SCIENCE LEARNING
ACTIVATION LAB

Science Learning Activation: Positioning Youth for Success

ITEST PI Summit: June 15-16, 2017

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

SCIENCE LEARNING ACTIVATION LAB

Overview

Learning Activation

The Instruments

How you can use them

Similar instruments

SCIENCE LEARNING ACTIVATION LAB

Guiding Question

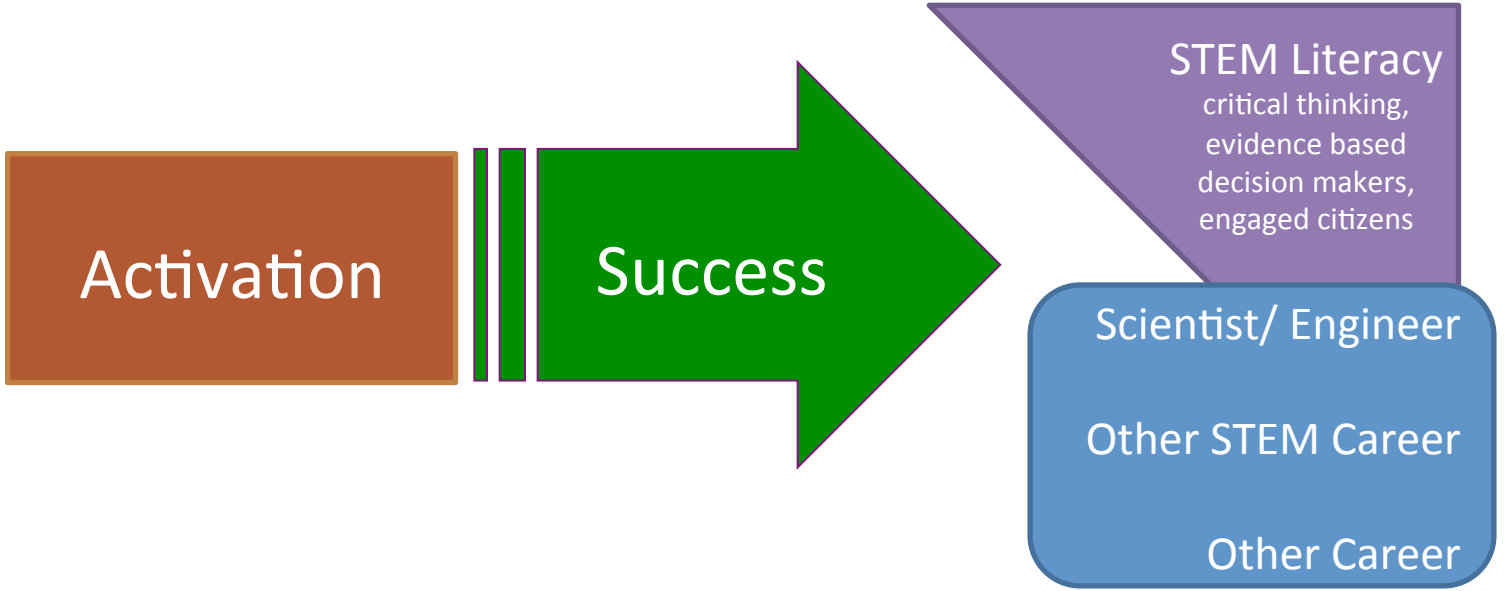
What positions youth
for success in science?

SCIENCE LEARNING ACTIVATION LAB

Theory of Activation

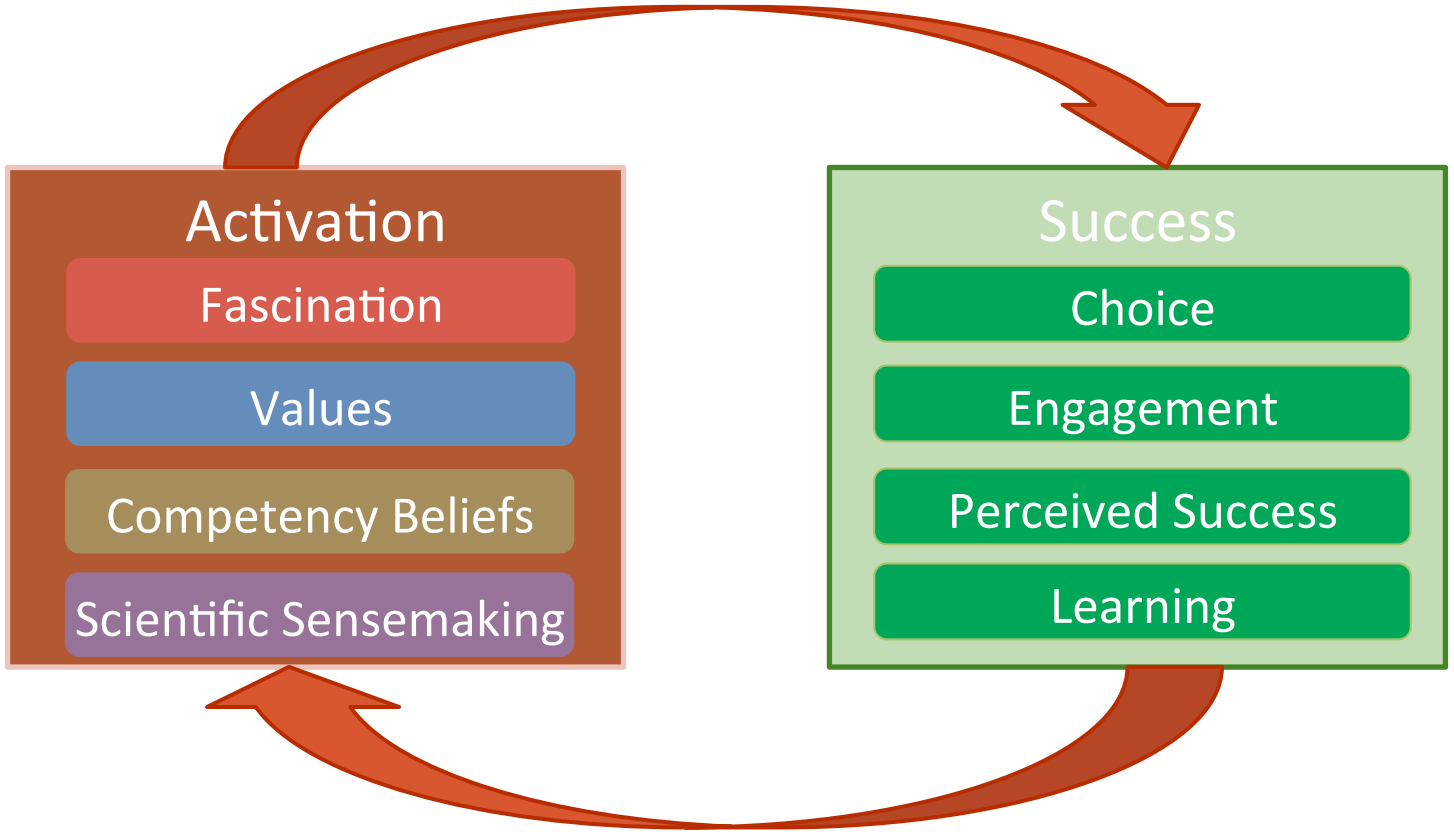
Science learning activation =

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



SCIENCE LEARNING ACTIVATION LAB

Theory of Activation



SCIENCE LEARNING ACTIVATION LAB

Science Activation Dimensions

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).

SCIENCE LEARNING ACTIVATION LAB

Fascination

Fascination with natural and physical phenomena refers to an individual's emotional and cognitive attachment with science topics and tasks.

1. Curiosity/Wonderment
   - In general, I find science: (very interest, interesting, boring, very boring)
2. Positive affect
   - In general, when I work on science, I think its cool
3. Obsession
   - In general, when I work on science, I love it
   - After a really interesting science activity is over, I can't stop thinking about it

(Harty & Beally, 1984; Gardner, 1987; Loewnstein, 1994; Litman & Spielberger, 2003; Hidi & Renninger, 2006; Kind et al., 2007; Reid, 2006; Osborne et al., 2003; Gardner 1975; Baram-Tsabari & Yarden, 2005; Dawson & Bennett, 1981; Germann, 1988; Dawson, 2001; Girod, 2001; Ames, 1992)

SCIENCE LEARNING ACTIVATION LAB

Values

Values science refers to the degree to which learners value science, including the knowledge learned in science, the ways of reasoning used in science, and the role that science plays in families and communities.

1. Everyday value
   - Do you think science is useful in your life?
   - I talk about science or science ideas with people or someone in my family outside of school
2. Career value
   - Do you think you could become a scientist someday?
   - I think learning science is useful for what I want to do as a job.

(Eccles & Wigfield, 2002; Azevedo, 2011; Lemke, 2001; Driver, 1996; Lederman, 1992; Lederman, Ab-El-Khahlick, Bell, & Schwartz, 2002)

SCIENCE LEARNING ACTIVATION LAB

Competency Beliefs

Competency beliefs in science refers to the extent to which a person believes that she is good at science.

1. Functions
2. Tasks
3. Settings

- I can do the science activities I get in class.
- I can answer all the questions on a science test in class.
- I can figure out how to finish a science experiment at home.
- If I went to a science camp for kids my age, I could understand what was going on.
- I can find and understand what I am looking for on any website for kids my age that has science information on it.

(Bandura, 1986; Schunk, et al., 2008; Lau & Roeser, 2002; Lawson, Banks, & Logvin, 2007; Linnenbrink & Pintrich, 2003; Durik et al., 2006)

SCIENCE LEARNING ACTIVATION LAB

Scientific Sensemaking

Scientific sensemaking is engagement with science-related content as an activity of constructing explanations across representations, using methods generally aligned with the practices of science . Sub-dimensions include:

- **Questions:** Identifies investigable problems and generates appropriate questions
- **Experiment:** Designs experiments appropriate to a research question
- **Evidence:** Extracts evidence; interprets and analyzes data accurately and with intention
- **Explanation:** Understands the relationship between claims, evidence, and reasoning; Constructs mechanistic explanations of phenomena.
- **Nature of Science:** Understands how science as a discipline works; knows that science is both a body of knowledge and a process.

(Coutinho & Albergaira-Alemda, 2014; Chin & Osbourne, 2008; Chen & Klahr, 1999; Apedoe & Ford, 2010; Erduran & Jimenez-Aleixandre, 2007; Lehrer, Schauble, & Petrosino, 2001; Klahr & Dunbar, 1988; Kuhn & Crowell, 2011; Lederman et al. 2002; Khishfe & Lederman, 2006)

SCIENCE LEARNING ACTIVATION LAB

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

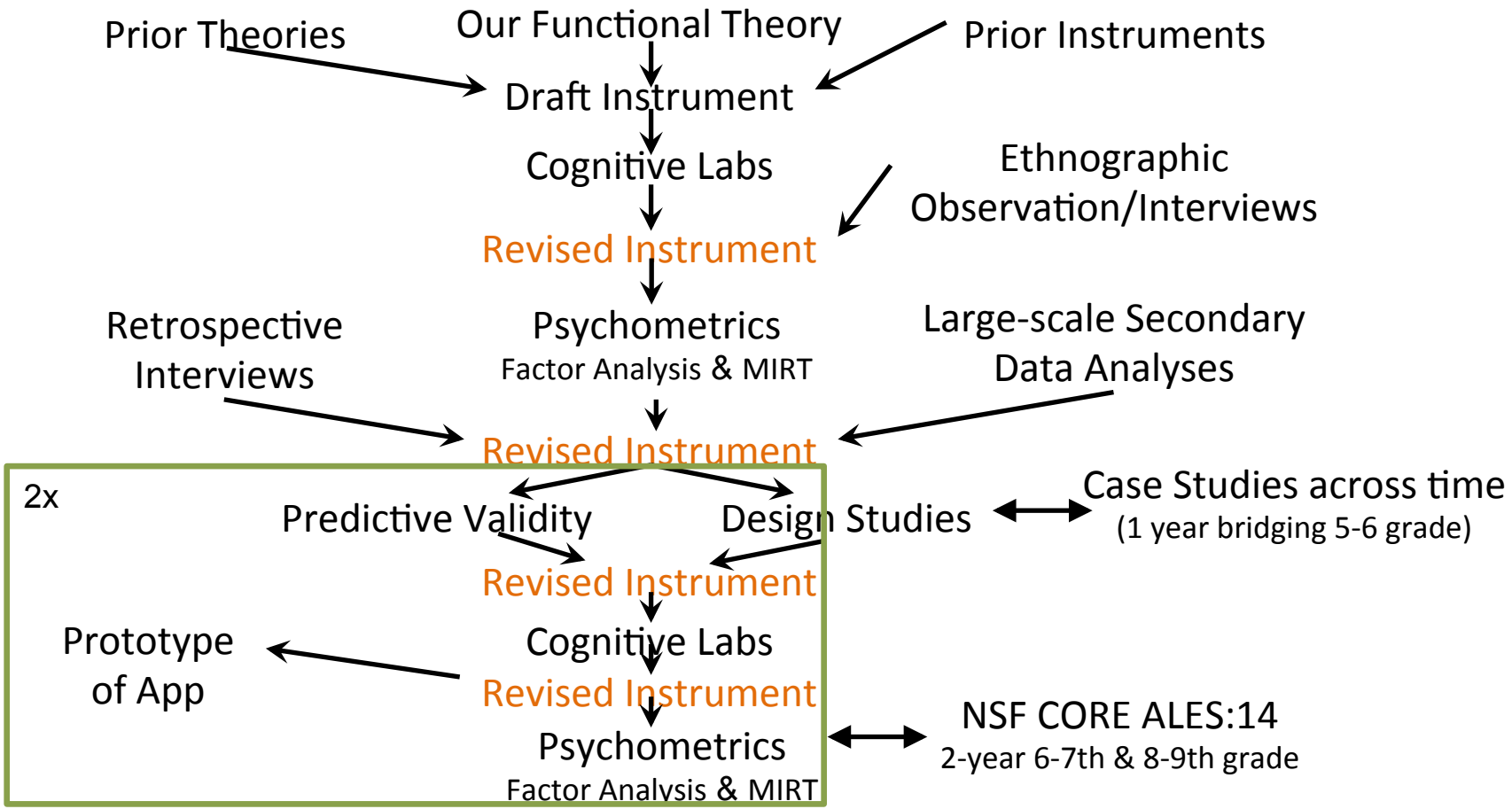
Feeling successful in completing science learning tasks in absolute and relative terms.

Learning

Achieving the learning goals for a particular science experience.

SCIENCE LEARNING ACTIVATION LAB

Development Process 3.4

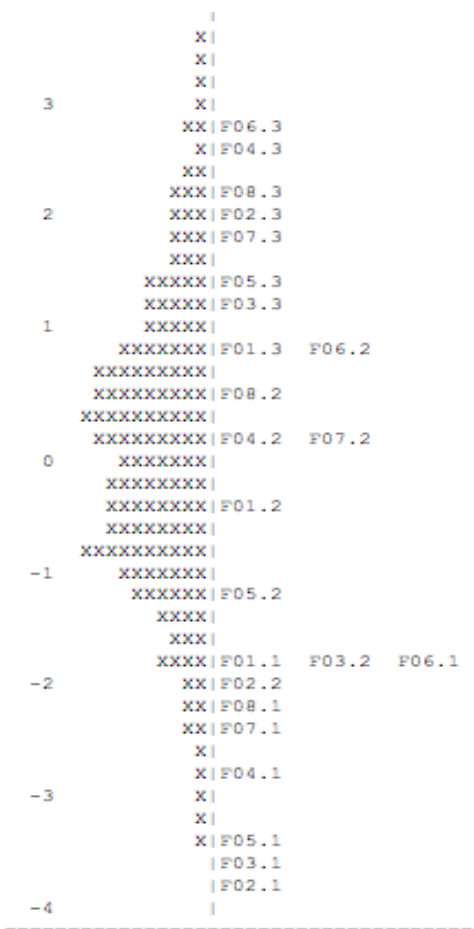


Fascination

8 items, α=0.90

Fascination with natural and physical phenomena refers to an individual's emotional and cognitive attachment with science topics and tasks.

1. Curiosity/Wonderment
   - In general, I find science: (very interest, interesting, boring, very boring)
2. Positive affect
   - In general, when I work on science, I think its cool
3. Obsession
   - In general, when I work on science, I love it
   - After a really interesting science activity is over, I can't stop thinking about it



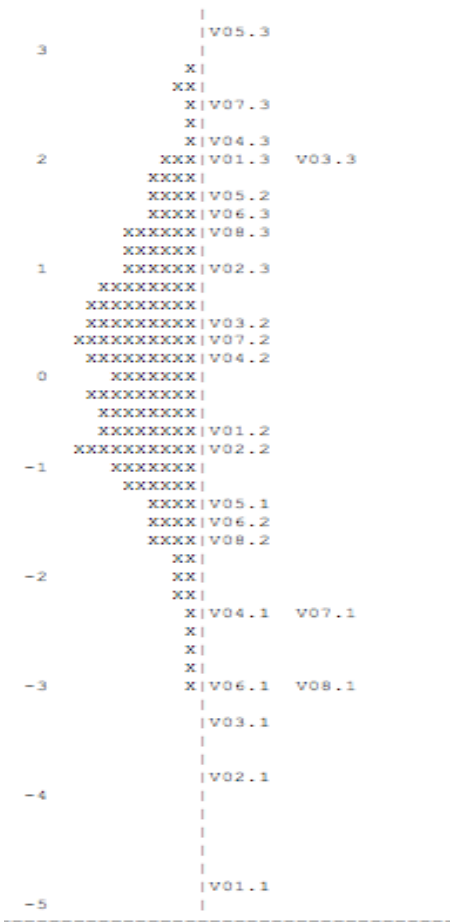
SCIENCE LEARNING ACTIVATION LAB

Values

8 items, α=0.87

Values science refers to the degree to which learners value science, including the knowledge learned in science, the ways of reasoning used in science, and the role that science plays in families and communities.

1. Everyday value
   - Do you think science is useful in your life?
   - I think science is more important than anything else.
2. Career value
   - Do you think you could become a scientist someday?
   - I think learning science is useful for what I want to do as a job.



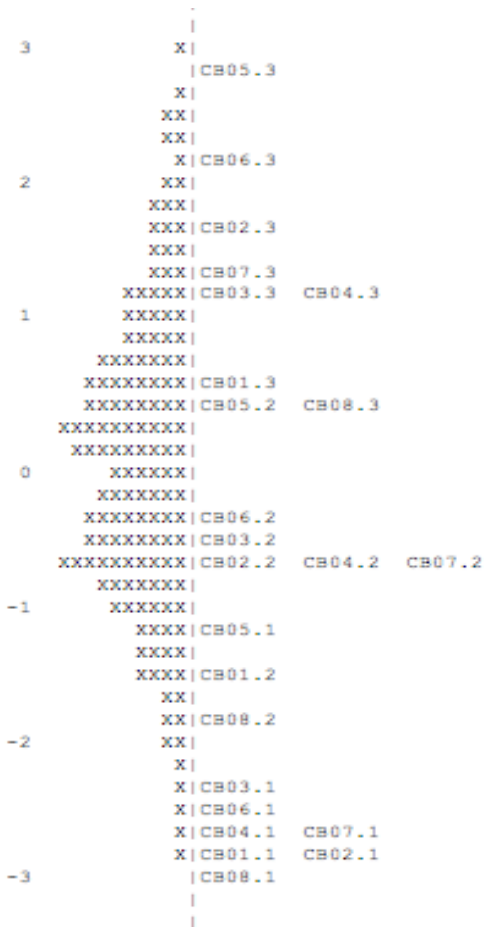
Competency Beliefs

8 Items, α=0.87

Competency beliefs in science refers to the extent to which a person believes that she is good at science.

1. Functions
2. Tasks
3. Settings

- I can do the science activities I get in class.
- I can answer all the questions on a science test in class.
- I can figure out how to finish a science experiment at home.
- If I went to a science camp for kids my age, I could understand what was going on.
- I can find and understand what I am looking for on any website for kids my age that has science information on it.



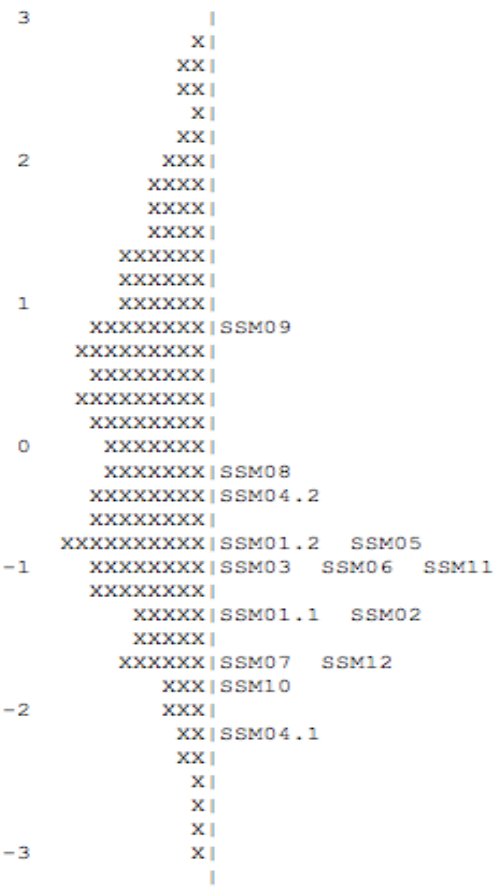
SCIENCE LEARNING ACTIVATION LAB

Scientific Sensemaking

12 Items, α=0.89

The degree to which the individual engages with science **learning** as a sensemaking activity. Including:

- **Questions:** Identifies investigable problems and generates appropriate questions from them
- **Experiment:** Designs experiments appropriate to a research question with relevant control of variables
- **Evidence:** Extracts relevant evidence; interprets and analyzes data accurately and with intention
- **Explanation:** Understands the relationship between claims, evidence, and reasoning; Constructs mechanistic explanations of phenomena.
- **Nature of Science:** Understands how science as a discipline works; knows that science is both a body of knowledge and a process.



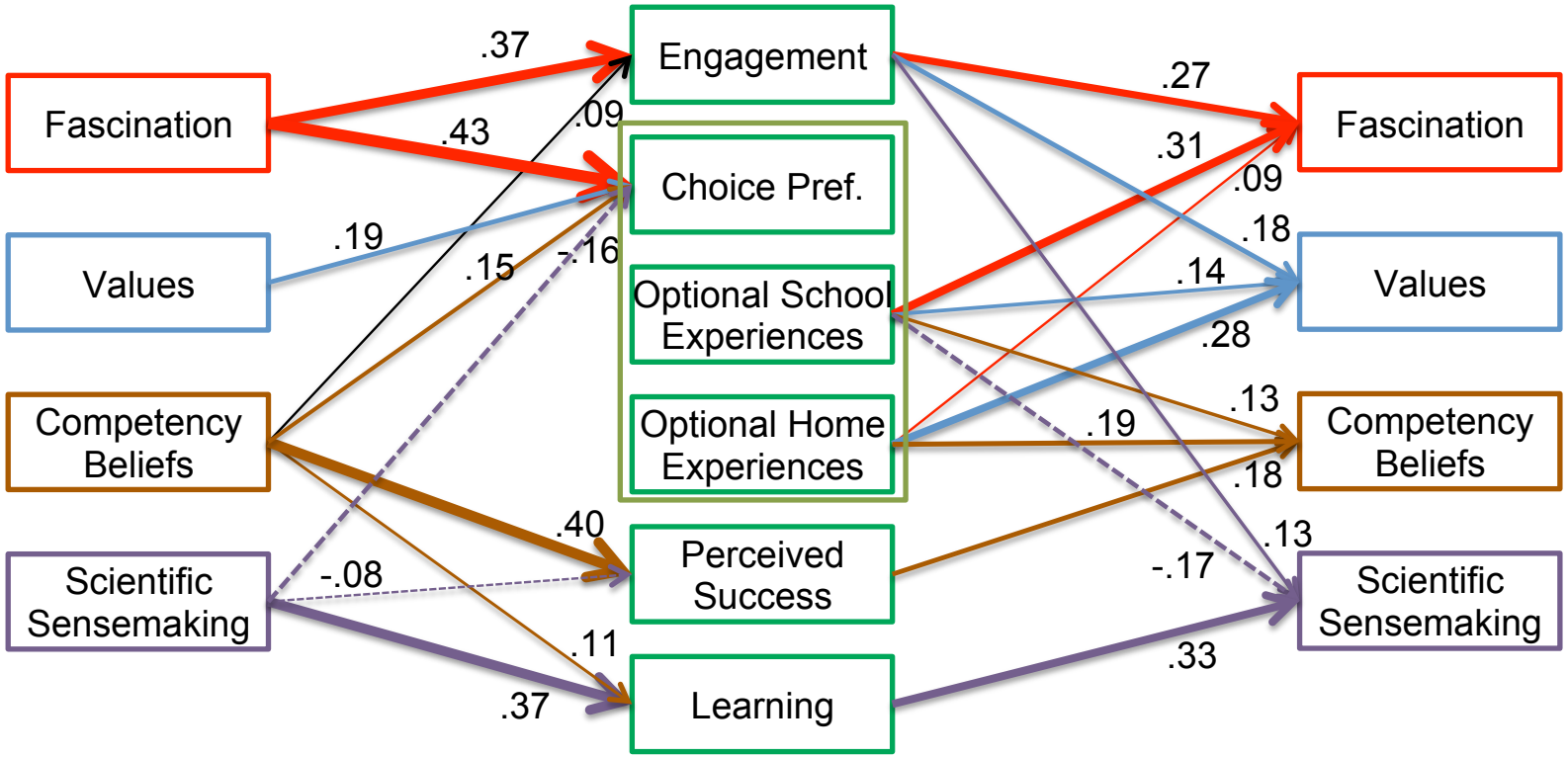
SCIENCE LEARNING ACTIVATION LAB

NSF CORE: Malleable Factors (ALES14)

Data collection		6th + 8th grade 4 hands-on / 4 textbook schools			7th + 9th grade	
Fidelity / Activity Logs		Mid 4 times	End 4 times		Mid 4 times	
Activation		Begin	Mid	End	Begin	Mid
Family Background		Begin				
Prior/Recent Experiences		Begin	Mid		Begin	Mid
***Content knowledge**		Pre	Post		Pre	Post
Engagement		4 times	4 times		4 times	
Choice Preferences		Begin		End	Begin	
State tests			8th only			
Career Interest		Begin		End	Begin	
Perceived success		4 times	4 times		4 times	

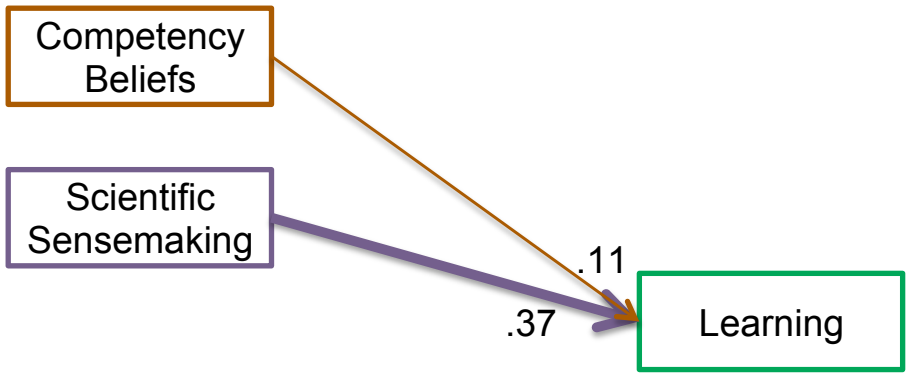
SCIENCE LEARNING ACTIVATION LAB

Interactive Cycle



SCIENCE LEARNING ACTIVATION LAB

Use Cases



SCIENCE LEARNING ACTIVATION LAB

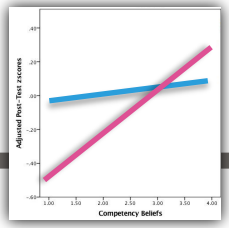
Sensemaking to Learning

Dr. Megan Bathgate

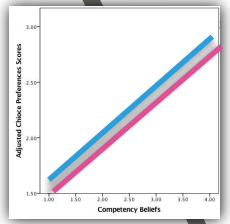
SCIENCE LEARNING ACTIVATION LAB

Competency Beliefs to Learning

Competency Beliefs

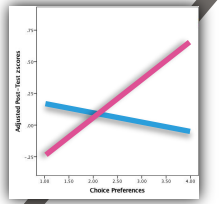


Learning Outcomes

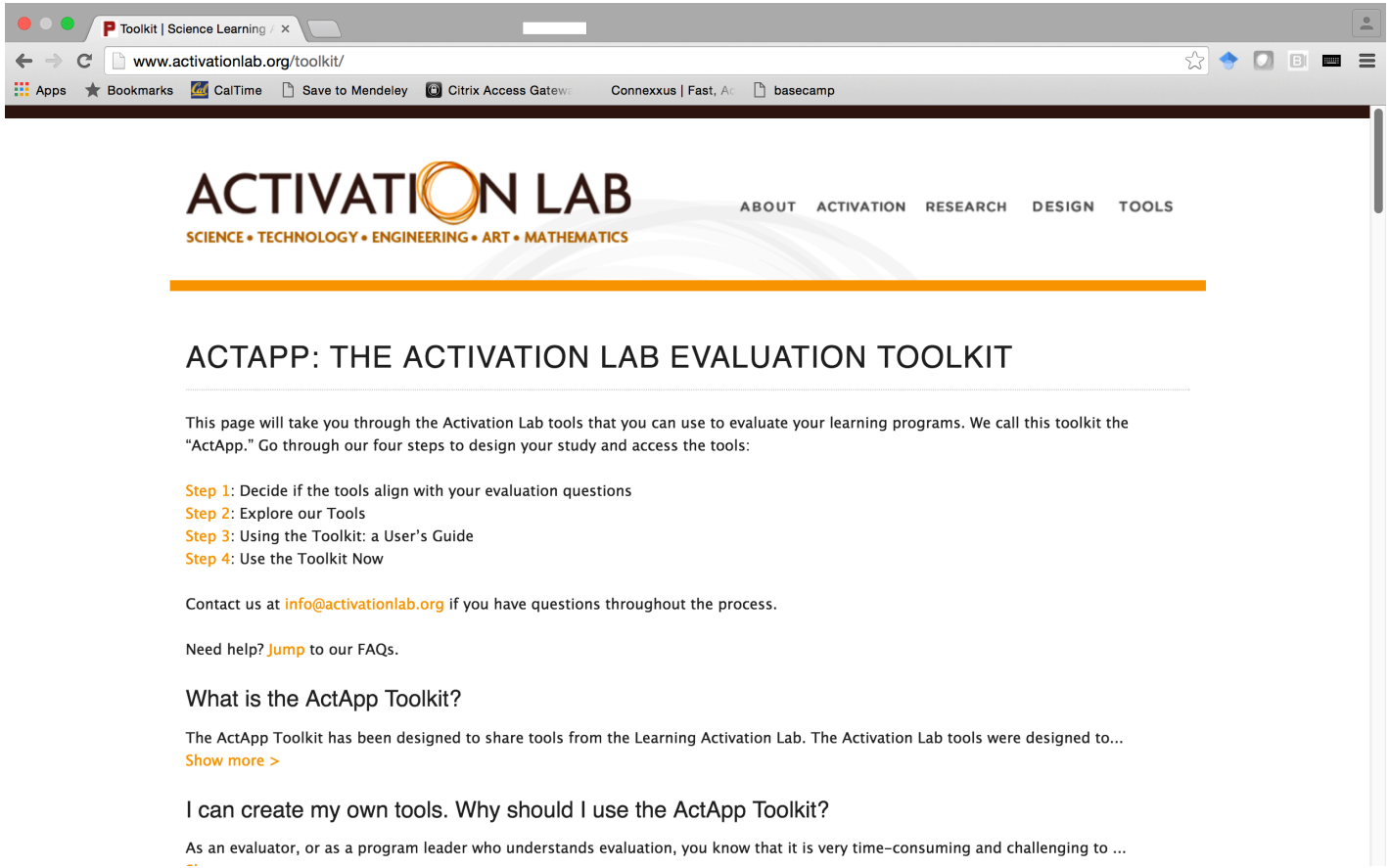


Behav./Cog. Engagement

Choice Preferences



ActApp: Toolkit



SCIENCE LEARNING ACTIVATION LAB

Toolkit Structure

Step 1: Decide if the tools align with your evaluation questions

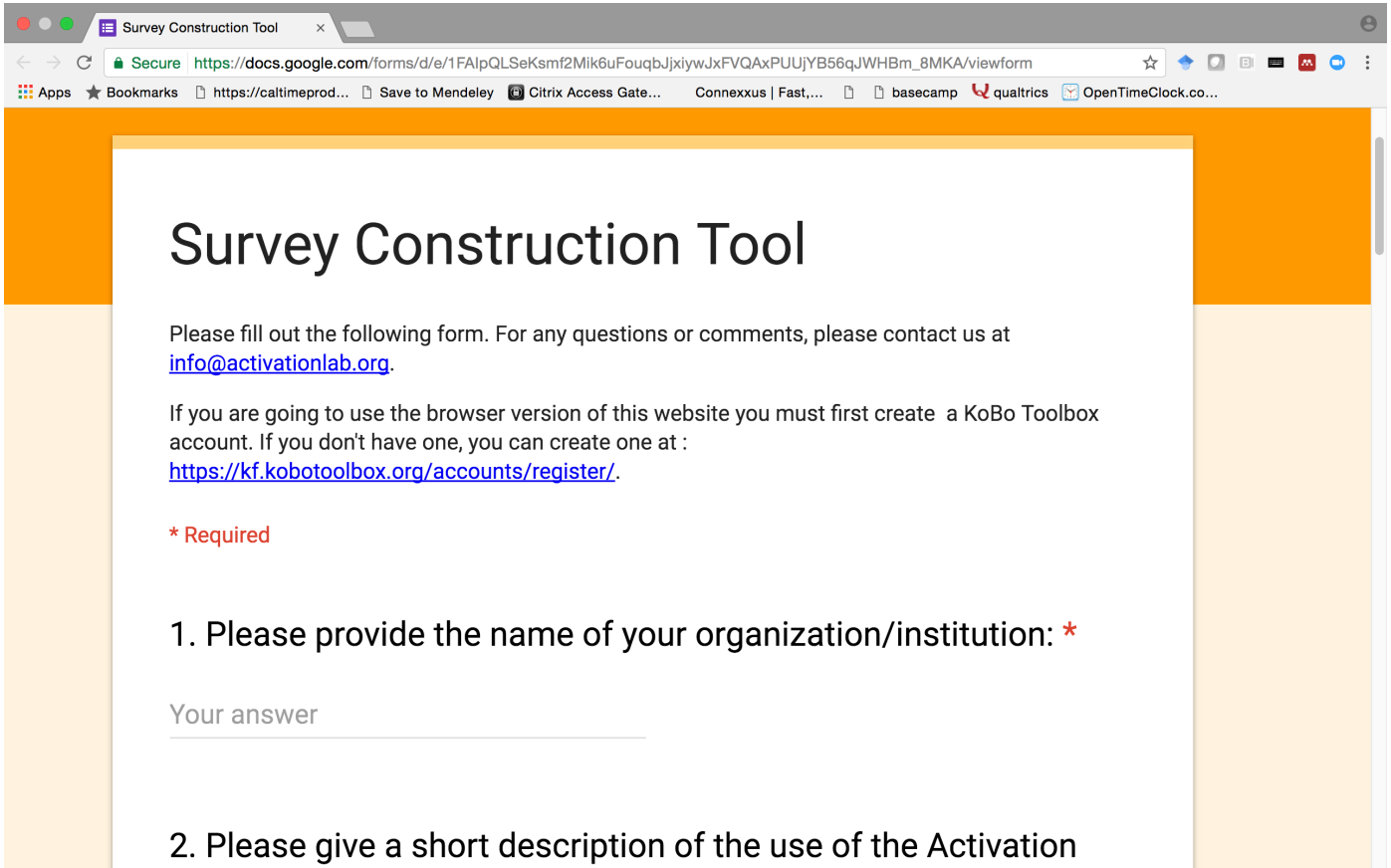
Step 2: Explore our tools

Step 3: Using the toolkit: A User's Guide

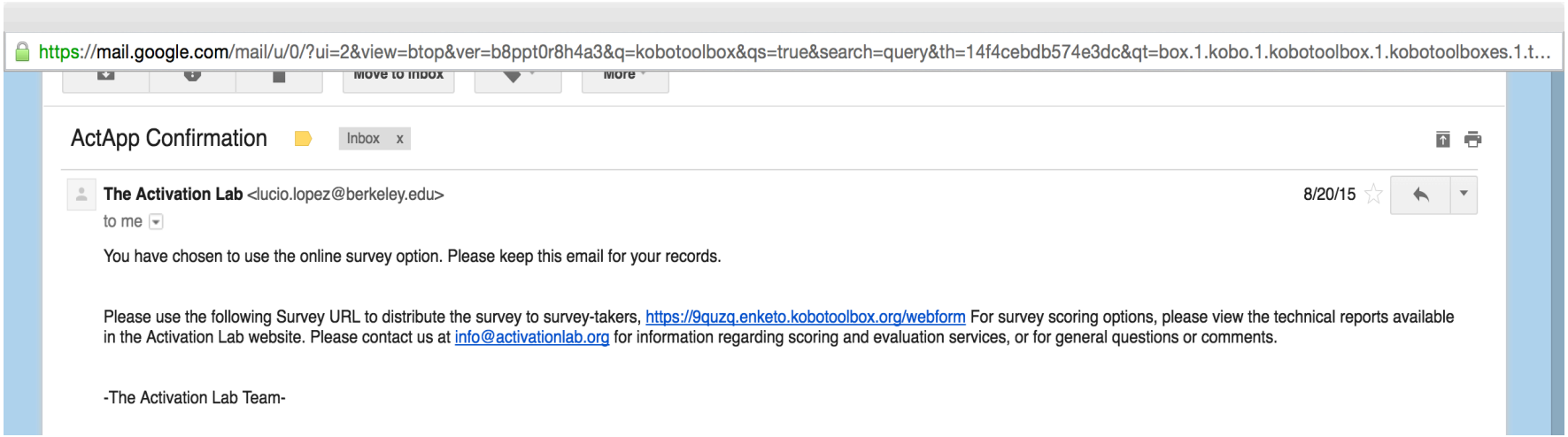
Step 4: Use toolkit now

SCIENCE LEARNING ACTIVATION LAB

Google Form

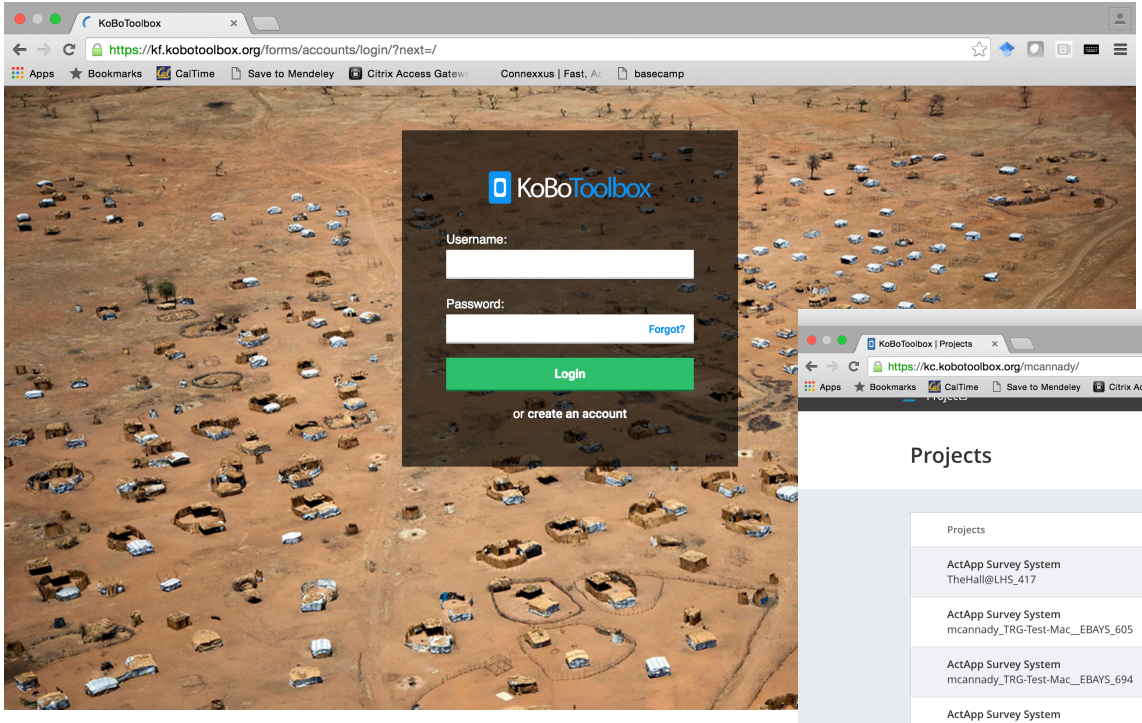


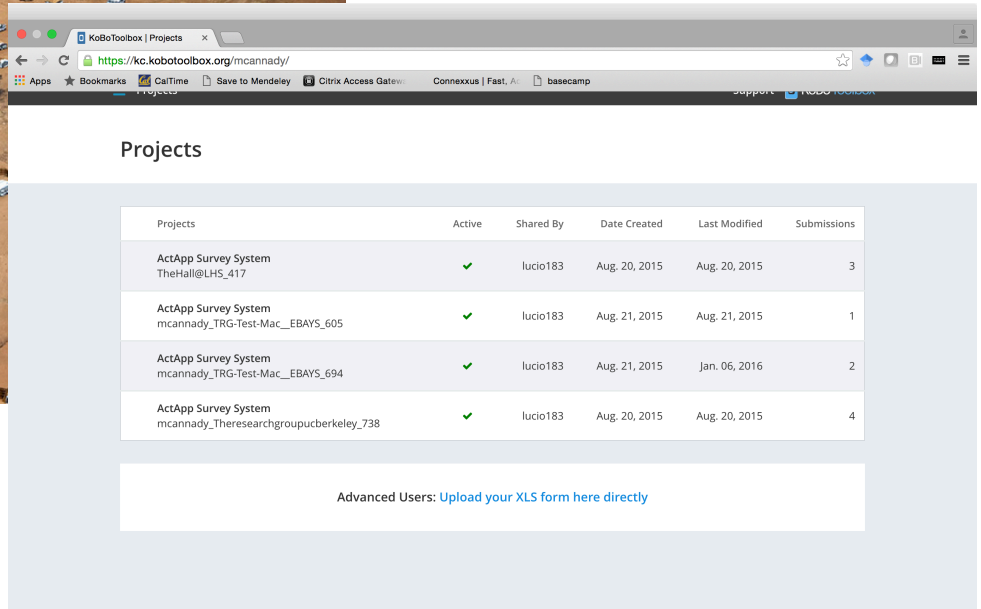
You've got email!



SCIENCE LEARNING ACTIVATION LAB

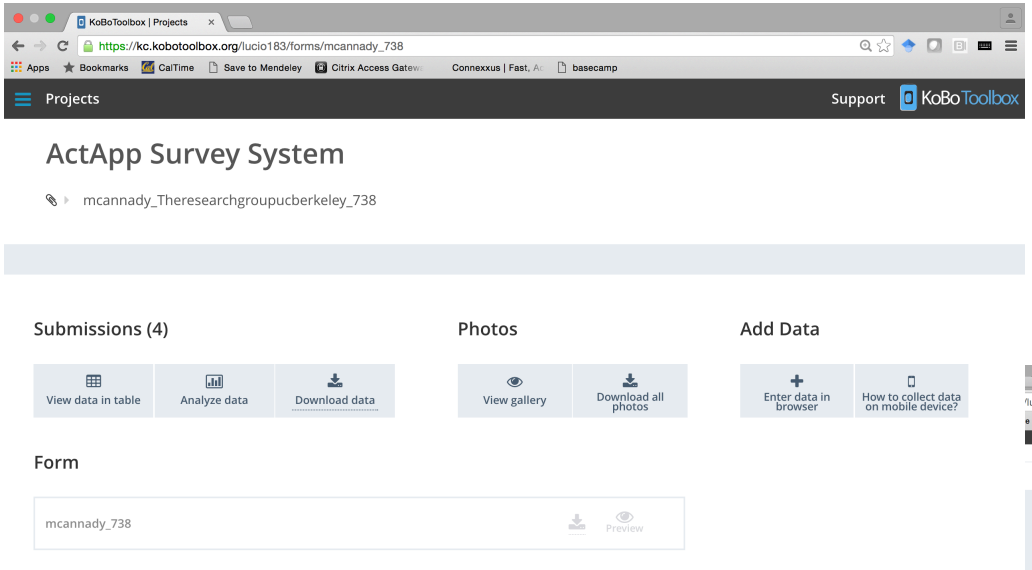
Kobo Toolbox

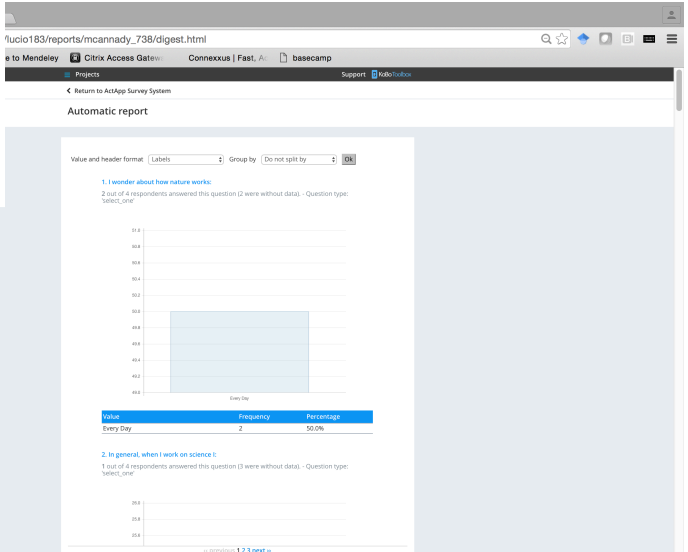




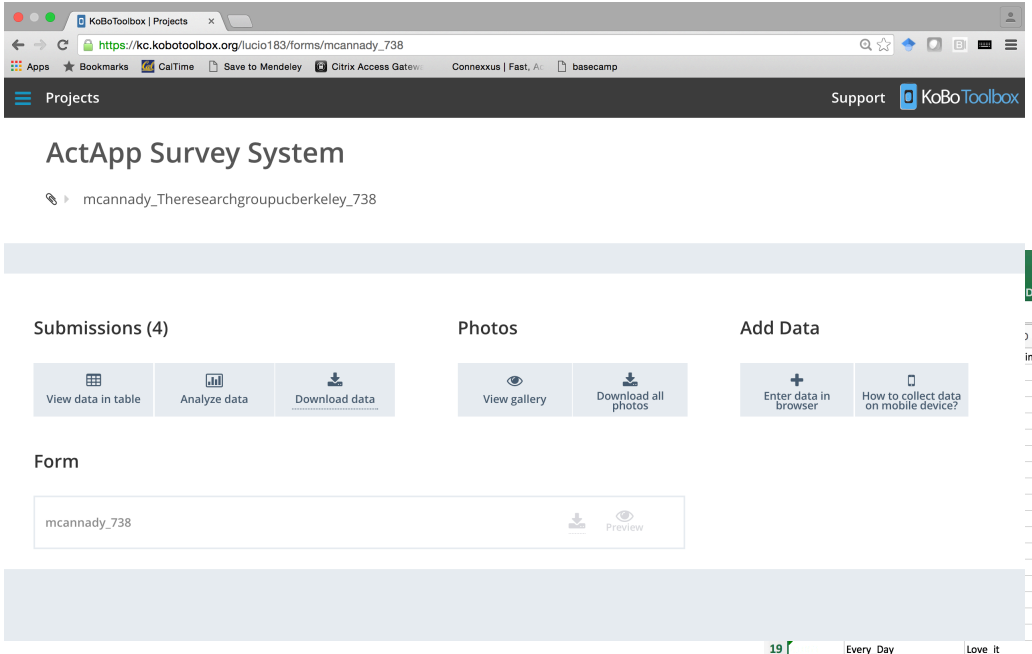
ACTIVATION LAB
SCIENCE LEARNING

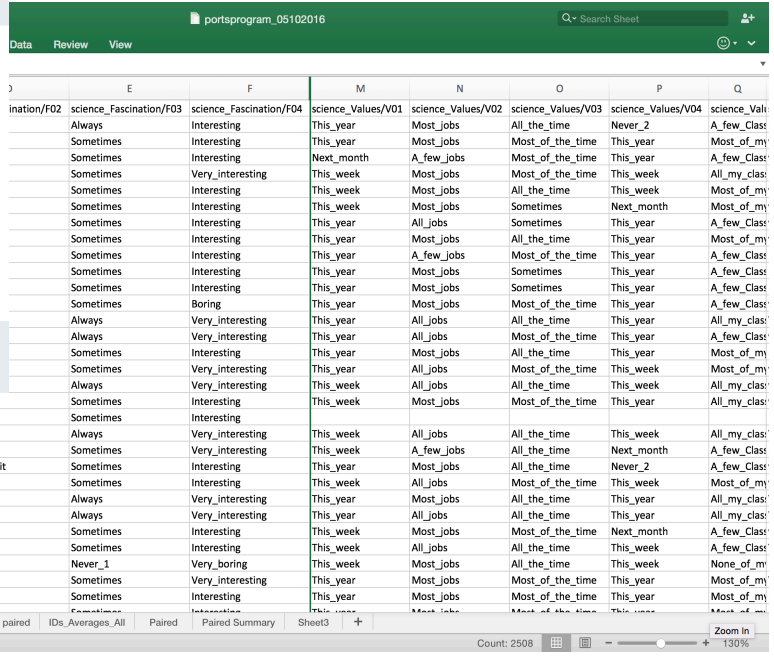
Kobo Toolbox





Kobo Toolbox





SCIENCE LEARNING ACTIVATION LAB

Users of Activation Tools

MakerEd	STEM Activation
FIRST Lego League	Emerging STEM Activation
Qualcomm: Qcamp & Thinkabit	STEM Activation
National Geographic BioBlitz	Science Fascination
Evalfest	Engagement
NYSci	STEM Activation
Residential Outdoor Science Education	Science Activation
Education Outside	Science Activation
Ports: Heal the Bay	Science Activation
Girl Scouts of America	Emerging STEM Activation

10,000+ respondents

SCIENCE LEARNING ACTIVATION LAB

Other Tools & Instruments

STELAR (http://stelar.edc.org/resources)

54 under youth motivation and interests in STEM

PEAR Institute

- The Common Instrument (CIS)
- Dimensions of Success (programmatic level)

Career Interest Questionnaire

- Tools for evaluating public participation in science research projects
- Other funding sources

SCIENCE LEARNING ACTIVATION LAB

Thanks!

Mac Cannady

mcannady@berkeley.edu

www.activationlab.org/toolkit

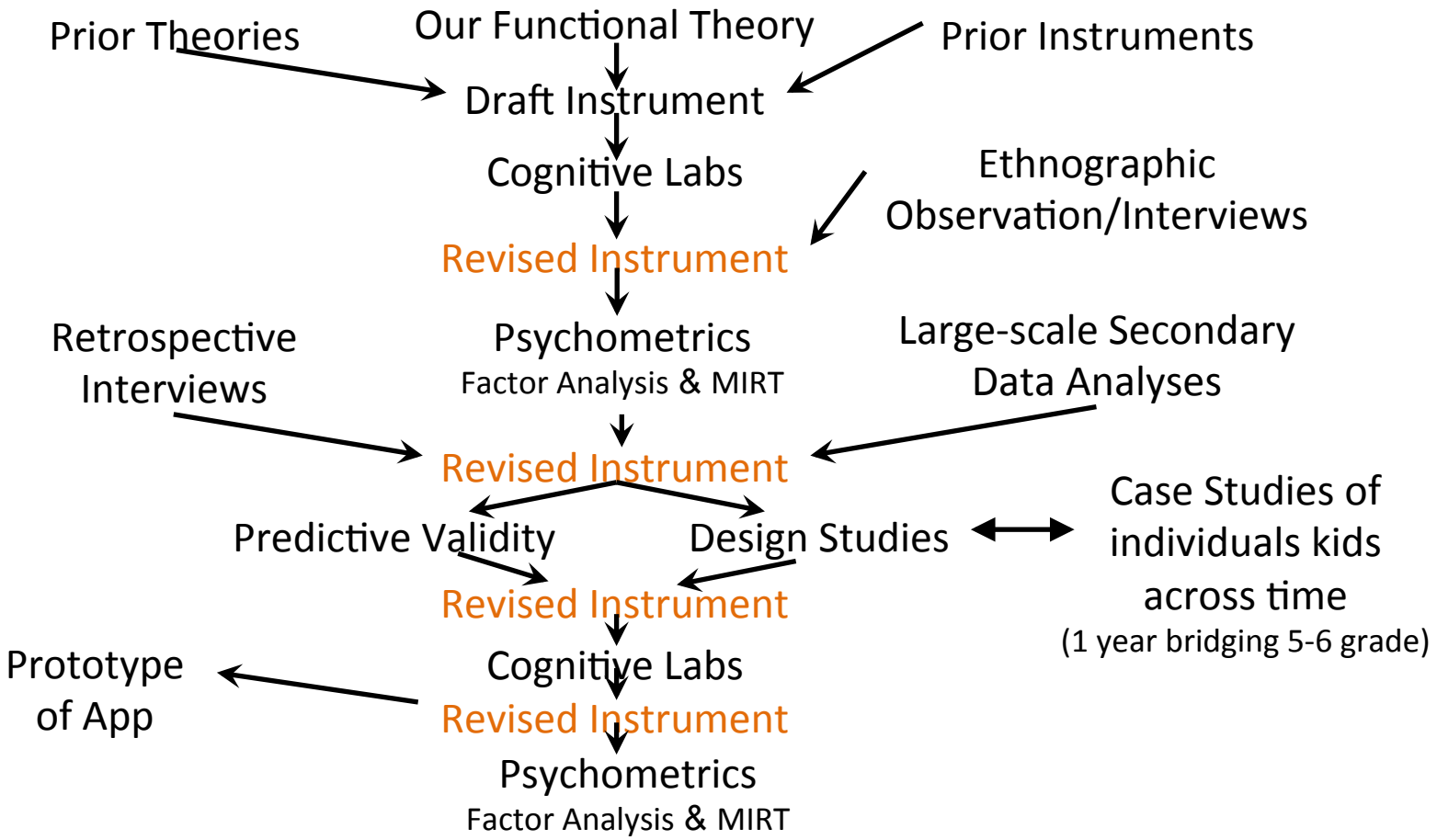
ebays

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

ARDUSAT

SCIENCE LEARNING ACTIVATION LAB

Development process 2.0



SCIENCE LEARNING ACTIVATION LAB

Challenges

The content problem:

- Science sensemaking is deep integration of content and practices of science
- But not interested in measuring content knowledge per se (unlike the NGSS)
- Students vary too much in prior content instruction

Effort problem

- Sensemaking requires effort: what is incentive for spending the effort?

Length problem

- Reasoning items significant learner time; long assessments are hard to use in research and a disaster in evaluation work

Longitudinal measurement problem

- Pre/post or longitudinal designs require new items; how made equivalent?

SCIENCE LEARNING ACTIVATION LAB

Our Strategy

Content problem

- Scenarios that leverage common rather than rare content knowledge (and scenarios embed/support access of content knowledge)

Effort problem

- Use charismatic megafauna: everybody likes dolphins (& monkeys, eagles, ...)

Length problem

- Sample subdimensions lightly (no need for reliable subscores)

Repeated testing problem

- Different scenarios pre/post or time1,2,3,...
- Equate difficulty of scenarios

SCIENCE LEARNING ACTIVATION LAB

Scenario opener

Grey Shanked Douc Monkeys are *critically endangered* and will be extinct in only a few years if something is not done to help them. We wonder whether the monkeys are affected by construction, trash, or different types of trees. We want to know which of these things is most harmful to the monkeys.

The amount of construction might matter, so we will study monkeys in two different forests with different amounts of construction.

Lots of construction

Little construction

Mechanism

A group of students are observing monkeys in a rainforest.

Diana and Elizabeth both think:
• Monkeys are affected most by the amount of construction.

• Many monkeys left the rainforest when there was construction.

Diana says: Monkeys cannot sleep when there is a lot of noise from the construction, so they leave.
Elizabeth says: Monkeys leave because there is construction, so when there is a lot of construction they leave.

Whose reasoning for why the monkeys leave the rainforest is more scientific?

0=Elizabeth because she repeats the important idea.
1=Diana because she explains how the construction causes a problem.
0=Elizabeth because she uses data collected from a study.
0=Diana because I would also leave if my environment was noisy.

SCIENCE LEARNING ACTIVATION LAB

Argument

David and Javier are talking about whether monkeys are affected by construction: David says: It's not amount of trash because the rainforest is messy anyway. It's not the number of different types of trees because monkeys eat from all trees. Javier says: I don't think monkeys like construction in the rainforest. I wouldn't want to live in a place with lots of construction. Whose reasoning for why the monkeys leave the rainforest is more scientific?	0=Javier because he repeats the important ideas. 0=Javier because he explains how the trash causes a problem. 0=David because he uses data collected from a study. 1=David because he explains why it is not the other causes.

SCIENCE LEARNING ACTIVATION LAB

Questions, Evidence

Elijah wonders if the temperature outside makes a difference in how much monkeys play. Which question is the best to ask to investigate this?

- A. Do monkeys play in hot weather?
- B. Which other animals live in the same part of the jungle as monkeys?
- C. Do monkeys like hot or warm weather?
- D. Do monkeys play more when the weather is hot or warm?

Maria is wondering which monkey eats the most. What is the best evidence she could get to answer her question?

- A. She could guess which monkey eats the most.
- B. She could choose a monkey and count the number of pieces of fruit he eats and compare it to the number of leaves he eats.
- C. She could ask her friends which monkey looks like it eats the most.
- D. She could count the number of things all of the monkeys eat.

Seth says that monkeys are full after they eat 7 pounds of food.

Monkey	Amount of food given	Amount of food eaten
Monkey #1	3 pounds	3 pounds
Monkey #2	5 pounds	5 pounds
Monkey #3	7 pounds	7 pounds
Monkey #4	9 pounds	7 pounds

Which piece of evidence in the table above makes Seth think this is true?

- A. Monkey #4 got 9 pounds of food which is the most.
- B. Monkey #1 got the least amount of food and ate it all.
- C. Monkey #4 got 9 pounds and only ate 7 pounds of food.
- D. Monkey #3 got 7 pounds and ate 7 pounds of food.

Choice Preferences

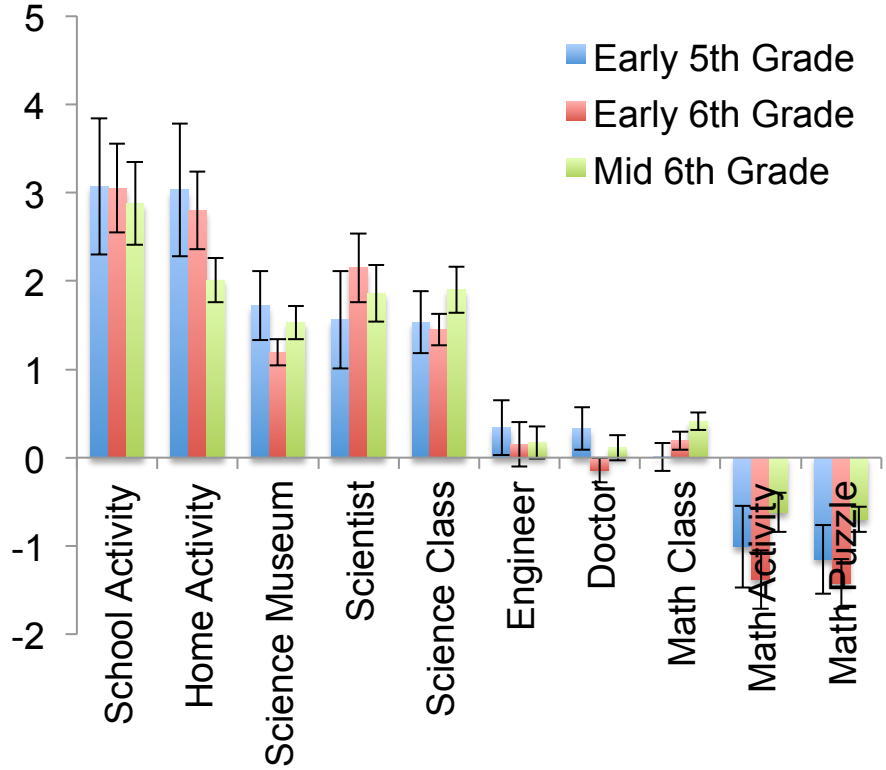
10 items, α=0.84

Choice: Choosing to participate in the next opportunity for science learning

Choice preferences: Preferring science options from alternatives

I would like to…

1. Formal
   - Talk to a science teacher about good science books or websites.
   - Do my homework or projects for science class with other students
2. Informal
   - Watch TV programs about science topics.
   - Attend a science camp next summer.
   - Join a science club at school next year.



Engagement

8 items, α=0.85

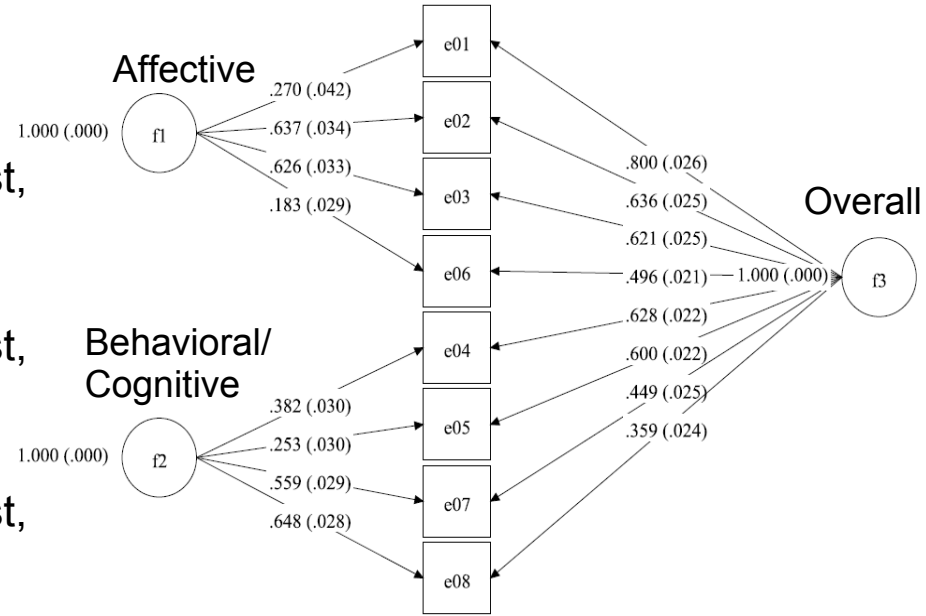
Engagement includes affective, behavioral, and cognitive components (e.g., excited about the materials, doing the science activities at hand, and thinking about science ideas).

1. Affective
   - In general, I find science: (very interest, interesting, boring, very boring)
2. Behavioral
   - In general, I find science: (very interest, interesting, boring, very boring)
3. Cognitive
   - In general, I find science: (very interest, interesting, boring, very boring)

Bi-Factor Model

Affective: α=0.84

Behavioral/Cognitive: α=0.77



SCIENCE LEARNING ACTIVATION LAB

Perceived Success

6 items, α=0.83

Do students feel successful in completing science learning tasks in absolute and relative terms?

During this activity…

1. Absolute (Relative to Self)
   - It was easy for me.
   - I did a good job.
2. Comparison (Relative to Others)
   - I did better than the others.
   - I was more successful than everyone else.

Early psychometrics:

1. EFA: Separate from Engagement
2. Eng – PS only r=.42
3. Factor loadings all > .64
4. Forced two factor separates Absolute vs. comparison

SCIENCE LEARNING ACTIVATION LAB

Some Results: Activation Lab, Enables Success Studies

(ALES11, ALES14)

SCIENCE LEARNING ACTIVATION LAB

ALES11 Study

Context

- 10 schools implementing FOSS curriculum
- 38 6th grade classrooms
- broad range of classroom diversity (although all urban public)
- 4 months of instruction on weather & climate

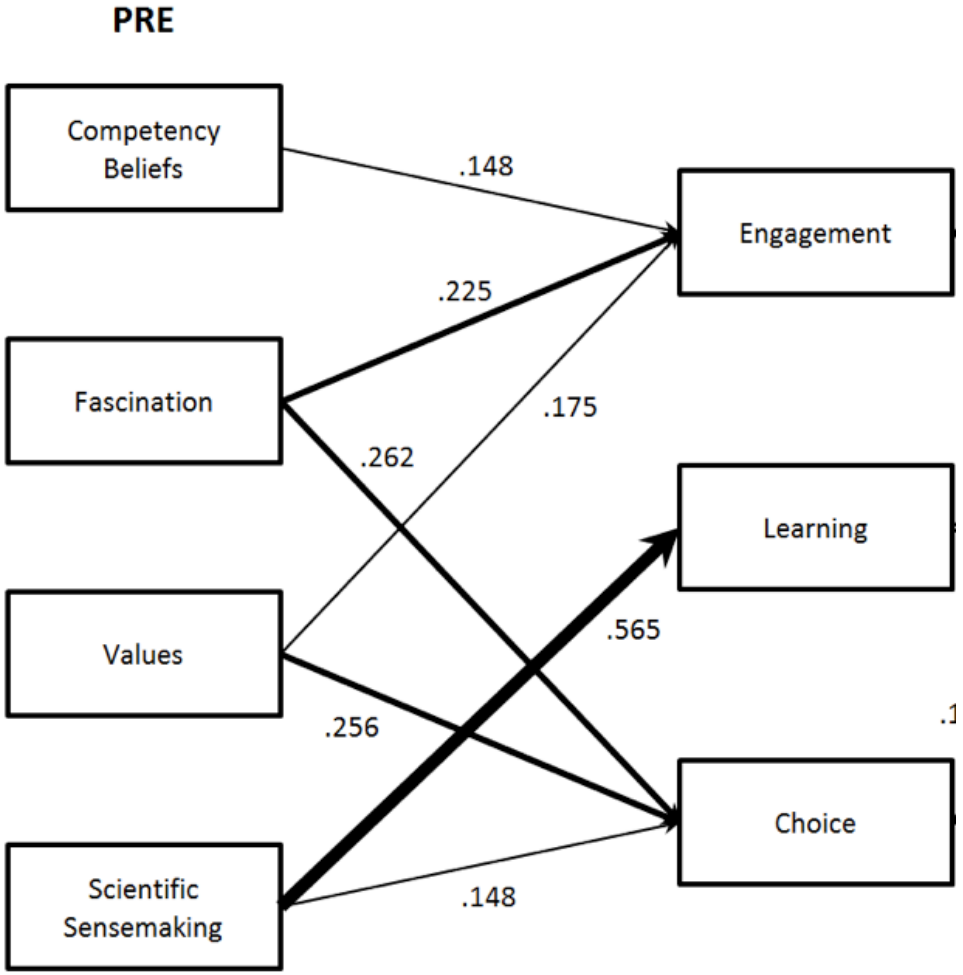
Measures

- pre-post content tests
- engagement measured during 4 activities
- choice preferences measured at beginning (and at end)

Predicting success

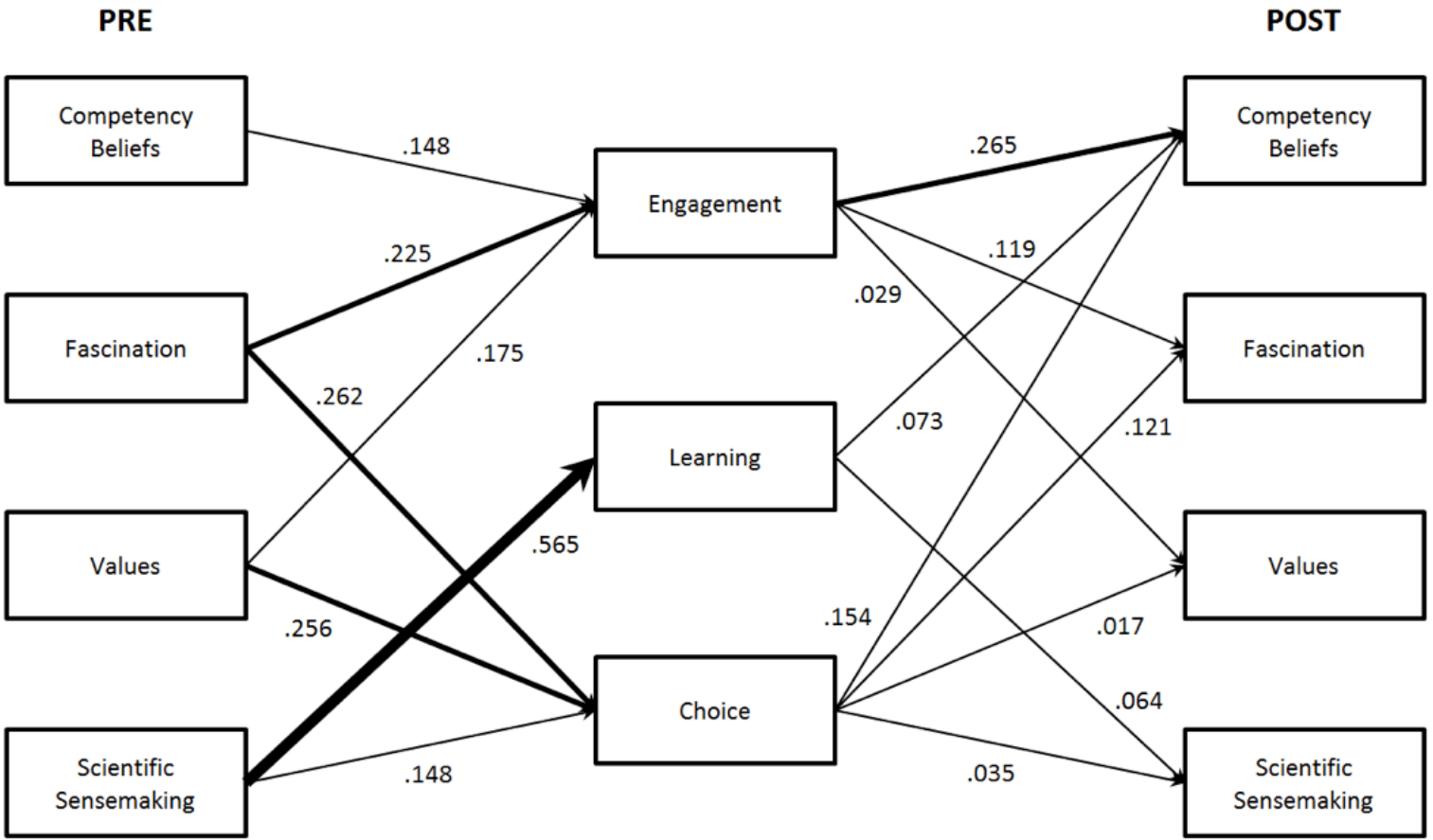
Predicting Learning without and with controlling for other factors

Pre Competency Beliefs	0.073 0.052
Pre Fascination	0.026 0.086
Pre Values	-0.011 -0.038
Pre Scientific Sensemaking	0.565*** 0.341***



SCIENCE LEARNING ACTIVATION LAB

Change in Activation

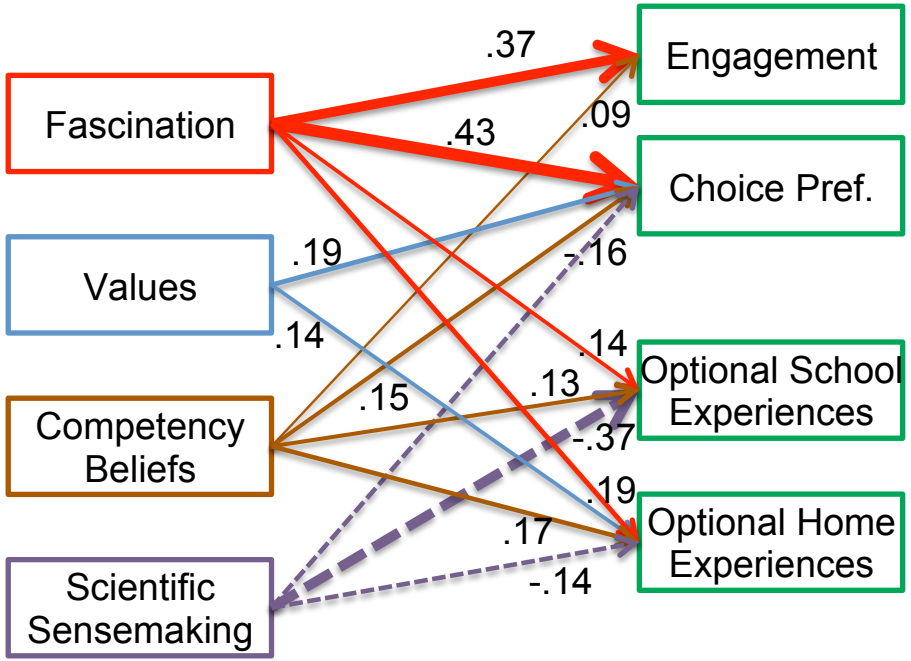


Malleable Factors NSF grant (ALES14)

SCIENCE LEARNING ACTIVATION LAB

Data collection		6th + 8th grade 4 hands-on / 4 textbook schools			7th + 9th grade	
Fidelity / Activity Logs		Mid 4 times	End 4 times		Mid 4 times	
Activation		Begin	Mid	End	Begin	Mid
Family Background		Begin				
Prior/Recent Experiences		Begin	Mid		Begin	Mid
***Content knowledge**		Pre	Post		Pre	Post
Engagement		4 times	4 times		4 times	
Choice Preferences		Begin		End	Begin	
State tests			8th only			
Career Interest		Begin		End	Begin	
Perceived success		4 times	4 times		4 times	

Activation Associated with Success

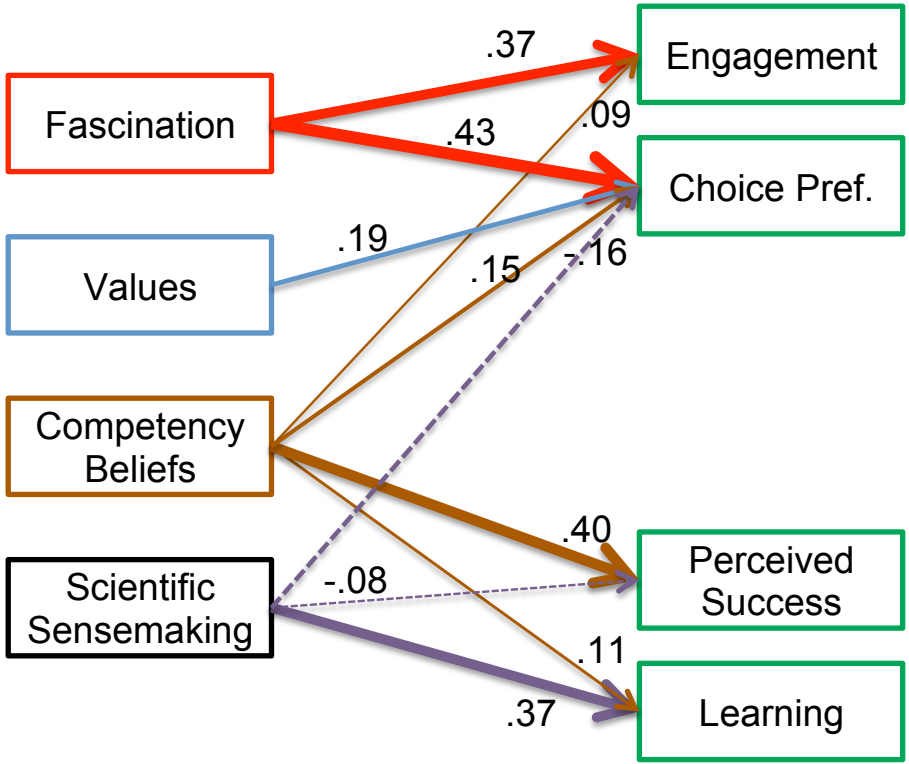


- Study group for science class
- Extra credit research project
- Part of science club

- Watch science TV
- Read science or scifi books
- Go to science websites
- Do science experiments at home

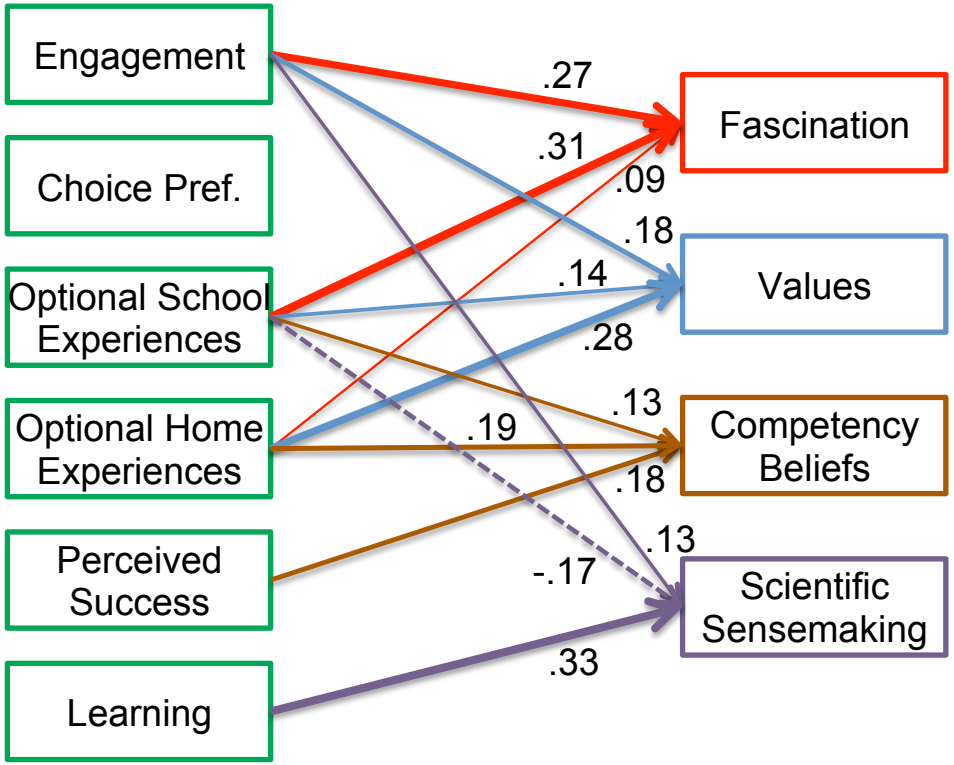
SCIENCE LEARNING ACTIVATION LAB

Activation Associated with Success



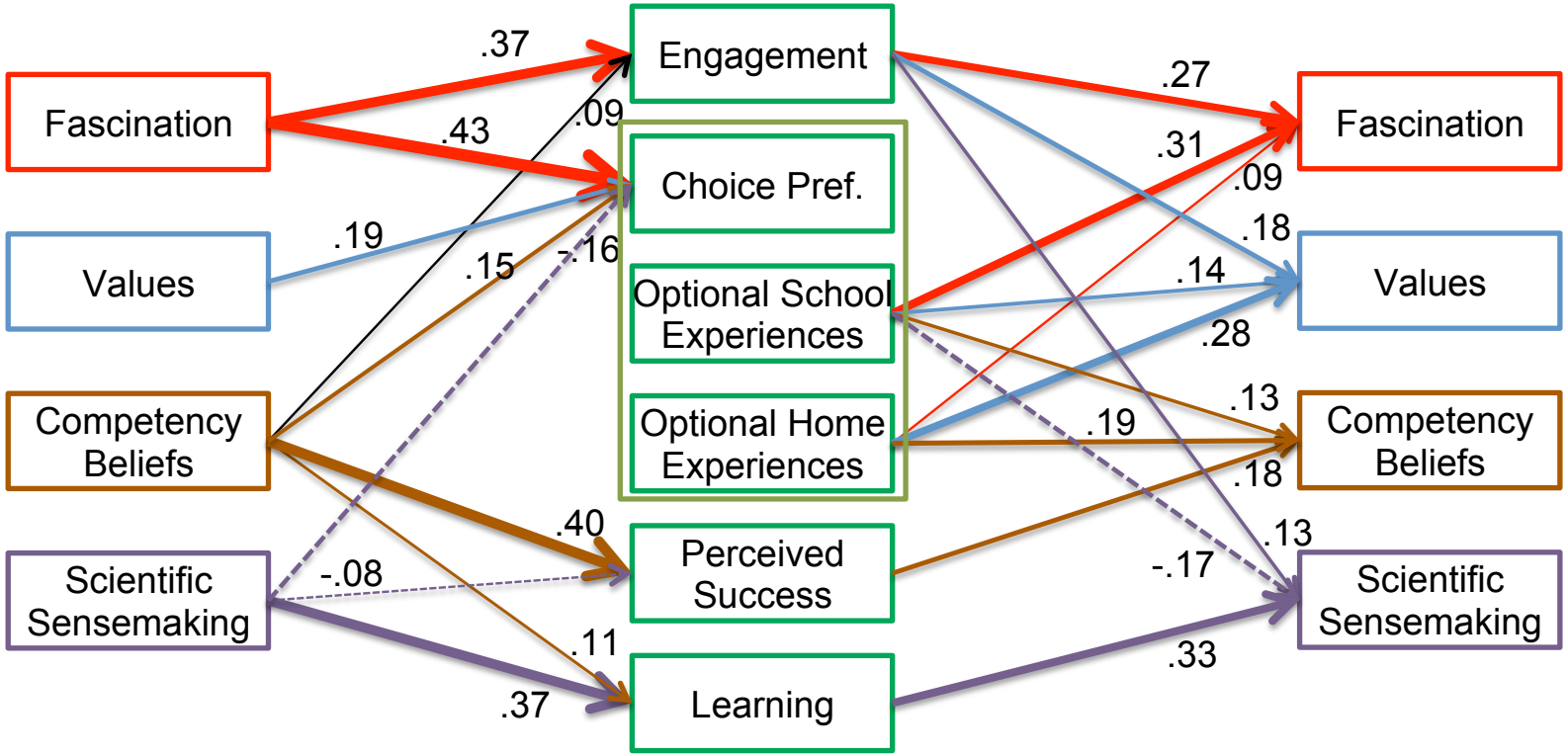
SCIENCE LEARNING ACTIVATION LAB

Success Associated with Activation Change



SCIENCE LEARNING ACTIVATION LAB

Interactive cycle



SCIENCE LEARNING ACTIVATION LAB

Other Users

Who has used these surveys?

- MakerEd (STEM)
- First Lego League (Early Activation)
- Qualcomm's Qcamp (STEM)
- National Geographic BioBlitz (Fascination)
- EvalFest (Engagement)
- NYSci (STEM)
- UC Berkeley's girls engineering camp (STEM)
- TechHive (STEM)
- Education Outside (Science)

~9,000 students

SCIENCE LEARNING ACTIVATION LAB

Current Project
ActApp

SCIENCE LEARNING ACTIVATION LAB

PRIME NSF grant

The goal of this project is to transform the measures of science learning activation and related surveys and protocols that were previously developed for research purposes into evaluation instruments.

1. (other stuff)
2. Transpose the revised instruments to tablet platform and develop back-end algorithm to produce individualized scores.
3. Explore functioning of revised instrument in evaluation context.
4. Develop a toolkit that will help non-experts administer, analyze, disaggregate, and interpret results from the instrument.
5. Implement dissemination strategies.

SCIENCE LEARNING ACTIVATION LAB

Toolkit Structure

1. About the Tools
    a. Instruments
    b. Why you should use them
2. About Activation
    a. Theory
    b. Components
    c. How dimensions align with commonly used terms (e.g., interest, efficacy)
3. Making sure this aligns with your program needs
    a. Purpose/Research design
    b. Context
    c. Subjects/audience
    d. Data collection methods
    e. Resources available
4. Exploring instruments (based on categories above)
5. Scoring and scoring options
6. Analysis

SCIENCE LEARNING ACTIVATION LAB

ActApp

ActApp Demo

SCIENCE LEARNING ACTIVATION LAB

Alternative Measurement Approaches

Name of Project	Age Range of Participants	Domains of Learning	Key Technologies	Potential Activation Scales Relevant to Context
Alternate Reality Game	13-17	Astrobiology, Deep Time Sciences Scientific Inquiry Skills	Social Media Platforms Mobile Game Apps Story Platform	Fascination Sensemaking Competency Beliefs
ScienceKit and Science Everywhere	9-14	Scientific Inquiry Skills Technology (computer programming) Science Literacy (e.g., science fiction, science journalism, media, etc.)	Social Media App: ScienceKit	Fascination Sensemaking Competency Beliefs
BioTracker –- Floracaching	18 and Over	Plant Phenology Citizen Science in which participants contribute data to a national project	Gamified App: Floracaching	Fascination Values Competency Beliefs

SCIENCE LEARNING ACTIVATION LAB

Questions

- **Possible strategic areas of effort**
  1. How-to videos
  2. Use case success stories
  3. Improved usability of collection and reports
- **Sustainability plans**
  1. Pay service?
  2. Other funding sources
- **Dissemination strategies**
  1. Audience very specifically defined
  2. Where are they and how do you reach them
  3. Most effective ways to reach audience (webinar vs. live workshop)
- **What's next?**
  1. User studies (tools, toolkit)
  2. Evaluation of Activation in other domains (Art, STEAM) or other content (broad platform)