



LESSON GUIDE

Prosthetics



Level	Beginner
Academic Connections	Prototyping, Design for Manufacturability, Engineering, Design Thinking, Hands-On Learning
Core Concepts	Engineering Design, Engineering Analysis, Design, Design Optimization, Print Optimization, Assembly, Computer Aided Design (CAD)
Duration	1 week

This lesson will take students' understanding of prosthetics and apply that to a real-world engineering design. Students will learn about an organization called e-NABLE, which partners groups with 3D printers and individuals, primarily children, around the world who are in need of prosthetic hands. Students will redesign the fingertips of a Raptor Reloaded hand. Students will design, create, and 3D print their revised fingertip designs.

LEARNING OBJECTIVES

- By the end of this workshop, the student will be able to:
 - Design, create, and 3D print their revised fingertip designs.

REQUIREMENTS

- Educator PC with access to:
 - Microsoft PowerPoint
 - QuickTime
 - Internet connection Projector
- 3D printer
- CAD design tool

ESSENTIAL QUESTIONS

- Use these questions to guide students' understanding:
 - What things can a child do with this prosthetic hand?
 - What activities would still be difficult to do with this prosthetic hand?
 - What activity do you think the Raptor Reloaded hand could be reimaged to better do?
 - Why would the Raptor Reloaded not do that task well in its current form?

INSTRUCTION PREPARATION

- See the TinkerCAD Guide, below, on how to set up TinkerCAD for your class and the process students will use to design, create, and 3D print their prosthetic hands.
- 3D print a completed Raptor Reloaded hand, found at Thingiverse #596966.
- 3D print Raptor Reloaded Knuckle Pins for single finger designs, found at Thingiverse #596966.
- 3D print Raptor Reloaded Double Knuckle Pins for 4 finger designs, found at Thingiverse #1954875.
- Download Single Finger and Combined 4 Finger STL files for student redesigns. Both can be found at Thingiverse #1954875.

LESSON PLAN

Before students start creating their own prosthetic devices let them explore the e-NABLE website at enablingthefuture.org to learn about their mission. On this site, students can watch videos showing the process of creating prosthetic hands. They can also see various prosthetic hands that can be downloaded directly from the site. Later on in the lesson, students will use TinkerCAD to create, download and 3D print their prosthetic hands.

See the TinkerCAD Guide to set up TinkerCAD for your class and for information about the process students will use to design, create, and 3D print their prosthetic hands.

1. Show students a complete Raptor Reloaded hand, or if time and materials allow, have them assemble a few hands in class.
2. Have students discuss the following questions:
 - What things can a child do with this prosthetic hand?
 - What activities would still be difficult to do with this prosthetic hand?
3. Students will now be challenged with the idea that the Raptor Reloaded hand can still be improved upon. As individuals or groups, students will choose an activity that the Raptor Reloaded hand currently cannot do as best as it could. Students will also choose an activity that a child using the Raptor Reloaded would like to do better. Then they will research an animal – with hands and fingers – that can do that activity really well, and redesign the Raptor hand based on the adaptation that allows the animal to do their chosen task well.
 - a. To help guide students through this process they can work through the Raptor Reloaded handouts found below.
4. The entire hand will not have to be redesigned by the students. They will still use all parts of the original Raptor Reloaded hand, but they will recreate the fingertips. They can choose between fusing all four fingertips together into one large adaptation (1-finger design) or redesign each fingertip separately (4-finger design). Both of these redesigns are described in further detail in the TinkerCAD Guide for this lesson.

Note: Depending on how many groups you have working at the same time you will want to print out as many full Raptor Reloaded hands so that students can attach, demonstrate, and present their redesigns at the end of this project.

Also, the groups that decide to work on the 4-finger design will need to use the double knuckle pins. One knuckle pin will be inserted on each side since the two middle fingers cannot be accessed with a single knuckle pin during assembly.

EXTENSION

Have students watch and discuss the following TED talk. https://www.ted.com/talks/aimee_mullins_prosthetic_aesthetics?language=en

In this TED talk, 1996 Paralympic games world record-breaker Aimee Mullins discusses her use of 12 different prosthetic legs and the different powers each gives her.

Sign up your class for the e-NABLE community. Get connected with individuals around the world in need of prosthetic hands and make a service-learning project out of it.

PROSTHETICS

TINKERCAD GUIDE

Before you begin: TinkerCAD is an extremely easy and powerful tool for making 3D objects. The CAD name in TinkerCAD stands for Computer Aided Design. CAD is one of the main ways that engineers, designers and makers create things to be produced by a 3D printer.

One of the most powerful aspects of TinkerCAD is that it lets you design objects simply by dragging, dropping, and re-sizing solid geometric shapes. These shapes can then be combined into larger, more complex designs, or they can be used to cut away from other shapes. This provides a simple way for students, teachers, and professionals alike to design, create and change their ideas.

If you would like to learn more about using TinkerCAD before introducing it into your classroom, you can sign up for a free account on TinkerCAD.com. You will then be able to work through as many lessons as needed before using it with your students.

STEP 1: SIGN UP FOR AN ACCOUNT

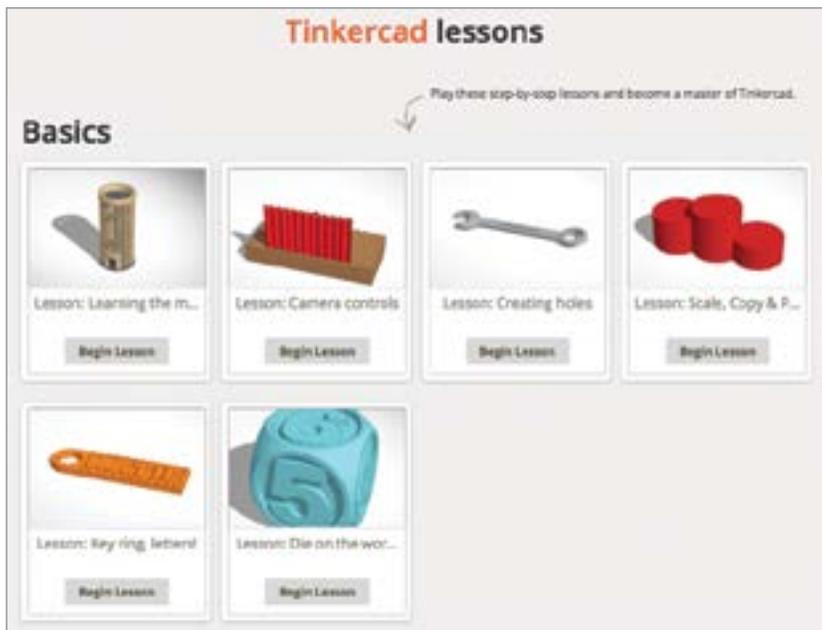
[SIGN UP](#)

Visit TinkerCAD.com and sign up for a new account.

Once you have logged into your new account you will have access to create a new design,



Or you can take the various step-by-step lessons to learn about TinkerCAD.



PROSTHETICS

STEP 2: GIVING STUDENTS ACCESS TO THE ACCOUNT

Get your students signed into TinkerCAD. There are two different ways they can access TinkerCAD.

The first method is to create one account for all students using a general email account. You will then give all of your students the login information to access that account. This method is the easiest to set up and manage student files. However, you will need to create one account for each class since having one account with hundreds of projects in it at one time will cause headaches for your students. Nevertheless, this method makes it easiest to see what your students are working on because you have access to all of their projects in one location and can easily download them for printing all in one place.

The second method is for students to sign up for individual accounts. If your students are all over 13 years of age this will be the easiest method. If they are younger than 13, you can still have them sign up for their own account but they will need you to verify their account as their teacher. The instruction for getting your students' accounts verified if they are under 13 can be found at [Tinkercad.com/teach](https://www.tinkercad.com/teach).



PROSTHETICS

STEP 3: USING TINKERCAD

Students can redesign the Raptor Reloaded hand from e-NABLE through two different methods.

The first way is to have students download the finger set they are using (either 1 finger or 4 fingers) from Thingiverse #1954875 and then import it into TinkerCAD.



The second is to access the files directly from within TinkerCAD. Once a student is logged into their account they can search at the top of the page for the file titles “LB Raptor Hand 4 Fingers” or “LB Raptor Hand 1 Finger.”



You can also access additional files with the following links.

LB Raptor Hand 1 Finger:

<https://www.tinkercad.com/things/4tXK68Wxg38-lb-raptor-hand-1-finger/edit>

LB Raptor Hand 4 Fingers:

<https://www.tinkercad.com/things/gqoejxowVBS-lb-raptor-hand-4-fingers>

Students can find this link on Thingiverse on the LB Raptor Reloaded Redesign page thing: 1954875.

Once students have accessed one of the above finger files, they will be able to use the tools and shapes within TinkerCAD to create their adaptation on the finger.

PROSTHETICS

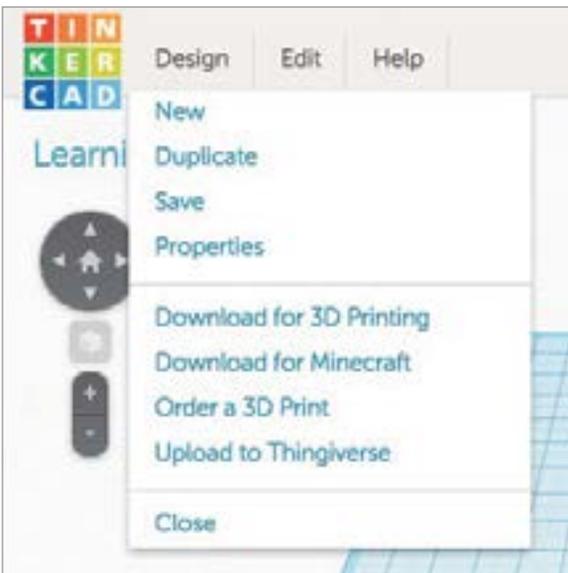
STEP 4: DOWNLOADING THE FILE FOR PRINTING

Once students are done with their projects you will need to download them for 3D printing. To download students' files open up the projects they are going to be print.

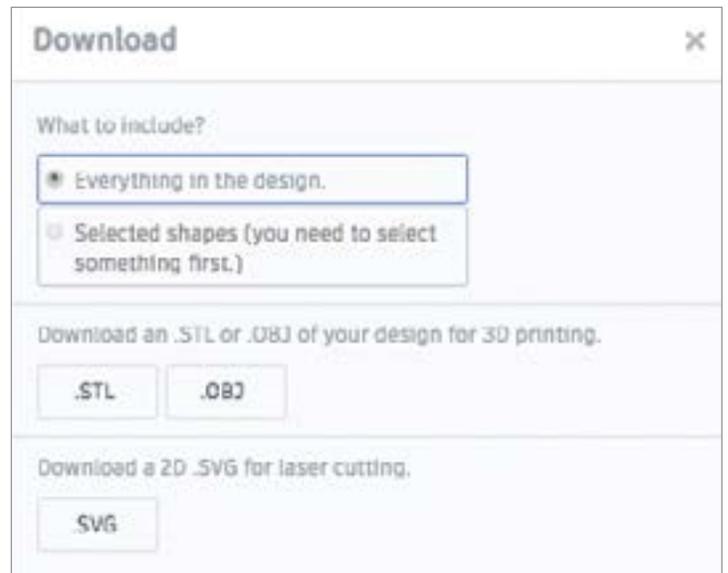
Open up the Design icon at the top of the page.



Choose Download for 3D Printing.



Click STL as the download format.



You are now ready to send the STL files to your 3D printer. If time allows, post back onto the original Thingiverse file with pictures of your students' designs.

Name _____

RAPTOR RELOADED WORKSHEET

Now that you have interacted with the Raptor Reloaded hand, what activity do you think it could be re-imagined to do better? Why wouldn't it do that task well in its current form?

ANIMAL STUDY

Now that you have identified the activity that you want to make the Raptor Reloaded hand better at, brainstorm at least three animals that do that activity well.

Animal

1. _____
2. _____
3. _____

For each animal, write what makes it good at doing your chosen activity and in the following box, as best you can, draw the animal's adaptation that allows them to do the activity well.

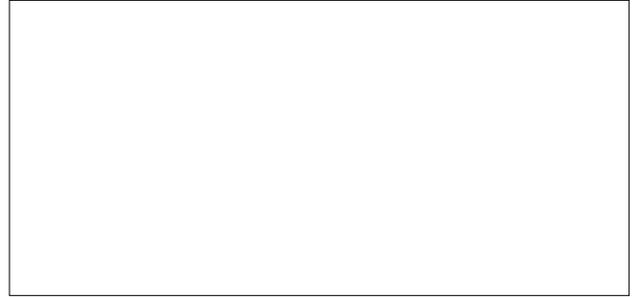
Animal

1. _____

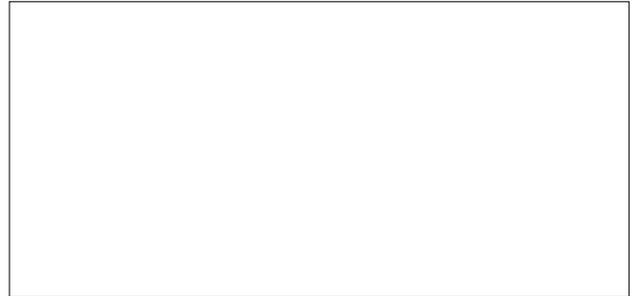


PROSTHETICS

Animal 1



Animal 2



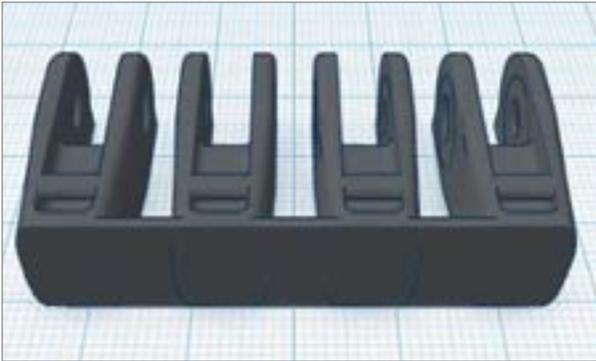
Animal 3



Based on what you have researched and seen for the three different animal adaptations, which ones do you think will work the best on your Raptor Reloaded redesign? Why?

PROSTHETICS

Before you start designing your adaptation in TinkerCAD, you will need to decide to either make your adaptation on individual separate fingers, like many animals have, or use the 4-finger design. Both have advantages and disadvantages but based on the animal that you choose above, circle the design below that you will be working with in TinkerCAD.



Based on the animal that you choose and the single or 4-finger design from above, sketch your final adaptation as a guide for when you start designing in TinkerCAD.

PROSTHETICS

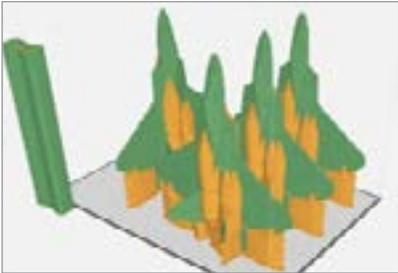
LEVEL	LEVEL 1 (50-59%)	LEVEL 2 (60-69%)	LEVEL 3 (70-79%)	LEVEL 4 (80-100%)
Knowledge/ understanding 3D drawing concepts	3D CAD drawings are incomplete or illegible.	There is limited use of 3D design features and tools.	Most 3D design tools and features have been used properly.	All 3D design tools and features have been used properly.
Thinking/ Inquiry Level of complexity	Student's adaptation does not meet the needs of chosen activity.	Student's adaptation partially meets the needs of chosen activity.	Student's adaptation meets the needs of chosen activity.	Student's adaptation meets the needs of chosen activity and design elements reflect the biological adaptation of choice.
Application Design concept	Final product does not meet design constraints put forth by the instructor.	Final product slightly meets the design constraints put forth by the instructor.	Final product meets the design constraints put forth by the instructor.	Final product meets the design constraints put forth by the instructor and satisfies overall goals of this lesson.

ASSESSMENT CRITERIA

SUGGESTED NEXT LESSONS

NESTING

Students will learn what nesting is and how it impacts the 3D printing process. Students will learn 3D printing considerations for tolerances and support material removal.



COMPUTER MOUSE

Keeping the users of your product in mind, design a wireless mouse that will provide optimum comfort and performance.



CAMERA ACCESSORIES

Design gadgets that can help take photos or videos. These can be added to conventional cameras, cellphones and action cameras.



To access additional 3D Learning Content and resources visit:

[http:// www.stratasys.com/3DLC](http://www.stratasys.com/3DLC)

ACKNOWLEDGEMENTS

Stratasys would like to thank Ryan Erickson for developing this lesson. Ryan's curriculum incorporates science, technology, engineering, art/architecture/design, and math (STEAM) to provide educators with active learning resources to inspire students and join the recent Fab Lab and Makerspace movements in education.

He is a 3D printing enthusiast and evangelist who has spoken nationally on how to build 3D printing programs into school systems. He holds a Bachelors of Arts Degree in Education and is currently pursuing a Master's Degree in Educational Technology. He teaches out of Cedar Park STEM Elementary in Independent School District 196, based in Apple Valley, MN.



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HEADQUARTERS

7665 Commerce Way,
Eden Prairie, MN 55344
+1 800 801 6491 (US Toll Free)
+1 952 937-3000 (Intl)
+1 952 937-0070 (Fax)

2 Holtzman St., Science Park,
PO Box 2496
Rehovot 76124, Israel
+972 74 745 4000
+972 74 745 5000 (Fax)

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