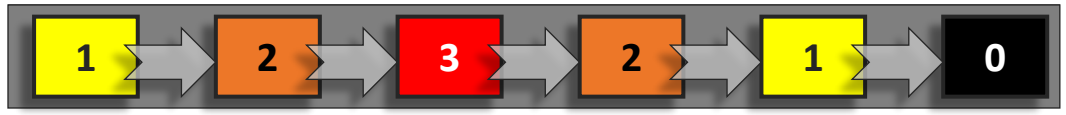
Vegetation:

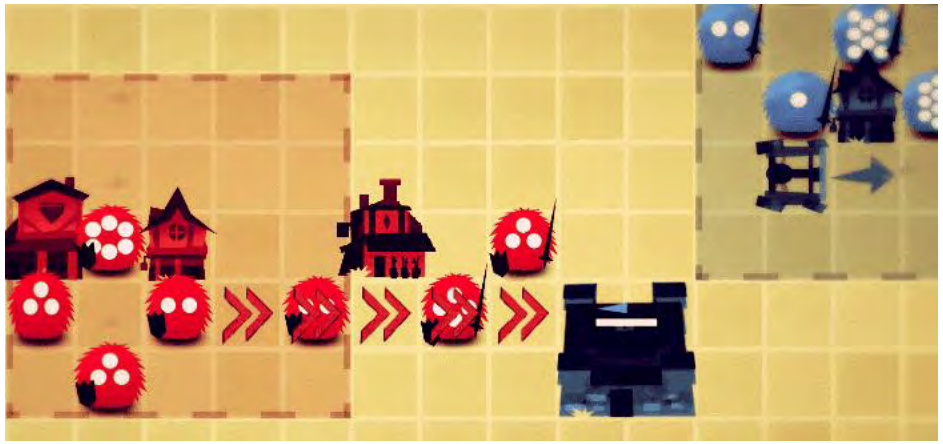


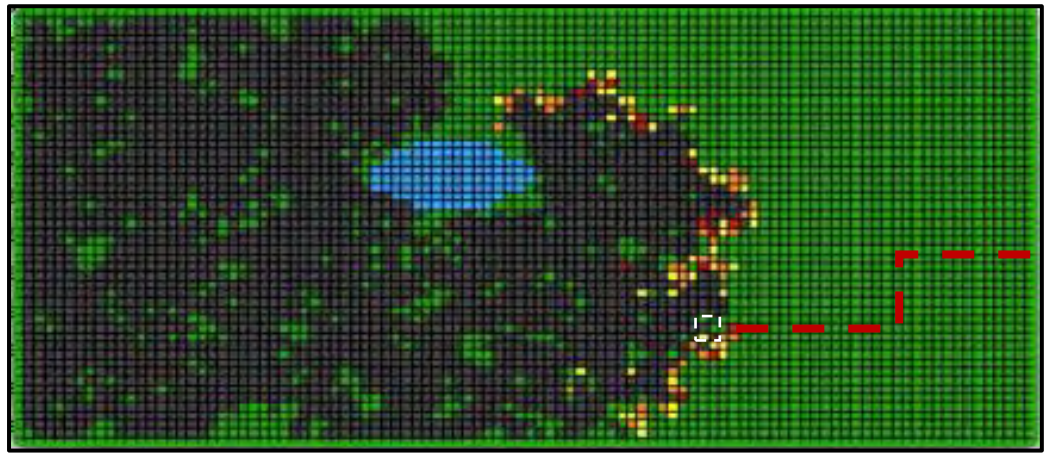
Water:

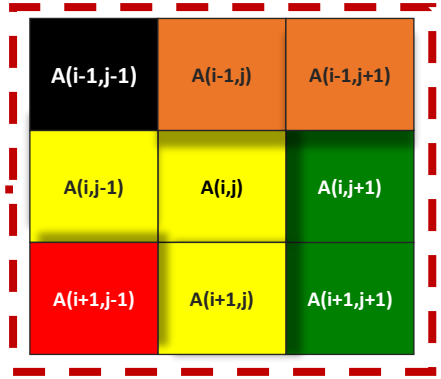


Fire:



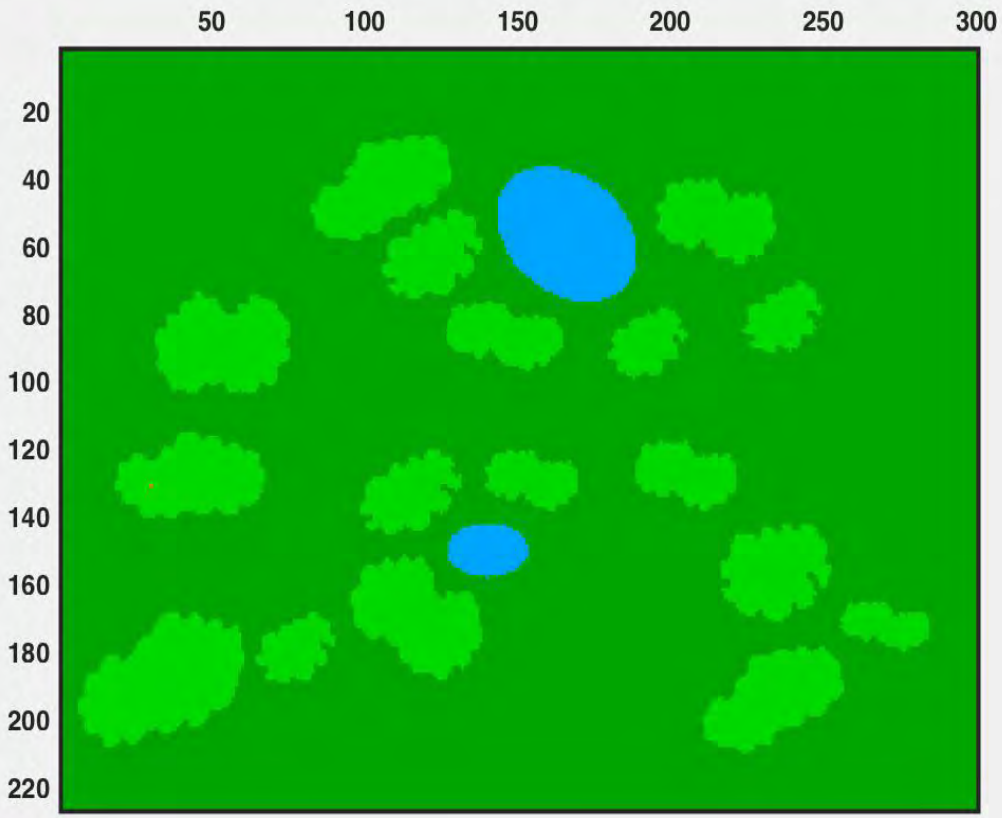




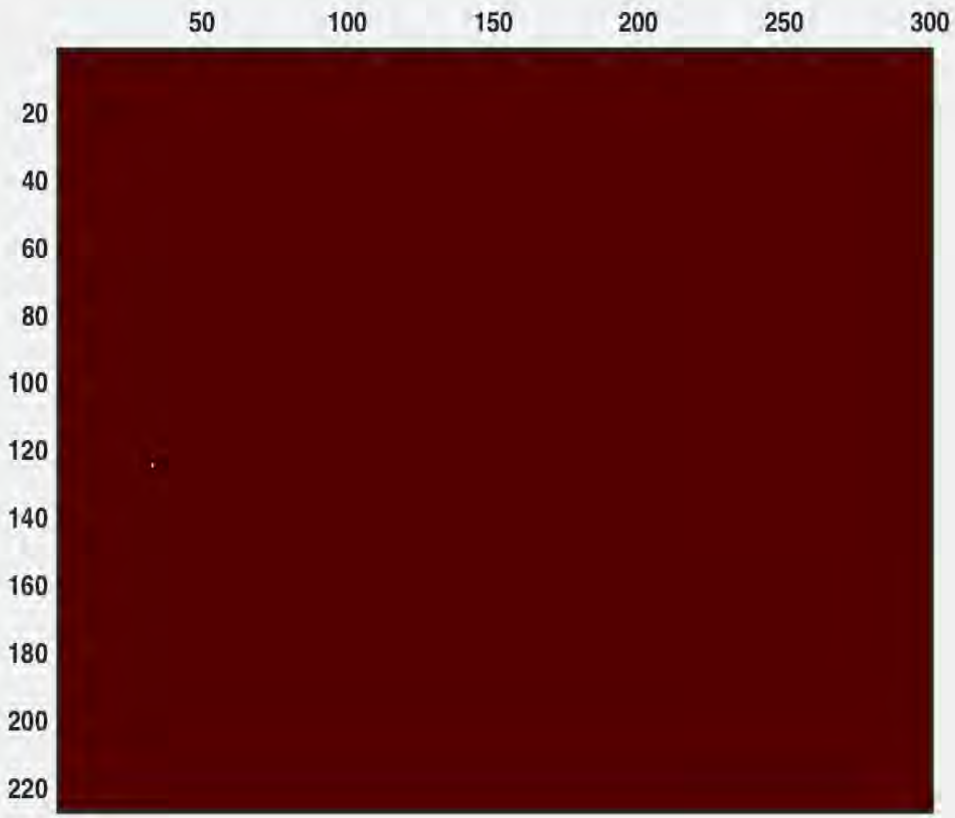


STEM Education Trends in Research – Wildland Fire Propagation (2)

Game Theory – Using Cellular Automata to Model Wildlands Fire



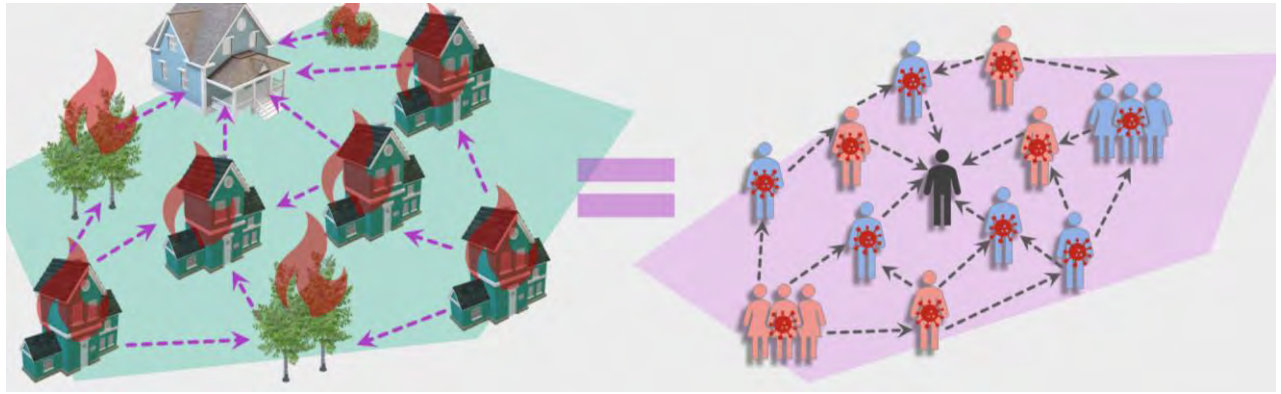
CA map showing wildfire propagation



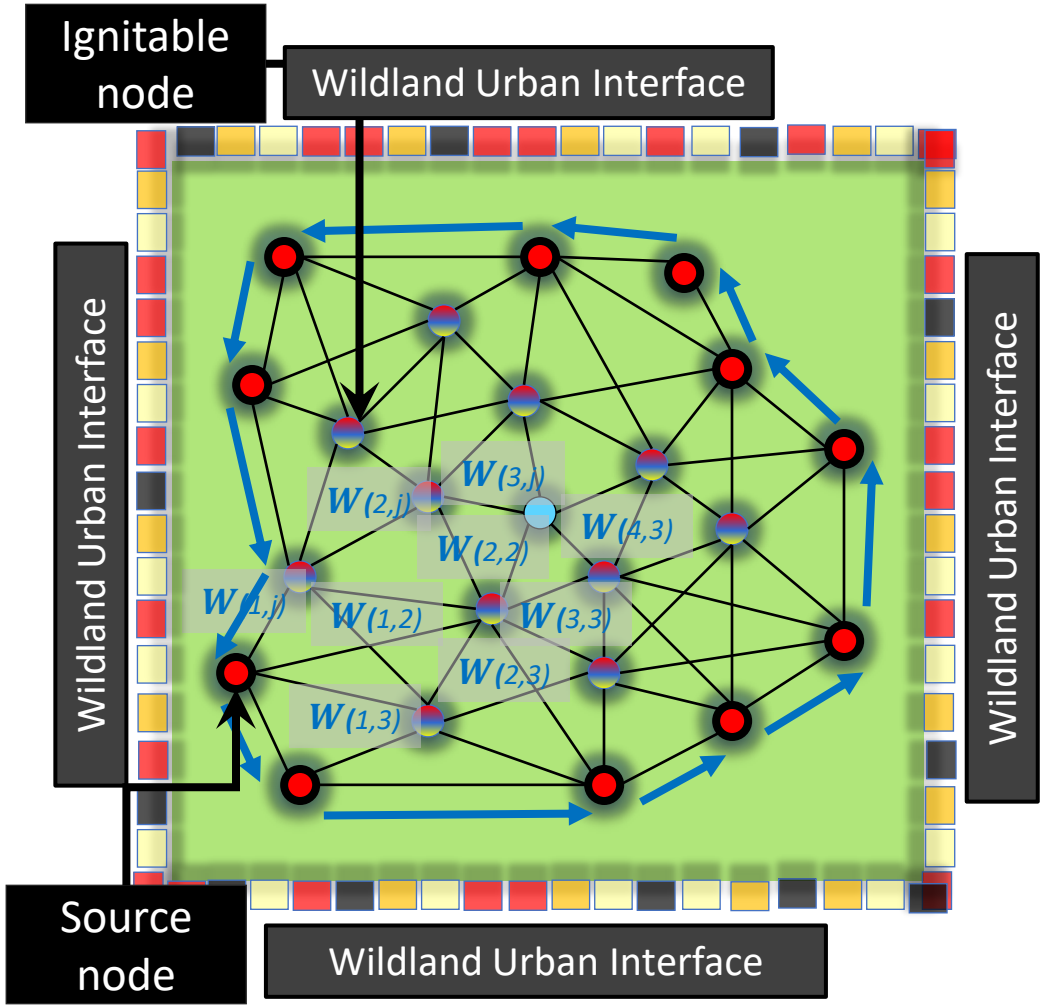
Tracking ember generation and trajectory

STEM Education Trends in Research – Community Fire Propagation (1)

Cross-Disciplinary – Borrow from Disease Transmission to Model Community Fire

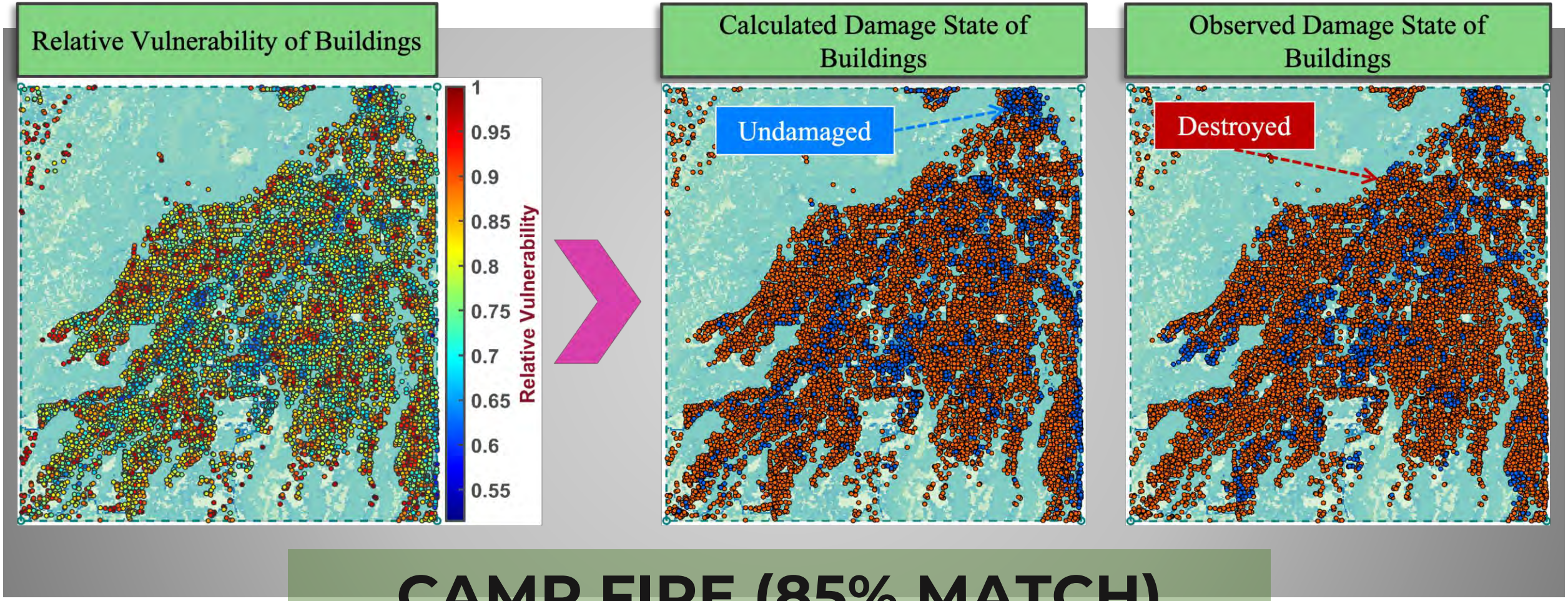


- Mapping structure surroundings (contact tracing).
- Clearing defensible space (social distancing).
- Hardening structures (immunization).
- Creating a buffer zone at the WUI (closing borders).



STEM Education Trends in Research – Community Fire Propagation (2)

Cross-Disciplinary – Borrow from Disease Transmission to Model Community Fire

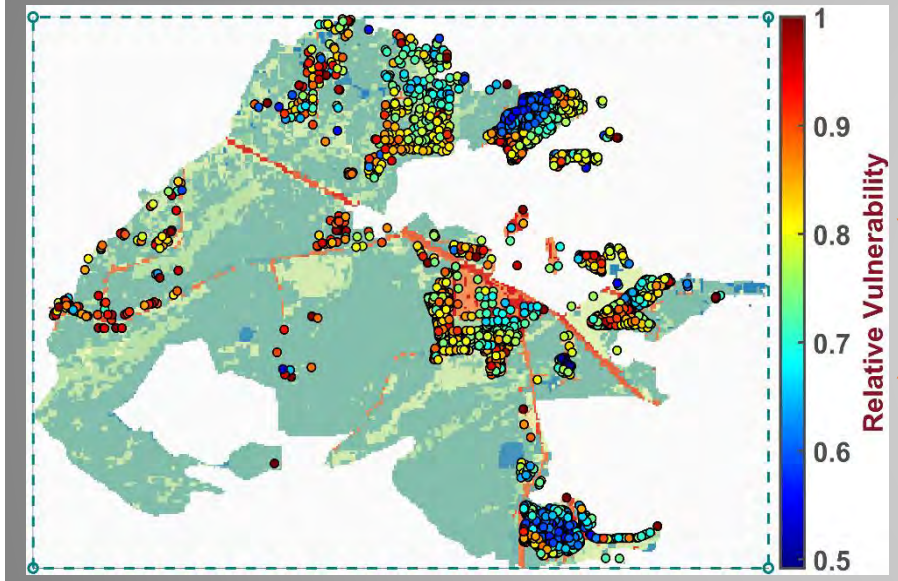


CAMP FIRE (85% MATCH)

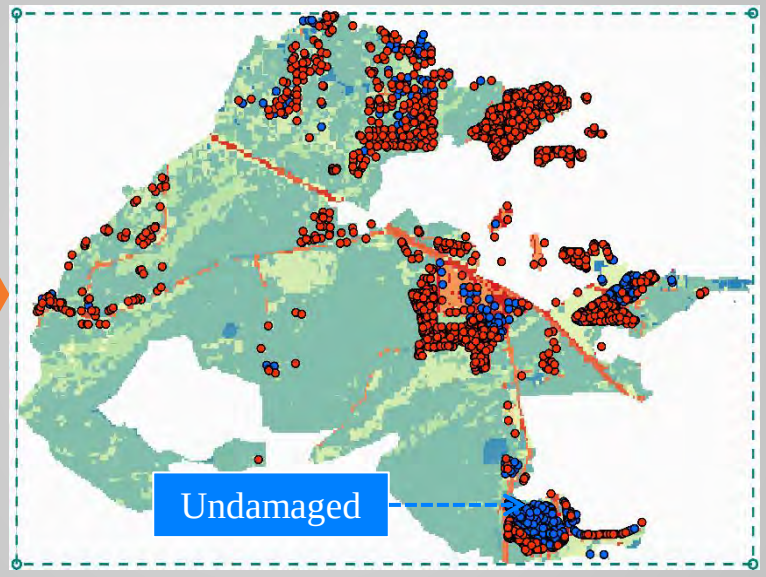
STEM Education Trends in Research – Community Fire Propagation (3)

Cross-Disciplinary – Borrow from Disease Transmission to Model Community Fire

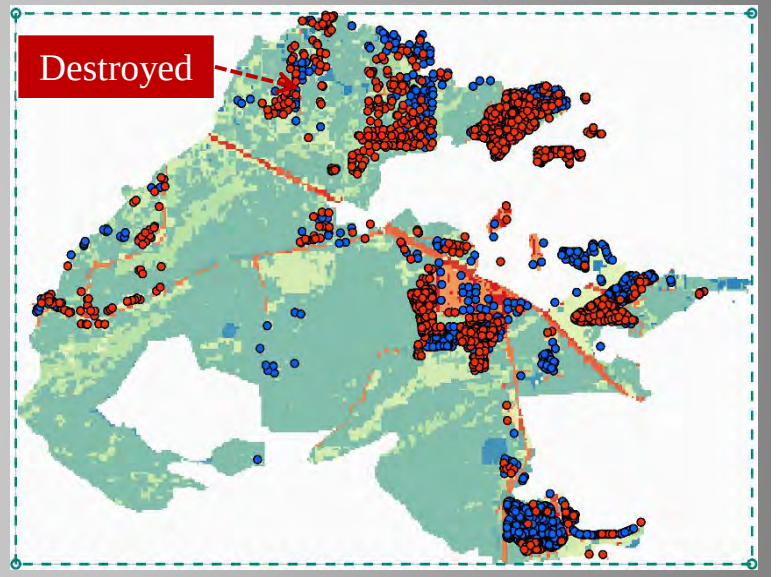
Relative Vulnerability of Buildings



Calculated Damage State of Buildings



Observed Damage State of Buildings



MARSHALL FIRE (72% MATCH)

Utilizing STEM Education Trends in Research

Recovering from extreme events

STEM Education Trends in Research – Recovery From Disasters

Community Analysis

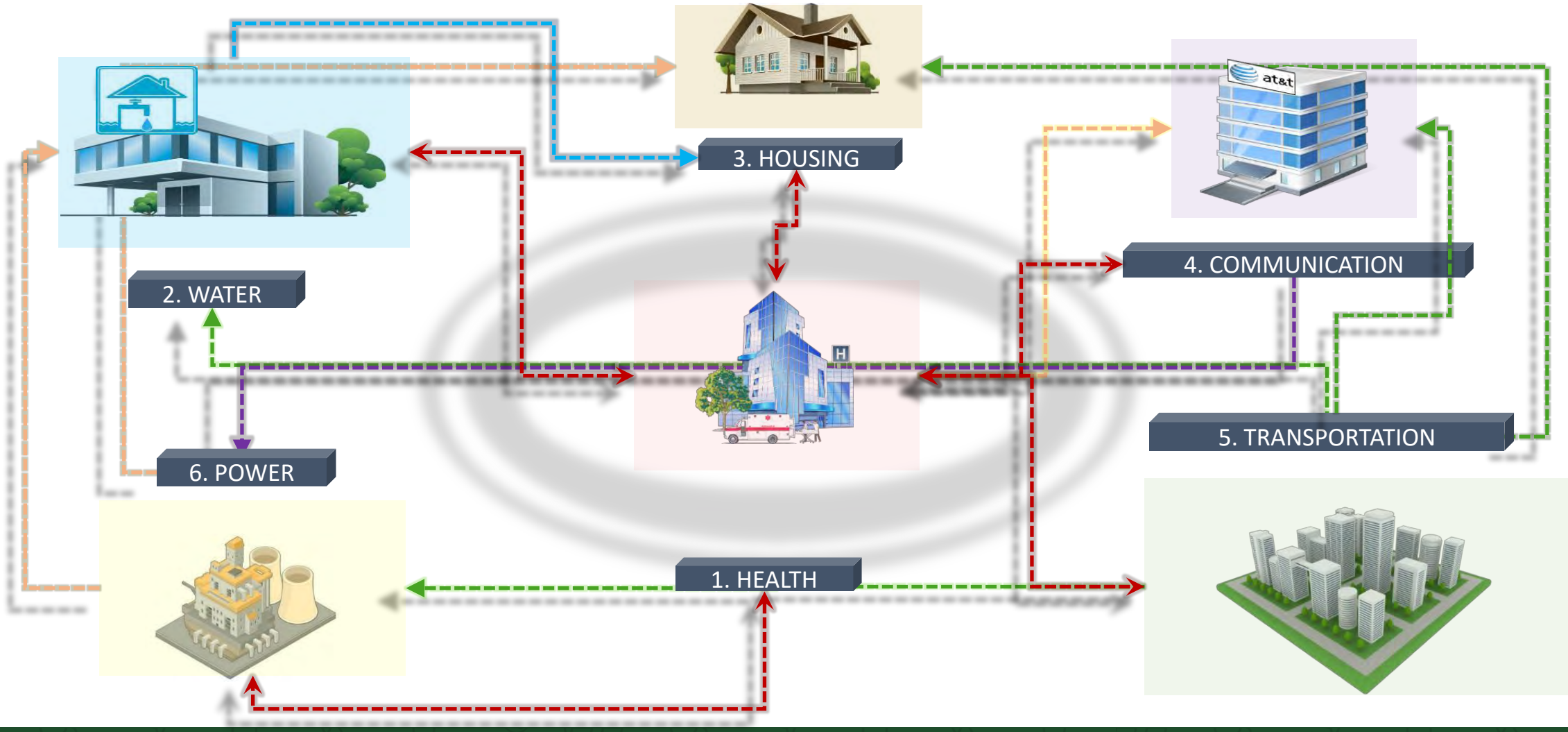
STEM Education Trends in Research – Recovery From Disasters

Community Analysis

STEM Education Trends in Research – Recovery From Disasters

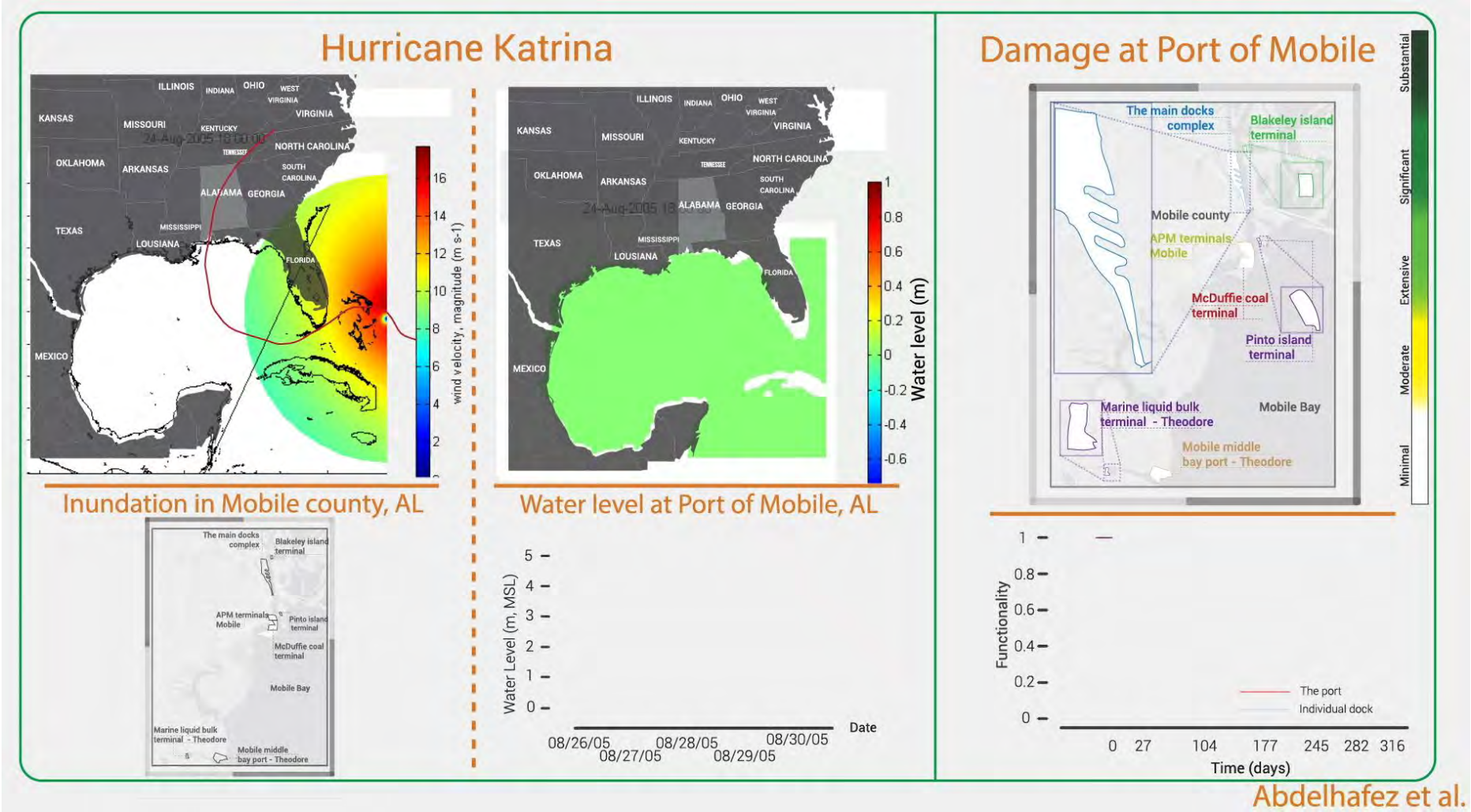
STEM Education Trends in Research – Interdependence

Multi-Disciplinary – Integrating Sectors Requires a Multi-Disciplinary Approach



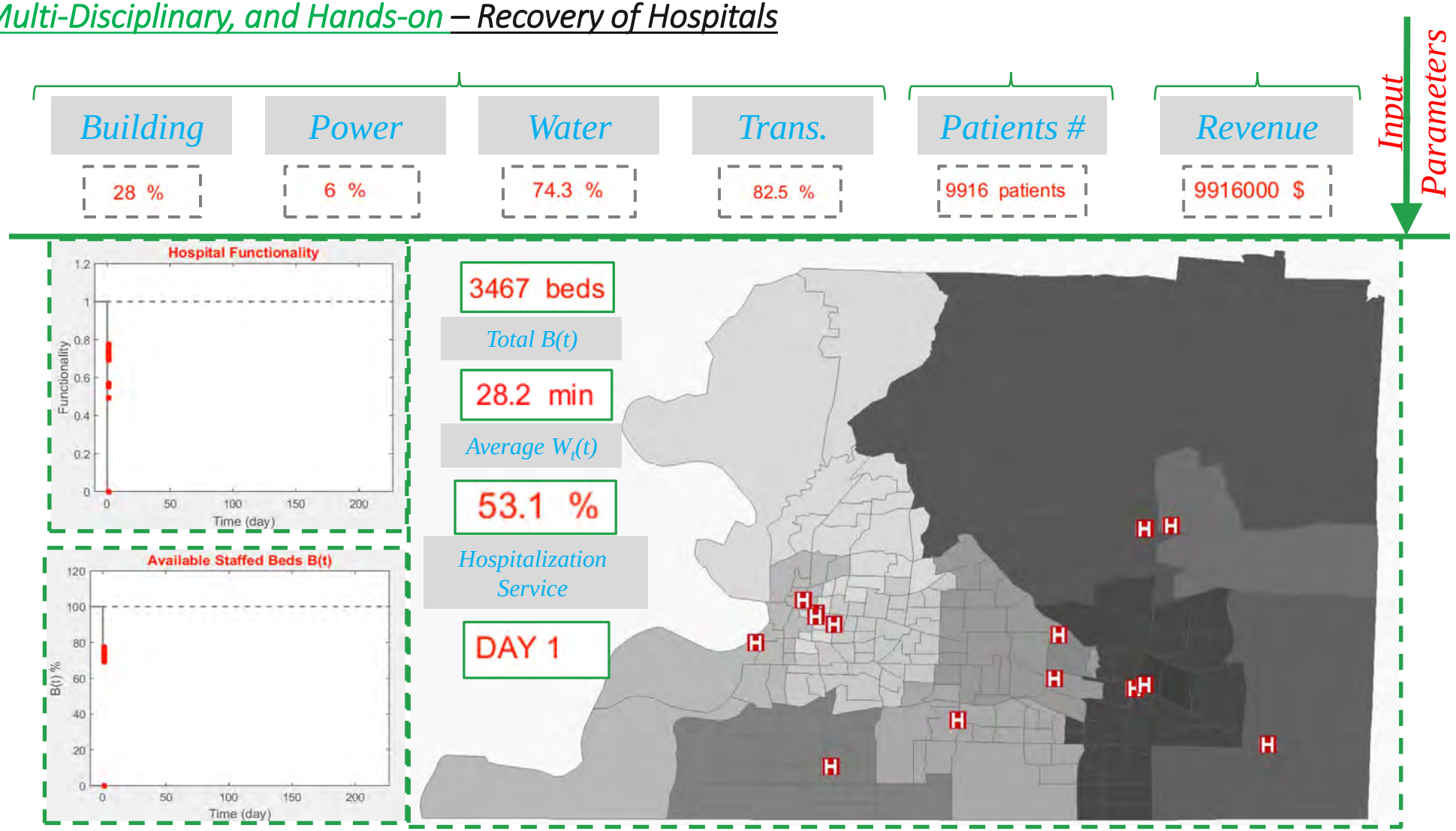
STEM Education Trends in Research – Recovery of Ports

Adaptive, Multi-Disciplinary, and Hands-on – Recovery of Ports



STEM Education Trends in Research – Recovery of Hospitals

Adaptive, Multi-Disciplinary, and Hands-on – Recovery of Hospitals



STEM Education Trends in Research – More Holistic View of the Problem

Potential Resilience Metrics

- Population dislocation
- Population outmigration

Social

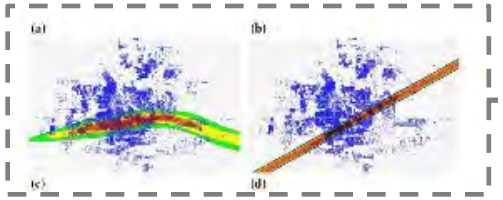
- Employment rate
- Fiscal impact
- Business interruption

Economical

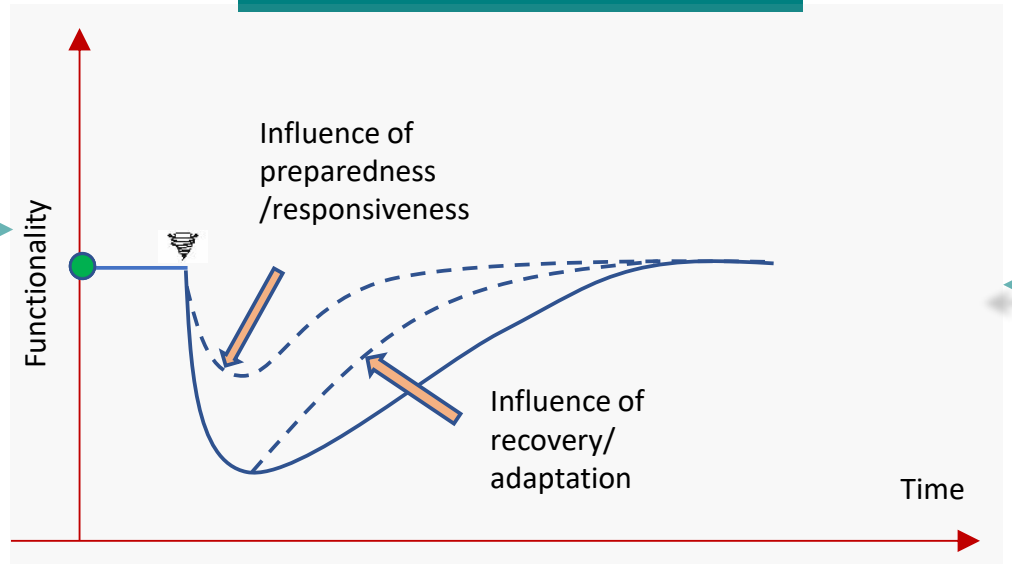
- Repair Recovery
- Functionality Recovery

Infrastructure

2011 Joplin Tornado - (*Attary, van de Lindt, Mahmoud et al. 2018*)



Functionality versus time



- *Built Environment Damage*
- Housing losses

Initial Conditions

STEM Education Trends in Research – The Need to Defy the Norm

Why do we have to select one or two metrics, and who decides on these?

AND

Why is the recovery a smooth curve?

AND

What if disruption is driven by social disruption or economic downtime?

STEM Education Trends in Research – Gotham City as a Testbed

Integrating STEAM (Art) – Using Art to Drive Research

Ra's al Ghul: "Start by storming Blackgate, and freeing the oppressed!"

Bruce: " You attacked Gotham before"

Ra's al Ghul: "Of course, over the ages our weapons have grown more sophisticated; with Gotham we tried a new one - Economics"

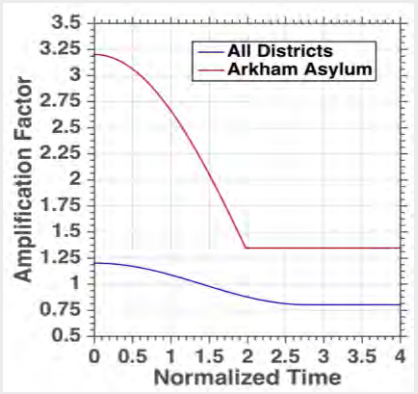
STEM Education Trends in Research – Recovering from Social Disruption

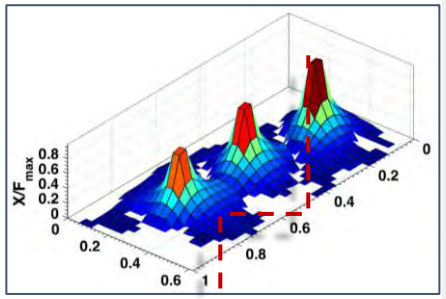
Adaptive, Multi-Disciplinary, and using Art to Drive Research – Recovery of Gotham

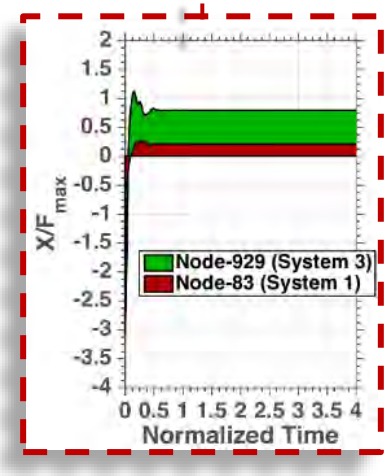
$$m_i(t)\frac{d^2X_i}{dt^2} + c_i(t)\frac{dX_i}{dt} + \sum_{j=1}^{N}[k_{ij}(t)X_j] = F_i(t)$$

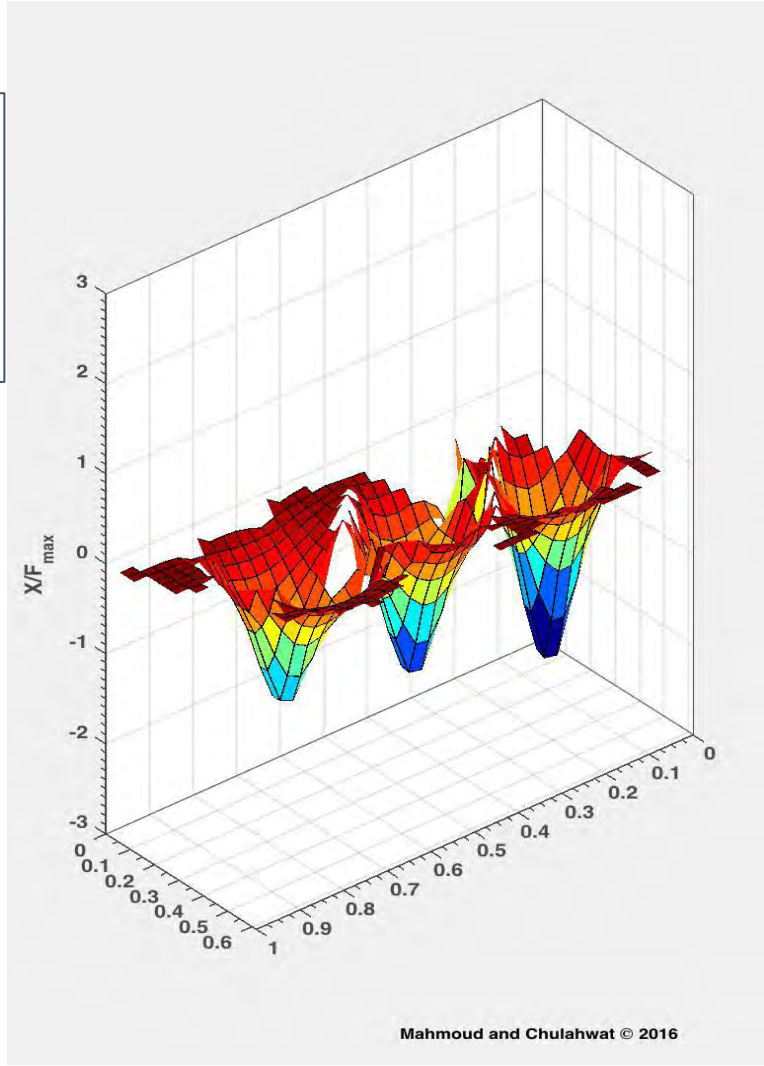
- $m_i(t)$: Social Vulnerability
- $c_i(t)$: Economic Stability
- $k_{ij}(t)$: Infrastructure Stability
- $F_i(t)$: Damage Function

Arkham has a “strong” infrastructure but low social stability.









Resilience order:

Downtown > Midtown > Arkham > Uptown

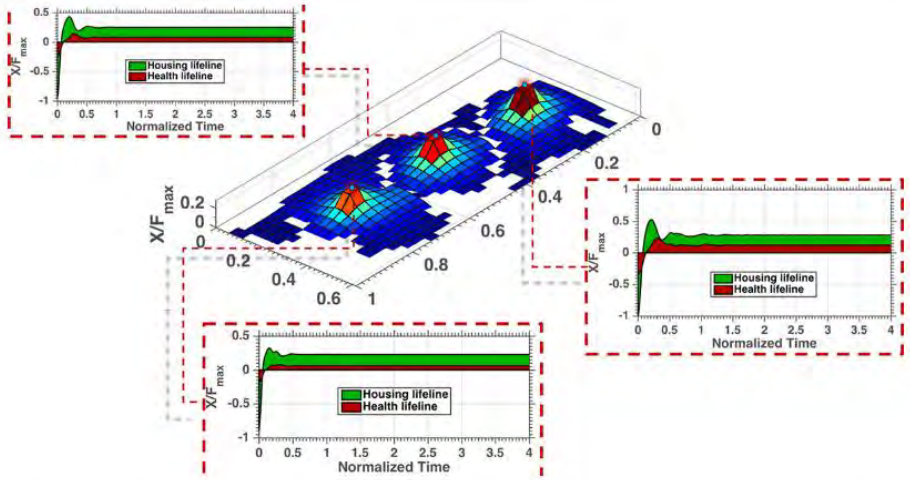
STEM Education Trends in Research – Potential Impact

COLORADO STATE UNIVERSITY | WALTER SCOTT, JR. COLLEGE OF ENGINEERING

College News | CSU Magazines | Latest Headlines | Students | Research | Events | Engineering Commun

Batman's Gotham City provides test case for community resilience model

04 Jan, 2018
By Anne Manning



A map of Gotham City is laid out in a Finite Element Analysis grid. The grid shows the recovery of different lifelines, and how they affect recovery of various parts of the city.

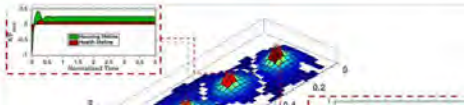
If a community is resilient, it can withstand and recover from an unanticipated disaster, like an earthquake, fire or flood.

CSU Engineering @CSUEngineering · Jan 24, 2018
This model aims to find the **resilience** of any community - even Batman's hometown, **Gotham** City col.st/HcZD9

Batman @BatmanStore
Batman's Gotham City provides test case for community resilience m
#DCComics tinyurl.com

Batman Share @BatmanShare · Jan 5, 2018
Batman's **Gotham City** provides tes
model - Science Daily dlvr.it/Q95w

WTW Climate and Sustainability @WTWClimate · Jan 19, 2018
Batman's **Gotham City** provides test case for community **resilience** model buff.ly/2mDQwf4



Characteristic of Future Engineers

Final thoughts: what else is missing?

Characteristics of Future Engineers – Insight from NASEM New Voices

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JEE

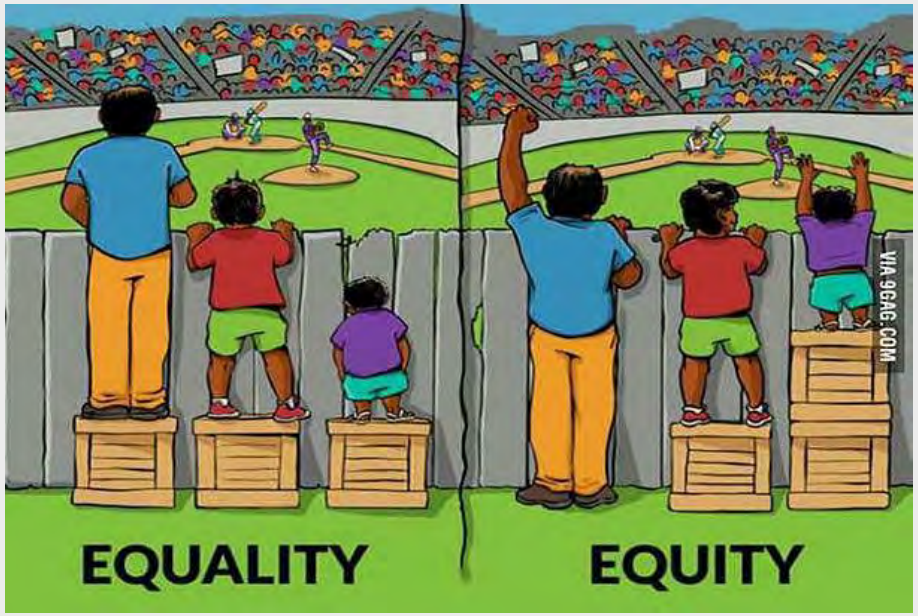
GUEST EDITORIAL

The climate is changing. Engineering education needs to change as well

- The New Voices is a young academy of the U.S. National Academy of Sciences, Engineering, and Medicine.
- To bring diverse perspectives from early-career U.S. leaders to critical dialogues around how science, engineering, and medicine are shaping the global future.
- New Voices members are leading significant initiatives on various topics, including STEM Education.

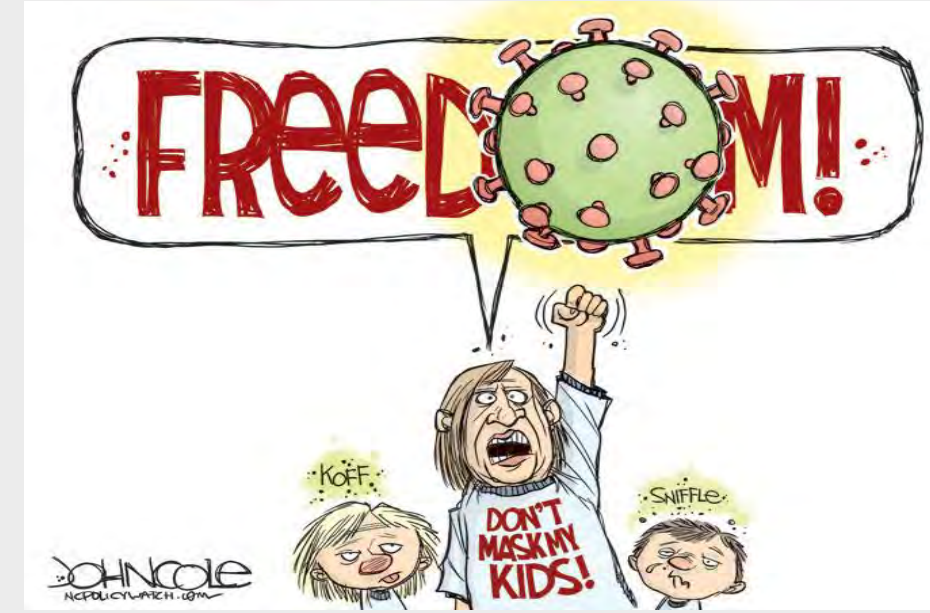
Characteristics of Future Engineers – Expanding Knowledge (1)

Understand how climate and sustainability, and resilience are linked.



Incorporate a wide range of disciplines into engineering solutions.

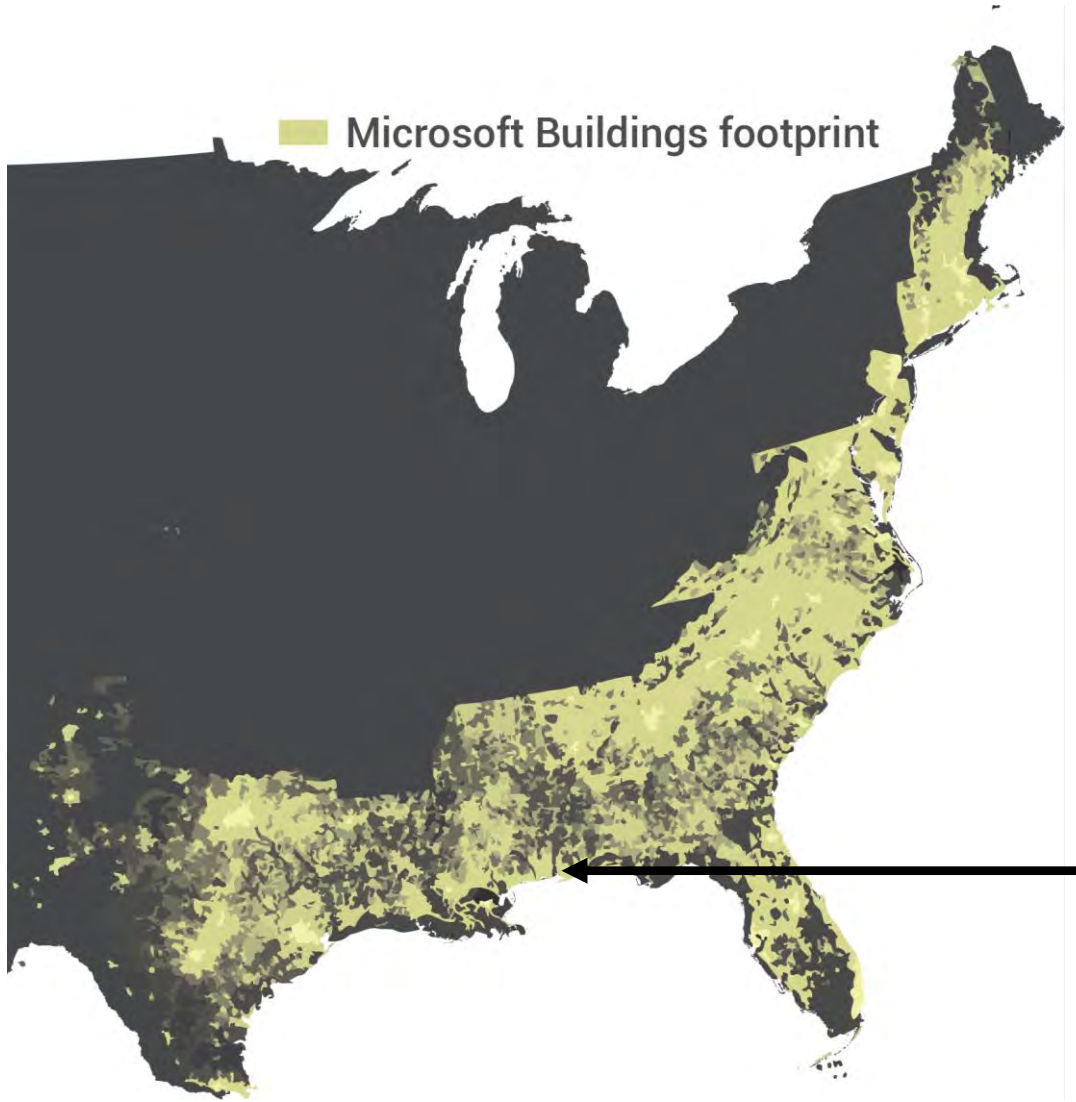
Characteristics of Future Engineers – Expanding Knowledge (2)

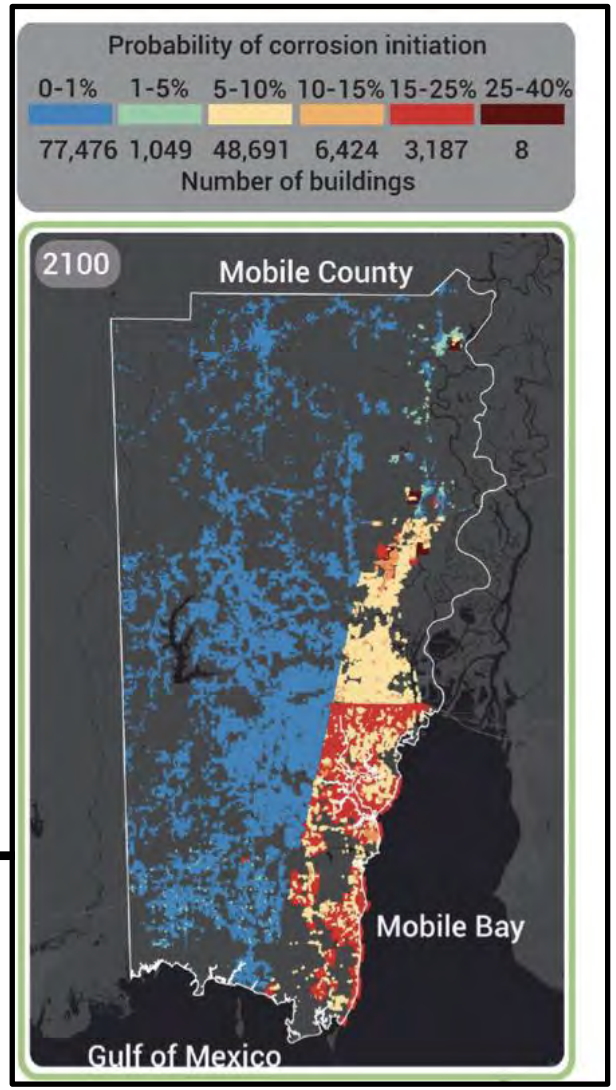


Understand the ethics and justice dimensions of engineering.

Listen to and collaborate with diverse communities.

Characteristics of Future Engineers – Why Knowledge Expansion (1)

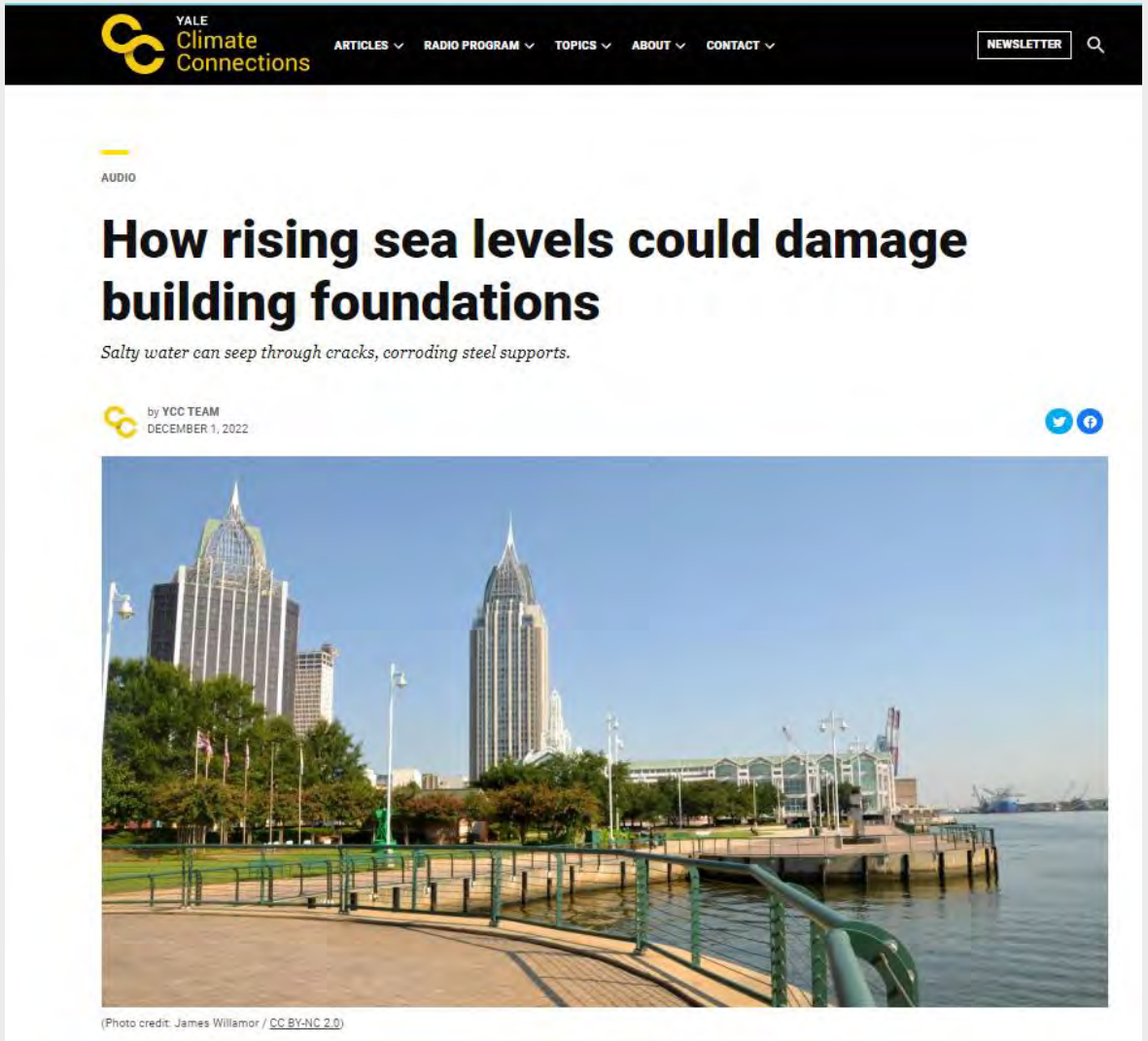


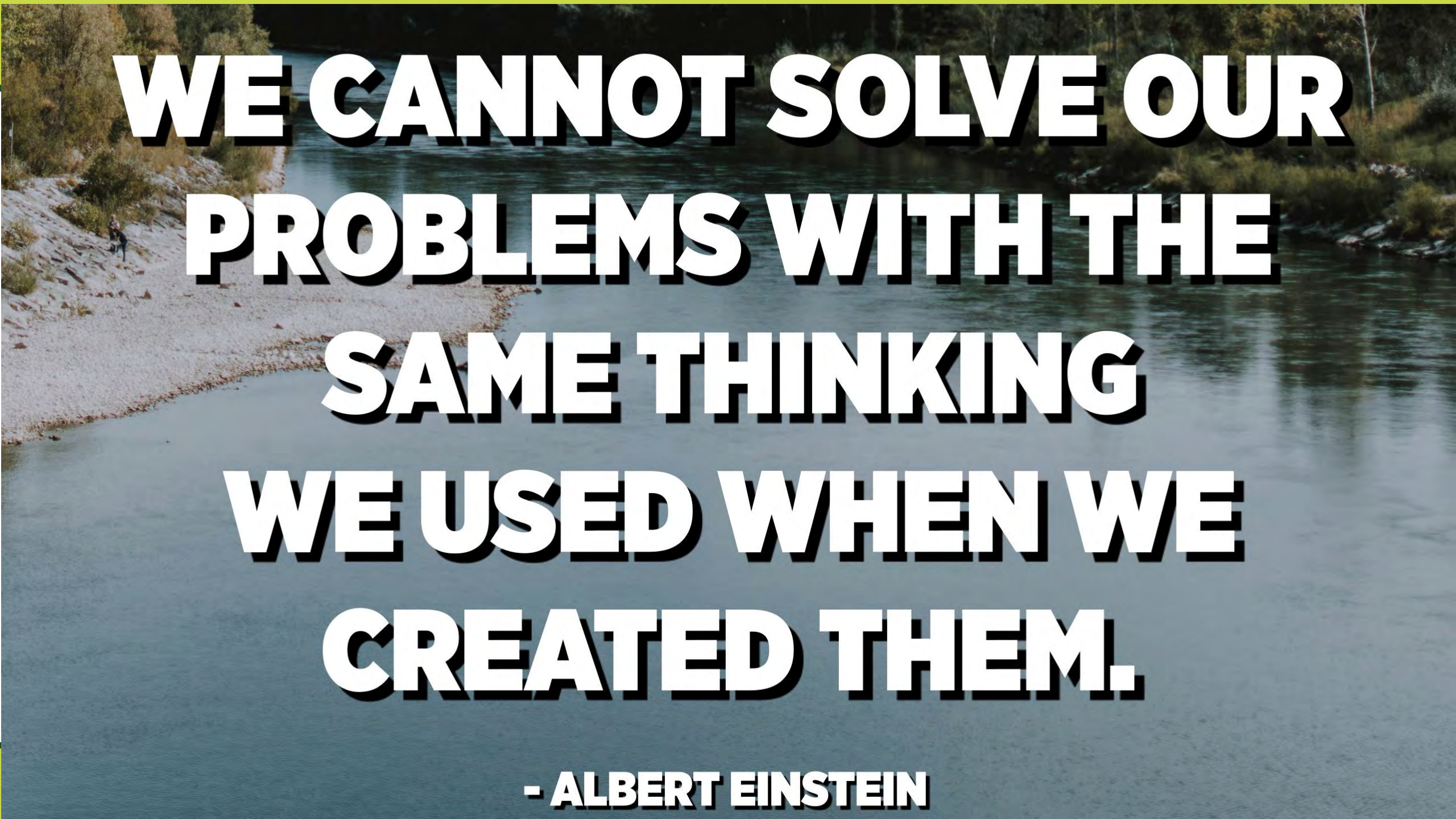


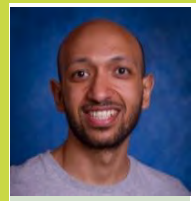
- Expansive soils cause an estimated $2.3 billion in building damages yearly in the US.
- Our analysis predicts that SWI may cause damages to building foundations in Southeast coastal counties equal to ~3 times that caused by expansive soils.

Characteristics of Future Engineers – Why Knowledge Expansion (2)

- Why was this not considered in the past?
  - Was there a lack of understanding the link between sustainability & resilience?
  - Was it a matter of ethics?
- Who pays to fix the homes?
  - How should we consider equality versus equity if resources are limited?
  - What are the consequence of bias selection?
  - Should we work with the community and let them decide?




WE CANNOT SOLVE OUR PROBLEMS WITH THE SAME THINKING WE USED WHEN WE CREATED THEM.
- ALBERT EINSTEIN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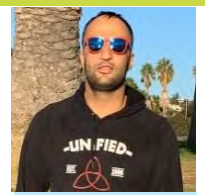
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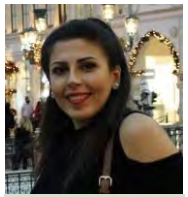
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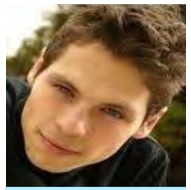
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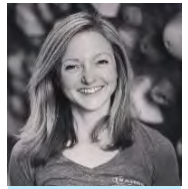
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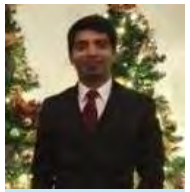
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H. Wen


T. Wilson

And All My Visiting Scholars and Collaborators!

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THANK YOU!

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