Through Their Eyes: Visualizing Engineering Learning

NSF (2415796): Collaborative Research: Identifying Features of Informal Engineering Programs that Foster Youths' Engineering Identities

February 25, 2026

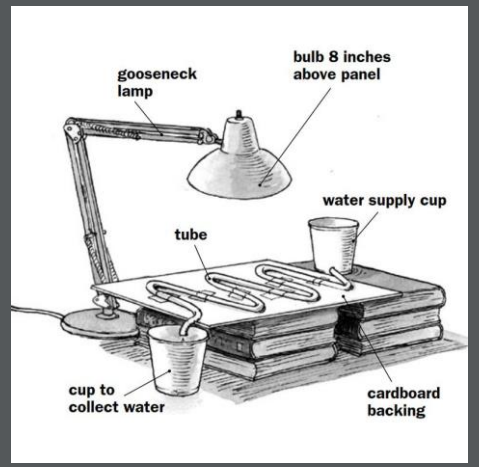
St. Elmo Brady STEM Academy (SEBA) Overview

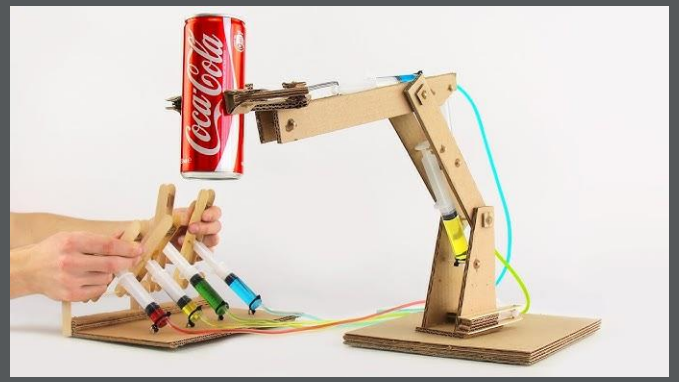
- Named after **St. Elmo Brady,** the first African American to earn a Ph.D. in Chemistry and a graduate of the University of Illinois
- First implement in 2013 in Illinois; Implemented in Houston since 2017

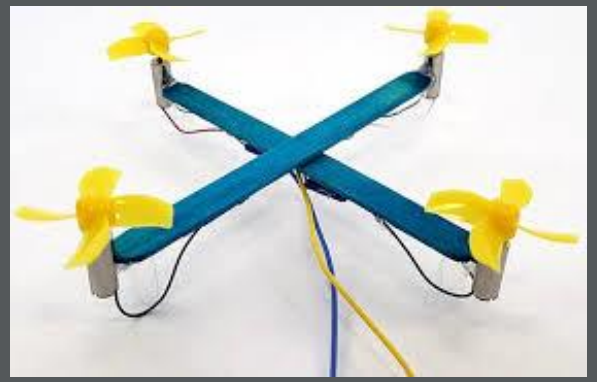
- Currently implemented in 4 locations (sites)
- Meets 3 days per week
- 16 weeks- 8 weeks Fall semester & 8 weeks Spring semester
- Hands-on STEM experiments
- Scientist of the Week (Day 1) & Math Problem of the Day (Days 2 & 3)
- Engage faculty, staff, students (4th & 5th grade/ UH undergraduates), and teachers
- Family engagement- families conduct experiments alongside participants
- Field trips to museums and laboratories
- Community Engineering Fair

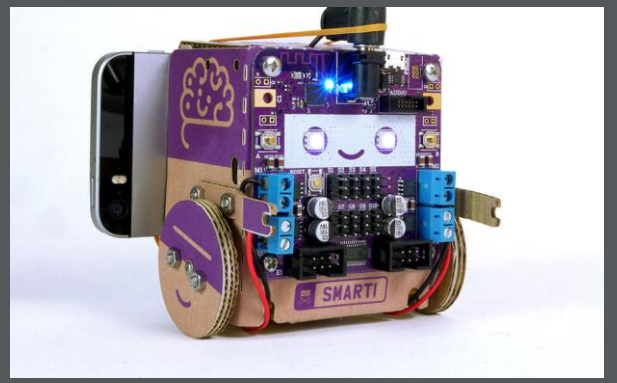
Example Design Projects

Week 1- Windmill Design
Week 2- Bio-gel Capsule Design
Week 3- Hydraulic Robot Design
Week 4- SmartiBot Build & Code
Week 5- SmartiBot Build & Code II
Week 6- Solar Water Heater Design
Week 7- Drones for Package Delivery
Week 8- Mint Mobile Design









AISL Project Goals

- Further develop P12 Framework-inspired engineering lessons that focus on engineering habits of mind and practice (widely disseminating)
- Deepening existing community partnerships and building additional ones
- Add to the extant literature on informal engineering learning (outlined in the research plan) and execute the end-of-the-year community engineering fair and photovoice exhibit

Components of Three-Dimensional Engineering Learning

DIMENSION 1: ENGINEERING HABITS OF MIND	DIMENSION 2: ENGINEERING PRACTICES	DIMENSION 3: ENGINEERING KNOWLEDGE DOMAINS
Optimism	Engineering Design	Engineering Sciences
Persistence	Material Processing	Engineering Mathematics
Collaboration	Quantitative Analysis	Engineering Technical Applications
Creativity	Professionalism	
Conscientiousness		
Systems Thinking		

What word(s) come to mind when you see this picture?

Why Photovoice?

- *Break past* language, traditional communication barriers, and power dynamics between researchers and participants
- Point to *different perspectives* than the mainstream narrative (Aboulkacem et al., 2021)

Three main objectives

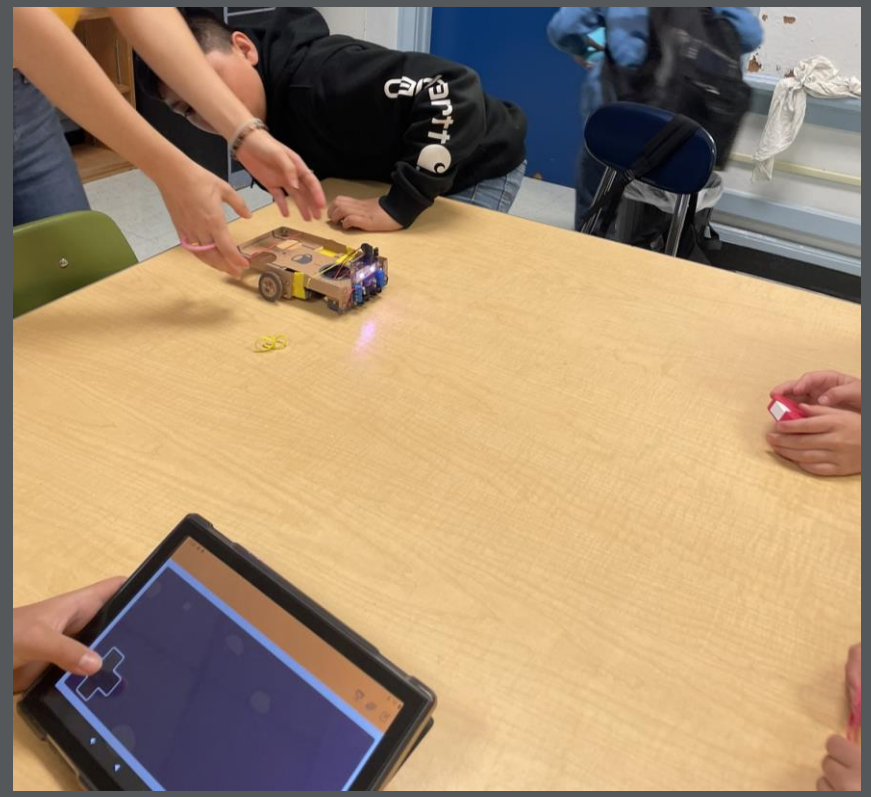
- Documenting and *reflecting* on one's community (Herrera et al., 2023)
- Engaging in *collaborative* group discussions (Henderson et al., 2023)
- *Promoting change* by reaching out to leaders and decision-makers within that community (Aboulkacem et al., 2021; Wang, 2022)

Researching **with** youth & mentors, **not on** them

Preliminary Findings
Address 2 Research Questions (RQs)

RQ 1: What aspects of engineering learning are exhibited within the informal learning environment?

RQ 2: What does student-centered practice mean in this learning environment, and how do mentors implement it?



How We Captured the Story

- Youth (n = 14)
- Mentors (n = 4)
- Open-ended Photovoice Prompts
  - Capture a picture of yourself, your team, or something that represents engineering.
  - Capture a picture illustrating what student-centered engineering practice looks like to you.

Provided by team 1 day per week

Submit camera & team downloads

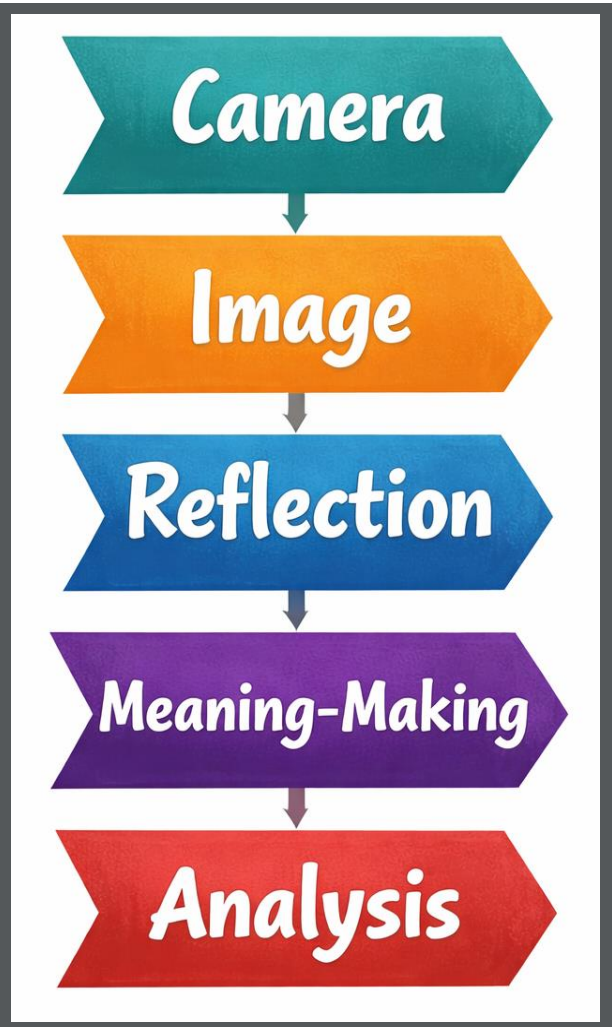
Select favorite 1 or 2 to discuss in focus group

"SHOWeD Method"

- What do we **s**ee here?
- What's really **h**appening
- How does it relate to **o**ur lives?
- Why does this strength/challenge exist?

Lived Experience-anchored in youths' words

- Thematic analysis



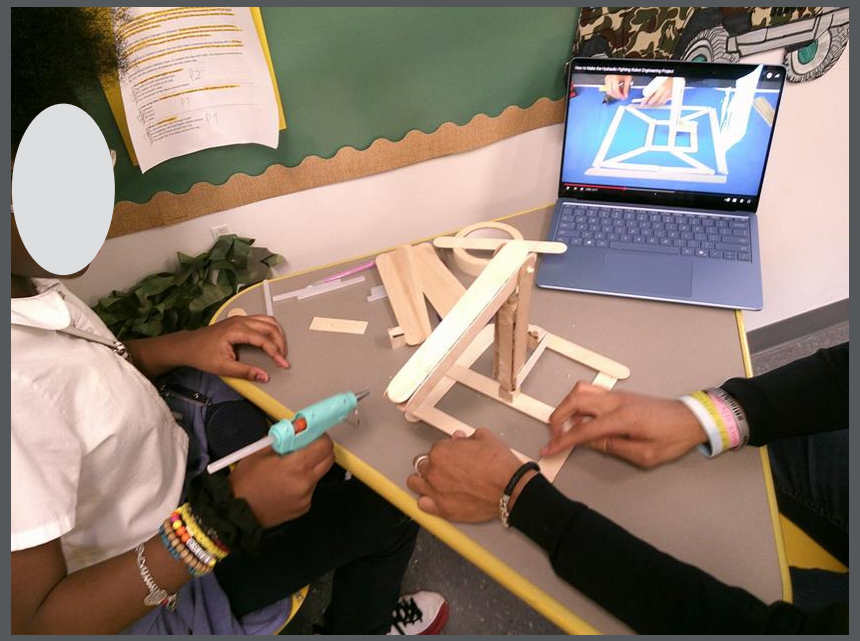
** Note: sharing fall 2024 preliminary findings*

What aspects of engineering learning are exhibited within the informal learning environment?

Iterative Design & Learning Through Trial-and-Error

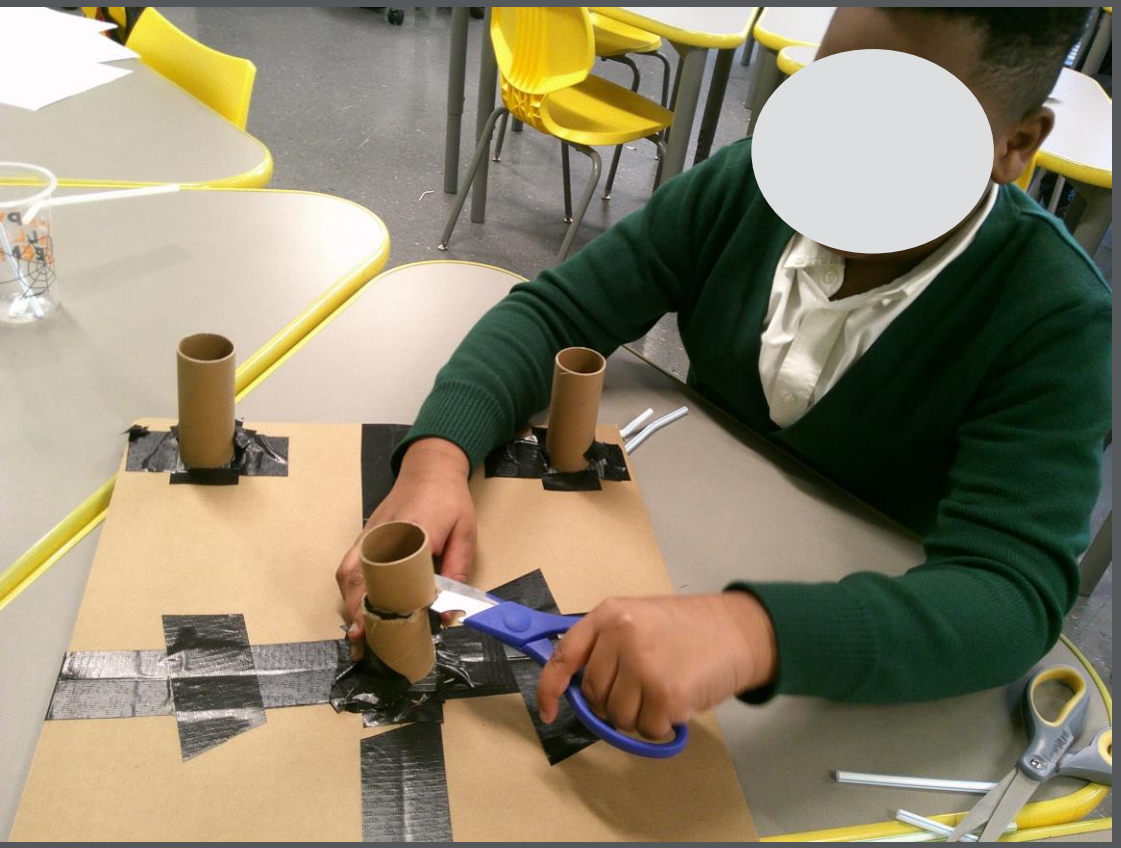
Youth leaning into engineering as testing, failing, redesigning, and optimizing under constraints

“The first time we tried it, it didn’t lift everything… we added more popsicle sticks to hold it down… then we successfully lifted it.”



Optimism
Persistence
Collaboration
Creativity
Systems Thinking

Iterative Design & Learning Through Trial-and-Error



"We looked at it. The cardboard was covered with tape… the tape's kind of heavy."

"Tries one, two, three… it was either too much tape, the cardboard was too heavy… trial four, it worked."

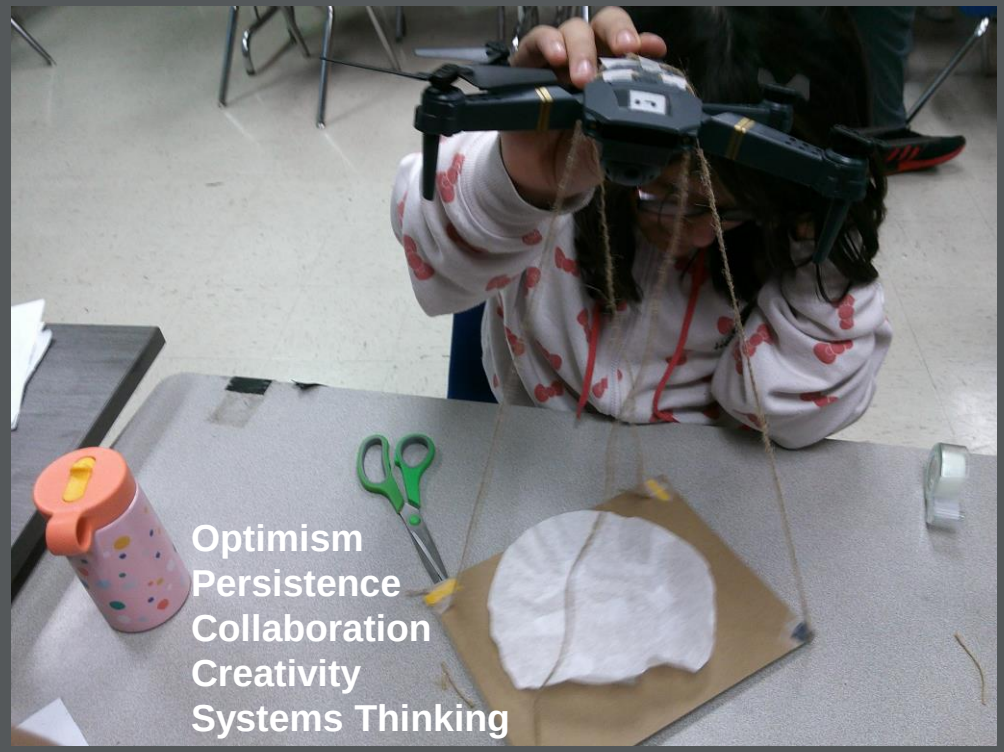
"It worked on the fourth try… Only after a couple of seconds, it did fall down, but I call that a success."

- Iterative engineering thinking
- Youth engaging with failure- failure is reframed as okay

Connecting to Everyday Life & Problem Solving

"The strings going down and the coffee filter made the drone's aerodynamics go wrong… that's why the drone cannot lift up because of the weighting."

"Maybe we could have done another type of design instead of cardboard, so maybe like metal or plastic."

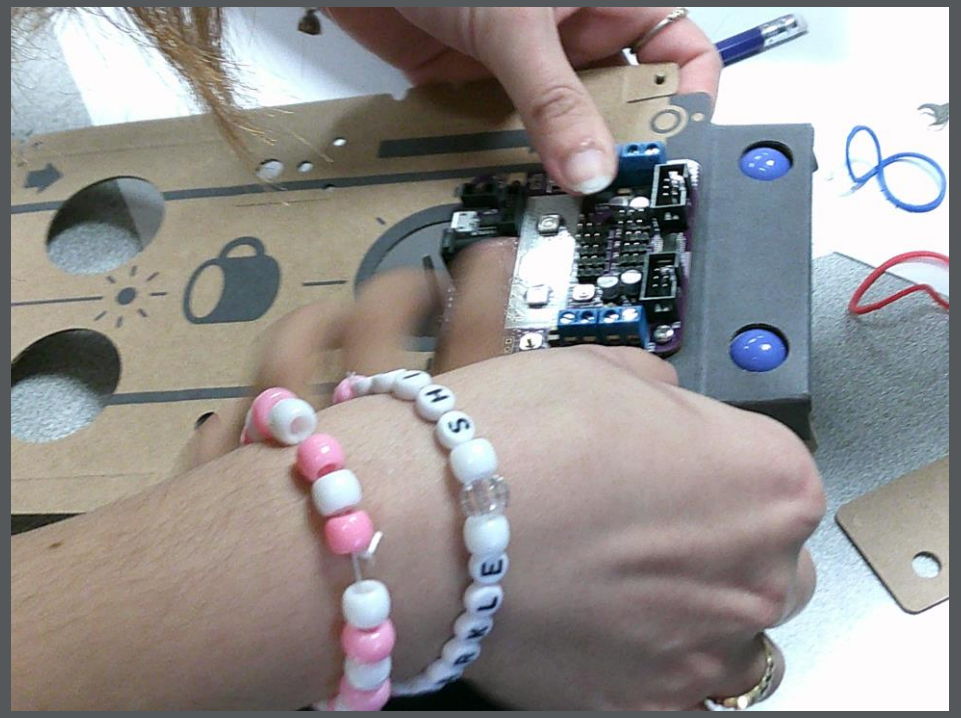


Youth making connections to their own worlds and engaging engineering language

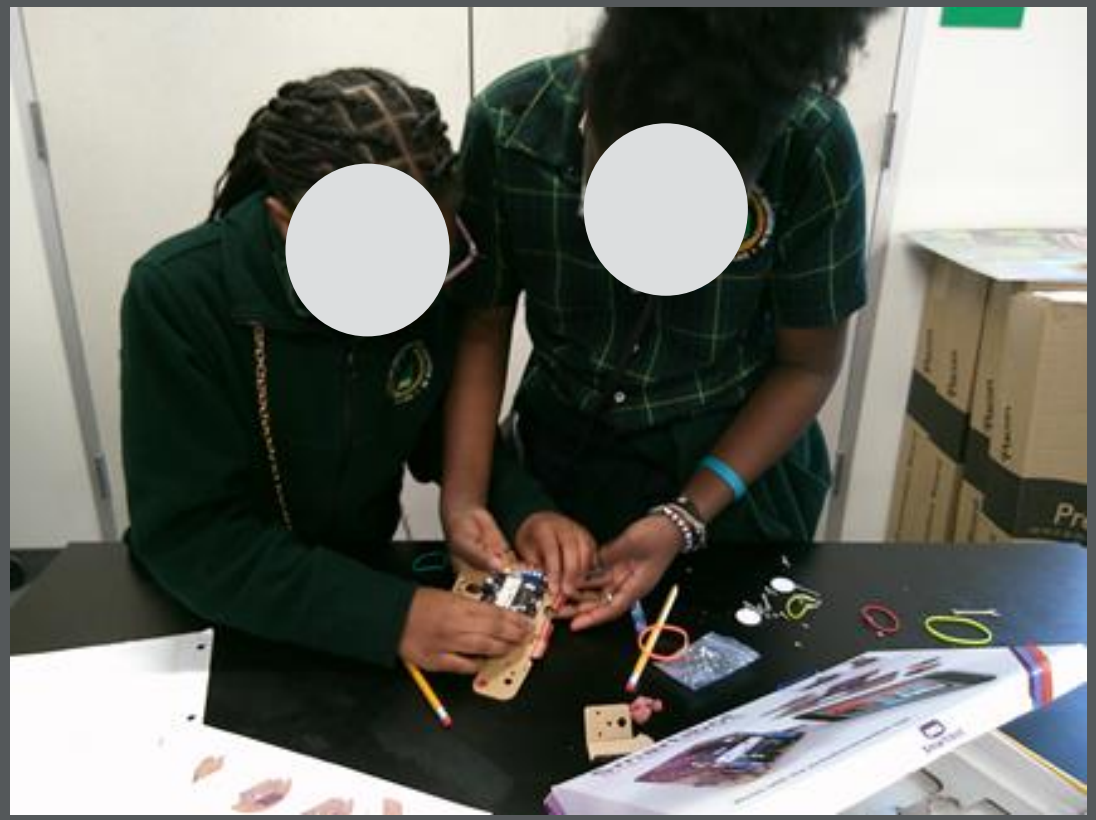
Connecting to Everyday Life & Problem Solving

"Package delivering by using the drones instead of delivering by biking.

"If there was a problem and you couldn't go to the place… You can send a robot there. That way you don't get sick."



Collaborative Problem-Solving



"Because if you're working by yourself, you might not always get it right the first time. So you have to ask for help and get everybody's opinion."

"To ask another teammate to hold one on while another person would try to screw it on tightly."

"Take your time, believe in yourself, and always get help when you need it."

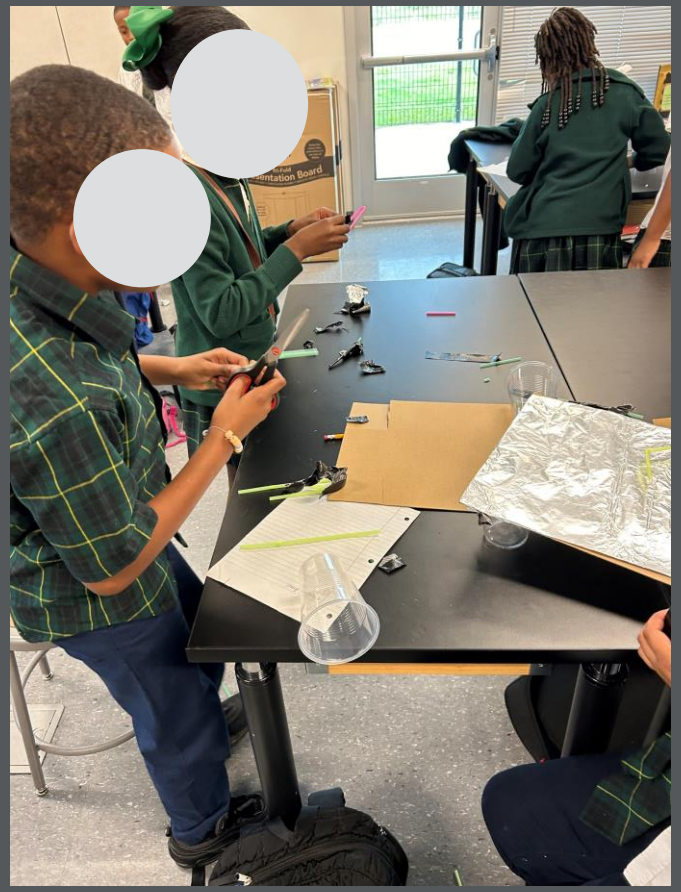
Youth describe engineering as collective work, not individual brilliance

Engineering learning is present and visible

If Youth Are Thriving… What Are Mentors Doing?

What does student-centered practice mean in this learning environment, and how do mentors implement it?

Collaboration

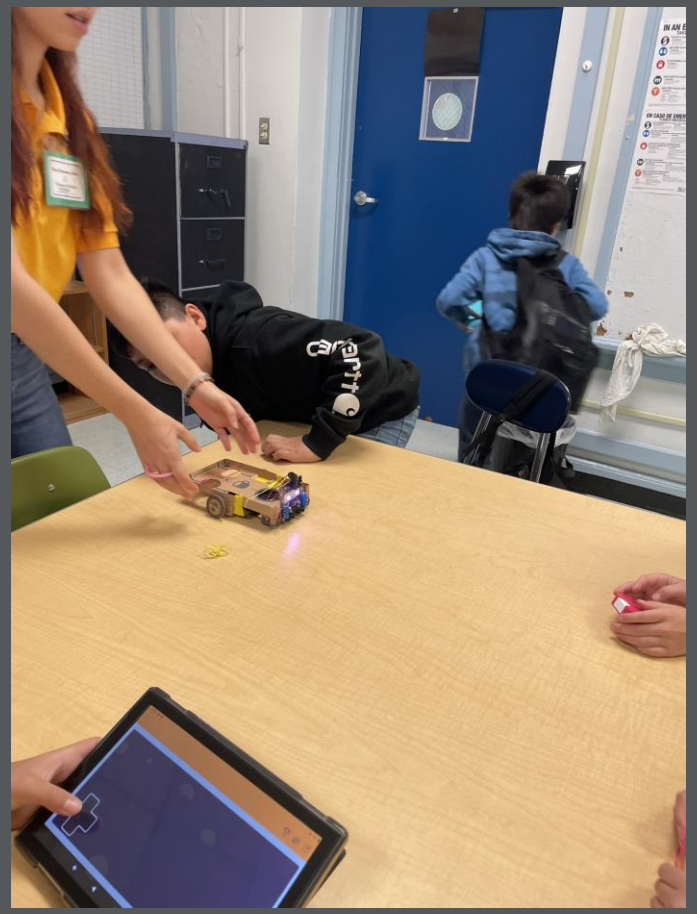


"As you can see in this team or in this photo…They're working together, and they're equally contributing, equally participating. That's just a great example of that doesn't matter of your gender or your background. That equal collaboration gets things done." [Kdot]

"You can see teamwork in this content… they can trust like each other doing their own task, but they can also care about what the other people are doing." [Wengi]

- Equal contribution and participation among students
- Learning process is not mentor-dominated
- Students are co-constructing knowledge together

Collaboration



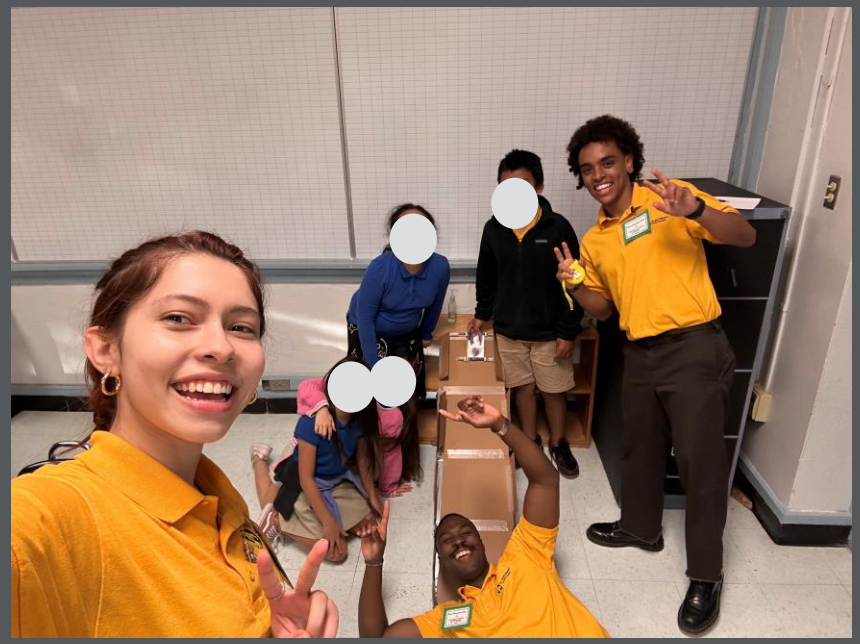
"It took both the mentors and the students a while for us to realize how to actually control the smarty bot." [Percy]

"We are setting an example of patience… and then say, 'We're going to now troubleshoot and try to find a solution." [Percy]

- Collective Problem-solving
- Mentors are not positioned as the sole expert
- Understanding emerges collaboratively

Supportive Learning Environment

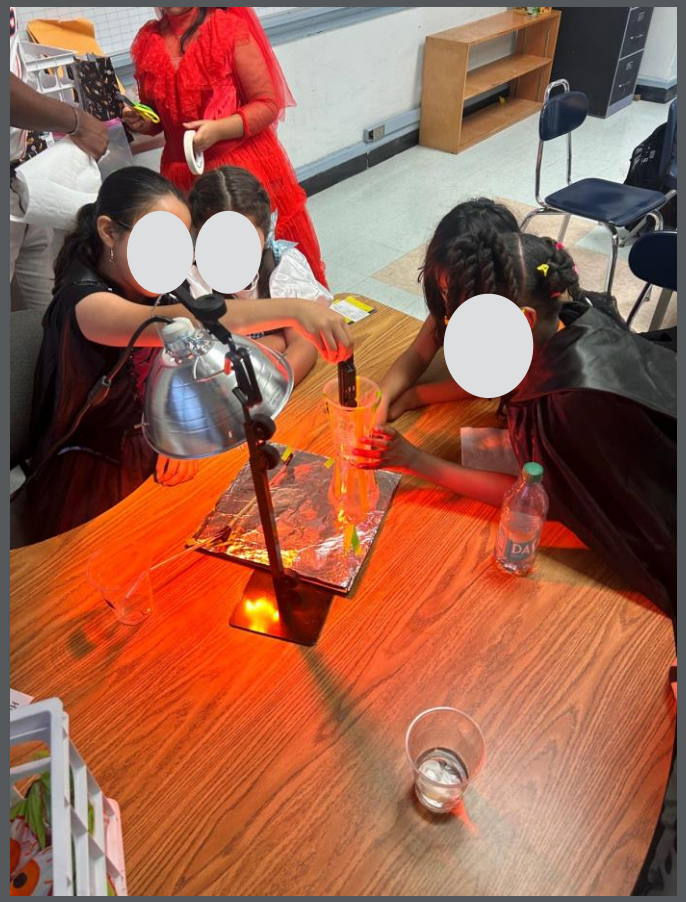
“When they are experiencing something like disappointment or sadness or dismay, they are going to express it… That’s where I think it's the job of the mentor… to help them regulate that emotion of dismay and help them develop a sense of patience when they're encountering a problem… So, after the troubleshooting, we're able to find a solution.” [Percy]



“We were trying to engage with them… trying to make them feel like they can say anything, and they won't be judged… which makes them comfortable… more safe space.” [Percy]

“So, this was the last day of this semester, and we were trying to do the mint mobile… [student], she's the one in the middle. At first, she was really shy… In here, you can see that she's really engaged.”

Intentional Engagement



“We gave them an example… if they have been in the car for five minutes or 10 minutes, which one is hot or warm? [Jelly]

“We’re always trying to make a connection with what they can see in their daily life… even if it is something they are learning from school, they find the connection between what you're doing every day or what you can see every day. [Wengi]

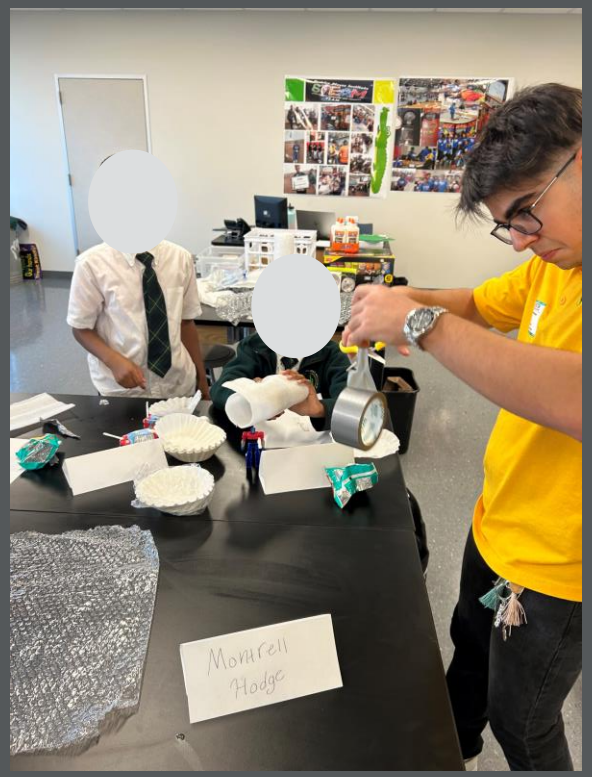
Connect STEM Concepts to Youths’ Lived Experience

Benefits for Mentors

“We do have different approaches and perspectives… we do disagree at times… but at the same time, that helps us be even better mentors for the kids… ‘Iron sharpens iron.’”

Mentors Growing Through Peer-to-Peer Collaboration

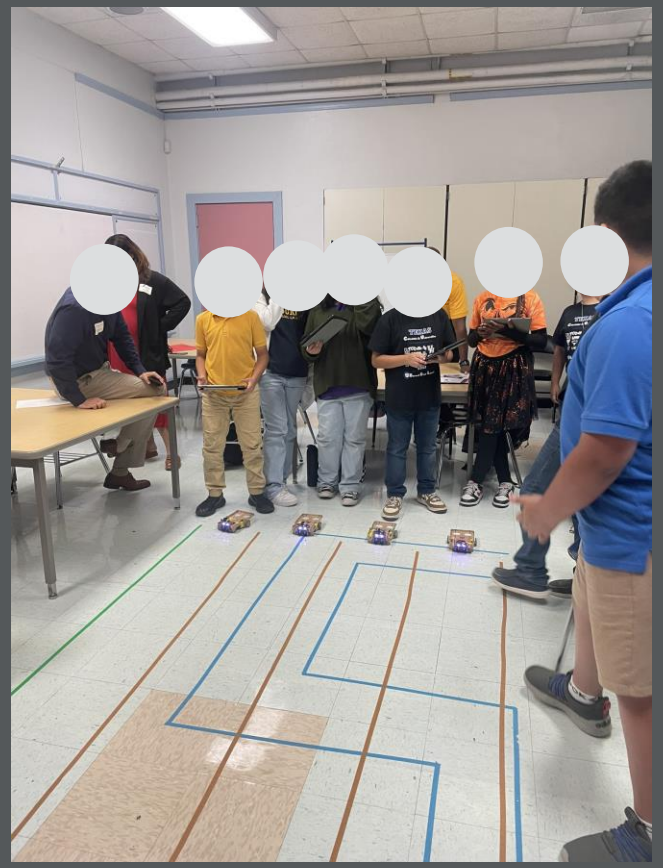
Benefits for Mentors



"Even me as a man… whenever I'm trying to go do the presentation. I'm learning something new. So, even at my age, I can still learn things new from basic STEM concepts."

Mentors Learning STEM Concepts Alongside Students

Access



Access to STEM Resources

“When I was in elementary school, I didn't have like a program like this. If there was a program like this, we wouldn't have had access to resources such as this, like the tablet and the smart bot.” [Percy]

Access to welcoming STEM Spaces

“The biggest thing I see here is… it feels like there's a space for them in SEBA.”

Access to early career exploration opporrtunities

“It might simply be irrelevant or just a small thing, but actually, you just learn something about you… I'm feeling like that's something really important to kids… because… I still have some friends right now who don't really know what they want to be in the future… because they didn't get a chance to touch different things.”

What We Are Learning

Youth Exhibit

- Creativity
- Resilience
- Collaboration

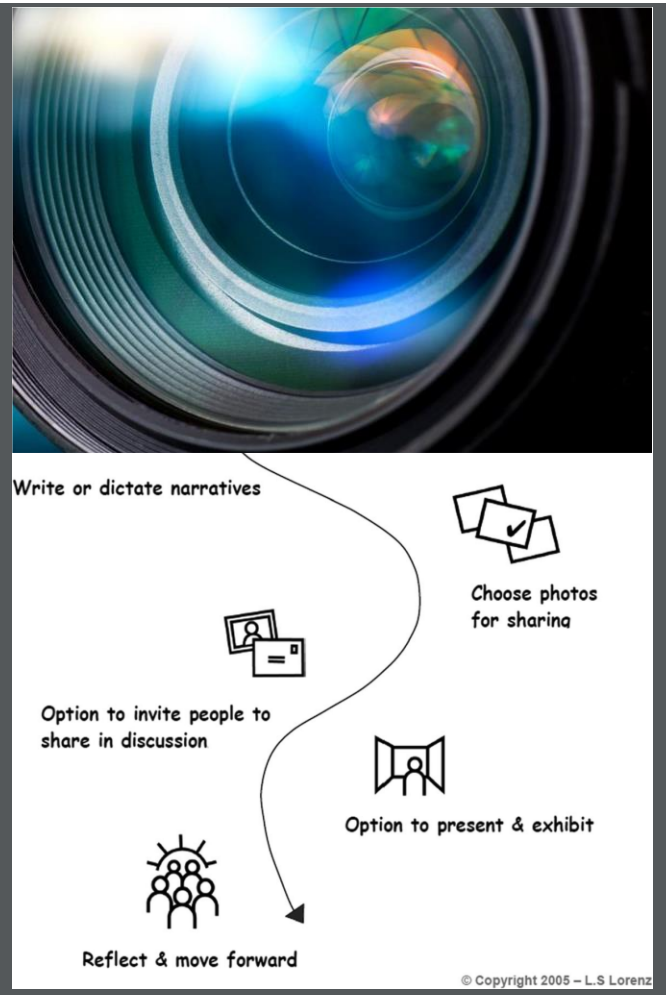
Mentors Advance Learning Through

- Active engagement
- Socio-emotional cultivation
- Exploratory space-making

- Messiness of data collection [photovoice, focus groups, pre & post surveys, video observations]
- Eliciting rich responses from youth is tough
- Research with vs. on is a delicate dance
- Student attendance varies with the time of year

What's next?

- Deeper dive into data analysis
  - Youth
  - Mentors
  - Parents/Families
- Photo-exhibition



(Connors et al., 2019)

Acknowledgements: Team Members

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