TECH TIP: Prototyping - Test, Reflect, Iterate

Engineering is a non-linear process that moves a design towards more effective and reliable solutions through iteration. When working to solve a design problem, engineers/designers collaboratively design a prototype, test it, find failure points and then go back and make modifications to their design (often hundreds to thousands of times). At The Tech, we have seen that encouraging learners to test their designs throughout the building process promotes iteration and allows students to persevere through design hurdles and device failures.

Design challenge activities incorporate opportunities for rapid prototyping, which pushes learners to practice designing and testing in a more condensed time format. When engineers and designers (of all ages) conduct rapid prototyping, it allows them the freedom to take bold risks with an idea, to persevere and learn from failures, helping them to practice and connect to the real-world process of working through multiple iterations to refine an idea.

FACILITATION

Rapid Prototyping and Testing

- Build time — Start with a slightly shorter build time than you expect participants to need. If they need more time to build, increase time incrementally as needed. This creates a sense of urgency that can help learners not to overthink their first design and gets them into the habit of actively building instead of prolonging hands-on engagement.

- Testing — Have everyone test their prototypes and identify any failure points. Ensure that any test areas or testing rigs are available throughout the build time. Encourage teams to test their designs early and often during this time. Include an open-ended observation section for engineers/designers to record general notes about the design's performance in their journal.

- Depending on topic or design complexity, have teams focus on one component of the design to allow a better understanding before undertaking the full design (e.g., maybe the design calls for a structure that rotates like wings of a hummingbird. Have learners play with the concept of rotation and what materials and mechanism most efficiently carry out this process through focused rapid prototyping and testing).

Encouraging Iteration

- Allow time for **multiple** iterations toward their goal of a final design (building and testing freely as needed). After each test, have teams record at least one thing they would alter about their design.
- Challenge cards — hand teams challenge cards (provided with design challenges) as they complete one possible solution to push them to re-imagine components of the design or introduce new criteria.
- Collecting data — this is an opportunity to teach reliability and repeatability as measures of success, as well as having students practice data collection methods as they iterate. Using data can also allow for measuring incremental success towards a goal.

COLLABORATION NORMS

Work with teams to establish norms to help collaboration. Here are a few to start with.

- Have teams establish a few positive hand gestures (e.g., "yes" = high five while "more of this" = bending pointer finger continuously up and down).
- Use "Yes, and...," instead of "Yes, but...."
- Constructively critique the design (not team members).
- Celebrate the successes, even when small ("Yes, it moved one centimeter!")
- Use "I" statements when contributing ideas and reflections.
- Establish words or phrases that can be used when students are feeling frustrated or notice a teammate struggling
    - When I _____ it makes me feel_____.
    - I noticed _____, is there something I/we can help with?

FACILITATIVE QUESTIONS FOR PROTOTYPING

You will want to ask a variety of questions for different situations during prototyping. See which ones work for your students and for different challenges. These questions also help to refocus the teams/learners on process rather than product and feel successful even when a whole device or idea doesn't work in that particular moment.

	Iteration Worked	Iteration Failed	Device Partially Built

30 min left to build	• What can your team try to make this design even better?
	• Does the solution work every time? How can your team improve its repeatability and reliability?
	• Since this design worked, what is a different way to solve the problem? (Offer a challenge card.)
	• What are ways to provide more efficiency, accessibility or sustainability with this solution?
		• What components are working in your team's design?
		• Which criteria did the device meet successfully?
		• Where and how did you see the device/solution fail? Where was/were the failure point(s)?
		  ◦ What caused the failure?
		  ◦ How can your team start to alter that part of the design?
			• This part of the design looks really great. What is your team going to do next?
			• Are there parts of this prototype that your team is still trying to understand or imagine; if so, which ones?
			• Which parts of the device can your team test to inform the overall design?

3 min left to build	• Are there any last adjustments your team can make? • Can your team show/explain how different components interact and contribute to the entire solution? • What new questions have come up while designing? • How is this solution different from what is already in the real world?	• What part of the building process needs support? • If we had more time, what would your team want to try next? • Can your team show/explain how different components work within the solution? • Where do you see other principles and concepts from class in your prototype?	• What can your team share about your plans for finishing this design? • What can your team do to show how part of your design works? • Is there a metaphor or analogy for the aspects of the design you have yet to physically build?

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