Teacher's Guide for Dragon Rescue Design Challenge

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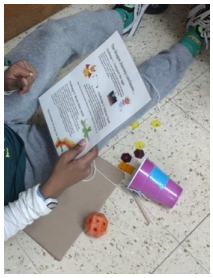


Would your students enjoy bravely rescuing dragon eggs from a ring of fire - while learning how to think creatively to solve real-world problems like engineers do? Engineering doesn't have to be so scary. This series of design challenges takes students through an iterative, hands-on design-build-test cycle, where they work with limited resources to create simple tools which help them collaborate to accomplish tangible lively challenges embedded in an exciting, motivating narrative. We tasked students with rescuing and caring for "baby dragons": delivering dragon eggs from their nest, and then feeding and brushing the teeth of the newly-hatched baby dragons. However, educators can readily change the theme to fit their educational context or design alternative challenges which emphasize our core learning principles of creatively using materials and working together to solve hands-on problems in an iterative design-build-test process.

Workshop Requirements

The mini challenges in this workshop can be run independently and in any order.

- **Suggested ages/grades:** Grades 3-5
- **Time required:** One hour
- **Required materials:**
  - 10 balls (these will be the eggs, but you can also use connectors from building sets, balled up newspaper covered with duct tape, or balled up aluminum paper)
  - 1 roll of duct tape

- 10, 8 x 8 in squares of cardboard
- 1 roll of string
- 10 plastic cups or bowls
- 1-2 packs of wooden rods/popsicle sticks
- 10 pairs of scissors
- Fake money (we made acrylic chips)
- 10 index cards
- 3 bowls of varying sizes
- 1-2 packs of pom poms

➢ **Optional Materials:**
- One laminated copy of this handout for each table

➢ **Prerequisite Knowledge**: none

Learning Goals

➢ Work as partners to design a tool for each of the challenges
➢ Develop problem-solving skills to design for a specific task
➢ Gain experience testing and iterating on an idea
- Comfort with failure and trying again

➢ Feel sense of ownership over the design and feel proud of it
➢ Teaming skills

Workshop Activities

This workshop consists of three activities, which are all dragon-themed engineering design challenges. Although these design challenges are all related, they can be done in any order that the student chooses. Having different students start with different challenges can keep all students engaged by having less time waiting for access to the challenges.

Students are tasked to design and build tools that will help them complete each of the challenges. The tools are made from scrappy materials and the only constraints are the amount of materials they are originally given and the distance they must stand away from the target. Each student is given a starter kit that includes some materials (see the suggestion for making the starter kit in the "usage of materials" section below) as well as fake money that they can use to buy more material or materials of "higher quality". Students are encouraged to work with partners or trios so that everyone can have an opportunity to take the lead on at least one of the designs. Students are encouraged to iterate on their designed tool as many times as they'd like. Encouraging iteration is meant to help normalize failure and to get students to try again and make improvements on their tool.

- **Mini Challenge #1**
  - Students are tasked to design a tool that can reach the dragon eggs (balls) from the dragon's nest (a structure prepared by the teacher; this can be a cardboard circle with holes cut out to hold the balls/dragon eggs) from behind the ring of fire (teacher can make out of cardboard or use a hula hoop). How many eggs can the students rescue without dropping them?
- **Mini Challenge #2**
  - Students are tasked to design a tool that can help them deliver food (pom poms) to the baby dragon's mouth (bowls) via a pulley system. Will the food be dropped into the dragon mouths? Will the tool have some sort of opening, such as a hole or a mechanism that opens and shuts? How will the students move the tool from one side of the pulley to the other?
- **Mini Challenge #3**
  - Students are tasked to design a tool that can clean the dragon teeth (structure made from cardboard; dirtiness on teeth can be pom poms that are attached to the teeth via velcro dots or rolled duct tape) from behind the ring of fire. Students must stand on opposite ends of the ring of fire and try to take as many pom poms out of the teeth.

Suggested Tips for Running this Workshop

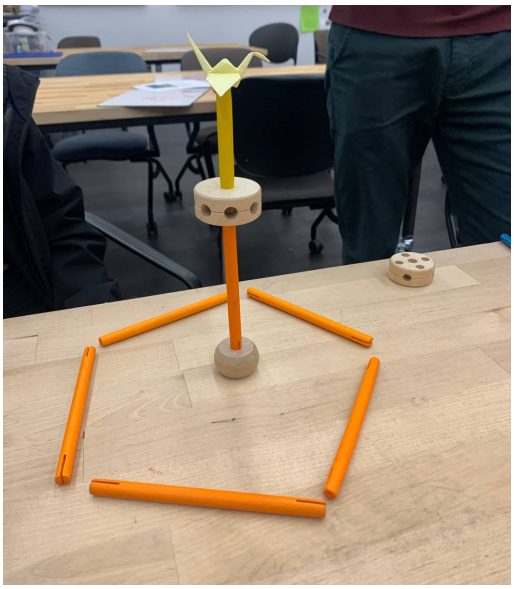
- **Pre-workshop preparation**
  - Physical room set up:
    - Dragon's nest
      - Alternative: circular piece of cardboard with 6 holes to hold the balls/dragon eggs)

    - ring of fire (if possible make 1 for each station)
      - Alternative: big red/orange hula hoop or string

- fake money
    - Alternatives: custom chips or custom laminated fake money ([teacher's name] dollars)

- dragon's mouth
    - Alternative: laminated paper with an image of an open mouth (make sure you can see the teeth) with pom poms duct taped to the the teeth; draw mouth with teeth on a whiteboard/chalkboard and tape pom poms to the teeth

- I suggest having each station for the mini challenge in different parts of the room. You can always mock up (prototype) what you want the activity will look like (see image below for our design prototype for the nest idea)



- You can suspend the nest with string for additional challenge, or you can keep it simple and place the nest on a table (pictured below).

- We used our prototype design to then set up the room. In our prototype we had the nest resting on a stick (which can be a stand or something similar). In our real-life set up, we hung the nest from the ceiling to add some complexity for the students since the nest would be swinging.
- If you do not have different sized bowls for the feeding mini challenge, you can cut out 3 different sized donuts and tape them to the bowl. You will also need two tables to suspend the pulley system (pictured below).

- Usage of materials:
  - You will want to make a starter kit of materials for all the student groups. The materials you might want to include in the starter kit are: 5 inches of duct tape, 8 inches string, 1 plastic cup/paper bowl, 2 wooden rods/popsicle sticks, fake money (to pay for more/better materials), and 2 index cards.
  - For an additional challenge, I would leave out wooden rods/popsicle sticks that would make it too easy to solve the challenge.
  - Plastic cups are a great choice for 2nd-3rd graders, however replacing them with paper bowls can add more challenge for 4th-5th graders.
  - The usage of tokens/fake money reinforces math concepts as the students need to add up their tokens to go to the "store".
    - This also mimics real-world constraints in real engineering challenges as there are always limited resources and careful decisions must be made about what to purchase.
    - We suggest the following prices for the items:
      - 5 inches of duct tape - 5 tokens
      - 8inx8in piece of cardboard - 10 tokens
      - 8 inches string - tokens
      - 1 wooden rod/popsicle stick - 2 tokens
      - 2 index cards - 2 tokens

➢ **Tips for grouping students:** I suggest students be grouped in pairs, since some of the challenges are designed to work much better with 2 kids working together. Teaming/partnerships work best when the task actually requires collaboration amongst 2+ people. Otherwise, it often devolves into one person taking over.

➢ **Additional constraints:**
- Regarding iteration: You can allow students 1 free opportunity to test their design and the rest of the tests are paid as an extra challenge for older kids.
  - If students continue to test continuously, I would suggest that each duo gets one shot at testing, and then they can go back to iterate/improve their design and wait in line again,
  - However, if you want to normalize failure, I would not do this.
- Regarding money: Currently once students run out of money, there is no way that they can earn more to buy more material. You can run the workshop in a way that allows the students to earn money as they go. For example, for each task that is completed or for each egg/food that is collected students earn money that can be used for the tool they will build for the next task. Another way to earn money could be by helping another team or modeling good behavior

➢ **Guiding questions:** These questions can be helpful to ask when students are stuck and/or to help students connect this fun activity to the STEM content lurking beneath the surface.

- Run me through your design. How does it work?
- What do you think will happen if you add [some material] to your design? Will it make it stronger?
- Think about different ways to get to the eggs. Do you have to grab it? Could you push it out of the way? Could you move it from underneath?

➢ **Intentional commentary:** Comments such as the following can help students build and recognize STEM-related mindsets and skills

- I see your tool didn't work like you wanted it to. Maybe you can iterate it! Go back and change [some element] and see what happens.
- Nice job designing the tool to do [some task]!
- What would happen if you added/ took away more weight here?

Closing Questions and Student Reflections

➢ At the end of the activity, you could have every team share out what they did for one of the mini challenges. They can show off their tool and explain to the class how they designed it and whether or not they went back to iterate on it.

➢ If it is appealing to your students, you can also have a fill-in-the-blank or free response handout that asks these questions.

Extensions and Enrichments

➢ Although these design challenges might seem trivial, the concepts being used and practiced translate into the real world of engineering practice. Every engineering team is required to build something with a set of requirements ranging from price, material, and time limitation. In this workshop, students are asked to design a tool for each mini challenge with an initial set of constraints: how much money they get to spend and what material they can use. They have an additional constraint of having to stand outside the ring of fire. Additionally, this workshop gives the students an idea of what the design process is like from the idea to the actual product. No matter what engineers are tasked to build, it always starts with a brainstorming session and is followed by the prototyping stage, which includes multiple rounds of iteration. Students are introduced to this process through a workshop with a theme that is appealing to them. If you would like more information on the design process and how to explain it to your students, please see this website:https://stemsmartly.com/engineering-design-process-for-kids/

➢ You might consider challenging students to design one tool that will work for all three mini challenges (design a multi-purpose tool)

Educational Design Principles Used to Create this Workshop

We are Olin College undergraduate engineering students who are practicing the engineering design cycle through the iterative design, development, testing, and improvement of STEM workshops for elementary (or middle) school students. We began our "user research phase" by visiting our partner students. We engaged our partner students with standard engineering design challenges as a way to get to know what they like, what motivates them, their fine motor building skills, their teaming skills, etc. This informed our creation of custom workshops for our partner students, which we then improved and tailored to work with a second class of students.

Our work has also been guided by our learnings about some educational design theories/principles. In this section, we provide information about how these educational design theories/principles have been used in the design of our workshop. We hope this will help teachers understand our motivations and therefore be more able to modify our workshops to work better for their students in their unique educational context.

Throughout our design work, we practiced keeping a tight loop between our goals (i.e., our learning objectives related to STEM content, social-emotional learning, and the development of confidence and belonging in STEM) and the activities we designed to achieve these goals.

- **Goal #1**: Use students' interests and creativity to motivate them to experience the engineering process of designing, building, and iterating.
- Why we had this goal: Students can be rowdy but super creative! Introducing high-level engineering topics might be too much for them to take in, but we do know that they really like to build/make stuff!
- How we achieved this goal: User-centered design (UCD) is all about getting to know the group of people you are designing for (their environment and needs) [1]. In UCD, you're continuously co-designing with your users. Prior to making this challenge, we were able to do some activities with the students and we noticed that they have a lot of energy and lecturing would not be an effective way to engage students at this age, so we wanted our activity to have the engineering concepts subtly embedded in it. We also used some of the things we learned from the UDL and CRT videos and readings when ideating for the design challenge. We wanted to make sure that while we were providing a flexible assessment [2, 5] and freedom for the students to create a tool to complete the task in any shape/form/size that they wanted, while still making sure there was some level of constraint. The way we chose to do this was by limiting the material used to make the tool. Everyone had the same starter-kit for materials, which included a variety of objects [3] that they could choose from. Teachers can use their students' interests as a guide for changing the theme or materials used for their challenges

- **Goal #2**: Every student should contribute something to the tool.
- Why we had this other goal: We really wanted students to get a sense of working with their peers, but also have some sort of ownership with the tool that they were to build. We didn't want any one student to take over or for someone to feel like they weren't

doing something. We wanted all hands on deck and for everyone to get a feel for designing for a purpose.

- How we achieved this goal: The students were tasked to create a tool that would help them rescue the dragon eggs from the nest without stepping into the ring of fire. Is this realistic to what a tool would be used for in real life? No. Was that intentional? Absolutely! We wanted the students to feel comfortable designing something for a specific purpose without making the task super high stakes. So, when we were designing the challenge we made sure to make the task something that they could relate to, to some extent [3]. We figure that most kids would think that dragons are cool and if we frame it in a way that no matter what they do, it is still serving some purpose and whatever they make is successful! We made sure to establish that there are multiple ways to get to the solution and no solution is incorrect [4]. The challenges we designed often required collaboration between students as a way to make sure that every student had an opportunity to contribute to their tool.

- **Goal #3**: To be flexible and accessible in how we present information to students.
- Why we had this goal: From our first deployment, we realized that having some sort of visual along with verbal instructions might help the students better understand what the task was and get them thinking about how to solve the problem.
- How we achieved this goal: Part 2 of the design challenge was more complex than the first. The second part of the challenge had 3 mini challenges that each pair of students had to complete. We noticed we got the same questions regarding the rules/constraints and even the overall goal of the challenge. In order to provide another way for students to digest the information, we decided to include a poster that had visuals along with written instructions for each of the mini challenges [2]. We made sure that the poster wasn't text heavy to not overwhelm students and present it in a fun way.

- **Goal #4**: Allow flexibility in the way that students tackle the challenge (allowing them freedom to choose which challenge they want to do first and also in what order they want to complete the three design challenges).
- Why we had this goal: We wanted students to not feel pressured to finish in a specific amount of time because their other peers were already on challenge 3, while they were still stuck on challenge 1. We wanted them to freely choose where/on what they wanted to spend their energy on.
- How we achieved this goal: On one hand, we could either opt to make the challenge more difficult, or offer a series of mini challenges that build off of each other. We chose the second option because we felt that there was more variety in level of difficulty and it would allow students to release their creative thoughts more. We included a poster with instructions to each of the mini challenges so that students could have some sort of autonomy when they went from station to station; this is how we chose to incorporate "choice assignments" form the UDL video [2]. We also chose to let them choose their own journey with the series of mini challenges because we didn't want to enforce one specific way and, in doing so, discourage them if they were "behind". We really wanted to embrace all levels of approaches [3, 5].

Please use these materials and tailor them to your students!

We encourage you to use these materials, editing and modifying them as appropriate for your students in your particular context! When you use, share, incorporate, or modify these materials, please keep the credit and license notice from the footer. We also humbly request that you email sarah.adams@olin.edu if you use these materials, as we are tracking their impact and how far they travel!

References

References used in the motivation and design of our workshop and/or extensions.

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[5] Stapleton-Corcoran, Erin. "Universal Design for Learning (UDL)." *Universal Design for Learning (UDL) | Center for the Advancement of Teaching Excellence | University of Illinois Chicago*, 12 Feb. 2022, https://teaching.uic.edu/resources/teaching-guides/inclusive-equity-minded-teaching-practices/universal-design-for-learning-udl/.