Emerging STEM Evaluation and Research Frameworks

ITEST PI Summit

May 15, 2018

Theory

Logic Model

Theory of Change

?

Theory

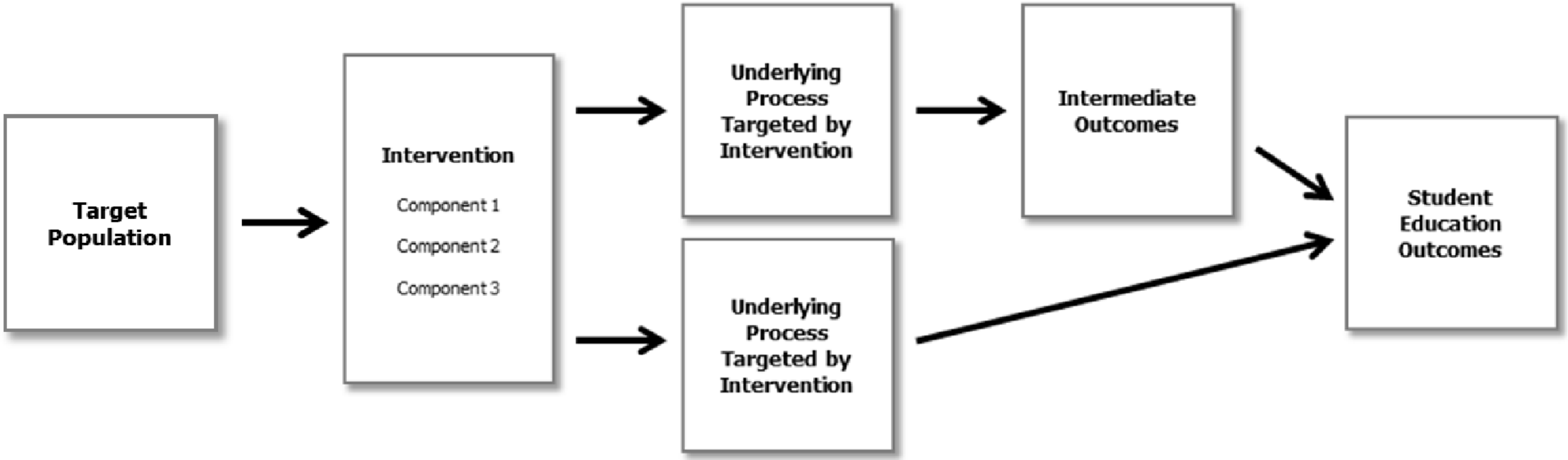
Learning Activation

STEM Ecology

STEM Identity

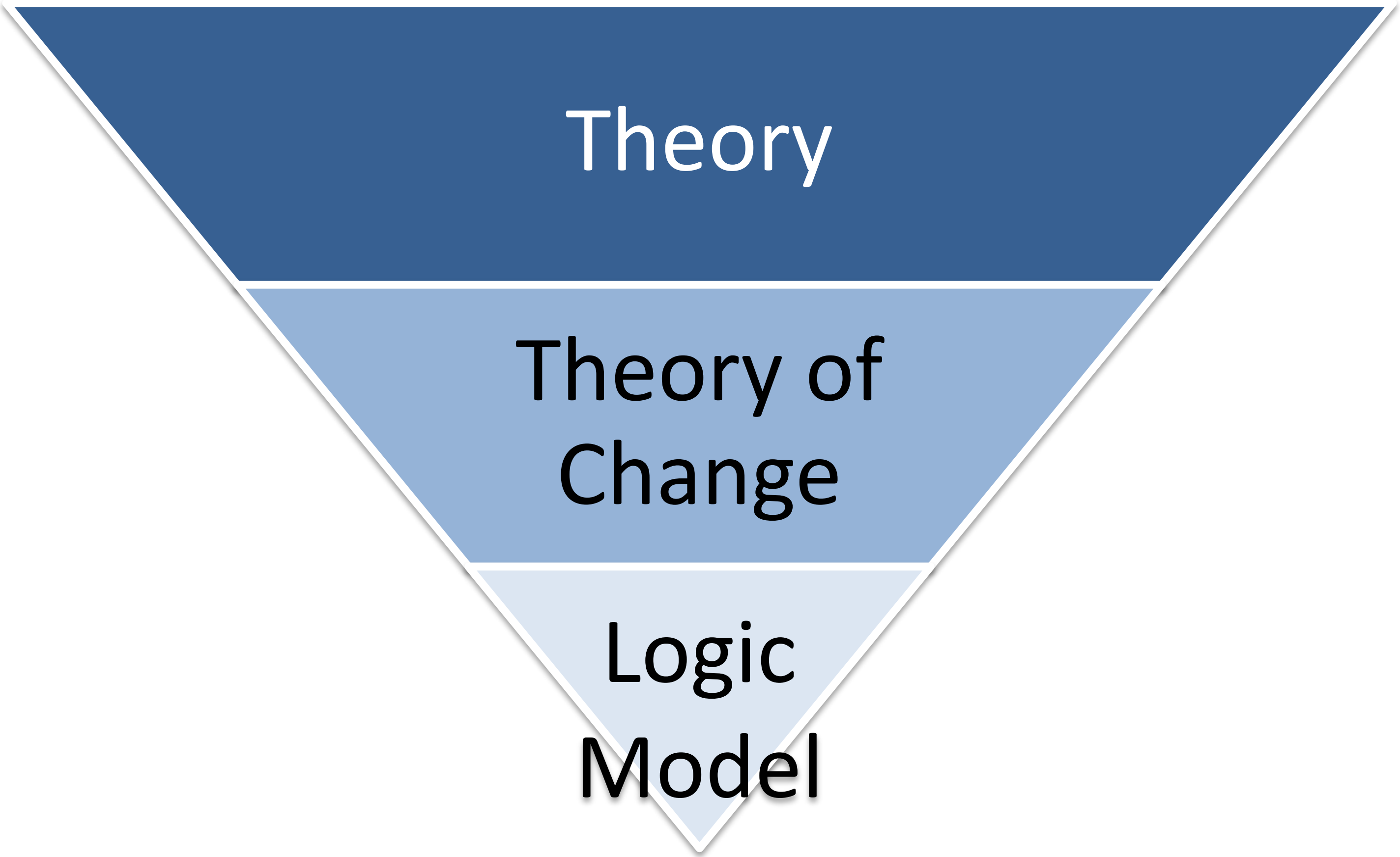
Socio-scientific Investigations

Theory of Change

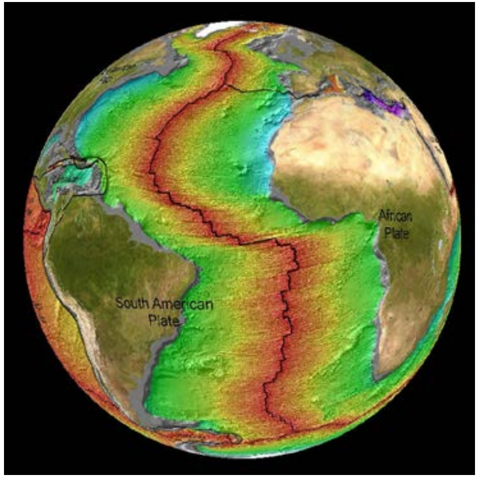


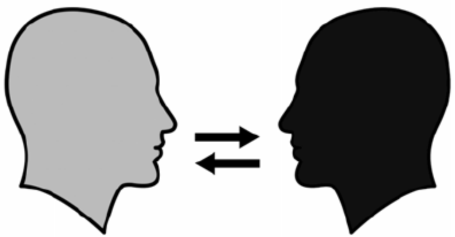
Source: Institution for Education Sciences Request for Applications 2017

Logic Model


Theory
Theory of Change
Logic Model

Theoretical Frameworks





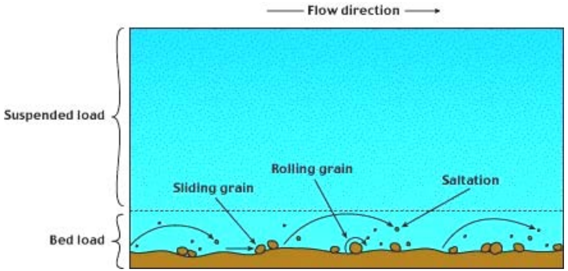
Models & Theories for ESS Research

PREDICTIVE

INPUT:
What does Earth look like?

PROCESS:
What is happening to Earth?

OUTPUT:
How has Earth changed?



RETRODICTIVE

OUTPUT:
What DID Earth look like?

PROCESS:
What HAPPENED to Earth?

INPUT:
What does Earth look like?

from Libarkin, 2017

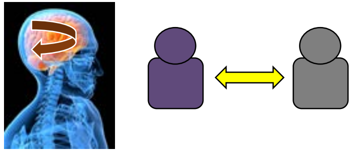
Models & Theories for Education Research

LEARNING THEORIES

INPUT:
What does learner/environ contribute?

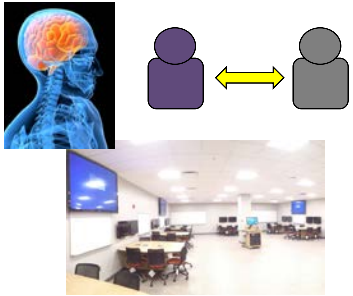
→

PROCESS:
What is happening to learner?



→

OUTPUT:
How has learner changed?



STUDENT DEVELOPMENT THEORIES

INPUT:
What does learner contribute?

→

ENVIRONMENT:
What does environment contribute? (includes proc)

→

OUTPUT:
How has learner changed?

Modified from Astin (1991) I-E-O model , from Libarkin, 2017

Models & Theories for Education Research

LEARNING THEORIES

INPUT:
What does learner/environ contribute?

→

PROCESS:
What is happening to learner?

→

OUTPUT:
How has learner changed?

BEHAVIORISM (*Skinner, Bandura, Pavlov*)
COGNITIVE CONSTRUCTIVISM (*Piaget, Bruner*)
SOCIAL CONSTRUCTIVISM (*Vygotsky*)

STUDENT DEVELOPMENT THEORIES

INPUT:
What does learner contribute?

→

ENVIRONMENT:
What does environment contribute? (includes process)

→

OUTPUT:
How has learner changed?

INTELLECTUAL AND ETHICAL DEVELOPMENT (*Perry*)
IDENTITY DEVELOPMENT (*Chickering*)
STUDENT INVOLVEMENT (*Astin*)

from Libarkin, 2017

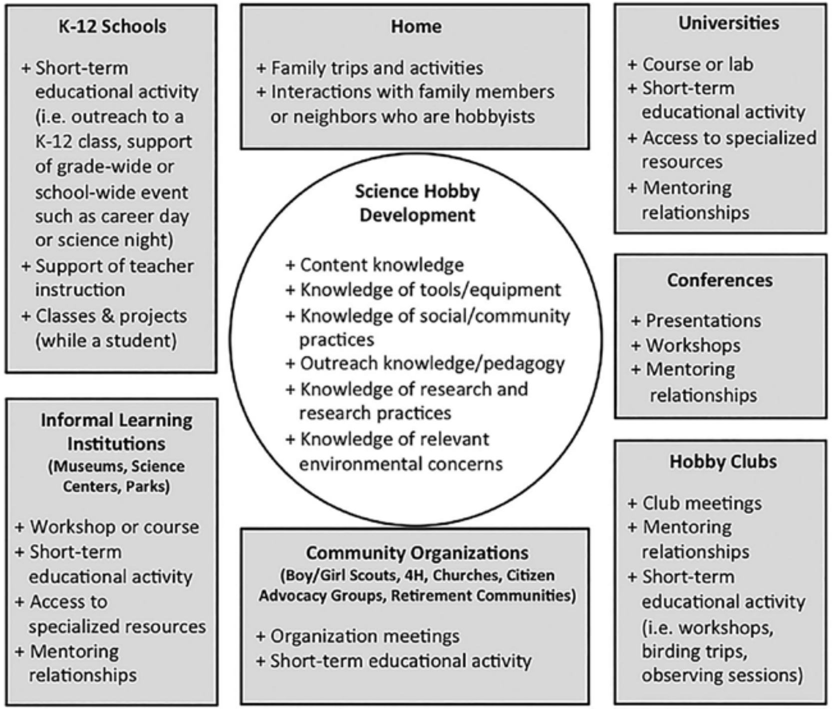
Practical Answer

- What is the problem or question?
- Why is your approach to solving the problem or answering the question feasible?

Lederman & Lederman, 2015

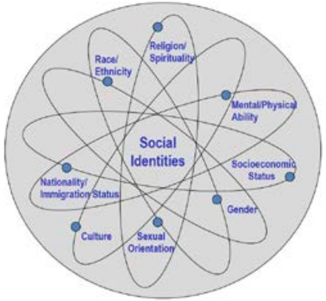
STEM Ecology Framework

Traill & Traphagen, 2015



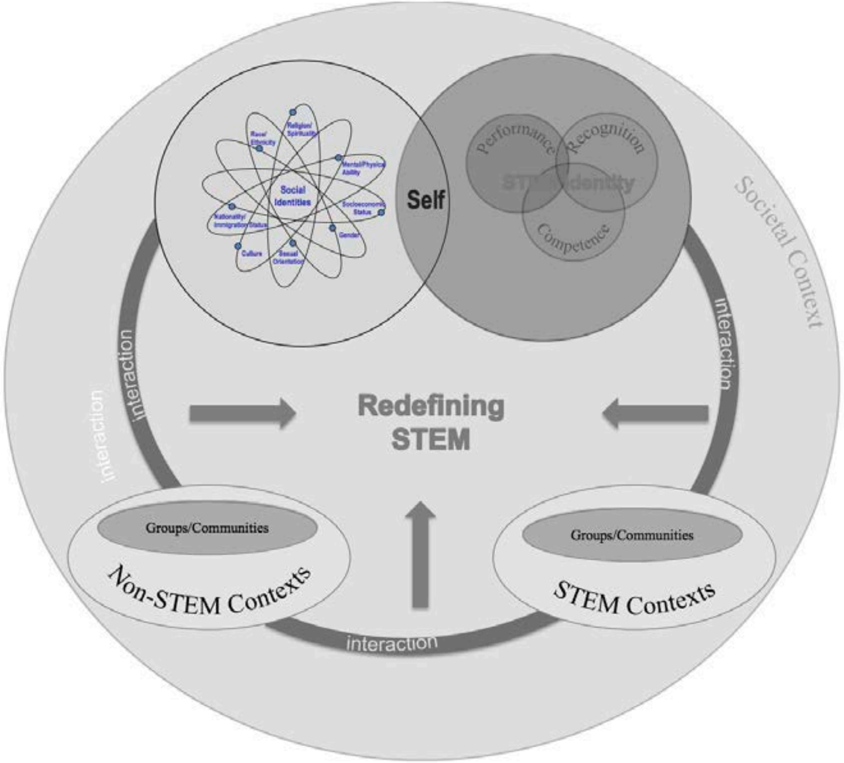
Corin et al., 2017

STEM Identity

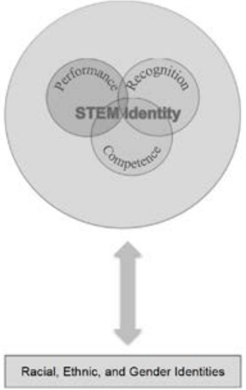


Model of multiple social identities, Jones &

McEwen, 2000



Herrera et al., 2012



Model of science identity, Carolone &

Johnson, 2007

Lens on Climate Change

Lens on Climate Change Project

CIRES - Cooperative Institute for Research in Environmental Sciences

CIRES Education & Outreach

Award number DLR -1513320

Contact:

Anne.U.Gold@Colorado.edu

http://cires.colorado.edu/outreach/LOCC

Center for Translational Science Education

Providing practical solutions to bring benchtop and bedside to desktop

STEM Evaluation and Research Frameworks

David Reider and Berri Jacque

The BIG Goals

1. **Capture student interest**

2. **Build career awareness**

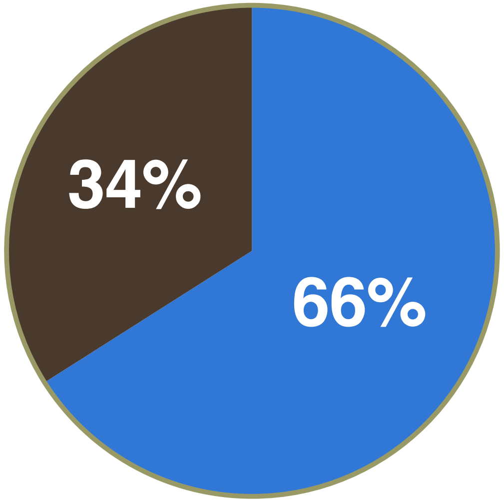
3. **Build critical skills and student perceptions**

Your average science classroom...

(iStockphoto)

Your average science classroom...

(iStockphoto)

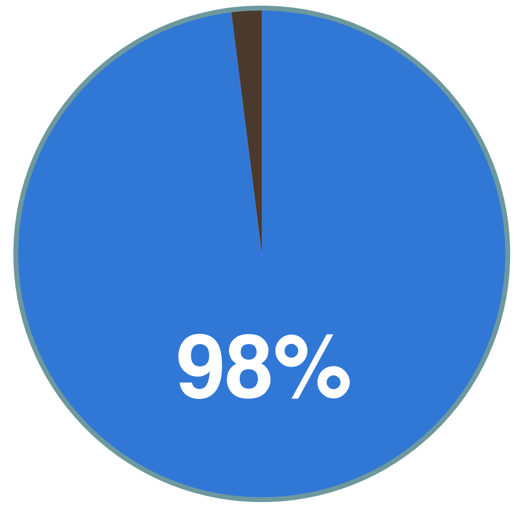


66% of students value learning about science

Data from PISA 2007

How interested are high school students in learning about health?

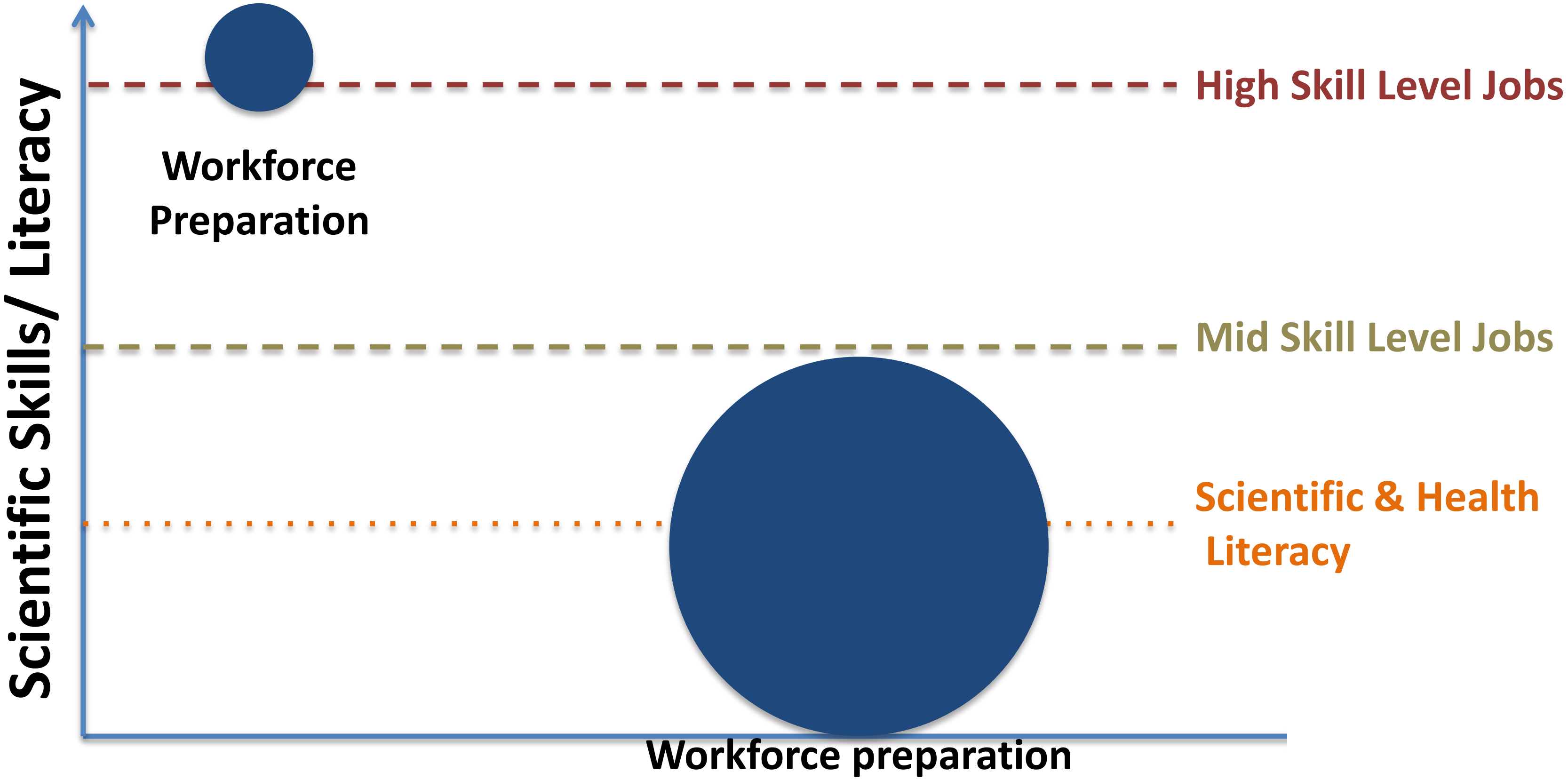
How interested are high school students in learning about health?



98% of students value learning about health

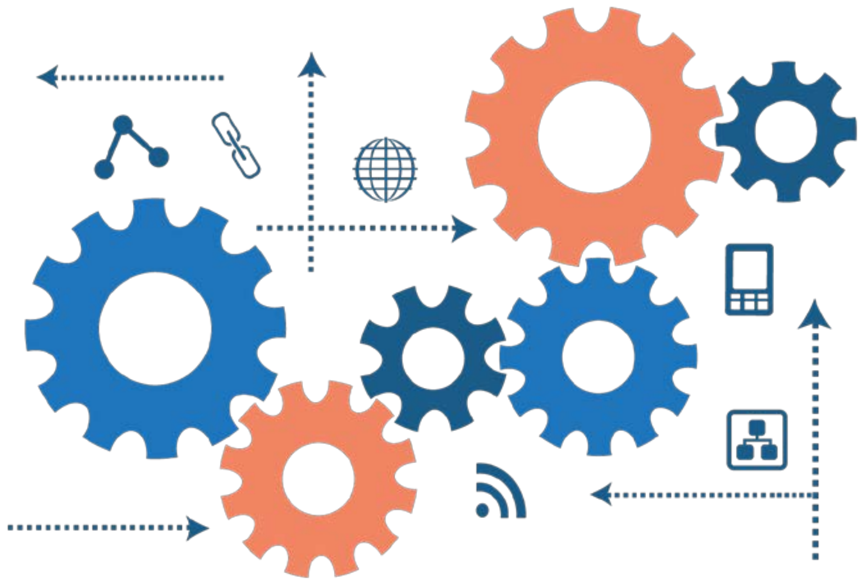
Scientific and health literacy needs are shifting

9 out of 10 bioscience jobs are in health



Our approach

Integrate STEM literacy and career awareness



Do something real and meaningful from the perspective of a career role!

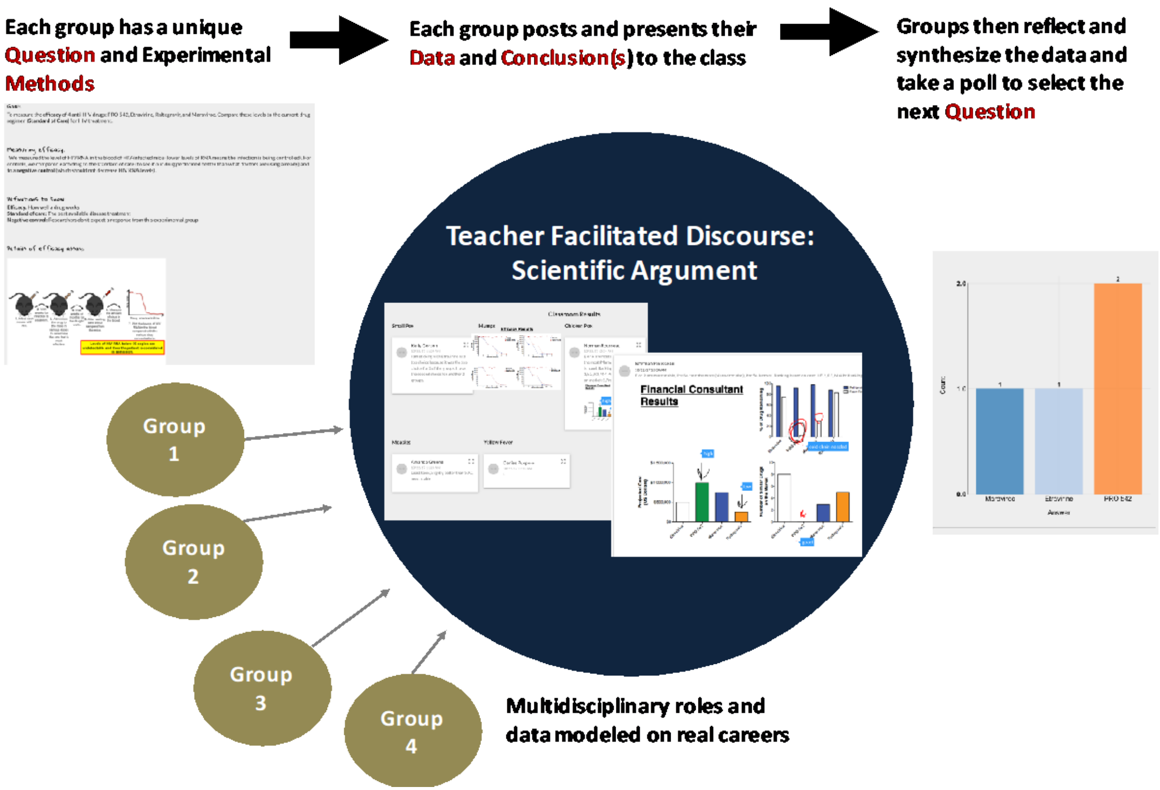
Technology built for multi-role interrupted case studies

Context - Students work together to design a new drug to combat HIV.

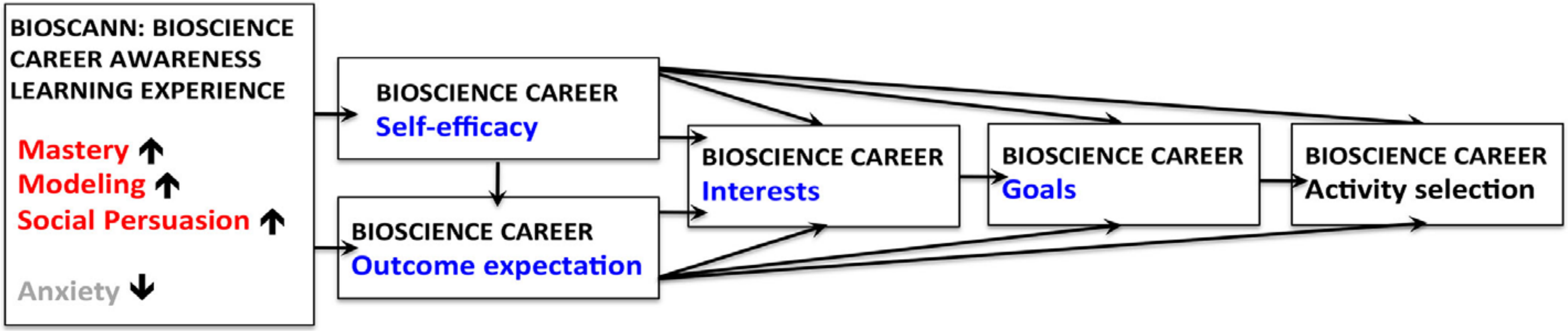
Roles - Students are each given a distinct role as a member of a drug discovery team.

Instructional approach -
Interrupted case study

- Team based problem solving
- Deliberation / collaborations
- Data analysis (skill)
- Communication



Social Cognitive Career Theory (SCCT): a framework for building and measuring STEM career selection



Social Cognitive Career Theory (SCCT) as a framework for building and measuring STEM career selection: *This model is adapted from Lent et al., 2013.*

Pros and cons of our model

- **Pros:**
  - Models collaboration as actual scientists practice
  - Engages different skillsets and professional training to model product development
  - Presents multiple decision factors that go into product development - science is just one of them
  - Models the importance of STEM literacy rather than STEM expertise as critical to participate in tomorrow's economy

- **Cons:**
  - Might raise instructor eyebrows with too little hard science content
  - Requires a collaborative learning context, not all schools foster this
  - Participant populations may/may not relate to disease of study, depending on location - issue of relevance

Socio-Environmental Science Investigations: Pedagogical Frameworks and Design Principles

Alec Bodzin, Lehigh University

2018 ITEST Principal Investigator and Evaluator Summit

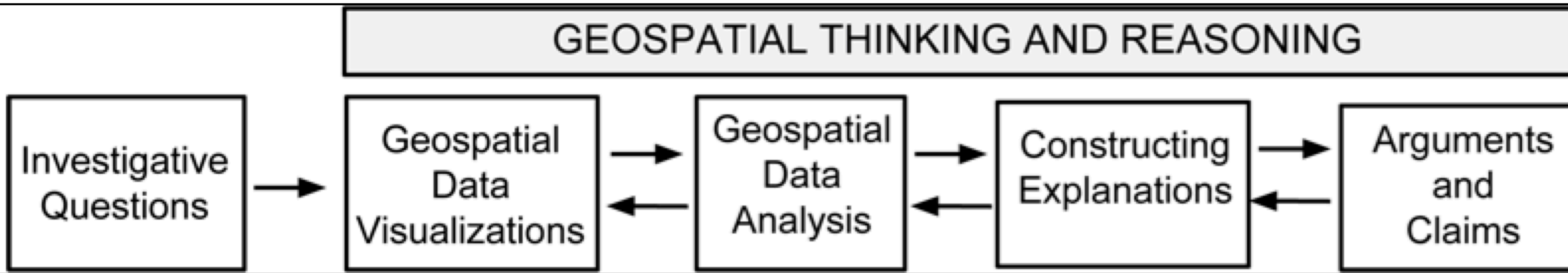
DRL-1614216

Socio-Environmental Science Investigations (SESI)

- Inquiry-based investigations
- Map-based mobile data collection
- Analysis with Web-based mapping software
- Local issues
- Field work in the local setting

Pedagogical Frameworks

- Place-based Education (Sobel, 2004; Semken, 2005)
  - Focuses on local or regional investigations
  - designed around engaging students in examining local problems
  - Utilizes fieldwork to gather evidence in that local setting
- Socio-scientific investigations (Sadler, Barab, & Scott, 2007; Zeidler & Nichols, 2009)
  - Use of evidence-based reasoning
  - Understanding scientific information through an active approach to learning
  - Placing science content within a social context in a way that supplies both motivation to and the ownership of learning by the student



Geospatial Science Technological Pedagogical Content Knowledge	**Earth and Environmental Science Content**	**Social Studies Content**
• Interactions between geospatial technology and pedagogical content knowledge to produce effective environmental science teaching and student learning. • Modeling geospatial data exploration and analysis techniques. • Scaffolding students' geospatial thinking and analysis skills.	• Human-Environment Interactions: Know and apply geographic information about relationships between nature and society. • Physical Geography: Know and apply geographic information about processes shaping the structure of the Earth's surface, physical landscapes, natural hazards, weather, climate, and atmospheric processes.	• Human-Environment Interaction: Place, Regions, and Culture • Human Population: Spatial Patterns and Movements

Geospatial Science and Analysis Skills

- Use GIS to manage, display, query, and analyze geospatial data.
- Use geospatial analysis to process geospatial data for the purpose of making calculations and inferences about space, geospatial patterns, and geospatial relationships.
- Use geospatial data analysis in which geospatial relationships such as distance, direction, and topologic relationships (e.g. adjacency, connectivity, and overlap) are particularly relevant.
- Use inductive and deductive reasoning to analyze, synthesize, compare, and interpret information.
- Use logic and reasoning to identify strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.

Design Principles

- Use motivating contexts and personally relevant and meaningful examples to engage learners.
- Design image representations that illustrate visual aspects of Earth and environmental scientific knowledge.
- Design Web GIS data to make geospatial relations readily apparent.
- Scaffold students (Jonassen, 1999; Quintana et al., 2004) to analyze geospatial relations.
- Develop curriculum materials to better accommodate the learning needs of all students, while also expanding the geospatial science pedagogical content knowledge in teachers.

Professional Development

- Design partnership model
  - Pedagogical expertise of teachers to adapt curriculum
- Active learning experiences
- Collaboration with peers
- Opportunities to reflect on teaching practices

Adapting and Implementing a Geospatial High School Course in Career and Technical Education Clusters in Urban Settings (SPREAD)

Steven McGee, The Learning Partnership
David Uttal, Northwestern University
Bob Kolvoord, James Madison University
Carolyn Jourdan, Chicago Public Schools

Chicago Public Schools

CTE
CAREER & TECHNICAL EDUCATION

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Education that Works

The Learning Partnership

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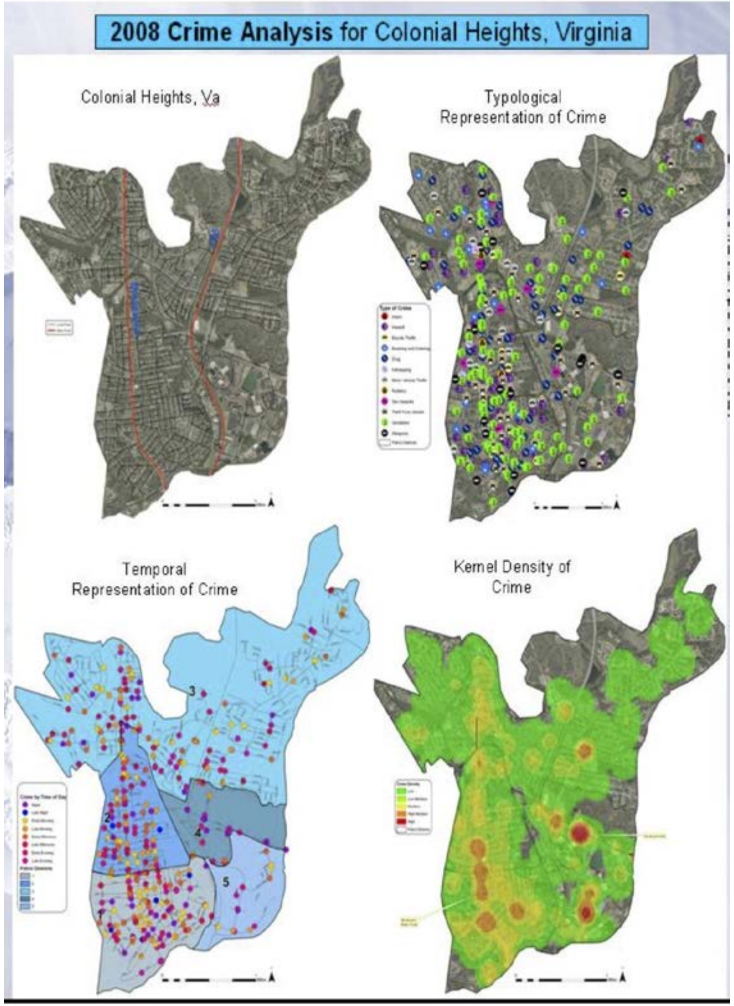
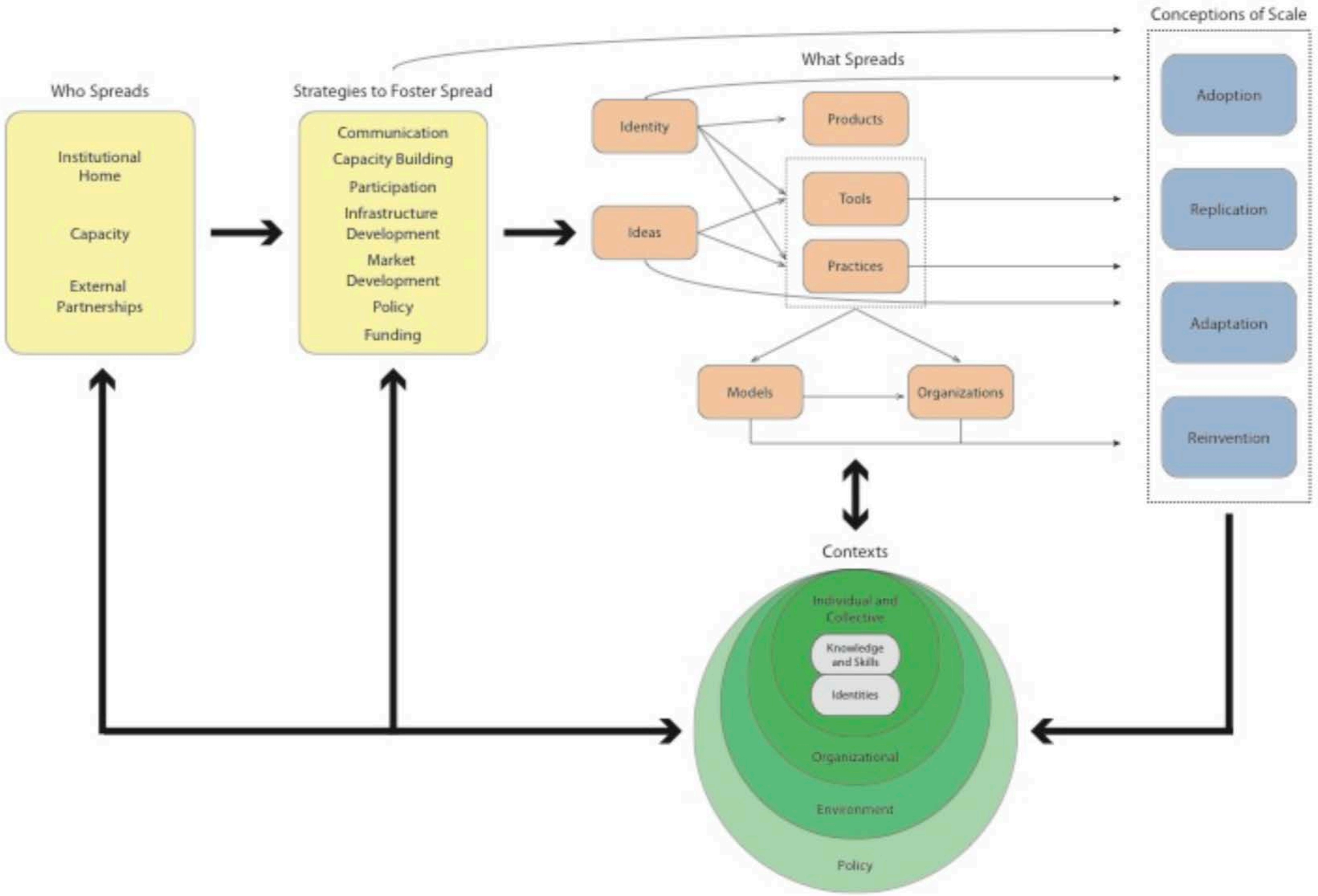
Northwestern

Geospatial Semester Curriculum




Who Spreads
Institutional Home
Capacity
External Partnerships
Strategies to Foster Spread
Communication
Capacity Building
Participation
Infrastructure Development
Market Development
Policy
Funding
What Spreads
Identity
Ideas
Products
Tools
Practices
Models
Organizations
Conceptions of Scale
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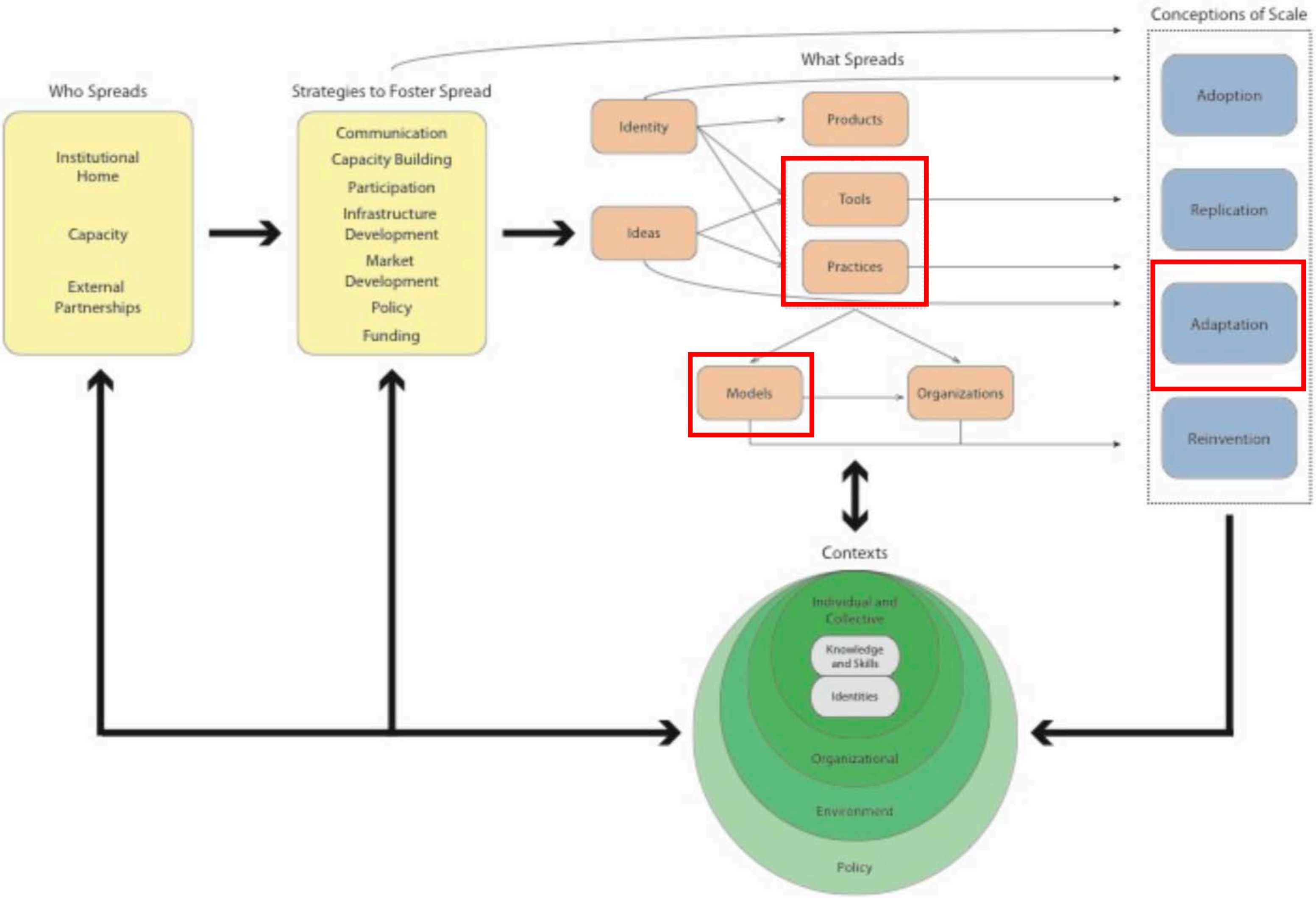
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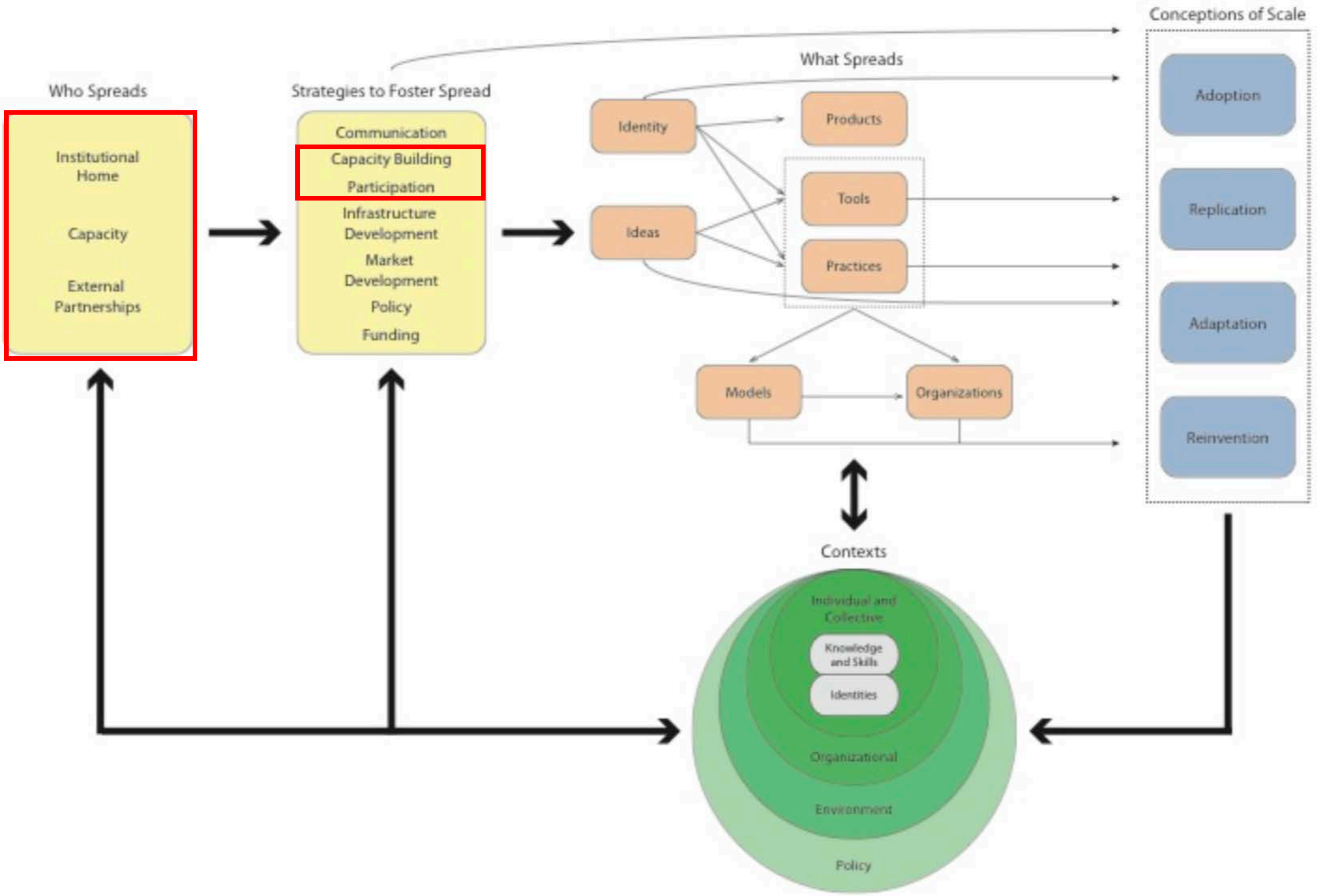

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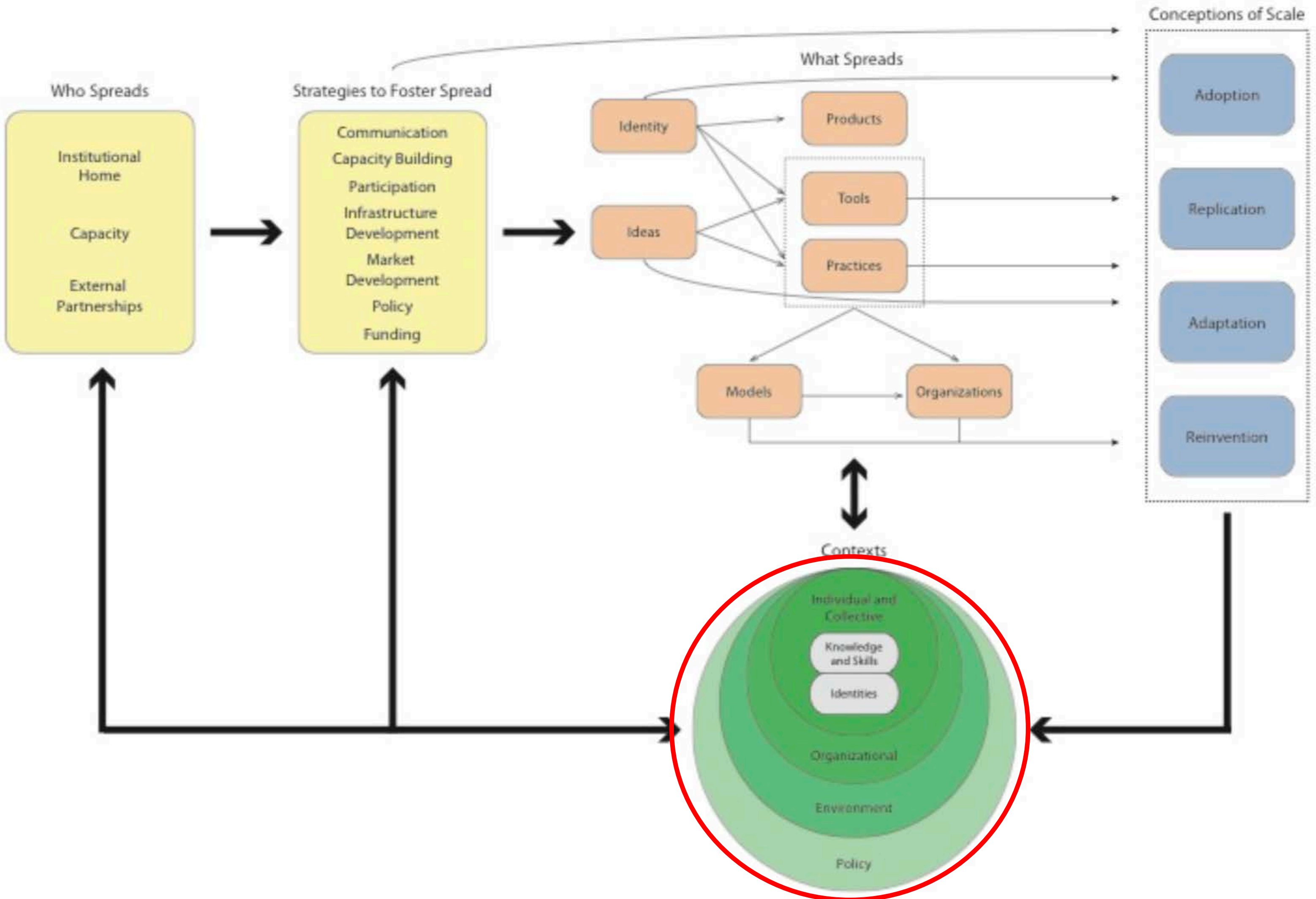
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Collaborative Research: Connected STEM Promoting STEM Education through Connected Devices and Building Automation

Michael D. Johnson
Emel Cevik
Jenn Whitfield
Jay Porter
Joe Morgan
Mathew Kuttolamadom
Bugrahan Yalvac

Dwight Look College of ENGINEERING
TEXAS A&M UNIVERSITY

ENGINEERING TECHNOLOGY & INDUSTRIAL DISTRIBUTION
TEXAS A&M UNIVERSITY

Populations

Teachers

Students

- Camp Students
- Traditional Class Students
- Dual Credit Students

Parents

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Method - Teachers

Intervention

1

Summer Workshop

2

Implementation of Exercises in the Classroom

3

Data

Draw an Engineer Test [3]


Draw an engineer

Design, Engineering, and Technology [1]

Teacher Efficacy and Attitudes Toward STEM [5]


MISO

DIRECTIONS:

Technology Teaching Efficacy and Beliefs

STEM
- Perception
- Efficacy

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Method – Students (non Dual)

Camp/Class

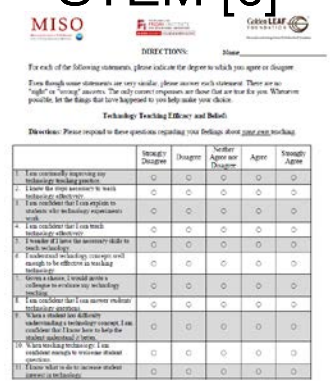
Intervention 1

2

Data

Draw an Engineer Test [3]

Student Efficacy and Attitudes Toward STEM [6]



STEM
- Perception
- Efficacy

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Method – Dual Students

Intervention

1

Dual Credit Course with Local Community College (Blinn College)

2

18 Month Follow-up

3

Data

Work-based Learning Survey [2]

Current College/Job Follow-up Data

STEM

- Awareness
- Career Goals

Method – Parents

Intervention **1** Camp or Classroom Intervention – Presentation or Family STEM Night **2**

Data

Pre/Post Student Perception

STEM Awareness [4]

STEM
- Awareness

References

- [1] Hong, T., Purzer, Ş., & Cardella, M. (2011), "A re-evaluation of the design, engineering and technology (DET) instrument ". Journal of Engineering Education, 100(4), pp. 800-818.
- [2] Unfried, A., Faber, M., Stanhope, D. & Wiebe, E. (2015), " The development and validation of a measure of student attitudes toward science, technology, mathematics, and engineering. " Journal of Psychoeducational Assessment. doi: 10.1177/0734282915571160
- [3] Knight, M., & Cunningham, C. M. (2004), " Draw an Engineer Test (DAET): Development of a tool to investigate students' ideas about engineers and engineering". Presented at the ASEE Annual Conference & Exposition, Salt Lake City, UT.
- [4] Yun, J., & Cardella, M., & Purzer, S., & Hsu, M., & Chae, Y. (2010), " Development Of The Parents' Engineering Awareness Survey (Peas) According To The Knowledge, Attitudes, And Behavior Framework. " Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. https://peer.asee.org/16293
- [5] Friday Institute for Educational Innovation (2012). Teacher Efficacy and Attitudes Toward STEM Survey- Science Teachers. Raleigh, NC: Author.
- [6] Friday Institute for Educational Innovation (2012). Student Attitudes toward STEM Survey- Middle and High School Students, Raleigh, NC: Author.
- [7] Dupree, Y.T. (2012), "Secondary-Work-Based Learning Students' Perceptions of Their Course and Work and Career-Related Issues", PhD Dissertation, University of Georgia.

Acknowledgement

This material is supported by the National Science Foundation under DRL Grant Numbers 1615019 and 1614496 . Any opinions, findings, conclusions, or recommendations presented are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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SCIENCE LEARNING
ACTIVATION LAB

Science Learning Activation: Positioning Youth for Success

ITEST PI Summit: May 14-15, 2018

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

UNIVERSITY OF PITTSBURGH
LRDC Learning Research & Development Center

SRI International

GORDON AND BETTY MOORE FOUNDATION

National Science Foundation
WHERE DISCOVERIES BEGIN

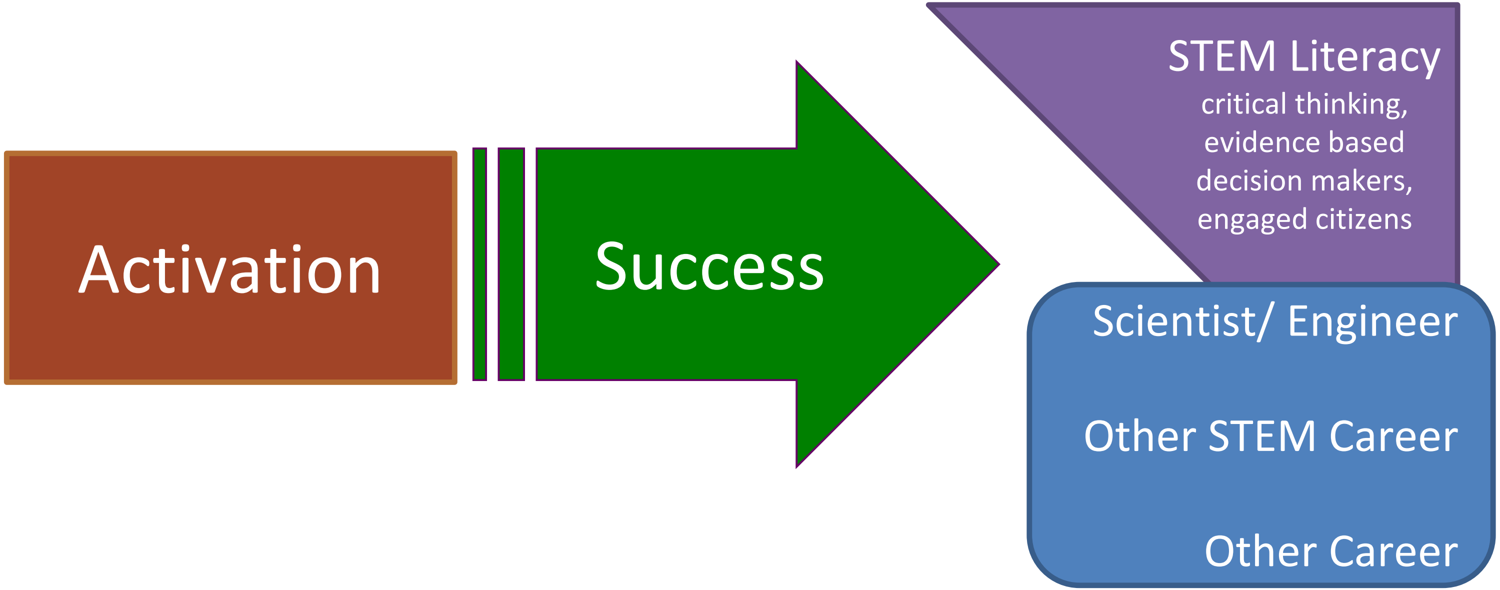
Guiding Question

What positions youth
for success in science learing?

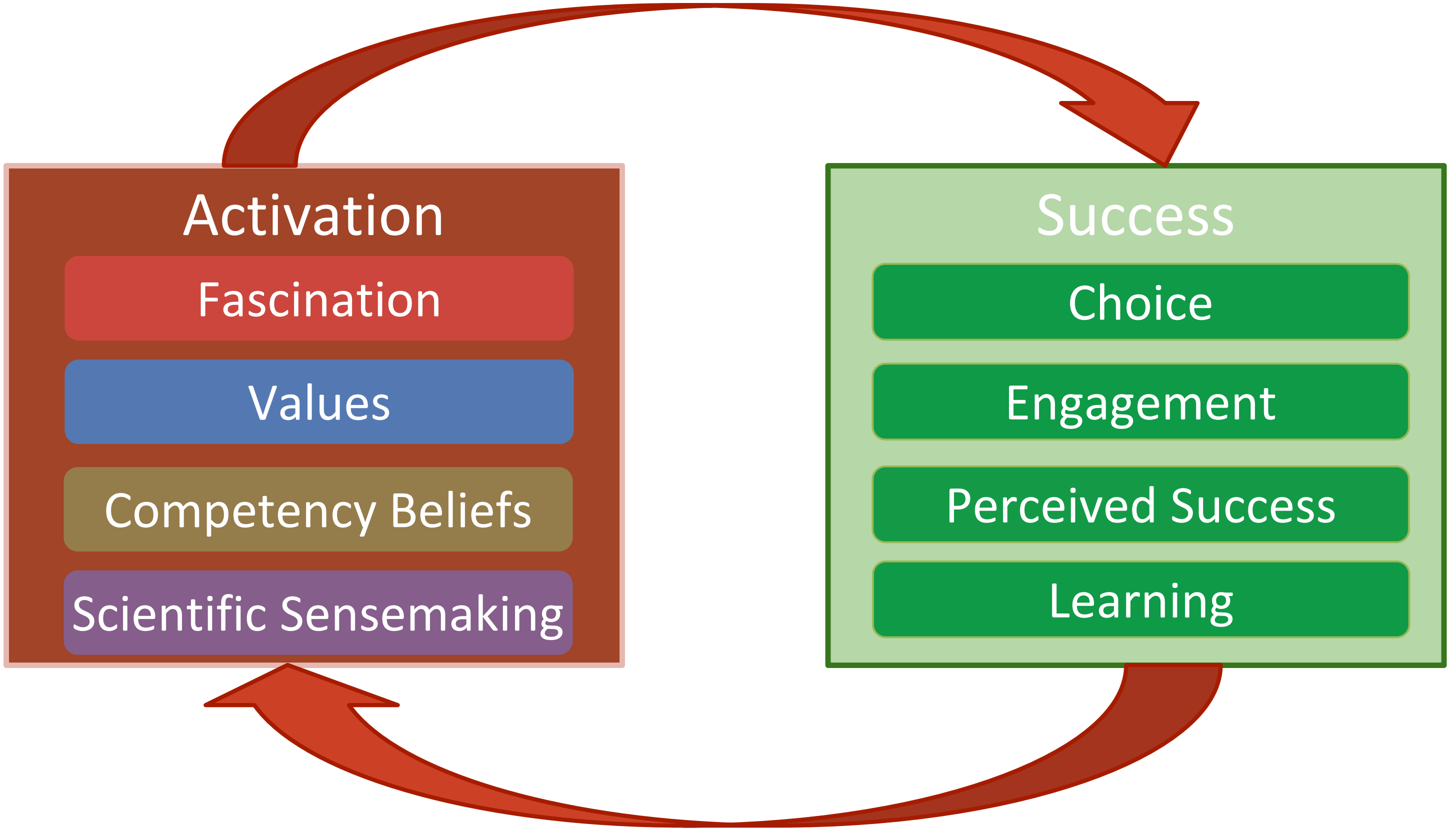
Theory of Activation

Science learning activation =

A composition of *dispositions, skills, and knowledge* that enables success in proximal science learning experiences.



Theory of Activation



Science Activation Dimensions

SCIENCE LEARNING ACTIVATION LAB

Fascination

A person's emotional and cognitive attachment with science topics and tasks.

Values

The degree to which a person values science, including the knowledge learned in science, the ways of reasoning used in science, and the role that science plays in families and communities.

Competency Beliefs

The extent to which a person believes that s/he is good at science.

Scientific Sensemaking

The degree of engagement with science-related content as an activity of constructing explanations across representations, using methods generally aligned with the practices of science (questions, experiment, evidence, explanation, and nature of science).

Success Dimensions

Choice

Choosing to participate in the next science learning opportunity (e.g. camp, museum visit, watching a science program).

Engagement

Includes affective, behavioral, and cognitive components (e.g. excited about materials, doing the science activities at hand, and thinking about science ideas).

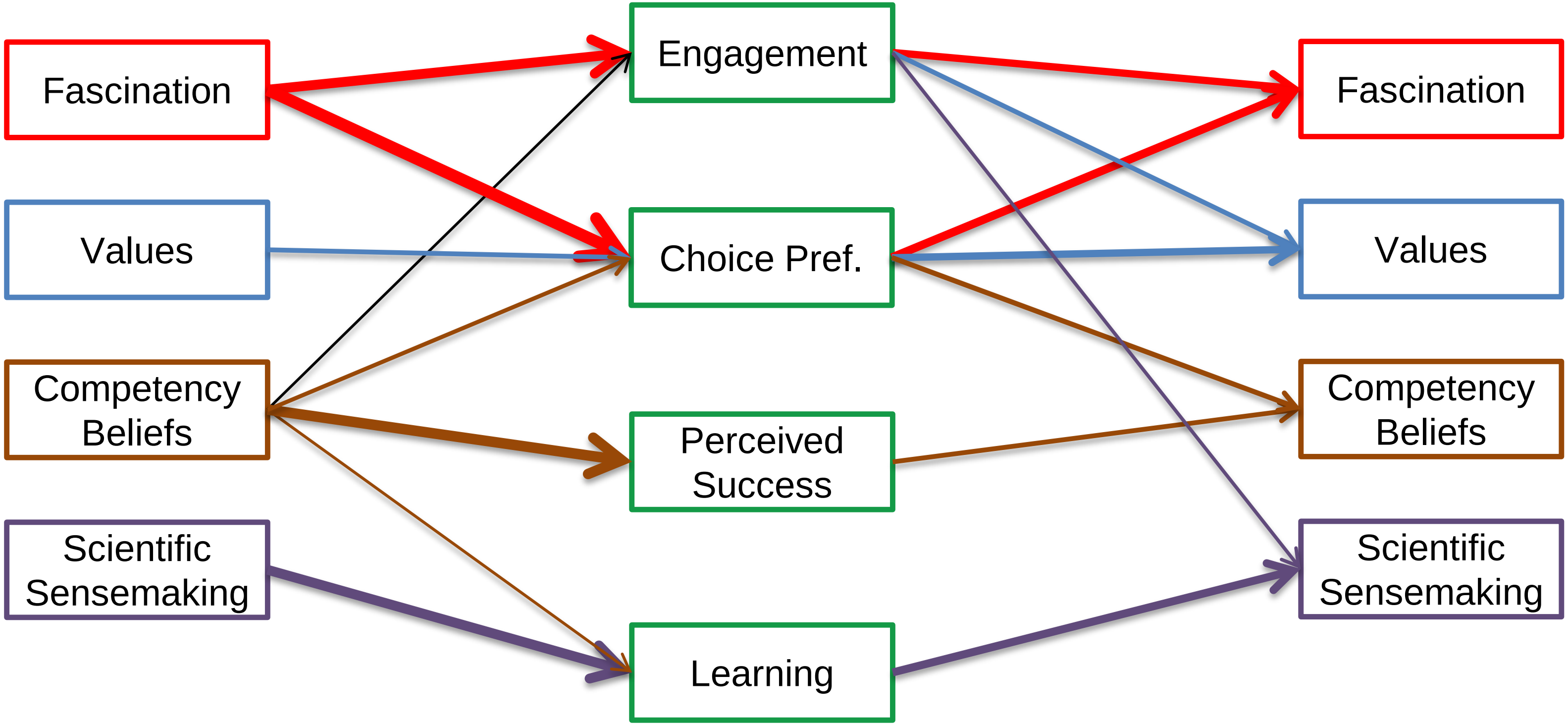
Perceived Success

Feeling successful in completing science learning tasks in absolute and relative terms.

Learning

Achieving the learning goals for a particular science experience.

Interactive Cycle



Thanks!

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www.activationlab.org/research

Emerging STEM Evaluation and Research Frameworks:

Student Innovation Experiences Related to STEM Self-Efficacy and Research Confidence

Melissa K. Demetrikopoulos, Ph.D.
External Evaluator
Chair, Program Development and Evaluation
Institute for Biomedical Philosophy

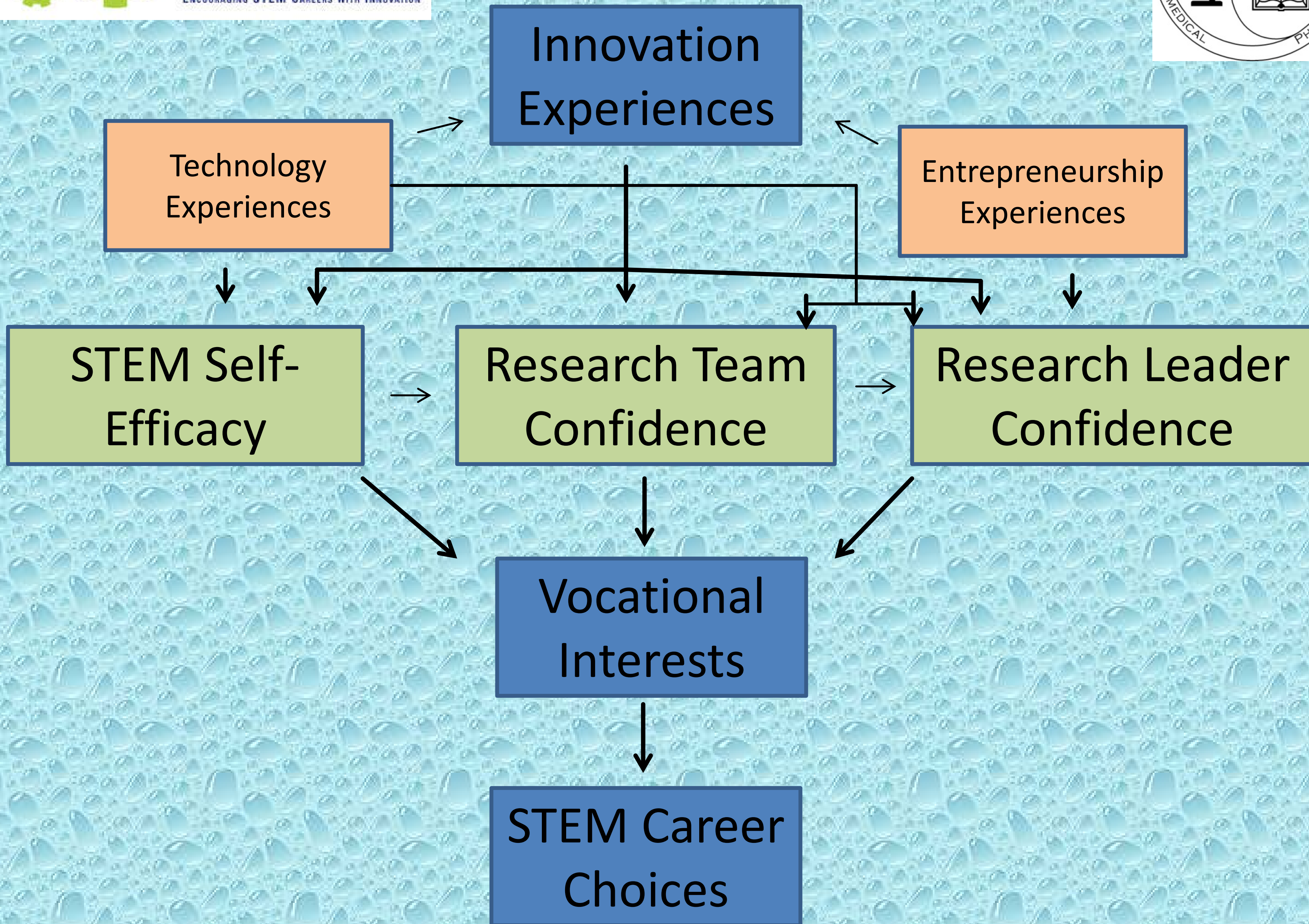
iSTEM - Innovative Science, Technology, Engineering and Mathematics Strategy Project:
Encouraging STEM Careers through Innovation

Cynthia E. Trawick, Ed.D. Principal Investigator,
Willie S. Rockward, Ph.D. & Tiffany R. Bussey, D.B.A. Co-Directors
Jamie P. Clayton, M.Ed. Program Manager
Morehouse College
Atlanta GA

Funded through the National Science Foundation ITEST grant (DRL-1512957)

Morehouse College iSTEM
Encouraging STEM Careers with Innovation

Institute for Biomedical Philosophy



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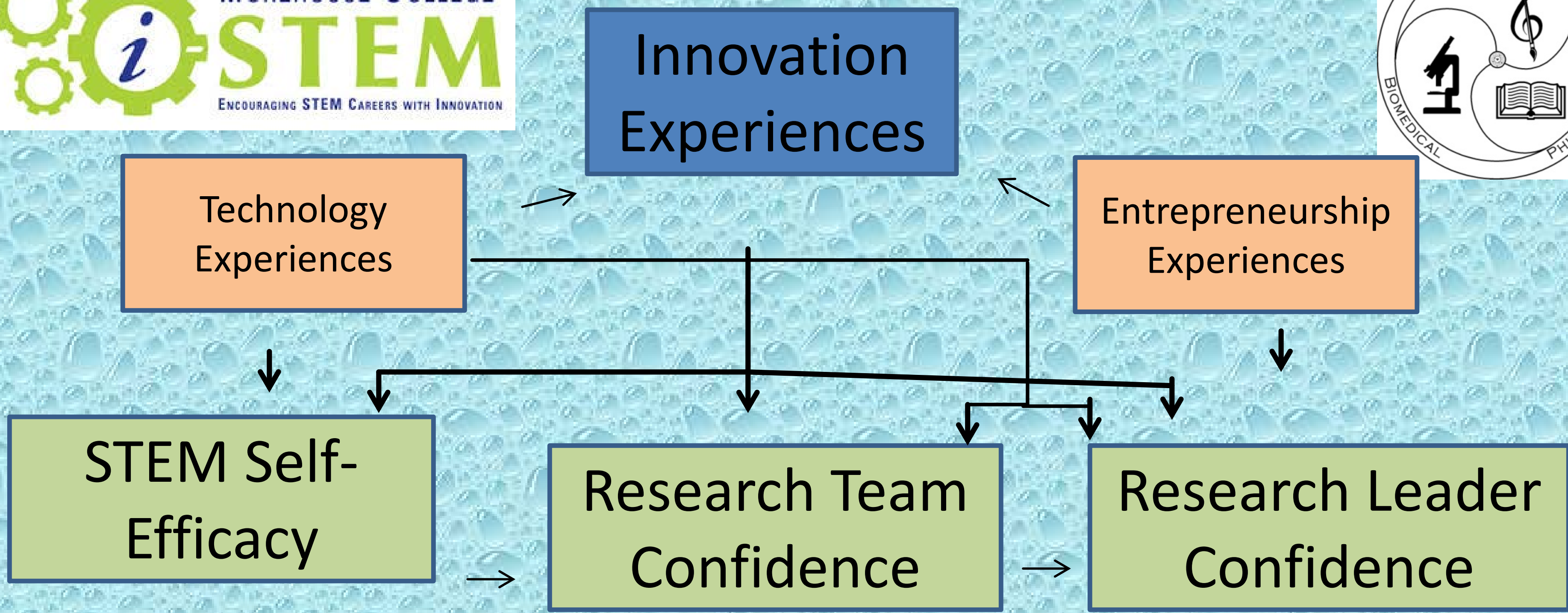

- Overall STEM Self-Efficacy
- Science Self-Efficacy
- Math Self-Efficacy
- Technology Self-Efficacy
- Problem Solving Self-Efficacy
- Innovation Self-Efficacy

- **Cooperate as a team member**
- **Easily take orders and follow instructions**
- **Ability to function on a team**
- **Can provide strong support for other members**
- **Know how to be a good team member**

- **Know what it takes to be a good leader**
- **Help team accomplish goals**
- **Ability to influence a team**
- **Know how to encourage good team performance**
- **Allow other team members to contribute**

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STEM Self-Efficacy → Research Team Confidence → Research Leader Confidence

↓

Vocational Interests

ENTREPRENEURSHIP

- Selling or promoting
- Work as part of a tear
- Leading a team

INNOVATION

- Inventing
- Designing
- Building or Constructing
- Problem solving
- Creating
- Innovating
- Change the World
- Try new things

TECHNOLOGY

- Programming
- Using technology:
    - as part of a school assignment
    - as part of a job
    - for fun

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Vocational Interests

↓

STEM Career Choices

I Would like to be a scientist
I Could be a scientist
Scientist is a good career choice

I Would like to be an engineer
I Could be an engineer
Engineer is a good career choice

I Would like to be a mathematician
I Could be a mathematician
Mathematician is a good career choice

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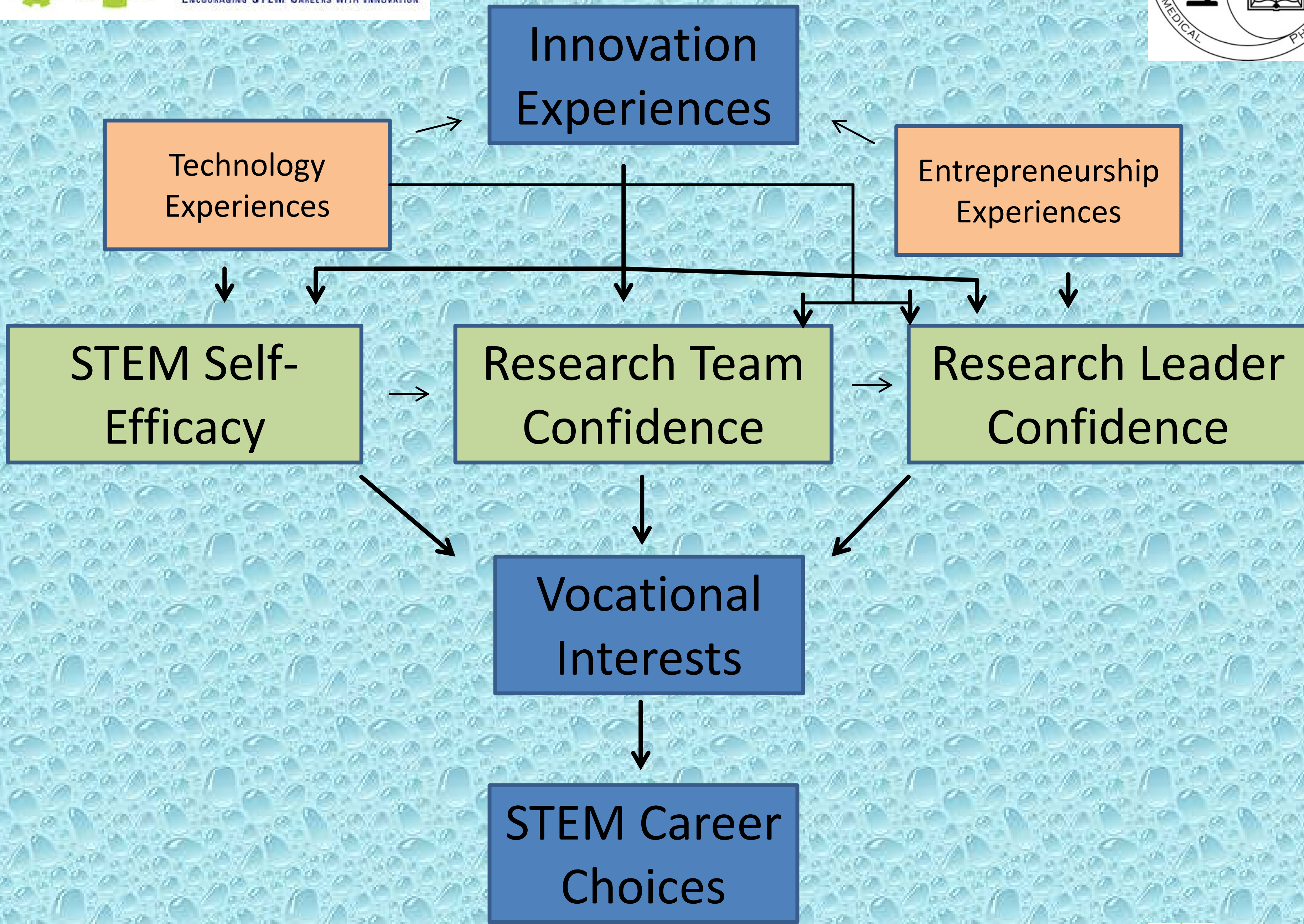

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Lead Institution: Morehouse College

Partners:

- Atlanta Public School System
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