Advancing ecological designs for STEM: Biographical approaches as a resource for research and practice

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Need for new visions of assessment

- Exemplify synergistic models
- Identify transformative elements of ecosystems
- Map equality of resources
- Target opportunities for brokers, mentors, and collaborative partners

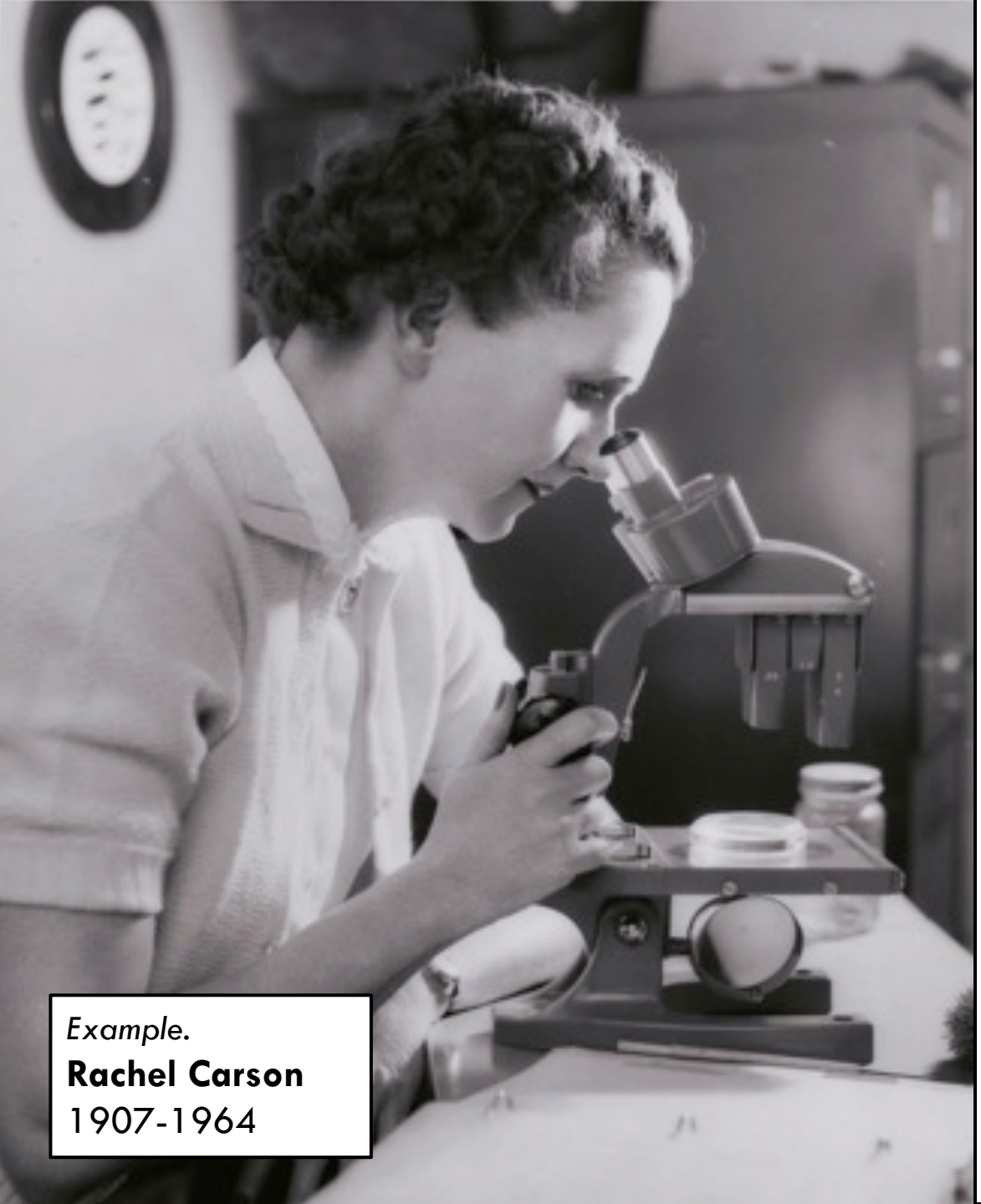
Questions for today

- What forms of assessment and approaches to research do we need to advance an ecological approach to STEM learning?

- How can we collectively engage in inquiry across projects to advance systemic design?

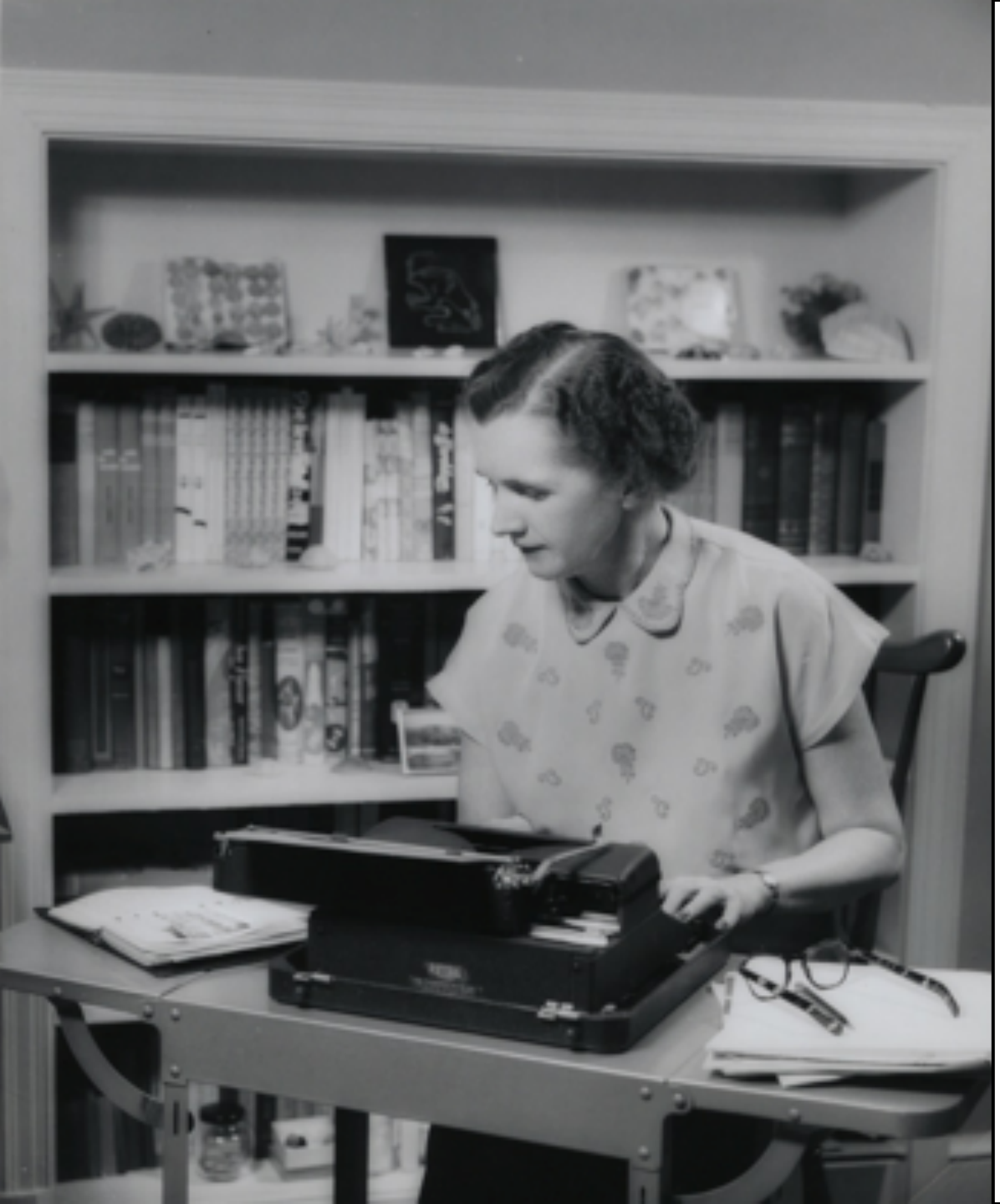
Danger of relying solely on near-term assessments

- Typically it is not one experience that makes a difference but **a confluence of opportunities;** *committed learning accumulates gradually*.
- If our assessment toolkit only has near-term measures, we may lose the opportunity to build a robust STEM ecosystem because we won't communicate its real value.
- We know from retrospective studies of scientists, science teachers, and science-interested citizens that there are multiple pathways to enduring interests. Consider the case of Rachel Carson…

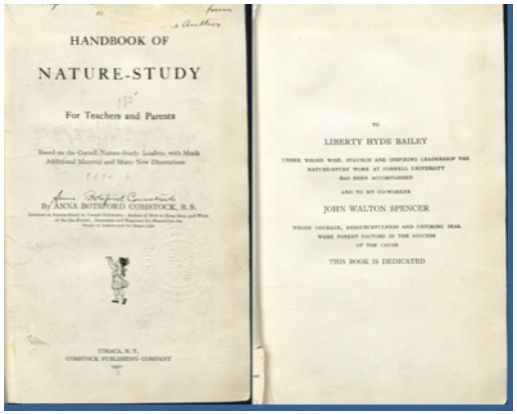


Example.
Rachel Carson
1907-1964

- Famous for launching the environmental movement with her book *Silent Spring*
- Her passion for science was not identified until she was a junior in college and fulfilling a science requirement by taking a biology class
- She decided to change her major from English and pursue a science degree
- But, in retrospect one can see the role of early experiences in preparing for her future engagement in both writing and connection with natural world



- Writing was her first passion and becoming a writer was her career objective
- The children's literary magazine *St. Nicholas* was a source of inspiration; she published her first story there in 1918, at age 10
- Her mother engaged her in daily nature walks, drawing on ideas from the 1911 *Handbook of nature study: For teachers and parents*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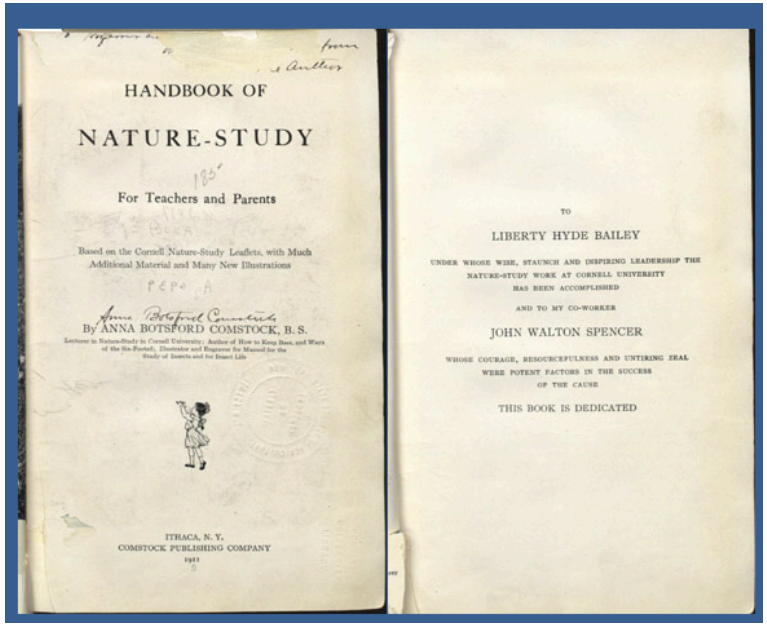
For Teachers and Parents
By ANNA BOTSFORD COMSTOCK, B.S.
TO
LIBERTY HYDE BAILEY
AND TO MY CO-WORKER
JOHN WALTON SPENCER
THIS BOOK IS DEDICATED

Lear (1997) Witness for Nature

Ideas in the air: Conceptual and experiential ecology

- *Handbook of Nature Study* was linked to a broader movement led by progressive educators and scientists
- Congruent focus in the children's magazine *St. Nicholas*, publishing articles on nature as well as fiction
- Local library provided favorite books including the Beatrix Potter series – her later approach to scientific writing develops animal characters to build empathy and dramatize prose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AND TO MY CO-WORKER
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WHOSE COURAGE, RESOURCEFULNESS AND UNTIRING ZEAL WERE POTENT FACTORS IN THE SUCCESS OF THE CAUSE
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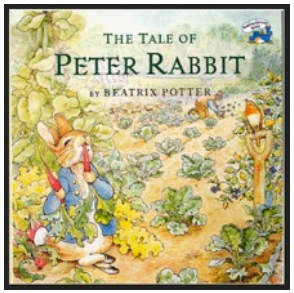
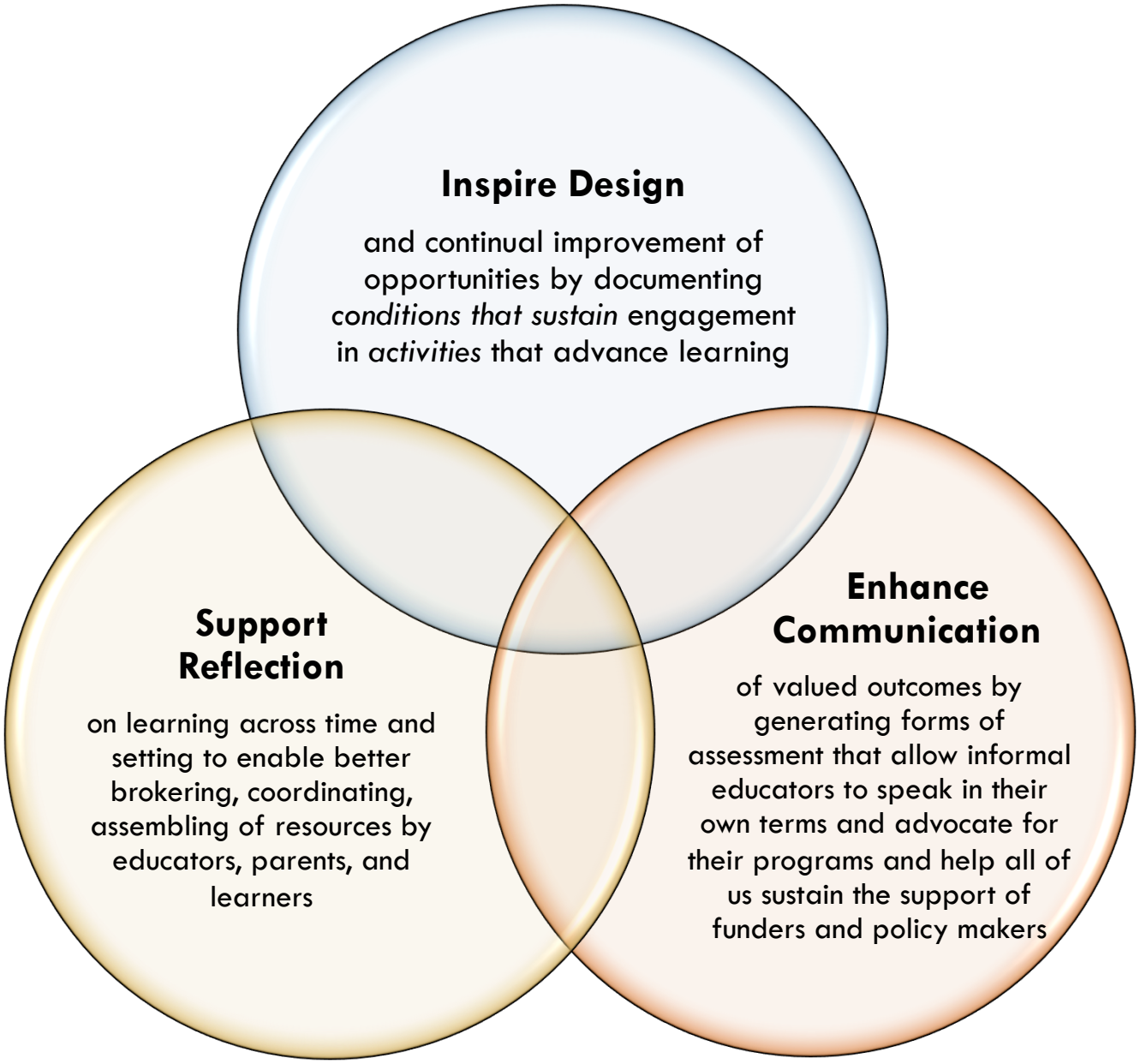


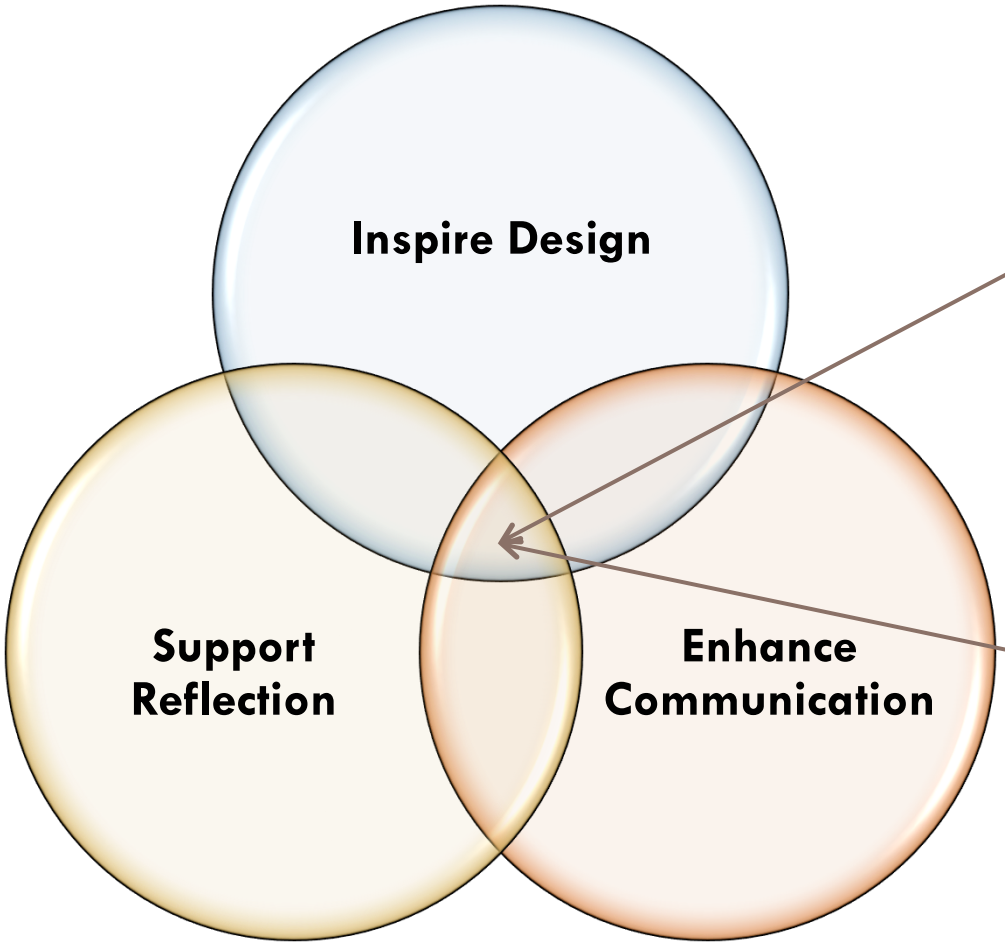
Implications

- We can speculate that her early experience observing the natural world, guided by her mother and the curriculum embodied in Nature Study laid the foundation for her transformative experience in a college biology class,
- And both that experience and her immersion in reading and writing literature were influential in her later career pathway and eventual contribution to environmental science.
- Had she been asked early on about a career in science she probably would have said no, despite the enduring influence of her connection to her local ecology and informal inquiry experiences.
- So, we need assessment approaches that can capture continuities and discontinuities, in relation to all kinds of learning opportunities and choices

Additional Requirements



Assessment to advance ecological approaches to STEM learning

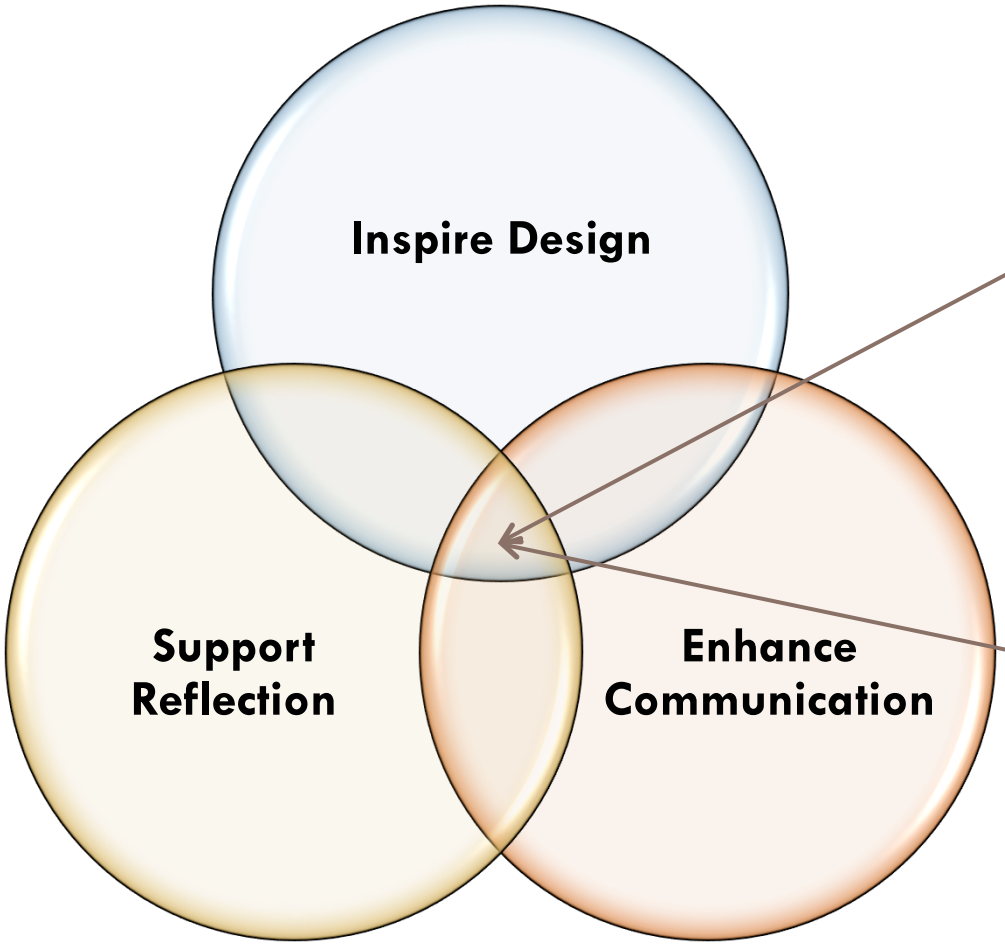


Place-based

Records:
Video and observation of interactions, practices, activities, relationships

Representations:
Documentaries, activity guides, curriculum, text based description

Assessment to advance ecological approaches to STEM learning



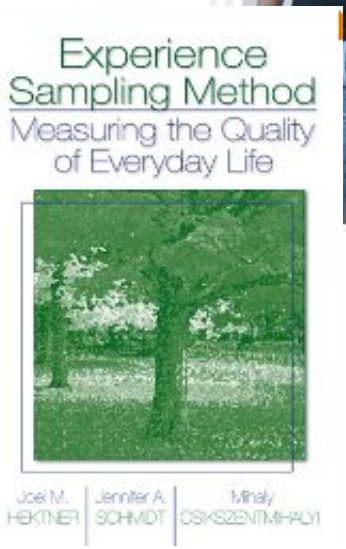
Person-based

Records:
Biographical, observational, spatial, histories of relationships

Representations:
Narratives, timelines, social networks

Alternative assessments

- Portfolio approaches
- Performance assessments
- Narrative evaluations
- Video records of activity
- Continuous language input
- Experience sampling
- **Biographical studies and representations**

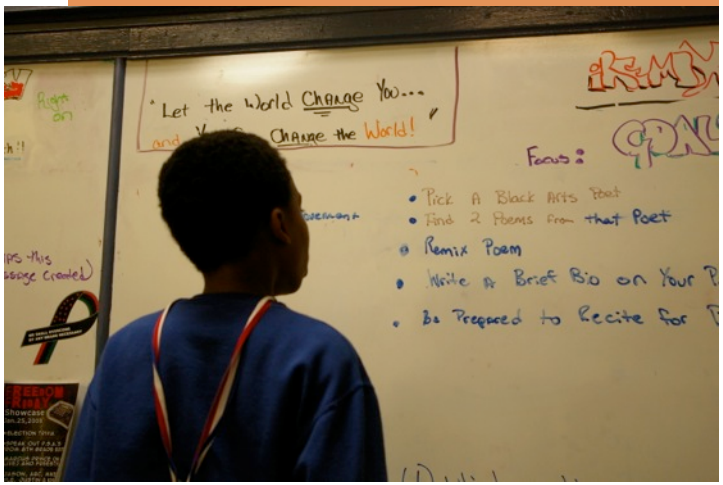


Methodological roots: Life course studies

- Retrospective case based approaches (e.g. Bloom, 1985), life course and longitudinal studies more generally (Elder, 1974; Eccles, 2002; Gruber, 1981; Plath, 1980).
- Cross-setting ethnographies of STEM learning (E.g., Azvedo, 2011, 2012; Barron, Gomez, Pinkard, Martin, 2014; Bell, 2012; Calabrese-Barton, 2011, 2013; Crowley, Barron, Knudson, Martin, 2014; Polman, 2012; Leander, 2006; Tai and colleagues; Zimmerman, 2014)
- Capture experiences, choices, temporal shifts, the nature and role of learning opportunities

Mapping Personal Learning Ecologies

Designers and activists at the Digital Youth Network in Chicago



Partnering with innovative STEM programs in and out of schools to theorize *sustained engagement in activities for learning*

Digital Creators in a high tech public school in Silicon Valley

Media Makers at Intel Computer Clubhouses

Citizen Scientists for Vital Signs in Maine

Biographical approaches to complement near term assessment

Ontology for Sustained Engagement in Activities for Learning

- Creating personal projects beyond structured opportunities
- Choosing to participate in activities or courses
- Seeking out informational resources for learning
- Developing learning partnerships, identifying guides, collaborators
- Sharing expertise with family, peers, community

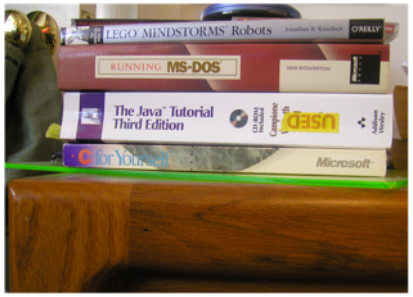
For today, five quick examples of learner biographies

Craig

Robotics hobbiest in high-tech public school in Silicon Valley

I don't remember like the first time, but I do remember some early experiences with computers. *I thought they were fascinating, how they were such a little machine but could do so many things.* …I always watched my Dad kind of on the computer and how he would do different things, open different things. I just thought it was amazing how it did everything and it did it so quickly. —*Craig, 8th grade*

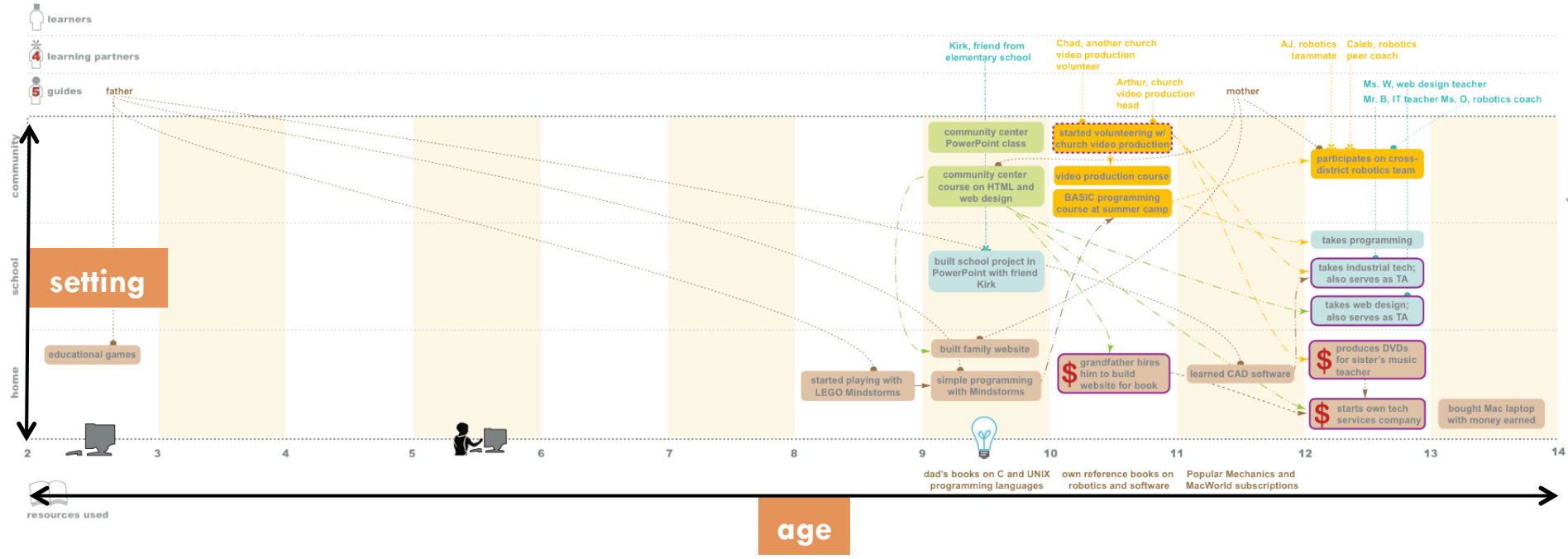
Craig



- 13-years-old, 8th grade
- Silicon Valley
- Specialized expertise at **home** (father is an engineer)
  - Early onset of tech activities; robotics kits at age 8 with dad
  - Extensive access to books, software, computers, cameras
- Silicon Valley **community** expertise and opportunities
  - Age 9: Took summer classes on web design, HTML
  - Age 11-13: Apprenticed church videographer
- Public middle **school** with tech-focused classes and electives
  - Took programming, web design, industrial technology classes grade 7
  - Joined the robotics club, identified by his mother, mentored by his father
- **Sustained Engagement in Activities for Learning**
  - Grandfather hired him to build a website; learned through books, online forums
  - Started multiple money-generating businesses
  - Joined robotics club in high school

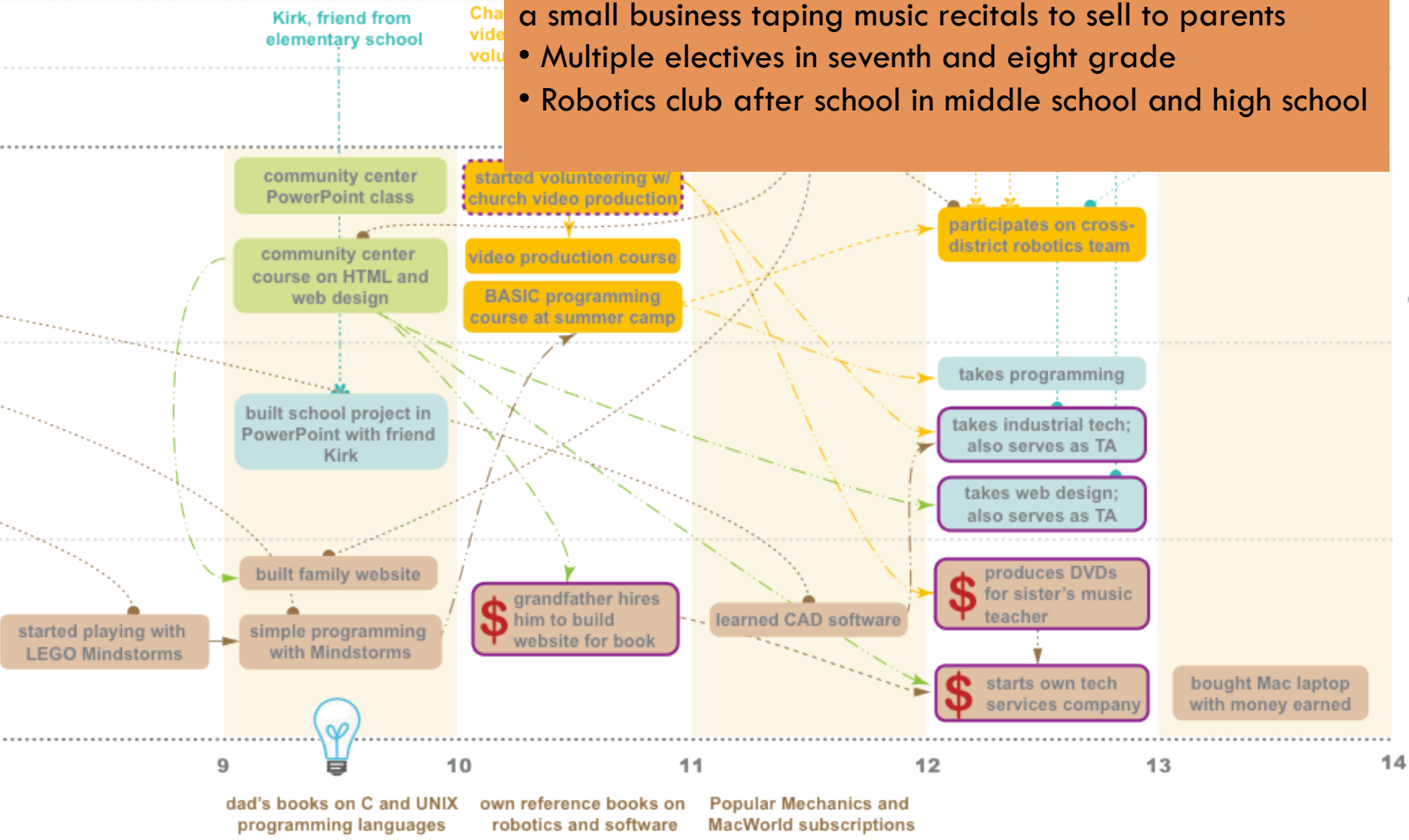
Craig

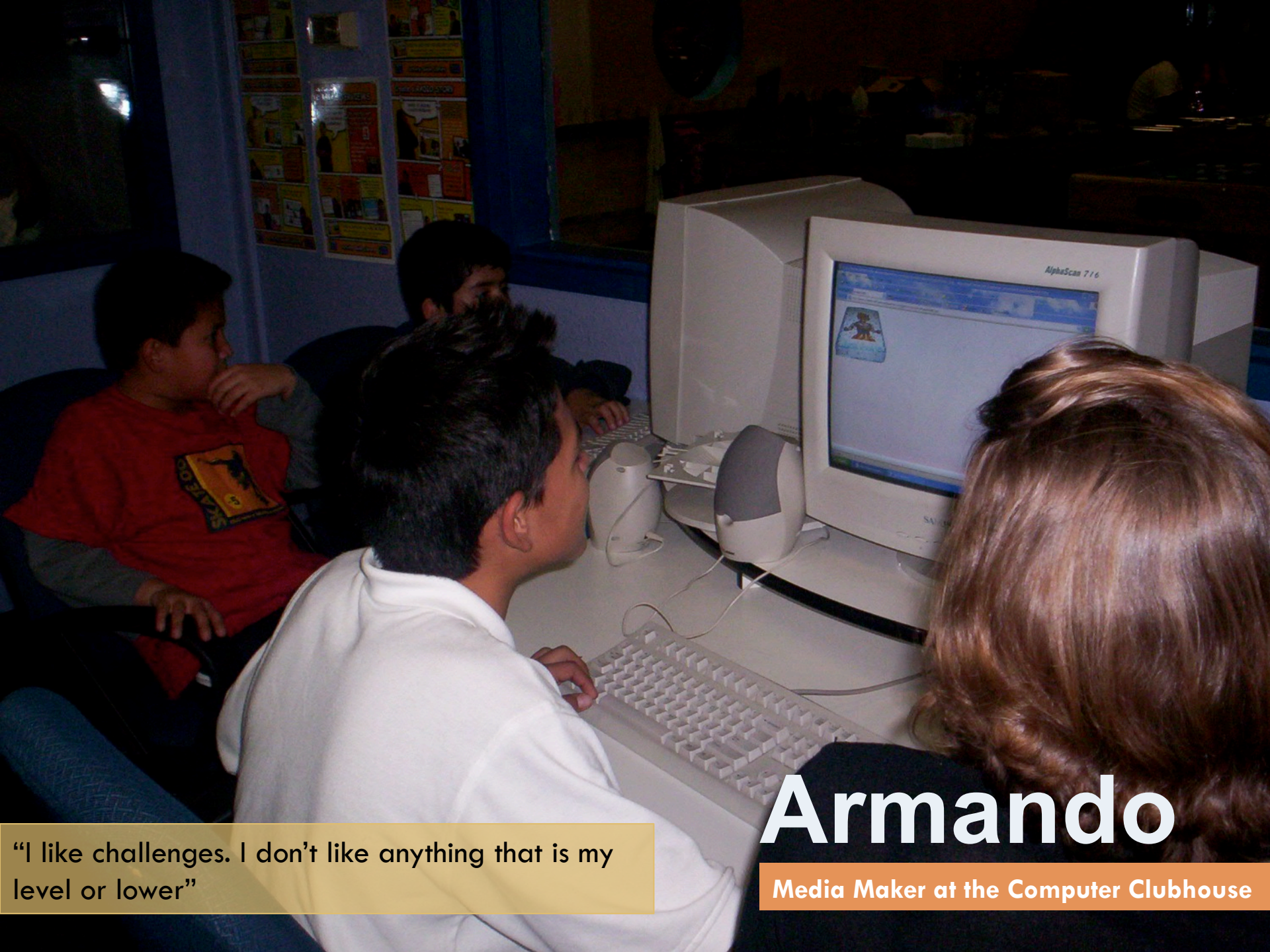
learning network



Sustained Engagement in Activities for Learning:

- Apprenticeship with church videographer set the stage for a small business taping music recitals to sell to parents
- Multiple electives in seventh and eight grade
- Robotics club after school in middle school and high school



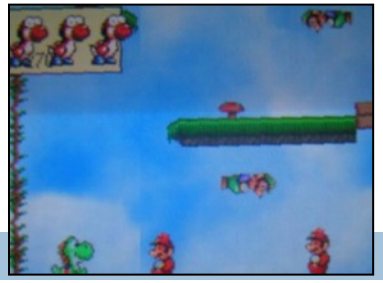


Armando

Media Maker at the Computer Clubhouse

"I like challenges. I don't like anything that is my level or lower"

Armando



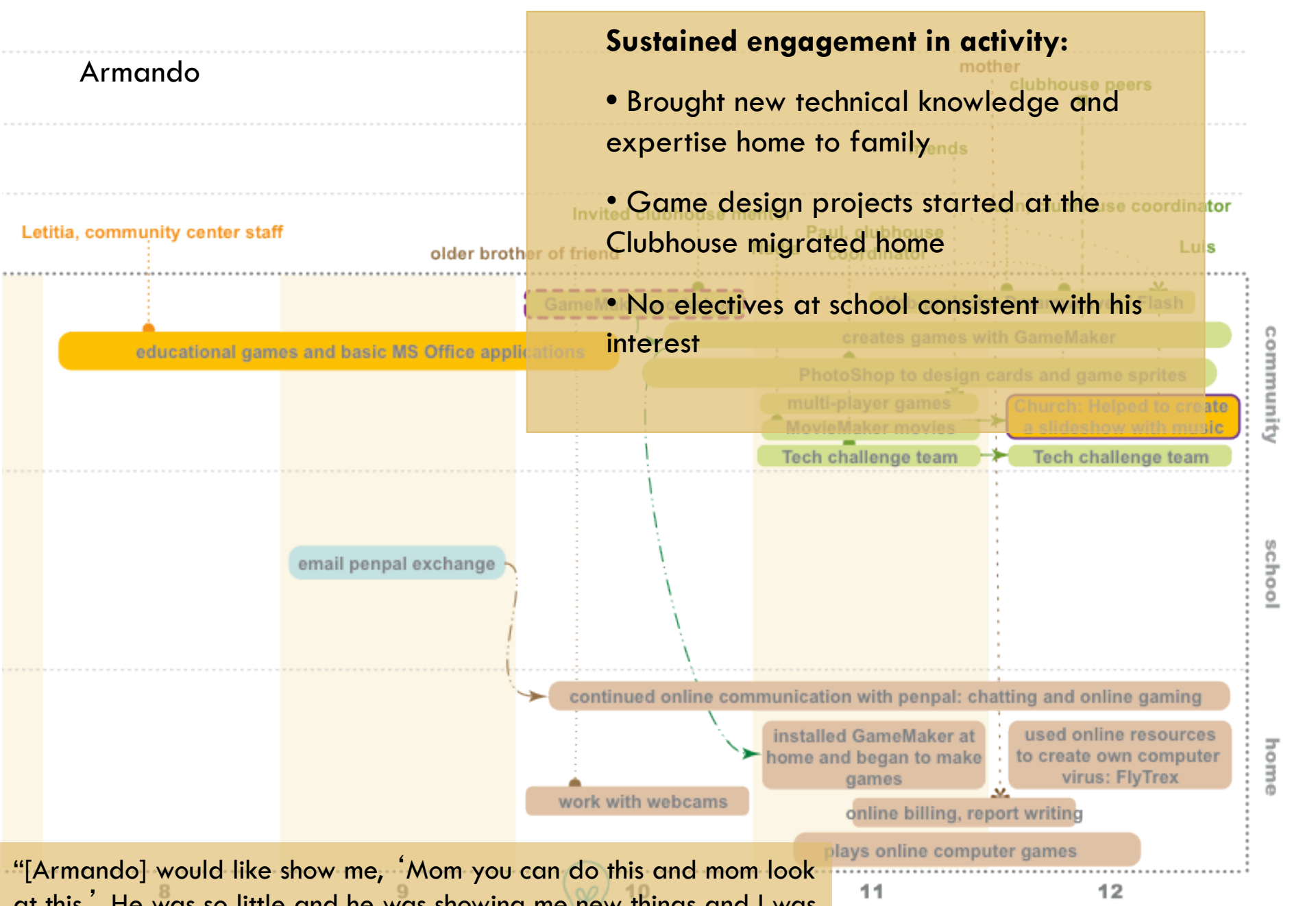
- 12-years-old, 7th grade
- Silicon Valley, public middle school
- 1 computer at **home** that family shares with neighbors
  - Single-parent household; 2 younger siblings
  - Family immigrated to U.S. after Armando was born in Central America
  - Mom works at day-care center and is pursuing undergrad degree
- A regular at the **Computer Clubhouse** at local **community** center
  - Avid video game designer; interested in programming, viruses
  - Attended a game design workshop led by guest Clubhouse mentor
- No technology related courses at his public middle **school**
- **Sustained Engagement in Activities for Learning**
  - Brought new technical knowledge and expertise home to family
  - Game design projects started at the Clubhouse migrated home

GameMaker: Studio

Armando

Sustained engagement in activity:

- Brought new technical knowledge and expertise home to family
- Game design projects started at the Clubhouse migrated home
- No electives at school consistent with his interest



"[Armando] would like show me, 'Mom you can do this and mom look at this.' He was so little and he was showing me new things and I was like – amazing to see how he was learning and showing to me so I am really happy that – **he has been like a teacher for me.**"

Calvin

Designer at the Digital Youth Network in Chicago

"When I apply for an engineering job, I will say I have had eleven years with working with technology from middle school to college. . . . I remember one of my friends asked, "Why do you want eleven years of technology?" I just said, '*Because I just need it—I just want it to make a good foundation, so once that foundation is finished, then I can start getting a job. Then one day maybe I will make history.*"

—Calvin (8th grade)

Calvin

digital youth network

- 11-years-old, 6th grade
- South side of Chicago
- Charter school with **classroom, after school, online** **DYN** programming
  - Laptop program starting in 6th grade
  - Participated in 9 after school tech clubs (called “pods”)
  - Especially captivated with game design and robotics
  - Guidance and encouragement from multiple mentors
- 1 computer at **home** shared by 6 people
  - Developed aspirations to be an engineer
- **Sustained Engagement in Activities for Learning**
  - Became known at school as a game design expert
  - With laptop and pod skills, created 20 + projects outside of class requirements
  - Taught younger brother about game design and software

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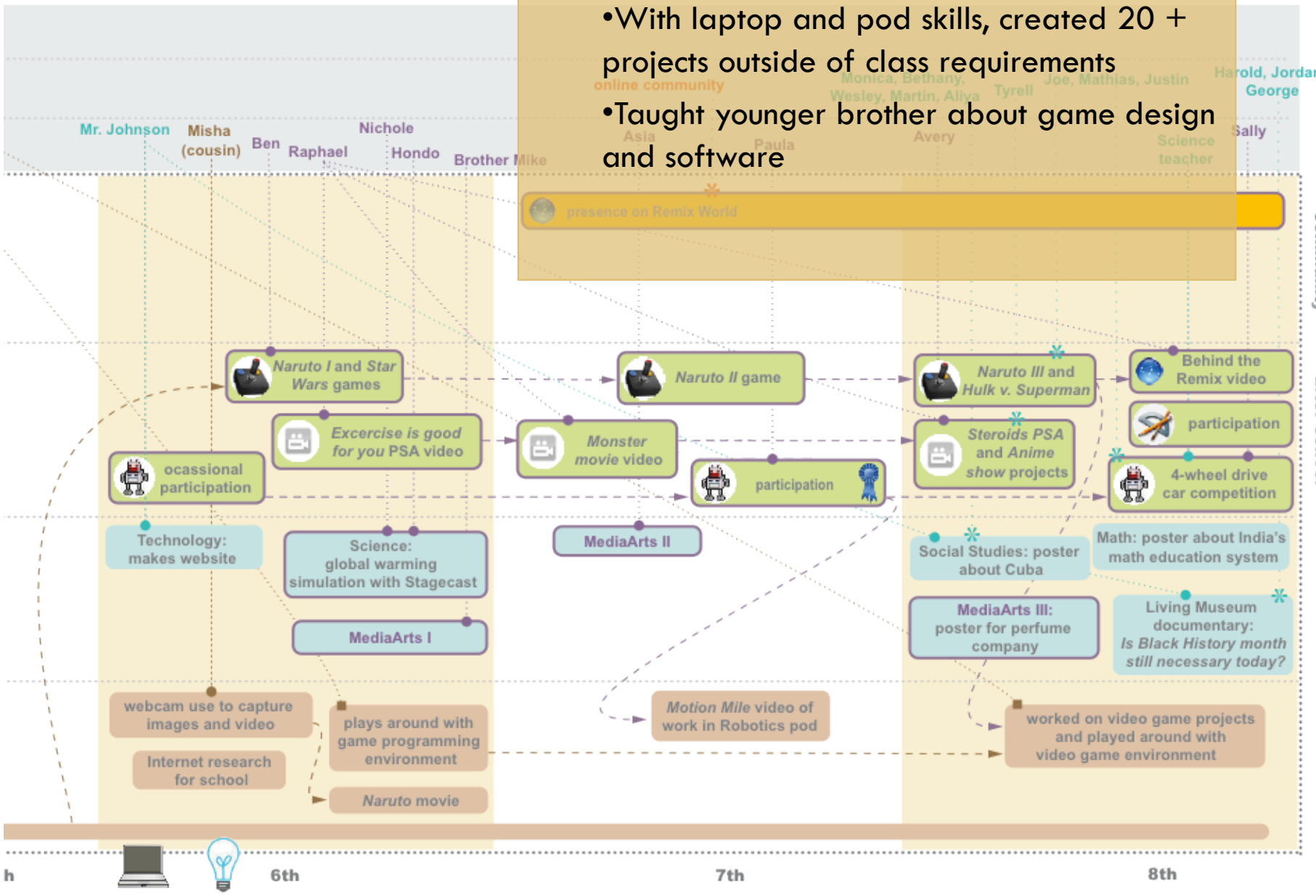
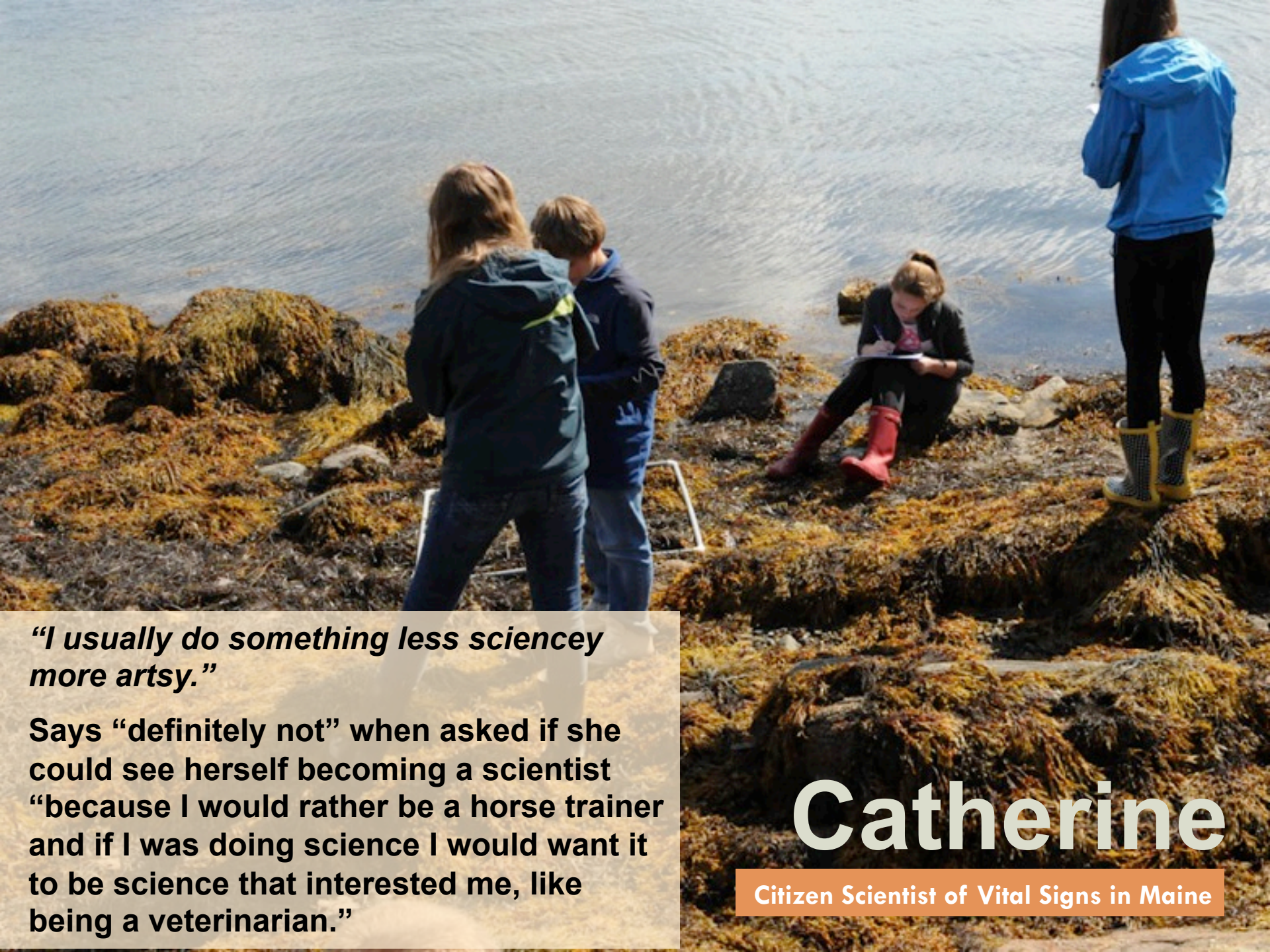
Sustained engagement in activity:

- With laptop and pod skills, created 20 + projects outside of class requirements
- Taught younger brother about game design and software





Catherine

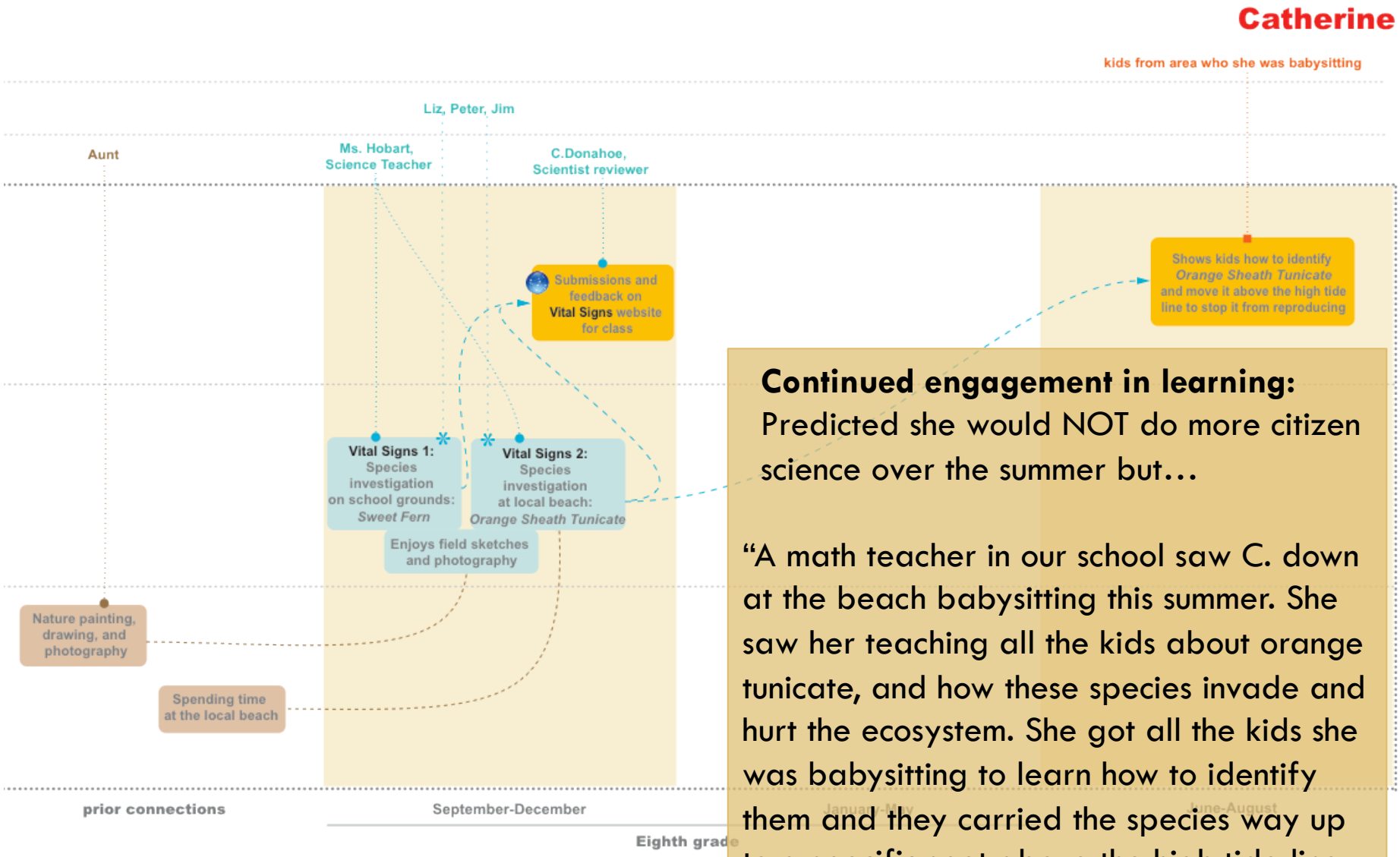
Citizen Scientist of Vital Signs in Maine

"I usually do something less sciencey more artsy."

Says "definitely not" when asked if she could see herself becoming a scientist "because I would rather be a horse trainer and if I was doing science I would want it to be science that interested me, like being a veterinarian."

Catherine

- 13-years-old, 8th grade
- Coastal Maine, loves animals and nature
- Lives at **home** with parents and older brother
  - Support for her interest in art and music
  - Aunt is a professional painter; they paint nature together
- Public middle **school**, only 4% qualify for subsidized lunch
  - Science teachers take students in the field to investigate local invasive species
  - Students contribute their data to **Vital Signs**, a networked citizen science program
  - Predicted she would NOT do more citizen science over the summer
- **Continued engagement in learning activities**
  - Leads **community** intervention during the summertime



Continued engagement in learning:
Predicted she would NOT do more citizen science over the summer but…

"A math teacher in our school saw C. down at the beach babysitting this summer. She saw her teaching all the kids about orange tunicate, and how these species invade and hurt the ecosystem. She got all the kids she was babysitting to learn how to identify them and they carried the species way up to a specific spot above the high tide line to dry it out so it wouldn't reproduce."

—Catherine's Vital Signs teacher

Naomi

Citizen Scientist of Vital Signs in Maine

One, I want to pass middle school….Then I want to go to a college that specializes in entomology and biology.

Naomi

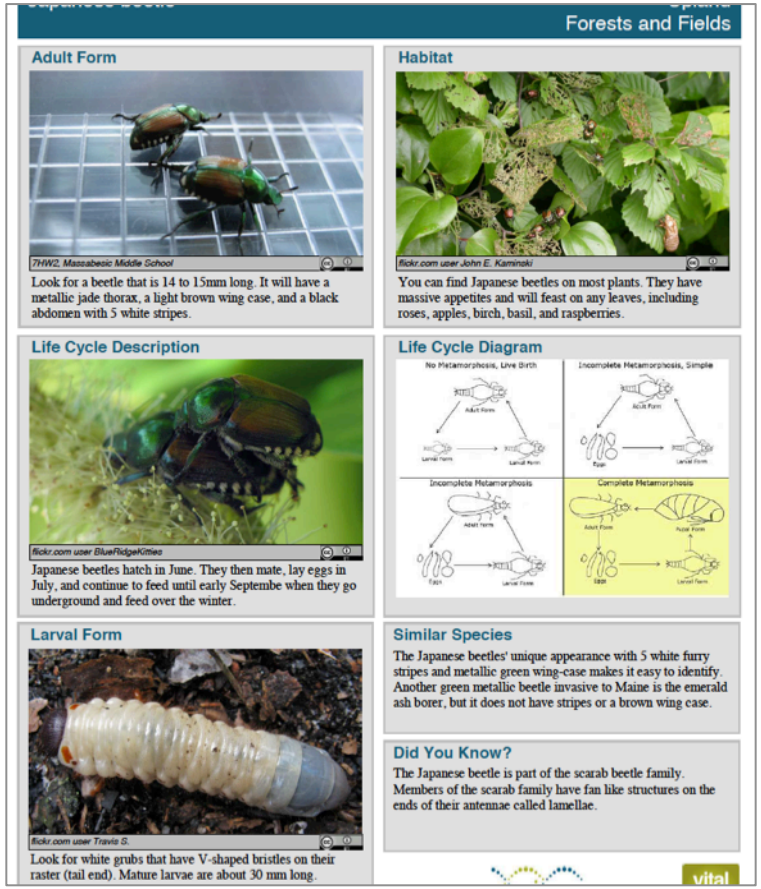
- 13-years-old, 8th grade
- Rural public middle **school**, 35% subsidized lunch
  - Participates in **Vital Signs** in 7th grade
  - Teacher recognized her enthusiasm and interests
  - Known as bug expert in school and on Vital Signs

- Lives at **home** with parents and older sister
  - Enjoys exploring the woods around her house
  - Observes, sketches and collects bugs in backyard
  - Uses online sources and books to identify and learn about bugs

- Shares through online **communities**
  - Blogs about her crocheting
- **Sustained engagement in activities**
  - Opportunities to publish for wider audience
  - Summer investigations on her own with recognition
  - Refined home insect documentation techniques

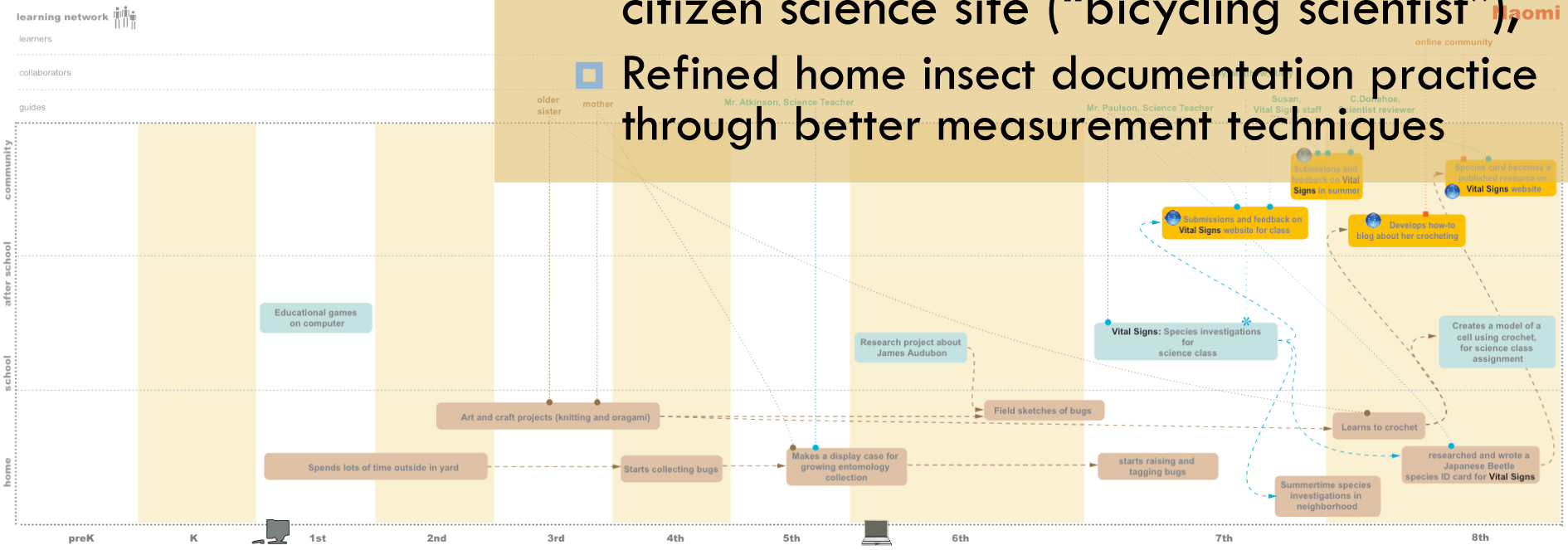
Opportunities to publish

Mr. P noticed that I had an interest for entomology, and so when we were doing Vital Sign's project, he came to me with a lot of entomological questions, and he saw that I really, really, really like Vital Signs. So he thought that, one. It is insects and two It is Vital Signs—[so] I might really like to do it (create a field guide). —*Naomi*



Sustained engagement in activities:

- Summer investigations on her own submitted to Vital Signs with Broader recognition on citizen science site ("bicycling scientist"),
- Refined home insect documentation practice through better measurement techniques



Intersection biographies: Links to educator practices

1970

Hunts & fishes growing up in rural N. Maine

Interest in science sparked

Teacher inspiration: Sister Madeline

"She took us on a field trip to a bog, and when we got to see pitcher plants with bugs in them and the sundew—the carnivorous plants, like, 'Holy cow!'"

1974-8

College: Majors in Natural Resource Management

1979

Receives masters in teaching

1980s

Teaches high school science in S. Maine

1994

Begins teaching middle school science

2008

NSTA conference: focus on invasive species

Practice as citizen scientist

"I decided that it was going to be worth the while to get out again [with students], and so I spent a summer making mistakes in N. Maine doing my own investigations."

2009

Teacher Institute for ME invasive species citizen science program

Project Learning Tree grant for field resources: paths on school grounds and a picnic table

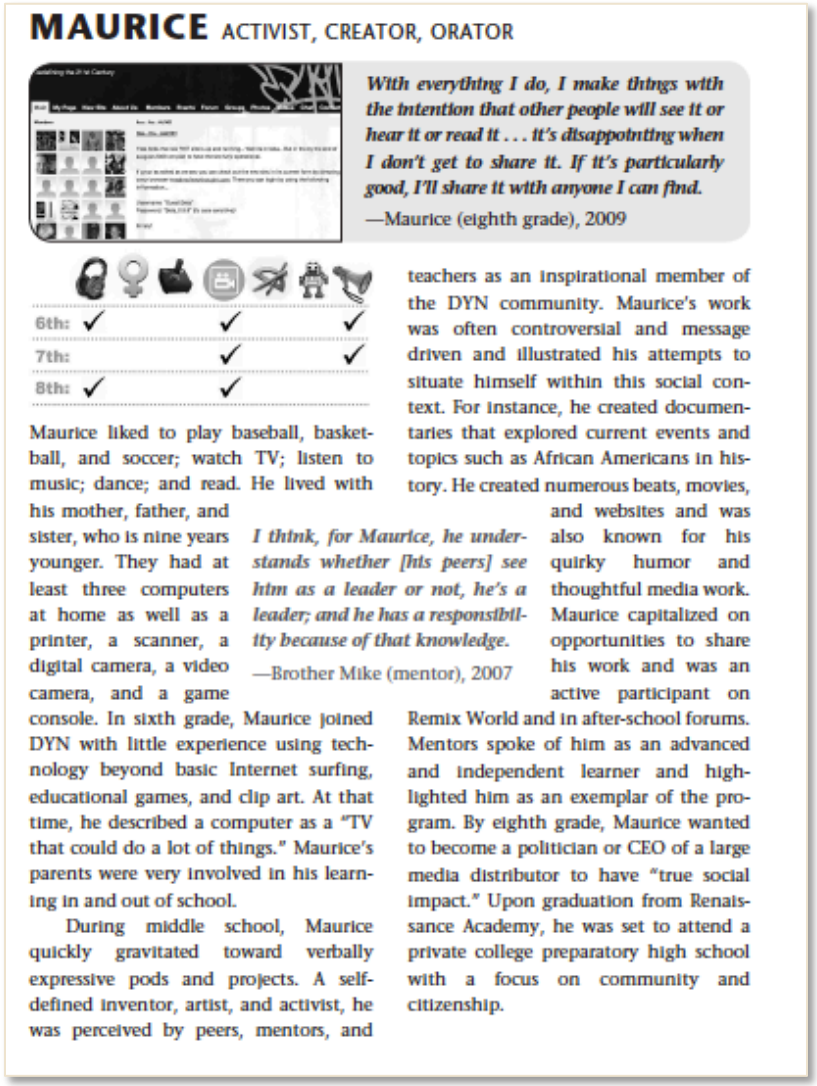
2010

Inspiring middle school students in the field

2012

Enhancing communication:

Narrative representations



MAURICE ACTIVIST, CREATOR, ORATOR

With everything I do, I make things with the intention that other people will see it or hear it or read it . . . it's disappointing when I don't get to share it. If it's particularly good, I'll share it with anyone I can find.

—Maurice (eighth grade), 2009

6th:	✓	✓	✓
7th:		✓	✓
8th:	✓	✓	

Maurice liked to play baseball, basketball, and soccer; watch TV; listen to music; dance; and read. He lived with his mother, father, and sister, who is nine years younger. They had at least three computers at home as well as a printer, a scanner, a digital camera, a video camera, and a game console. In sixth grade, Maurice joined DYN with little experience using technology beyond basic Internet surfing, educational games, and clip art. At that time, he described a computer as a "TV that could do a lot of things." Maurice's parents were very involved in his learning in and out of school.

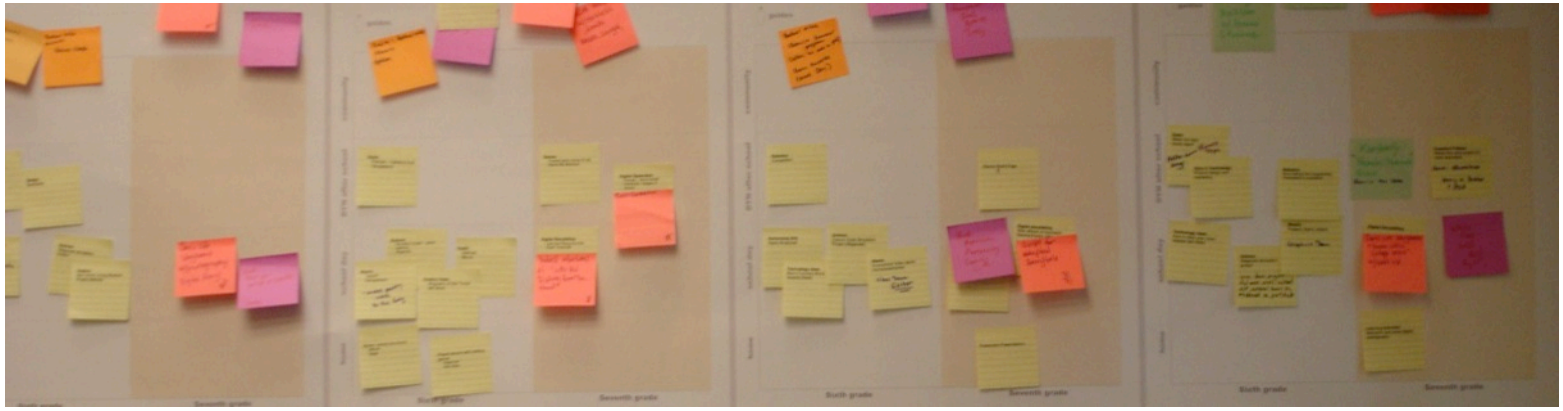
During middle school, Maurice quickly gravitated toward verbally expressive pods and projects. A self-defined inventor, artist, and activist, he was perceived by peers, mentors, and teachers as an inspirational member of the DYN community. Maurice's work was often controversial and message driven and illustrated his attempts to situate himself within this social context. For instance, he created documentaries that explored current events and topics such as African Americans in history. He created numerous beats, movies, and websites and was also known for his quirky humor and thoughtful media work. Maurice capitalized on opportunities to share his work and was an active participant on Remix World and in after-school forums. Mentors spoke of him as an advanced and independent learner and highlighted him as an exemplar of the program. By eighth grade, Maurice wanted to become a politician or CEO of a large media distributor to have "true social impact." Upon graduation from Renaissance Academy, he was set to attend a private college preparatory high school with a focus on community and citizenship.

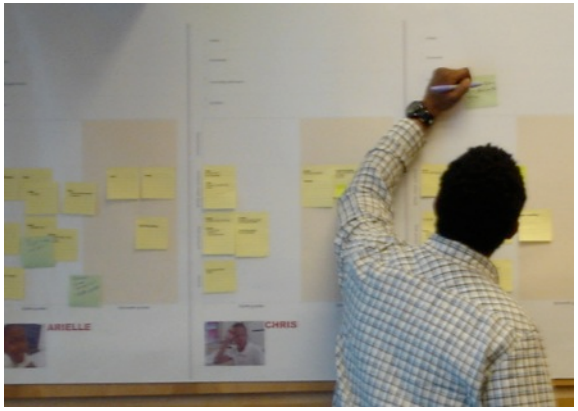
I think, for Maurice, he understands whether [his peers] see him as a leader or not, he's a leader; and he has a responsibility because of that knowledge.

—Brother Mike (mentor), 2007

- Allow us to share learning biographies that include point of view, meaning making, and that incorporate words of child, family, mentors, teachers, friends
- Possible to use as case-based materials for mentors or leaders

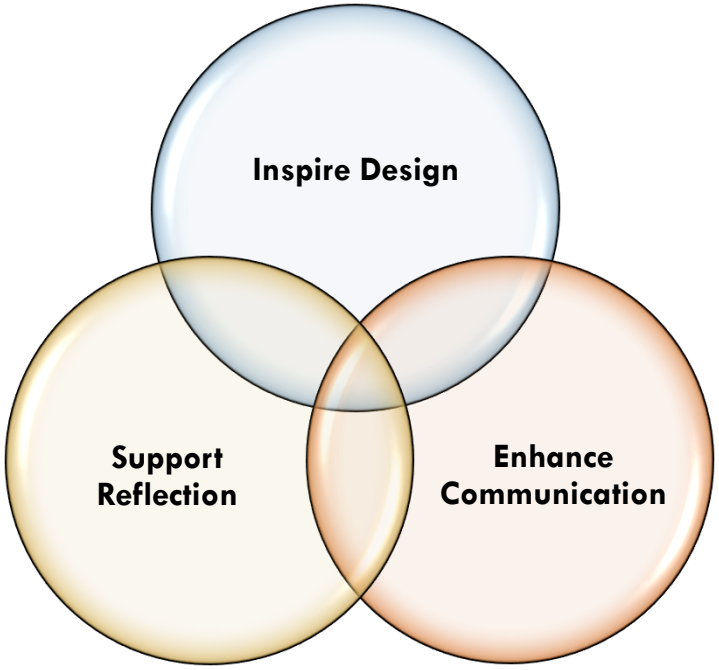
Supporting reflection:
Joint construction of maps



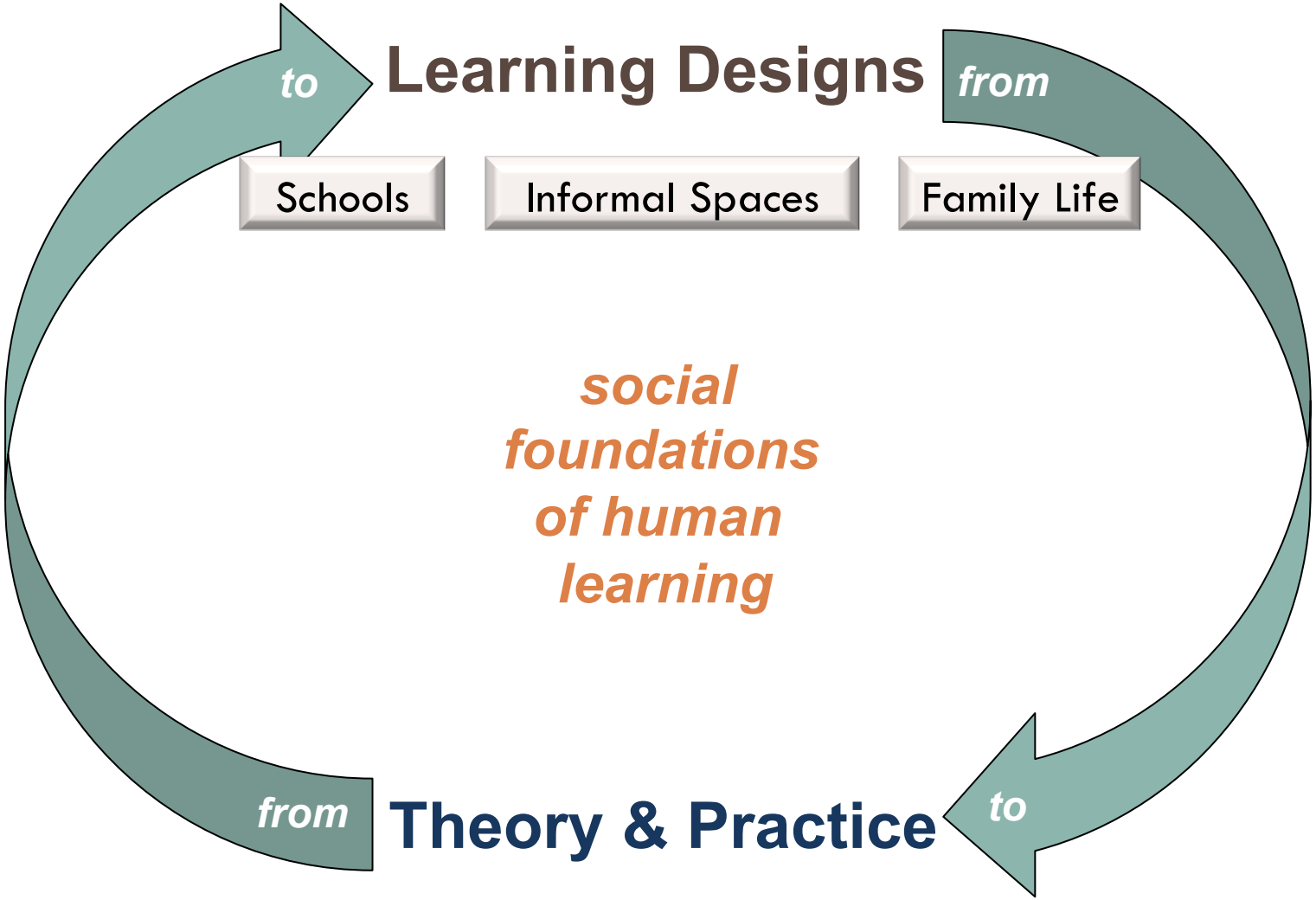


Summing up: Biographical representations can . . .

- Help researchers see, map, and describe sustained engagement in activities for learning what Maehr (1976) called *continuing motivation*.
- Identify critical roles that parents, educators, peers play in brokering and encouraging new opportunities
- Map equality or lack thereof in learning opportunities
- Inspire designers to create activities and resources that may cross setting
- Lead Educators, parents, and learners to reflect on their broader learning ecology and identify needs and opportunities
- Help informal educators communicate program goals and provide examples of positive outcomes and ways to improve



Use-Inspired Research



Closing: Next steps

- Biographical approaches are an important complement to other research and assessment approaches
- Collections of narratives across projects could be a powerful resource for the STEM field to inspire designers, educators, and funders
- They are labor intensive; we need to develop tools to make them easier, faster, and quantifiable to begin to validate continued engagement as a valued outcome of out-of-school STEM learning opportunities

Not everything that matters can be measured and not everything that is measured matters.

—Elliot Eisner, 1933-2014

Expanding range of valued outcomes

I sincerely believe that for the child, and for the parent seeking to guide him, it is not half so important to know as to feel. If facts are the seeds that later produce knowledge and wisdom, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow. …Once the emotions have been aroused – a sense of the beautiful, the excitement of the new and the unknown, a feeling of sympathy, pity, admiration, or love—then we wish for knowledge about the object of our emotional response. Once found, it has lasting meaning. It is more important to pave the way for the child to want to know than to put him on a diet of facts that he is not ready to assimilate.

—*Rachel Carson,* The Sense of Wonder

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Thanks to the program designers, parents, teachers, mentors, and youth who contributed their time to this effort.

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