Science Learning Activation: Positioning Youth for Success

ITEST PI Summit: June 15-16, 2017
Overview

Learning Activation
The Instruments
How you can use them
Similar instruments
Guiding Question

What positions youth for success in science?
Science learning activation =
A composition of *dispositions, skills, and knowledge* that enables success in proximal science learning experiences.
Theory of Activation

Activation

- Fascination
- Values
- Competency Beliefs
- Scientific Sensemaking

Success

- Choice
- Engagement
- Perceived Success
- Learning
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).
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; Loewenstein, 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)
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)
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)
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.

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.
Development Process 3.4

Prior Theories
- Our Functional Theory
  - Draft Instrument
    - Cognitive Labs
      - Revised Instrument
        - Psychometrics
          - Factor Analysis & MIRT
            - Revised Instrument
              - Predictive Validity
                - Design Studies
                  - Case Studies across time (1 year bridging 5-6 grade)

Prior Instruments
- Ethnographic Observation/Interviews
  - Large-scale Secondary Data Analyses

Retrospective Interviews
- Cognitive Labs
  - Revised Instrument
    - Psychometrics
      - Factor Analysis & MIRT
        - Revised Instrument
          - Cognitive Labs
            - Prototype of App
              - 2x

NSF CORE ALES:14
- 2-year 6-7th & 8-9th grade
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

8 items, $\alpha=0.90$
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

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.
Scientific Sensemaking

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.
**NSF CORE: Malleable Factors (ALES14)**

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>6th + 8th grade</th>
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<tr>
<td>*Content knowledge</td>
<td>Pre Post</td>
<td>Pre Post</td>
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<tr>
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<td>4 times Mid</td>
<td>4 times Mid</td>
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<tr>
<td>Choice Preferences</td>
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<td>State tests</td>
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<td>8th only</td>
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<tr>
<td>Career Interest</td>
<td>Begin End</td>
<td>Begin</td>
</tr>
<tr>
<td>Perceived success</td>
<td>4 times</td>
<td>4 times</td>
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</tbody>
</table>
Sensemaking to Learning

- Competency Beliefs
- Scientific Sensemaking
- Perceived Success
- Learning
- Engagement

Dr. Megan Bathgate
Competency Beliefs to Learning

Competency Beliefs

Behav./Cog. Engagement

Choice Preferences

Paulette Vincent-Ruz
ACTAPP: THE ACTIVATION LAB EVALUATION TOOLKIT

This page will take you through the Activation Lab tools that you can use to evaluate your learning programs. We call this toolkit the "ActApp." Go through our four steps to design your study and access the tools:

Step 1: Decide if the tools align with your evaluation questions
Step 2: Explore our Tools
Step 4: Use the Toolkit Now

Contact us at info@activationlab.org if you have questions throughout the process.

Need help? Jump to our FAQs.

What is the ActApp Toolkit?

The ActApp Toolkit has been designed to share tools from the Learning Activation Lab. The Activation Lab tools were designed to... Show more >

I can create my own tools. Why should I use the ActApp Toolkit?

As an evaluator, or as a program leader who understands evaluation, you know that it is very time-consuming and challenging to...
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
Survey Construction Tool

Please fill out the following form. For any questions or comments, please contact us at info@activationlab.org.

If you are going to use the browser version of this website you must first create a KoBo Toolbox account. If you don’t have one, you can create one at: https://kf.kobotoolbox.org/accounts/register/

* Required

1. Please provide the name of your organization/institution: *

Your answer

2. Please give a short description of the use of the Activation
You've got email!

ActApp Confirmation  Inbox  

The Activation Lab <ducio.lopez@berkeley.edu>  
8/20/15

You have chosen to use the online survey option. Please keep this email for your records.

Please use the following Survey URL to distribute the survey to survey-takers, https://9quzq.enketo.kobotoolbox.org/webform. For survey scoring options, please view the technical reports available in the Activation Lab website. Please contact us at info@activationlab.org for information regarding scoring and evaluation services, or for general questions or comments.

-The Activation Lab Team-
ActApp Survey System

Kobo Toolbox
<table>
<thead>
<tr>
<th>Users of Activation Tools</th>
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<tbody>
<tr>
<td>MakerEd</td>
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<tr>
<td>FIRST Lego League</td>
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<tr>
<td>Qualcomm: Qcamp &amp; Thinkabit</td>
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<tr>
<td>National Geographic BioBlitz</td>
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<tr>
<td>Evalfest</td>
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<tr>
<td>NYSci</td>
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<tr>
<td>Residential Outdoor Science Education</td>
</tr>
<tr>
<td>Education Outside</td>
</tr>
<tr>
<td>Ports: Heal the Bay</td>
</tr>
<tr>
<td>Girl Scouts of America</td>
</tr>
</tbody>
</table>

10,000+ respondents
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
Thanks!

Mac Cannady
mcannady@berkeley.edu
www.activationlab.org/toolkit
Development process 2.0

Prior Theories → Our Functional Theory → Prior Instruments

Draft Instrument

Cognitive Labs

Revised Instrument

Psychometrics

Factor Analysis & MIRT

Retrospective Interviews

Ethnographic Observation/Interviews

Large-scale Secondary Data Analyses

Case Studies of individuals kids across time (1 year bridging 5-6 grade)

Predictive Validity

Design Studies

Prototype of App

Cognitive Labs

Revised Instrument

Psychometrics

Factor Analysis & MIRT

Revised Instrument

Prototype of App
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?
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
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.
### 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. |
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.
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.

<table>
<thead>
<tr>
<th>Monkey</th>
<th>Amount of food given</th>
<th>Amount of food eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monkey #1</td>
<td>3 pounds</td>
<td>3 pounds</td>
</tr>
<tr>
<td>Monkey #2</td>
<td>5 pounds</td>
<td>5 pounds</td>
</tr>
<tr>
<td>Monkey #3</td>
<td>7 pounds</td>
<td>7 pounds</td>
</tr>
<tr>
<td>Monkey #4</td>
<td>9 pounds</td>
<td>7 pounds</td>
</tr>
</tbody>
</table>

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

**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

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: $\alpha=0.84$
Behavioral/Cognitive: $\alpha=0.77$

8 items, $\alpha=0.85$
Perceived Success

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

6 items, $\alpha=0.83$
Some Results: Activation Lab, Enables Success Studies (ALES11, ALES14)
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

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>Learning</th>
<th>Choice</th>
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<tr>
<td>Competency Beliefs</td>
<td></td>
<td>-0.148</td>
<td></td>
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<td>Fascination</td>
<td>-0.225</td>
<td></td>
<td></td>
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<tr>
<td>Values</td>
<td>-0.262</td>
<td>-0.565***</td>
<td></td>
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<tr>
<td>Scientific Sensemaking</td>
<td>-0.256</td>
<td></td>
<td>-0.148</td>
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</table>

| 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*** |        |
Change in Activation

PRE

- Competency Beliefs
- Fascination
- Values
- Scientific Sensemaking

POST

- Competency Beliefs
- Fascination
- Values
- Scientific Sensemaking

Edges:

- Competency Beliefs to Engagement: 0.148
- Fascination to Engagement: 0.225
- Values to Engagement: 0.175
- Scientific Sensemaking to Engagement: 0.565
- Engagement to Learning: 0.565
- Learning to Choice: 0.265
- Choice to Competency Beliefs: 0.029
- Choice to Values: 0.073
- Choice to Scientific Sensemaking: 0.121
# Malleable Factors NSF grant (ALES14)

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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
Success Associated with Activation Change

Engagement → Fascination: 0.27
Choice Pref. → Values: 0.31
Optional School Experiences → Competency Beliefs: 0.14
Optional Home Experiences → Competency Beliefs: 0.28
Perceived Success → Scientific Sensemaking: 0.19
Learning → Scientific Sensemaking: 0.33

Optional School Experiences → Values: 0.13
Optional Home Experiences → Competency Beliefs: 0.18
Perceived Success → Scientific Sensemaking: -0.17
Interactive cycle

- Fascination
- Values
- Competency Beliefs
- Scientific Sensemaking
- Engagement
- Choice Pref.
- Optional School Experiences
- Optional Home Experiences
- Perceived Success
- Learning

Correlation Coefficients:

- Engagement to Fascination: 0.27
- Engagement to Values: 0.31
- Engagement to Competency Beliefs: 0.09
- Engagement to Scientific Sensemaking: 0.37
- Choice Pref. to Fascination: 0.31
- Choice Pref. to Values: 0.09
- Choice Pref. to Competency Beliefs: 0.18
- Choice Pref. to Scientific Sensemaking: 0.11
- Optional School Experiences to Fascination: 0.14
- Optional School Experiences to Values: 0.15
- Optional School Experiences to Competency Beliefs: 0.16
- Optional School Experiences to Scientific Sensemaking: -0.08
- Optional Home Experiences to Fascination: 0.28
- Optional Home Experiences to Values: 0.28
- Optional Home Experiences to Competency Beliefs: 0.19
- Optional Home Experiences to Scientific Sensemaking: -0.16
- Perceived Success to Fascination: 0.13
- Perceived Success to Values: 0.13
- Perceived Success to Competency Beliefs: 0.19
- Perceived Success to Scientific Sensemaking: -0.17
- Learning to Fascination: 0.33
- Learning to Values: 0.33
- Learning to Competency Beliefs: 0.40
- Learning to Scientific Sensemaking: -0.08
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
Current Project
ActApp
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.
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
<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Age Range of Participants</th>
<th>Domains of Learning</th>
<th>Key Technologies</th>
<th>Potential Activation Scales Relevant to Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate Reality Game</td>
<td>13-17</td>
<td>Astrobiology, Deep Time Sciences</td>
<td>Social Media Platforms</td>
<td>Fascination</td>
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<tr>
<td></td>
<td></td>
<td>Scientific Inquiry Skills</td>
<td>Mobile Game Apps</td>
<td>Sensemaking</td>
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<td>Story Platform</td>
<td>Competency Beliefs</td>
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<tr>
<td>ScienceKit and Science Everywhere</td>
<td>9-14</td>
<td>Scientific Inquiry Skills</td>
<td>Social Media App: ScienceKit</td>
<td>Fascination</td>
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<td></td>
<td></td>
<td>Technology (computer programming)</td>
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<td>Sensemaking</td>
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<td></td>
<td>Science Literacy (e.g., science fiction, science journalism, media, etc.)</td>
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<td>Competency Beliefs</td>
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<tr>
<td>BioTracker — Floracaching</td>
<td>18 and Over</td>
<td>Plant Phenology</td>
<td>Gamified App: Floracaching</td>
<td>Fascination</td>
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<td>Citizen Science in which participants contribute data to a national project</td>
<td></td>
<td>Values</td>
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<td>Competency Beliefs</td>
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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)