UNIVERSITY of WASHINGTON

*All young people should be able to decide their futures.*

INSTITUTE for Science + Math EDUCATION

# Important qualities of the extended STEM learning pathways of youth

Philip Bell

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*University of Washington*

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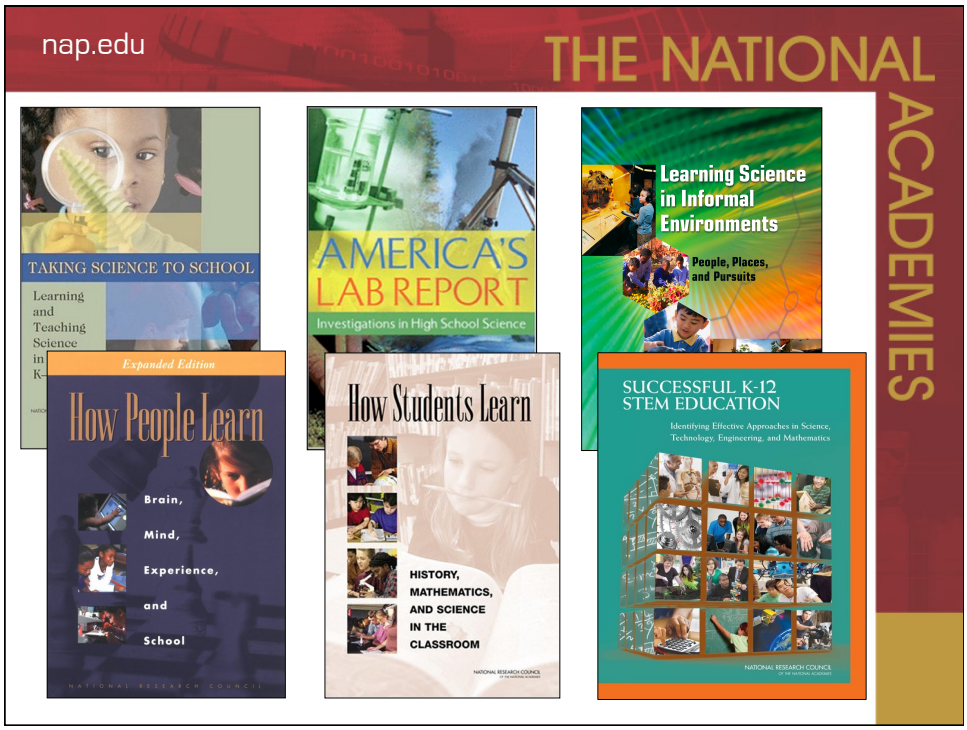


## Multiple Venues for Science Learning

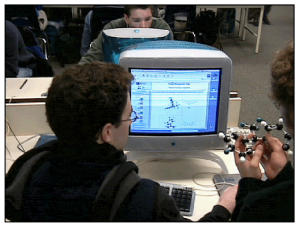
"The committee found abundant evidence that across all venues—everyday experiences, designed settings, and programs—individuals of all ages learn science." (NRC, 2009)

**Everyday Settings & Family Activities**

*(e.g., Callanan & Oakes, 1992; Crowley & Galco, 2001; Goodwin, 2007; Bell et al., 2006)*

**Designed Informal Settings**

*(e.g., Allen & Gutwill, 2004; Callanan & Jipson, 2001; Rennie & McLafferty, 2002)*



**Classroom Instruction**

*(e.g., Barton, et al., 2003; Davis, 2003; Linn, 2006; Newton, Driver & Osborne, 1999; Reiser et al., 2004)*

**Programs for Young & Old**

*(e.g., Halpern, 2002; Noam, et al., 2003; Gibson & Chase, 2002)*

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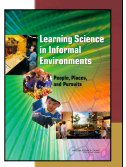
## Cultural Variation & STEM Learning

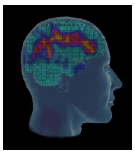
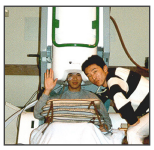
***In terms of broadening participation in STEM, studies do suggest that informal learning environments may be particularly effective for youth from historically non-dominant communities.*** However, there is variability in the success of these environments in attracting and engaging diverse audiences. We believe that a better understanding of the naturally occurring science learning in a diverse range of communities is needed to inform basic theory about how people learn and to inform the design of learning experiences tailored these communities.



# The Learning in Informal and Formal Environments (LIFE Center)

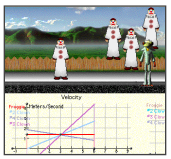
*University of Washington • Stanford University • SRI International*
*Northwestern University • University of California, Berkeley*

**Development:** social cognition, neural commitment, imitation, language learning

**Practices:** context, distributed participation, interaction, appropriation of tools, culture, improvisation


**Design:** transfer, preparation for future learning, adaptability, efficiency, design of tools

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# Identity & Social Positioning as Central

- Primary construct for psychologists concerned with academic identity and school success (Chavous, Rivas-Drake, Smalls, 2008; Oyserman, Grant, Ager, 1995; Roser & Lau, 2002; Rowley, Sellers, Chavous, 1998)
- Identity increasingly central in analyses of learning, esp. practice-linked identities (Bell, et al., 2012; Carlone & Johnson, 2007; Gresalfi, 2006; Nasir, 2012; Polman, 2009; Wenger, 1998)
- There has been progress thinking about intersections of culture, race and learning; negotiating multiple identities is key (Lee, 2012; Nasir & Hand, 2006)
- Identify focuses attention on how youth are socially positioned to learn (Harré et al, 2009; Holland et al., 1998; Bell et al., 2012)

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## LIFE Ethnographic Research

| Study | | |
|---|---|---|
| **Technobiographies of youth creators in Silicon Valley** | N=16<br>Lower(, Middle, Upper SES<br>African American, Hispanic, Asian, White; Ages 13-14 | Homes, computer clubhouse in a Boys & Girls Club, online spaces, school classes |
| **Digital Youth Network learners in the south side of Chicago** | N=9<br>Lower – Middle SES<br>African American<br>Ages 12-14 | School day classes, afterschool clubs, online spaces |
| **Everyday Science in Seattle** | N=13<br>Lower-Middle<br>African American, Asian, White<br>Ages 9-12 | Schools, homes, museums, parks, zoos, clubs |
| **Money Matters Seattle** | N=8<br>Lower, middle, upper<br>Ages | Homes |
| **Early Childhood Across Contexts Seattle** | N=8<br>Middle<br>Ages 3-5 | Homes, preschools |
| **Family Math Bay Area, CA** | N=20<br>Lower-Middle<br>Ages 12-14 | Homes |
| **Citizen Science for Biodiversity Maine** | N=16<br>Lower(n=8) - Middle/upper(n=8)<br>White, African American<br>Ages 12-14 | Outdoor coastal and woodland fieldwork online, classrooms |
| **Identities in Motion for Youth with Disabilities Seattle & Bay Area, CA** | N=12<br>Lower – Middle SES<br>Ages 15-18, students with formal disability designations | Afterschool clubs, project-based school courses, homes, community settings |

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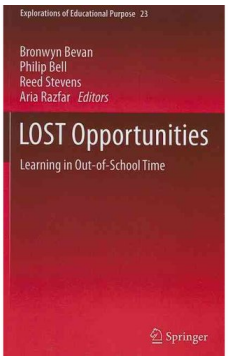
## Synthesis of High-Level Findings Across LIFE Studies

Finding: With respect to STEM learning, informal environments and project-based environments can support domain epistemic practices and knowledge that are more aligned with professional forms of those domains.

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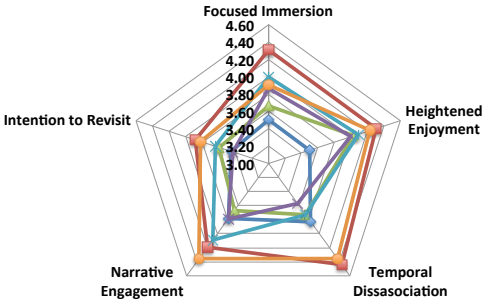
## Sam's design practice pervades his out-of-school settings for years—school largely resists it

Key Features:
- Pathway started at a one week summer ISE program
- Engaged in series of sustained STEM projects of increasing complexity over years (e.g., he dominated museum exhibits)
- Mother served as multifaceted learning partner
- Projects leveraged epistemic practices of design—as detailed in the NRC Framework. (Design competencies should be more welcome at school with NGSS.)

## Supporting Science Identification Through Project-Based Curricula (Van Horne, Bricker & Bell)

*Engage students in contemporary biology investigations supported by volunteer network of disciplinary experts*

Study Engagement Dynamics Through Exit Tickets

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educurious learning that connects

# Synthesis of High-Level Findings Across LIFE Studies

Finding: *Cultural Learning Pathways*—Participation in activity in multiple learning environments engenders learning pathways, which link experiences in discrete learning settings and increase participation and STEM-linked outcomes, including science-linked identification.

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## Fieldwork has been conducted in the following settings…

- **Homes, Apartments & Neighborhoods (Urban City and Suburban Cities)**
- **Granite Elementary (classrooms, lunchroom, playground, multiethnic dinner, science-math night, assessment night, class fieldtrips)**
- **Afterschool Programs at Granite Elementary (sports, tech, science, day care)**
- **Overnight Environmental Camp (school fieldtrip)**
- **Mountain Watershed & Visitor Center (school fieldtrip)**
- **Neighborhood Parks (playgrounds, fields)**
- **Interactive Science Center / Museum**
- **Dog Training School ("puppygarten" class)**
- **Mountain Campground (overnight family camping trip)**
- **Public Libraries**
- **Cultural Dance Event (Granite Hills park)**
- **Little League Baseball (Urban City park)**
- **Youth League Football Game (Urban school field)**
- **Youth League Soccer Tournament (Rural City park)**
- **Public Garden (observing family's organic gardening)**
- **Neighborhood Walks**
- **Summer School Program for "At-Risk" Gifted Students**
- **Community Center Basketball Game**
- **Church Summer Music Program**
- **Aviation Museum**
- **Aquarium, Zoo**
- **Art Museum**
- **Shopping Malls**
- **Restaurants**
- **Church**

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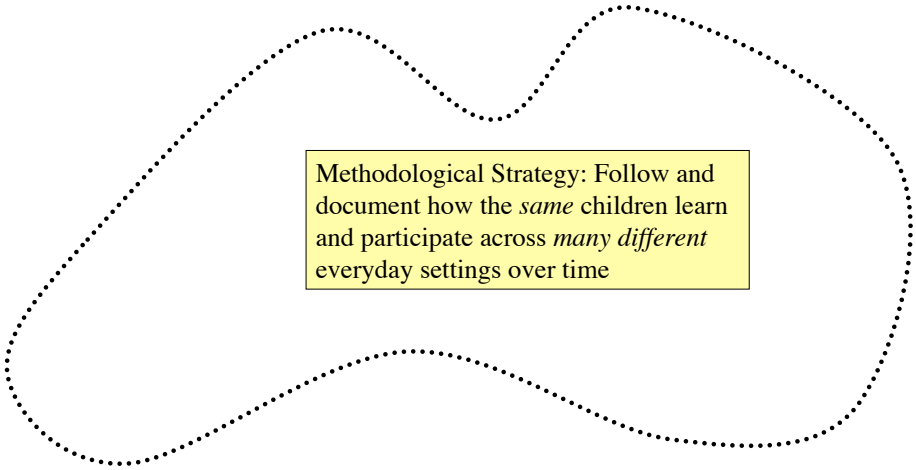
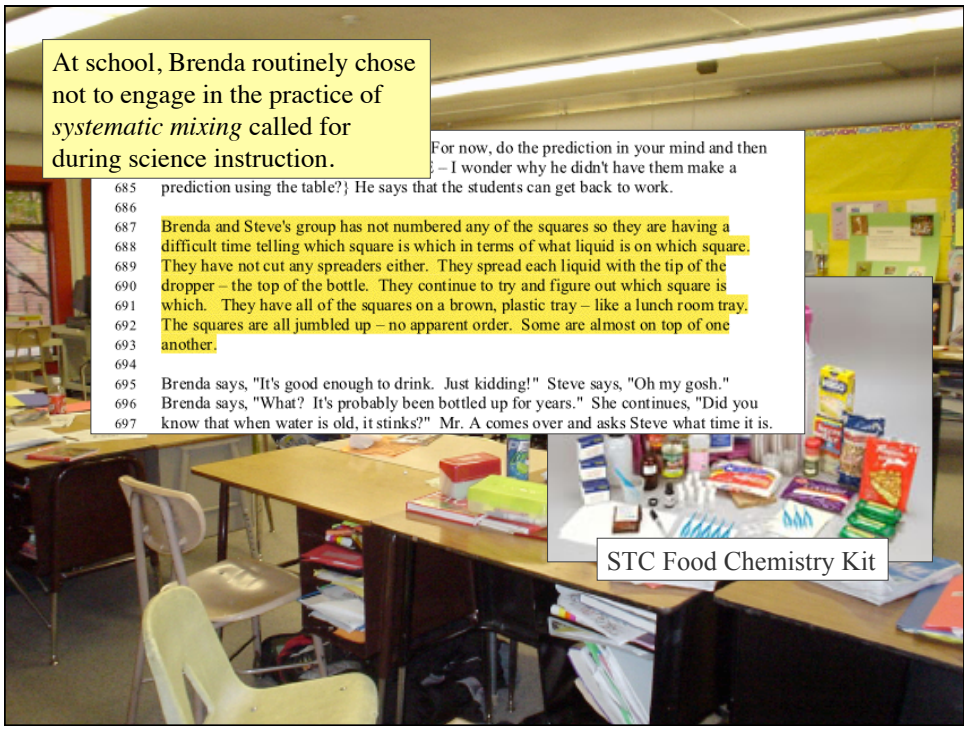
Overarching Scientific Question: How do everyday moments—experienced across settings, communities, and pursuits—lead to understanding, expertise, identity, and consequential actions?



Methodological Strategy: Follow and document how the *same* children learn and participate across *many different* everyday settings over time

Bell, Bricker, Reeve, Zimmerman & Tzou, 2012, *LOST Opportunities: Learning in Out of School Time*.



At school, Brenda routinely chose not to engage in the practice of *systematic mixing* called for during science instruction.

For now, do the prediction in your mind and then
– I wonder why he didn't have them make a
685 prediction using the table?} He says that the students can get back to work.
686
687 Brenda and Steve's group has not numbered any of the squares so they are having a
688 difficult time telling which square is which in terms of what liquid is on which square.
689 They have not cut any spreaders either. They spread each liquid with the tip of the
690 dropper – the top of the bottle. They continue to try and figure out which square is
691 which. They have all of the squares on a brown, plastic tray – like a lunch room tray.
692 The squares are all jumbled up – no apparent order. Some are almost on top of one
693 another.
694
695 Brenda says, "It's good enough to drink. Just kidding!" Steve says, "Oh my gosh."
696 Brenda says, "What? It's probably been bottled up for years." She continues, "Did you
697 know that when water is old, it stinks?" Mr. A comes over and asks Steve what time it is.

STC Food Chemistry Kit

But she routinely engaged in that practice at home.

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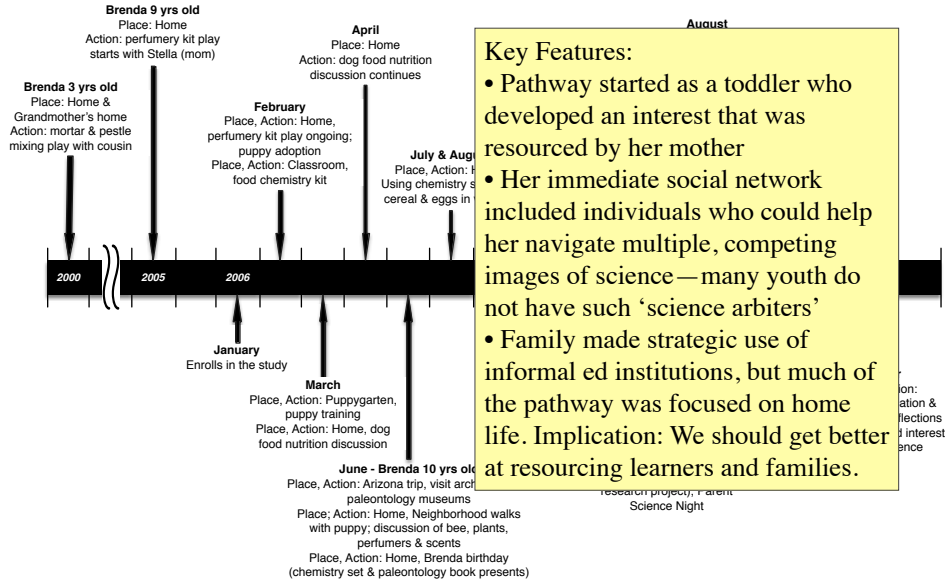
# Brenda's Cultural Learning Pathway




Key Features:
- Pathway started as a toddler who developed an interest that was resourced by her mother
- Her immediate social network included individuals who could help her navigate multiple, competing images of science—many youth do not have such 'science arbiters'
- Family made strategic use of informal ed institutions, but much of the pathway was focused on home life. Implication: We should get better at resourcing learners and families.

Bricker & Bell, 2014, *Journal of Research in Science Teaching*

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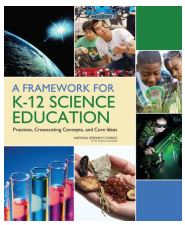
## Dimension 1: Science and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

NEXT GENERATION SCIENCE STANDARDS

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## Synthesis of High-Level Findings Across LIFE Studies

Finding: STEM represents a broad set of disparate pursuits and fields. Youth need to make sense of multiple, often competing, images of science in order to locate relevant learning resources and partners to extend their learning.

Some youth must navigate conflicting epistemologies of science across the communities in which they participate (e.g., Bang & Medin, 2010)

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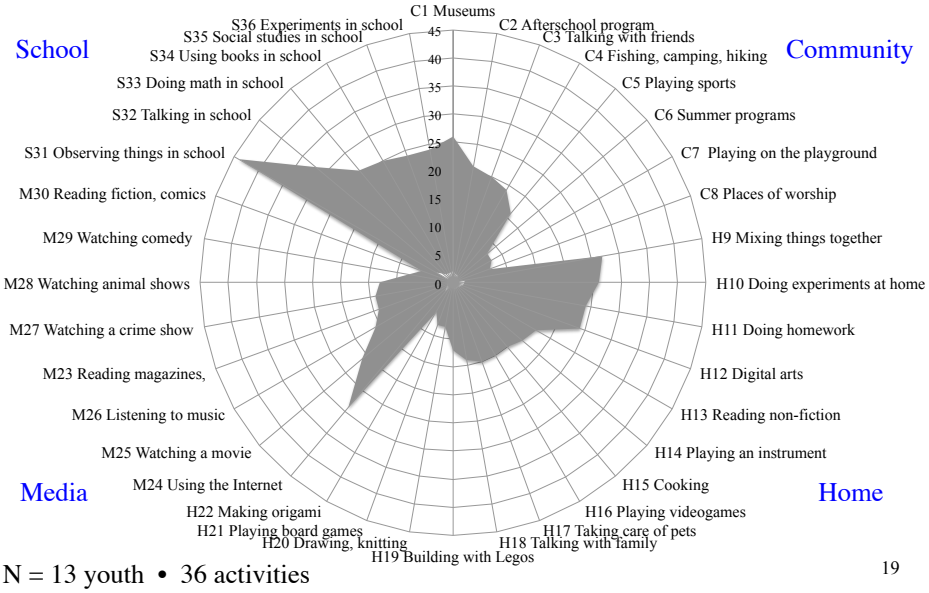
# Where Young People See Science: Everyday Activities Connected to Science




N = 13 youth • 36 activities

Zimmerman & Bell, 2012, *International Journal of Science Education*

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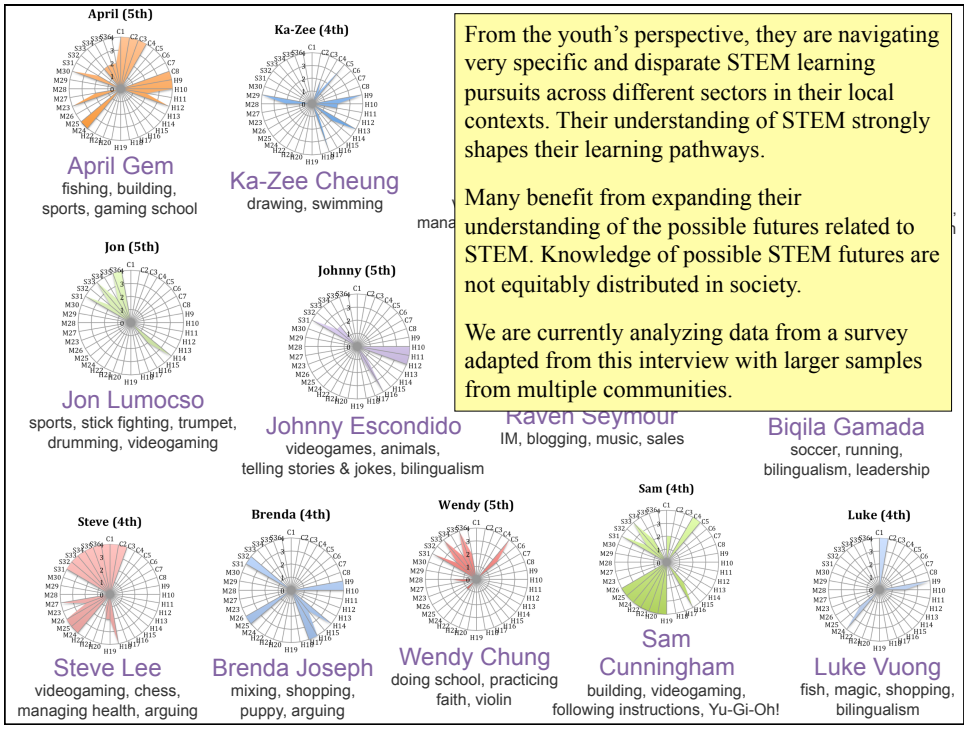


From the youth's perspective, they are navigating very specific and disparate STEM learning pursuits across different sectors in their local contexts. Their understanding of STEM strongly shapes their learning pathways.

Many benefit from expanding their understanding of the possible futures related to STEM. Knowledge of possible STEM futures are not equitably distributed in society.

We are currently analyzing data from a survey adapted from this interview with larger samples from multiple communities.

## Synthesis of High-Level Findings Across LIFE Studies

Finding: Youth who construct or are provided with personally meaningful STEM learning experiences and agency for their learning develop a sense of themselves as capable STEM learners.

Science-linked identities renegotiated in out-of-school time can transform their academic identities and their recognition as a science learner in school.

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## Afterschool Science Apprenticeship Case Study: Science Identification through Expanded Roles (Project COOL)

- Nick was African American high school youth not doing well in science class
- Reluctant to participate in informal ed
- Engaged in authentic science investigation; his work with peer and a happenstance structural circumstance provided Nick with expanded project and leadership roles
- Positioning led to increasingly important, visible role in the scientific work—and an improved academic identity with family and in school

Stromholt & Bell, in review

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## Design Principles for Equitable Extended Learning

- (Re)position youth as developing experts contributing to authentic project work
- Adverse stereotypes about youth need to be debunked and reframed
- STEM learning experiences should grow out of the lives of learners
- Broaden 'what counts as STEM' based on everyday and professional forms

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## Conclusions & Policy Strategies

- Educational equity and broadening participation should be a leading focus when cultivating STEM ecosystems. It is crucial to better understand the cultural range of extended STEM learning pathways that relate to local community interests (Lee, 2008; NRC, 2009).
- OST has a large impact on STEM learning around efforts that position youth in increasingly ambitious *project work* involving deep engagement in the *science & engineering practices*
- Also, the NRC Framework can be leveraged related to:
  - Building on prior interest and identity (p. 286)
  - Leveraging the cultural funds of knowledge of youth (p. 287)
  - Equalizing opportunities to learn STEM (p. 280)
- We have a shared set of STEM learning outcomes for "formal" and "informal" education—at least as a baseline (NRC, 2009, 2012). Different environments afford and constrain specific dimensions of this learning—but not along that particular dichotomy. We should flexibly build a redundant network of STEM "charging stations" within communities in and out of school as locally possible.

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## To Learn More...

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- Learning in Informal and Formal Environments (LIFE) Science of Learning Center
  http://life-slc.org/
- My contact info:
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