**HOW TO START WITH THE E-NABLE HAND PROGRAM Updated 3-28-15**

[**http://STEAMtechTeams.com**](http://STEAMtechTeams.com) **and STEAMtechTeams@gmail.com**

1. **Background**
   1. Our STEAM tech TEAM formed at OLLI at Furman (OSHER Life Long Learning Institute) in spring 2014. We went together and purchased a Robo 3 D printer and in the Fall of 2014 learned how to use it and made our first hand. Our desire is to work with schools and other organizations to help them learn about e-NABLE hands and how they might make hands and develop a curriculum around the hands. We are also working with UPSTATE STEM Collaboration on getting STEM and volunteers into upstate schools. <http://www.upstatescstemcollaborative.org/> Some of our group has interest in other technologies like robots, drones (quadcopters), Raspberry PI, aruino cards.
   2. E-NABLE [www.enablingthefuture.org](http://www.enablingthefuture.org) is an Internet-based Social Network comprised today of more than 3,000 volunteers on five continents around the world. It is dedicated to providing 3-D printed prosthetic devices free of charge. During its first full year of operation (last year) its volunteers provided approximately 700 devices to clients. In the fall of 2014 there was a [conference at John Hopkins University](http://enablingthefuture.org/?s=john+hopkins) bringing many interested parties, including kids together. <http://enablingthefuture.org/?s=john+hopkins>. There is also a strong link with the Rochester Institute of Technology in Rochester NY.
   3. How the hand project got started <http://enablingthefuture.org/our-tree/>
   4. E-NABLE is organized primarily through a website. People volunteer as “Designers,” “Matchers,” “Fabricators,” “Fitters,” “Follow-up Quality Assurance,” “Programmers,” and “Other Volunteers.” A school might enroll as a “Fabricator” but could find itself involved in “Fitting” and “Follow-up Quality Assurance.”
   5. Devices include individual fingers, 4-5 hand designs, hand designs modified for useable fingers the client may have, arm-hand combinations, a myoelectric hand-arm, and various other devices. The files for most of these devices reside at [www.thingiverse.com](http://www.thingiverse.com) (search under E-Nable). Except for files sent via “Hand-o-matic,” the files need to be scaled up before printing.
   6. There is a very active Internet Forum with 10-30 entries per day.
   7. Program alternatives for schools
      1. Make hands for testing, analysis and improvement
      2. Make hands for general hand drives: Haiti, Syria, etc.
      3. Make hands for individual clients
   8. Other
      1. Why do people need hands? Birth anamolies is one reason. There are many causes to use a limb but one frequent one is amniotic band syndrome which affects the upper body limbs of 1 in 1200 births. Learn more here <http://amnioticbandsyndrome.com/>. Other causes are accident, disease and war victims.
      2. What has changed that makes this possible? Many 3D technology patents are expiring and there is more competition in the market place that brings down the price.
      3. Liability – e-NABLE has worked diligently to protect the makers of hands from legal recourse should something go wrong. Nothing can be 100% but we feel the risk is low.
      4. FDA and other regulatory agencies have recently become more open to ways to make some medical technology less regulated and more assessable and cost effective.
2. **Test Prints and Assembly**
   1. As of 3-12-15 this is the most current link for the Raptor Reloaded hand
   2. [**http://www.thingiverse.com/thing:596966 https://youmagine.com/designs/raptor-reloaded-by-e-nable https://github.com/e-nable/RaptorReloaded**](http://www.thingiverse.com/thing:596966%20https:/youmagine.com/designs/raptor-reloaded-by-e-nable%20https:/github.com/e-nable/RaptorReloaded) **Print hand at 125%.**
   3. Print 1-2 finger files to evaluate your machine and operator capabilities (1-2 hours).
   4. We can help here
   5. After you are happy with the small prints, print all files. Print time for all files can be 20-30 hours.
   6. Assemble the hand. We have assembled totally just supervising motivated 6th graders. First time will take 4-8 hours. [12 page Raptor Assembly Guide](https://drive.google.com/file/d/0B7IZ4iPA1DJZZ3lRSV9YUXVWSjA/view)
   7. We can help here.
   8. Assembly YouTube videos available. For Raptor 2.0, go to <http://enablingthefuture.org/upper-limb-prosthetics/>
3. **Order Supplies**
   1. Filament, Tippi MicroGel Grips and hand assembly kits can be purchased with a 10% discount available to enrolled E-Nable volunteers. You must call 3D Universe, identify yourself as an E-Nable “Fabricator” and they will email the discount list to you.

Kit that has many of these supplies $25 <http://shop3duniverse.com/collections/3d-printable-kits/products/raptor-hand-by-e-nable-assembly-materials-kit>  
**Each kit includes the following:**

* (4 feet) Velcro, double-sided (2” wide)
* (8 feet) Non-flexible braided fishing line
* (5 feet) Flexible elastic cord (1mm, for smaller hands)
* (5 feet) Flexible elastic cord (2mm, for larger hands)
* (6) Tensioner screws (extra small)
* (6) Tensioner screws (small)
* (6) Tensioner screws (medium)
* (6) Tensioner screws (large)
* (4) Palm velcro attachment screws with stop nuts (smaller size)
* (4) Palm velcro attachment screws with stop nuts (larger size)
* (15) Palm velcro attachment screws (smaller size)
* (15) Palm velcro attachment screws (larger size)
* (10) Lee Tippi Micro Gel Fingertip Grips
* (12 inches) Firm Foam Padding (5 ¾” wide)
  1. Filament in preferred colors, normally 1.75 mm PLA or ABS (PLA preferred) - [http://shop3duniverse.com/collections/3d-printer-filament/products/colorfabb-pla-filament-175](http://shop3duniverse.com/collections/3d-printer-filament/products/colorfabb-pla-filament-175%20)
  2. Round Braided Elastic 1/32” (return tendons) – HobbyLobby or Jo-Ann’s
  3. 2” One-Wrap Velcro Strapping [- http://www.amazon.com/VELCRO-1806-OW-PB-Onewrap-Velcro-Length/dp/B00I0TTVVC/ref=sr\_1\_5?ie=UTF8&qid=1423507752&sr=8-5&keywords=Onewrap+velcro+2+inch](file:///C:\Users\Fay\AppData\Local\Temp\-%20http:\www.amazon.com\VELCRO-1806-OW-PB-Onewrap-Velcro-Length\dp\B00I0TTVVC\ref=sr_1_5%3fie=UTF8&qid=1423507752&sr=8-5&keywords=Onewrap+velcro+2+inch)
  4. Tippi MicroGel Grips (small, clear) – <http://shop3duniverse.com/collections/3d-printable-kits>
  5. Hypo-Allergenic Foam Pad 1/8” or ¼” (try to get peel-off sticky backing) –
  6. .9 mm Round Lift String (Hunter Douglas .9 mm Duette) [– http://www.amazon.com/Hunter-Douglas-Duette-Standard-lifting/dp/B00LU34278/ref=sr\_1\_fkmr2\_1?ie=UTF8&qid=1423508173&sr=8-1-fkmr2&keywords=duet+lift+string+.9+mm](file:///C:\Users\Fay\AppData\Local\Temp\–%20%20http:\www.amazon.com\Hunter-Douglas-Duette-Standard-lifting\dp\B00LU34278\ref=sr_1_fkmr2_1%3fie=UTF8&qid=1423508173&sr=8-1-fkmr2&keywords=duet+lift+string+.9+mm)
  7. #4, 1.0 inch Round Head Machine Screws (5 per hand) – Lowes/Home Depot
  8. #6 or #8 ¼-1/2 inch Flat Head Metal Screws, depending on palm size (3 per hand)– Lowes or Home Depot
  9. Tools Needed (some may have been included with 3-D Printer, most can be purchased from Lowes, Home Depot or HobbyLobby):
     1. Spatula (to remove parts from build plate)
     2. Calipers (digital recommended, not required) – Lowes/Home Depot
     3. Small Rubber Mallet (print Thwacker from Thingiverse)
     4. Small Needle Nose Pliers – Lowes/Home Depot
     5. Small Snips and /or Trimmer (for trimming plastic from parts) – HobbyLobby, only
     6. Micro Precision Screw Driver Set with Assorted Bits – Radio Shack
     7. Quick Grip Clamp – Lowes/Home Depot
     8. 6-Piece Needle File Set - Lowes
     9. Dremel Precision Drill Set (not absolutely necessary) – Lowes or Home Depot
     10. Awl – Lowes or Home Depot
     11. Pencil, Battery Powered Micro Screw Driver - Lowes
     12. Gardening Gloves (protection from hot-end extruder, filing) – Lowes or Home Depot
     13. Safety Goggles (for sanding with Dremel) – Lowes or Home Depot

1. **Printing Hand Components**
   1. Scale part files in slicing software as appropriate (generally 120-150%). Uniform scaling.
   2. Set slicer settings
      1. Precision: Medium (layer height .20-.25 mm)
      2. Infill: 22-25%
      3. Extruder Speed: Medium-Slow (16-30 mm/sec)
      4. Support: None
      5. Rafts: None
      6. Bed Temperature (if applicable): 60 degrees for PLA, Manufacturer Recommendation for ABS/Nylon
2. **Assembling the “Test” Hand(s)**
   1. Tools and supplies for assembly – see section 3 above
   2. See Raptor Assembly YouTube video at the following URL - <http://enablingthefuture.org/upper-limb-prosthetics/the-raptor-hand/>
   3. Files to be printed (Raptor 2.0 or Raptor Reloaded)
      1. Distal fingers (Finger Tips), 1-Long, 1-Short, 3-Medium
      2. Proximal phalanges – print five (5)
      3. Gauntlet
      4. Palm
      5. Tensioner block
      6. Dovetail cap
      7. Tensioner block pins – print five (5)
      8. Knuckle pins – print two (2)
      9. Finger snap pins – print four (4)
      10. Thumb pin – print one (1)
      11. Hinge pins – print two (2)
      12. Hinge pin caps – print two (2)
3. **Accepting Assignment**
   1. Enroll as a “Fabricator” at - <https://docs.google.com/forms/d/1fIiFAT8KN1qLPu8V9cxNRUPdifSHnGz0scQh4jykYSw/viewform>
   2. Two-three days after enrollment, receive an invitation to join the “E-Nable Matcher” forum. You will also receive a link to the Google+ spreadsheet listing the people in need of devices
   3. Post your name when you decide to volunteer to fabricate a hand
   4. You will see a link to pictures. Download the pictures and use “Tracker” to take precise measurements. The procedure for using “Tracker” can be found at the following URL – Tracker Measuring Tool: <https://www.cabrillo.edu/~dbrown/tracker/>
   5. Alternatively, you can use the following physical measuring tool. It also offers a significant amount of STEM-related activity: Hand-sizing Tool (3D Printed) and Instruction Video: Files are here:  
      <http://www.thingiverse.com/thing:659515>  
        
      and a tutorial video is here:  
      <https://www.youtube.com/watch?v=iHoCrLcgW2w>
   6. After measurements are completed, call the client to introduce yourself and to discuss colors, devices, etc. The E-Nable Matcher will email contact information.
4. **Fabricating a Prosthetic Device for a Client**
   1. Follow the procedures described in sections 4 and 5 above.
   2. Make arrangements for on-site fitting of the hand. If the client is local and no local “Fitters” are available, fitting may have to be done by the “Fabricator.” If the client is not local, local “Fitters” should be identified. Prosthetists, Physical Therapists, school nurses or primary care physicians are good candidates.
5. **Delivery of Prosthetic Device**
6. **Follow-up**
   1. Clients should be encouraged to use the device sparingly at first to reduce the risk of muscle strain. We recommend no more than 15 minutes each hour for the first week with parental follow-up daily.
   2. Start using the device with a sock insulating the hand from the devices. The client and/or the client’s parents should watch for redness in areas in contact with the device.
   3. The device should not be used for carrying weighty objects, hot or warm objects (melting point of PLA is as low as 110°F), the device should not be left in an enclosed automobile in direct sunlight, etc.
7. **STEM-STEAM Activities**
   1. There are numerous STEM or STEAM activities that can be pursued. They will be discussed in a follow-up document.
8. **Concluding Thoughts**