Day 4 - Engineering and Design with Cubelets,

Criteria and Constraints

Educator Pack Cubelets in the Classroom, 45 minute activity

Students work to design robots with respect to criteria and constraints, deepening their understanding of the Engineering Design Process.

For each class/group, this lesson plan includes 3 parts, 10-15 Minutes each:
1. A chance to reconsider robot designs with criteria to evaluate “what works best” for this problem
2. An opportunity to design a robot to address a problem using constraints to spark creative solutions
3. Now, students design a robot combining what they’ve practiced with criteria and constraints

These lesson plans have suggested age levels, but it is possible to use the younger grade activities as a ramp up to older grades; e.g. use the 6 years old - 9 years old activities to ramp up and extend a lesson plan for a group of 10-12 year olds. Similarly, the activities suggested for older students can become a way to expand on challenges presented to younger learners if there is time and interest.

Introduce the class to Engineering Principles for the day - Constraints and Criteria

Today we’re working with Cubelets again and learning about how Engineers design solutions to problem. Engineers always ask these questions:
1. What is the problem or situation we’d like to change? How can we define the problem?
2. What can we make or design to help with this problem?
3. How will we know our design succeeded? How can we test or measure success?

Sometimes we measure success by deciding ahead of time what would count as success or what we think success would look like - that’s called setting criteria. Engineers do it too. Criteria could be if people use a device the way it was designed, how efficiently it worked, or how much of a problem was fixed by it.

Sometimes we also have constraints like only having certain materials, or having to design for a certain shape or size. Constraints are when we have limitations or restrictions. If we designed a device to make us breakfast, some constraints might be what materials we have, or how much we can spend on materials, and criteria for success would be that it needs to make our toast without burning it, and not spill anything.

Now we’re going to practice designing with constraints and criteria. For every activity we’ll work to define the problem, understand the constraints, and make robots that meet criteria for success.
Part 1: Using Criteria to evaluate success


A hands-on opportunity for students to explore defining and using criteria with familiar Cubelets robots.

“Yesterday we worked to tinker with and change some working robots. Today we’re going to start with some working robots again. We will discuss a problem that the robot could solve, and then consider what criteria go along with how we define the problem. Then we’ll evaluate the robots as possible solutions to that problem according to those criteria.”

**Suggested age variations/progression:**

- **Pre-K to 6 years old:** “This is a robot that will spin as long as it sees light using the brightness sense. Here’s a problem: what if we needed a robot to spin and hold a plate of cupcakes? Will this work when the plate is on top? Can it see the light? If our decision about this being a good solution depends on this working with a plate on top of it, will we decide this is working well? Is it meeting the criteria of being able to work with the plate on it? Let’s test it and try.”
- **6 years old to 9 years old:** “Here are two spinning robots. One uses the distance sense, and another uses the brightness sense. If we want these to hold a plate of cupcakes, will either of these work? In what ways are these robots meeting the criteria? In what ways are they not meeting the criteria? Does one have an advantage over the other? Test each one and decide.”
- **9 years old to 12 years old:** As above and now ask students to also consider, “Can we make any do any of the changes we practiced before (reorient, configure, change functions) to improve them? Are there different senses, actions or configurations of components that will solve this better?”
- **12 years old and up:** As above. Add to this, “Are either of these spinning robots clear ‘winners’ according to our criteria or do they both have different ways they succeed and different ways they might not do as well at this job? What criteria, job or objectives could we assign to each one to evaluate it as successful?”

**Concepts Presented:** Evaluating designs, assessing success

**Vocabulary:** Criteria, success, evaluate, define, solutions, advantage, objective
Part 2: Solving Problems with Constraints and Criteria

Materials: Educator Pack of Cubelets. For groups doing the “no flashlight action” challenge please collect and put away all 5 flashlight actions

Students now practice solving a problem using Cubelets with constraints.

“Now you’ll be working on solving a problem using some simple Cubelets robots. Let’s start with a problem - getting out of a dark room!”

Suggested age variations/progression:

Pre-K to 6 years old: “If our objective is to make something that will help us get out of the dark, let’s first define the problem. What is the situation we want to change? Now let’s think about what the constraints are - what do we HAVE? How can we use only what we have? Who has ideas? Ok, let’s build it - how can we test it? How will we know if it worked? Can we turn the lights off and see what worked? We can try more than one kind of robot but let’s decide now what counts as a good problem-solving robot for this situation.”

6 years old to 9 years old: As above, but now also ask, “What if our constraints were to only use 5 Cubelets? What if our constraints were to only use 4 Cubelets? What if our criteria for success was getting out of the dark with no bumping into the wall? What if our criteria for success was getting out of the dark room in under 1 minute? What robot would we make?

Let’s build it and test it!”

9 years old to 12 years old: We’re in a dark place and the power is out! We don’t have flashlights but we do have our Cubelets! However, someone has stolen our all of our flashlight action Cubelets! Curses! How can we make a robot to help us solve this problem?

Define the problem.
What are the constraints?
What are the criteria for success? How will we know our robot was a good device for this situation?
Now let’s build it and test it!”

12 years old and up: As above.

Concepts Presented: Design, evaluating success, criteria, constraints

Vocabulary: Define, criteria, constraints, define, success, evaluation, assess, device, situation
Part 3: Capstone Cubelets Challenges


Students have now explored some of the challenges of design with constraints and criteria using Cubelets as a platform. As their final activity, they should begin to practice defining their own challenges, and the considerations of design constraints and success criteria as part of the questions they pose, as well as the potential solutions they build and test.

“Now that you’ve worked with working robots, taken them apart and rebuilt them to understand their components, and considered engineering solutions with constraints and criteria, I’d like for you to work in your groups to practice thinking like Engineers with these Cubelets. You will think of your own problem, define it, consider what constraints you have, and define criteria for success.”

Suggested age variations/progression,

- **Pre-K to 6 years old**: Now, let’s pick a different problem we can solve with Cubelets. What kind of robot could we make with these 6 (KT06) Cubelets? Let’s make a robot that could do a job have a purpose, or help solve a problem. What constraints do we have? How will we know the robot is a good solution?

- **6 years old to 9 years old**: Now, let’s pick a different problem we can solve with Cubelets. What kind of robot could we make with these 8 (KT06 plus inverse and rotate) Cubelets? Let’s make a robot that could do a job, have a purpose, or help solve a problem. What constraints do we have? How will we know the robot is a successful solution?

- **9 years old to 12 years old**: Now, you and the students in your group can define a problem of your own that you can solve by building a Cubelets robot. You will need to:
  - Define the problem or situation you would like to address. Think about the robot’s purpose or objective
  - Consider what constraints you have.
  - Consider what your criteria for success is. What counts as this robot working? How will you know it’s a good solution?
  Now build it and test it! It’s ok if you need to evaluate it against the criteria, and then make some changes. Engineers do that all the time!

- **12 years old and up**: As above

**Concepts Presented:** Design with constraints and criteria, evaluating success, test and redesign

**Vocabulary:** Constraints, criteria, success, define, solutions, purpose