

## **An Empathy-Driven Framework for Middle School STEM: Case Studies in User-Centered Prosthetics and Community-Focused Playground Installation (Resource Exchange)**

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Ms. Anne Mayoral is the Director of Girls in Engineering, the signature K-12 outreach program for the College of Engineering, The University of California, Berkeley. She holds a Bachelors and Masters of Science in Aerospace Engineering from The University of Texas at Austin and a Bachelors of Art in Industrial Design from The Academy of Art University. A strong proponent of "learning through play", she develops curriculum that blends science, art, and design as a hook to inspire students to ask questions and seek solutions through open-ended exploration. Ms. Mayoral strives to promote diversity in engineering and increase access for underserved and underrepresented populations; cultivate curiosity and appreciation for the natural world; create safe, supportive and welcoming learning environments; and help learners build capacity through learner-led, inquiry-based opportunities and empowered making.

## Implementing an Empathy-Driven Framework for Middle School STEM

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### Framework Principles

#### Principle 1: Foster Empathy through Listening

Deeply understanding a user unique needs and desires through interviews, User/Observer Experiences and Empathy Maps

#### Principle 2: Incorporate "Thinking on Paper" and Physical Prototypes

The Camper Notebook scaffolds the design process, providing dedicated spaces for organizing thoughts and ideation and presenting material in an approachable way.

#### Principle 3: Build a Progression of Knowledge and Skills with Authentic Tools

Activities start with low-stakes, low-fidelity materials to build conceptual foundations before advancing to authentic tools to complete high-fidelity technical tasks.

#### Principle 4: Integrate a Sense of Wonderment and Play

Play reduces anxiety about failure. By balancing just-right challenges with playful activities, students maintain a state of flow.

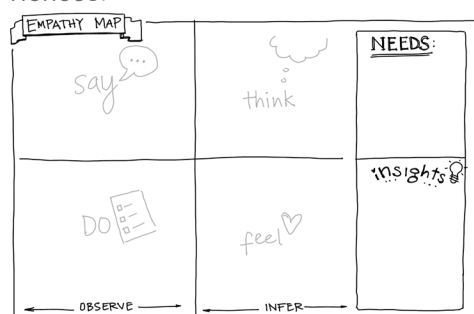
### Introduction

Research shows that girls and underrepresented minority (URM) students perceive engineering as a solitary, purely technical field devoid of social relevance. Implementing an empathy-driven framework can dispel these notions and increase students' sense of belonging, self-efficacy, and agency.

### Purpose

Demonstrate how an empathy-driven framework was implemented for a middle school summer camp for two summers.

Two case studies inform practitioners interested in adopting the camp curriculum and/or applying our framework to the future design of engineering education experiences.



**Grade Levels: Rising 6th - 8th**

**Resource Time: 1 week, 9am - 4pm daily**



[tinyurl.com/GiE-ASEE2026](https://tinyurl.com/GiE-ASEE2026)

### Resources

- Weekly Schedules
- Facilitator Guides (including materials)
- Camp Notebooks
- Reference Materials



## CASE 1:

### User-Centered Prosthetics (2024)

#### 1. The Valueholder & Empathy Discovery

Students designed for “Agent H,” an 8-year-old with a hand difference. By performing and observing tasks with restricted hand movement and live interviews, students created Empathy Maps and point-of-view (POV) Statements.

*Insight:* Students realized Agent H wanted a device that expressed his personality (Batman and Legos) as much as it provided function.

#### 2. Low-Fidelity Scaffolding

Students built cardboard hand models using straws as bones and string as tendons, allowing students to focus purely on the biomechanics before creating models of their ideas.

#### 3. Fabrication & Technical Synthesis: The “Try-On” Fitting

The instructors provided pre-printed components of the e-NABLE Phoenix Hand v2 to students.

*Human-Centered Scaling:* Each student groups’ assembled a different size hand so Agent H could try-on multiple sizes to determine the most ergonomic fit.

*Assembly:* Students installed knuckle pins, threaded the cords, adjusted tensioners, and thermoformed the plastic gauntlets to fit the user’s arm.

#### 4. The Delivery & Impact

Because Agent H lived in another state, students shipped handmade cards and the collection of 3D-printed hands (scaled at various sizes), transforming students from “builders” into “service providers” with a personal stake in the user’s success. Agent H shared an unboxing video, proving to the campers that their technical labor had a tangible and positive effect on a peer’s life, even from a distance.



## CASE 2:

### Community-Focused Playground Installation (2025)

#### 1. The Valueholder & Empathy Discovery

In partnership with a local non-profit, students designed components for a whale-themed climbing sculpture for local park. They developed User Personas to ensure the structure was inclusive and sparked wonderment.

#### 2. Low-Fidelity Scaffolding

Students visited a local climbing wall to research hold types and ergonomics. They then sculpted custom holds using paper mache, which were scanned into 3D models using Polycam for later fabrication.

#### 3. Fabrication & Technical Synthesis

Students fabricated 6-arm clock escapements and mechanical irises. These projects introduced complex mechanical concepts like gear ratios and oscillating movement through laser cutting and CNC routing.

#### 4. The Delivery & Impact

Students traveled to the Adventure Playground to install their holds and irises using power drills. This act of leaving a permanent mark on a public space gave students a “civic stake” in their community, cementing the connection between STEM and social impact.

