Closing The Gap
2020

3D-Printed Keyguards - Your Gateway to 3D-Printed Assistive Technology

Ken Hackbarth
President
Volksswitch.org
ken@volksswitch.org

Volksswitch.org
The People's AT

Welcome, and thank you for choosing to watch my presentation.

My name is Ken Hackbarth and my presentation will demonstrate the value of 3D-printed assistive technology and why 3D-printed keyguards are the best way for you to get started with this new technology.

Ken Hackbarth

I am the president of Volksswitch – an organization devoted to the democratization of assistive technology by leveraging the power and promise of 3D printing.

I have no financial relationships to disclose.

Volksswitch.org
The People's AT

First, a bit about me. I am the president of Volksswitch.

Volksswitch is an organization devoted to the democratization of assistive technology by leveraging the power and promise of 3D printing.

Volksswitch is committed to designing customizable, 3D-printable devices and putting those designs in the hands of the people who need them.

Prior to my current position I worked for almost three decades as a systems architect for AT&T Bell Laboratories and its subsequent divestitures.

I have a Master of Science in Systems Engineering from the University of Arizona and a Master of Education in Special Education, with a concentration in assistive technology, from Bowling Green State University.

I have no financial relationships to disclose.

Learning Objectives

❖How does 3D-printing, as a technology, differ from traditional manufacturing methods?

❖What activities comprise the 4-step process for designing and 3D-printing a keyguard?

❖Identify three options for producing a 3D-printed device.

Volksswitch.org
The People's AT

I have created three questions for you in association with this presentation.

They will cover these three topics.

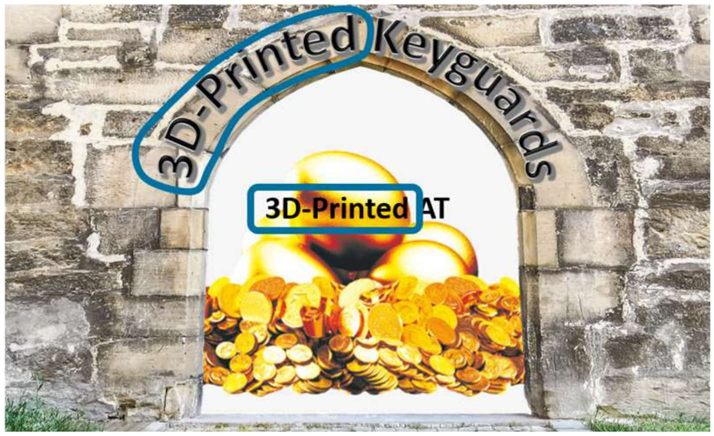
I've put an asterisk on the slides associated with these topics to help remind you to pay special attention when we get there.

3D-Printed Keyguards - Your Gateway to 3D-Printed Assistive Technology

Volksswitch.org
The People's AT

On this slide, I've tried to represent my proposal as a picture, and at the same time call out the two arguments that I need to convince you of.
First, I need to convince you that there is a wealth of high value, freely available, 3D-printable, easily accessible assistive technology designs that you can take advantage of right now. Even if you already believe that, you may believe that there's an impenetrable technological and financial wall between you and those devices.
My second goal will be to convince you that there's a gateway through that technological and financial wall called 3D-printed keyguards.

But first some context: "What is 3D Printing?"



Volksswitch.org
The People's AT

But first a little context. Let's all get on the same page as to what someone means when they use the words "3D Printing".

What is 3D Printing?

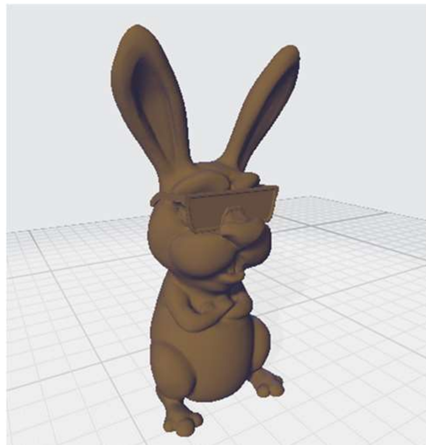
3D printing takes a digital model and, layer by layer, turns it into a physical object.

Volksswitch.org
The People's AT

The simplest definition of 3D printing that I can think of is "3D printing takes a digital model and, layer by layer, turns it into a physical object."

Start with a 3-dimensional digital model

3D printing takes a digital model and, layer by layer, turns it into a physical object.



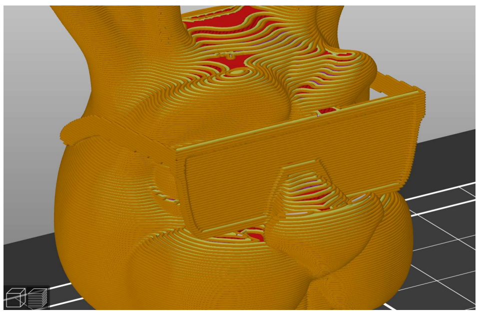
Volksswitch.org
The People's AT

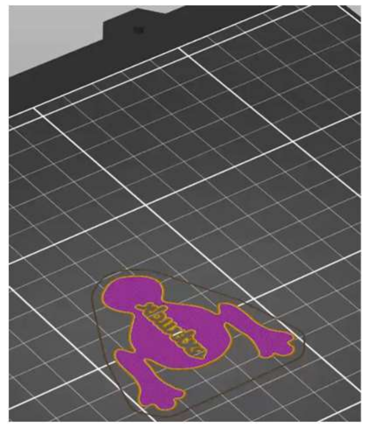
A digital model is a virtual object created using specialized software called "computer-aided design" or CAD software.

In this example, someone has created a virtual rabbit wearing sunglasses.

Slice the model horizontally into layers

3D printing takes a digital model and, layer by layer, turns it into a physical object.





Volksswitch.org
The People's AT

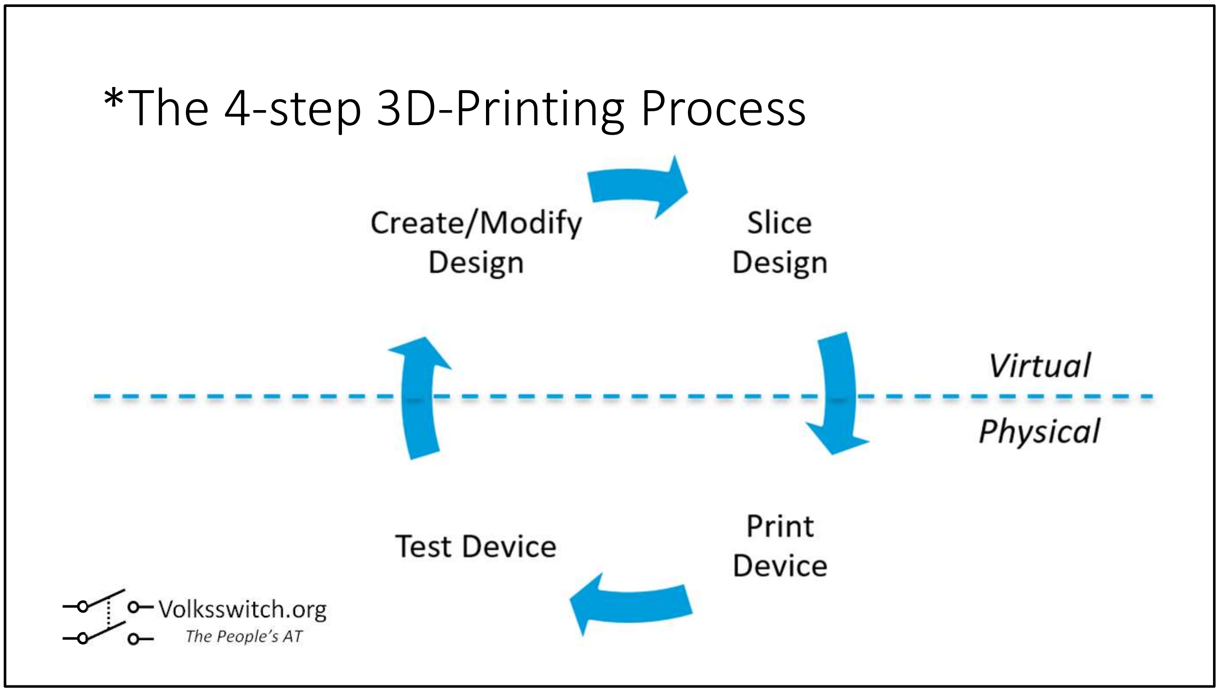
That digital model is then sliced into a series of horizontal layer by another piece of software called, of all things, a "slicer" program.
The slicer then tells a 3D printer to print each layer on top of the previous, starting at the bottom.

Printing the layers produces a physical object

3D printing takes a digital model and, layer by layer, turns it into a physical object.

Volksswitch.org
The People's AT

A 3D printer uses thermoplastic filament or photo-sensitive resin to create the final physical object.
The instructions can be repeated over and over to create additional copies.



But how does 3D design and printing work in actual practice?
This slide shows the process for creating an assistive technology device.
The process exists in both the virtual world of computer software and the physical world of 3D printers and human beings.
The process begins on the upper left side of this diagram with the creation of a design – a 3D model.
In truth, the process begins with the identification of a need or problem and a discussion of possible solutions.
You then draw-up the leading contender as a 3D design using CAD software.
Step 2 is to slice that design and hand the instructions to the 3D printer.
Step 3, you print the device.
Step 4 is the critical step of testing the device.
Great ideas on paper don't always translate to great ideas in the real world.
If you're like the rest of us, the trial will identify the shortcomings of your design or tell you that you need to take an entirely different path.
In either case, you go back to your original design and incorporate the improvements needed or create a new design.
The process repeats or "iterates" until you confirm that your device meets the needs of your customer.
Alternatively, you may learn that the need cannot be met with 3D printed device.

*Why is 3D-Printing Unique?

- 3D printers are inexpensive, general-purpose machines, using inexpensive materials.
  - Traditional manufacturing uses expensive, special-purpose machines.
- The time from idea to prototype or functional object can be very short.
  - Traditional manufacturing methods involve costly, time-consuming processes.
- Rapid prototyping and low cost encourages iteration toward a best fit/design.
  - Traditional manufacturing targets an average customer and is reluctant to modify a design because of the associated costs.
- "Local manufacturing" facilitates consumer involvement.
  - Customers rarely participate directly in the design of traditional products.

Volksswitch.org
The People's AT

With that in mind, why is 3D-printing so unique? How does it differ from traditional manufacturing?

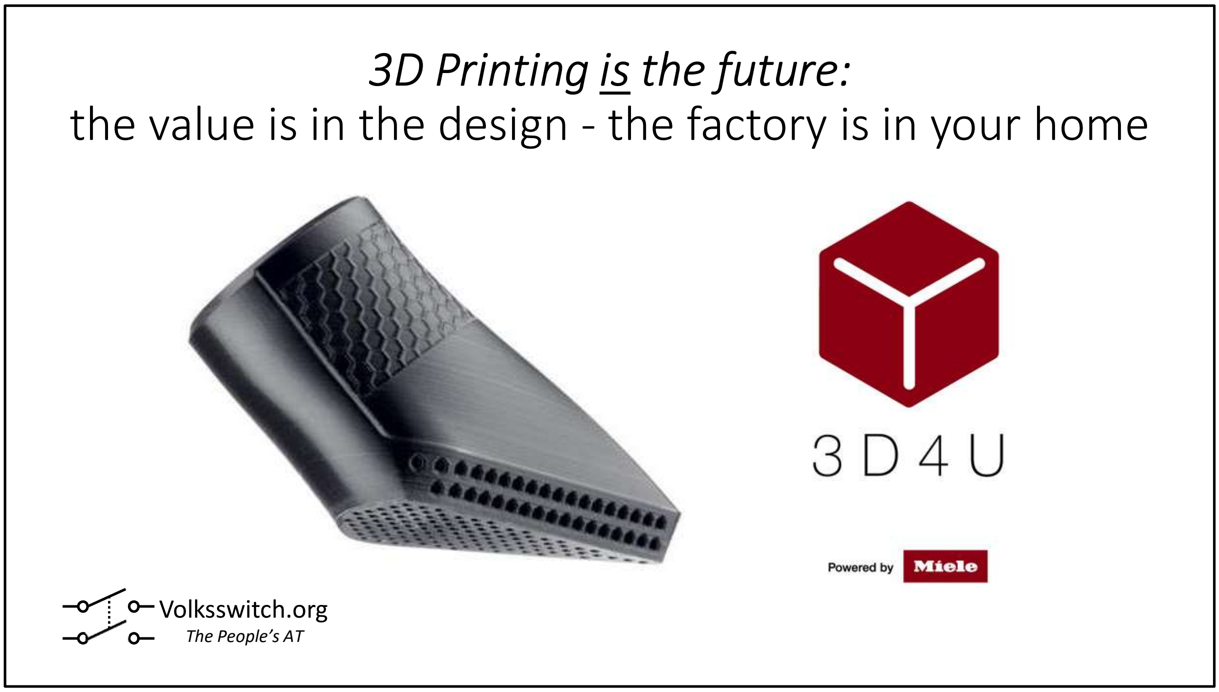
- 3D printers and the materials they use are relatively cheap now. They are general purpose by nature and can create something on the second run that is entirely different from the item created on the first run.
  - Traditional manufacturing methods utilize expensive, special-purpose machines and processes. Once those machines and processes are in place, there's no tolerance for changing the final product.
- Because of all the software support for design, and simplicity of implementation, you can implement a 3D printed solution very quickly.
  - In the traditional manufacturing world, a tremendous amount of time is put into the design of the product and process before a single machine is turned on.
- Rapid production of a physical object, and the fact that the cost of materials was very small, encourages iterating until the final result is just right.
  - Expensive machines, materials, and processes lock the manufacturer into a result that is locked in stone.
- Inexpensive printers and plastic filament make it possible to have a 3D-printing "factory" local to you in your home or business and put the process close to the people who will use the end product and facilitates their involvement in shaping the design so that it works for them.
  - Traditional manufacturers must design for an average customer and can't accommodate customization and personalization of their products.

3D Printing <u>is</u> the future:
the value is in the design - the factory is in your home

Volksswitch.org
The People's AT

Here are a couple of fun examples of why 3D printing is the future of manufacturing.
Several years ago, the astronauts on the space station needed a wrench to perform their work.
NASA was able to design a wrench for them, emailed the design to the space station, and the astronauts printed it on the space stations printer.
You can print that wrench for yourself by downloading the design from the NASA website.

https://www.nasa.gov/mission_pages/station/research/news/3Dratchet_wrench



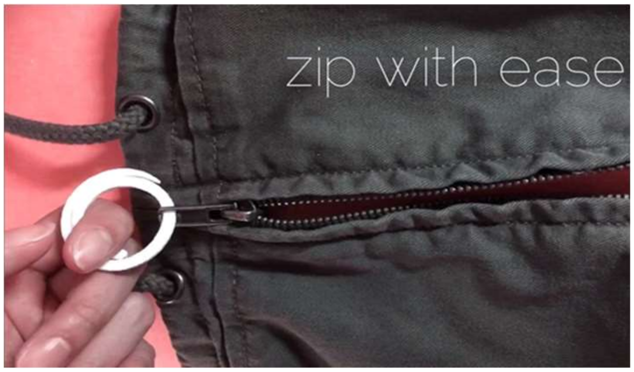
Many companies, like Miele, the vacuum cleaner company, make many of their parts and

Examples of Free, 3D-Printable AT Designs

Volksswitch.org
The People's AT

With that context, let's take a look at actual examples of freely available assistive technology designs.

“Quick-Zip” Zipper Aid



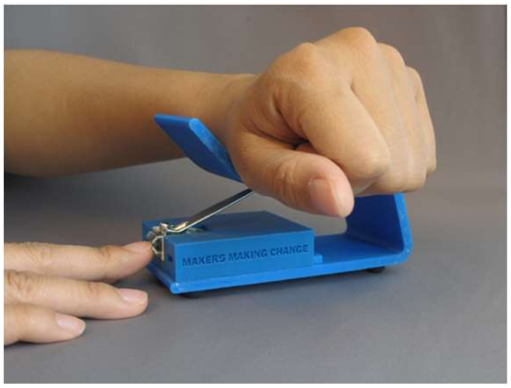
Cost of plastic: **3¢**

Volksswitch.org
The People’s AT

I’m going to quickly cycle through several examples. Each example will include a picture of the device and the cost of the plastic required to print one. The title of each slide includes a hyperlink to the 3D model.

https://pinshape.com/items/25738-3d-printed-zipper-aid-and-easy-keychain-ring

Nail Clipper Holder

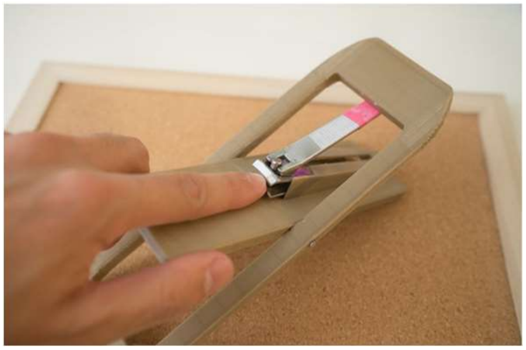


Cost of plastic: **$1.23**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2810056

Nail Cutter for One Hand



Cost of plastic: **$1.19**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2937655

Kobayashi Fidget Cube

Cost of plastic: **75¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:1269699

Arm Spork

Cost of plastic: **53¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:640839

Thumb Prosthesis

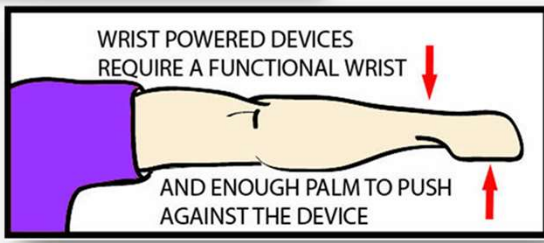
Cost of plastic: **89¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2246592

Wrist-Powered Prosthetic Hand

Cost of plastic: **$3.00**



Volksswitch.org
The People's AT

http://enablingthefuture.org/upper-limb-prosthetics/cyborg-beast/

Disability Friendly Pen Holder

Cost of plastic: **68¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:1324235

Drawer Opening Assistive Device

Cost of plastic: **68¢**

Volksswitch.org
The People's AT

https://pinshape.com/items/25355-3d-printed-drawer-opening-assitive-device

Smart One-Handed Bottle Opener

Cost of plastic: **46¢**

Volksswitch.org
The People's AT

https://www.youmagine.com/designs/smart-one-handed-bottle-opener

Universal Cuff Stylus

Cost of plastic: **75¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3490198

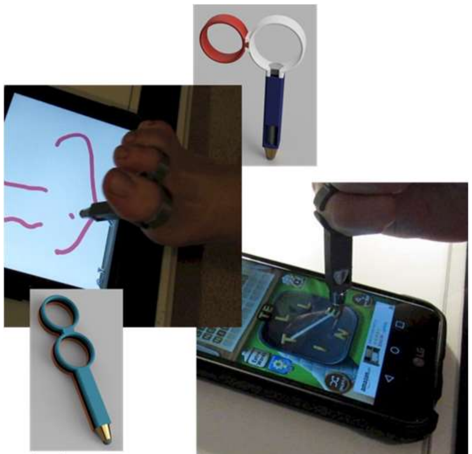
Dyslexia Reading Bar

Cost of plastic: **35¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2802065

Sixth Finger/Toe Stylus



Cost of plastic: **17¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3483326

Bottle Opener

Cost of plastic: **50¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2801157

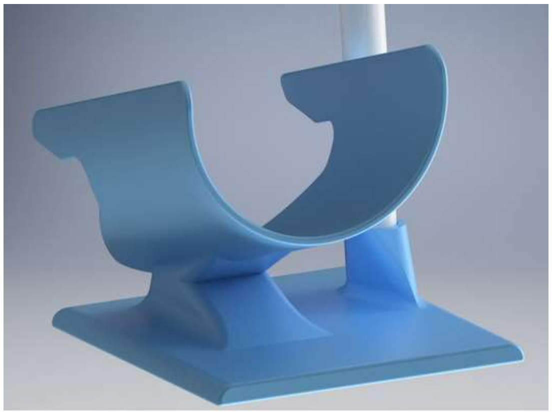
Pop-top Can and Bottle Opener

Cost of plastic: **75¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3043598

Sock Helper Mobility Aid



Cost of plastic: **$4.69**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2482788

Magnetic Shoelaces

Cost of plastic: **25¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3028911

Beverage Holder

Cost of plastic: **$3.50**

Volksswitch.org
The People's AT

https://www.myminifactory.com/object/3d-print-the-next-beverage-holder-57768

Head Pointer

Cost of plastic: **$1.15**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2542267

LipSync

Cost of plastic: **$1.84**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2800937

Ergonomic and USB Adaptable Switch

Cost of plastic: **$1.46**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3191057

DIYAT Switch V1

Cost of plastic: **57¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2792191

Volksswitch - the People's AT Switch

Cost of plastic: **$1.46**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3819575

Round Flexure Switch

Cost of plastic: **$2.00**

Volksswitch.org
The People's AT

https://www.makersmakingchange.com/project/round-flexure-switch-60mm/

ATMakers MX Switch

Cost of plastic: **17¢**

Volksswitch.org

The People's AT

https://www.thingiverse.com/thing:3230906

Universal Wireless Switch Access

Cost of plastic: **34¢**

Volksswitch.org
The People's AT

https://pinshape.com/items/25409-3d-printed-universal-wireless-switch-access

Microwave Door Opener

Cost of plastic: **$1.37**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:642874

Scale Model of the Eros Asteroid

Cost of plastic: **83¢**

Volksswitch.org
The People's AT

http://nasa3d.arc.nasa.gov/detail/eros

Open Assistive Technology - Key Turner

Cost of plastic: **15¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:1852950

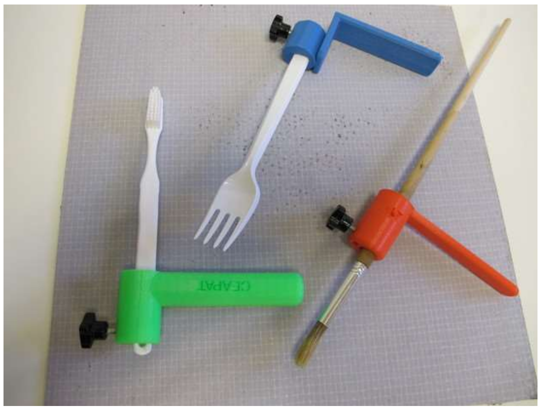
Toothbrush Adapter

Cost of plastic: **62¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2394134

Easy Grip Hand Support

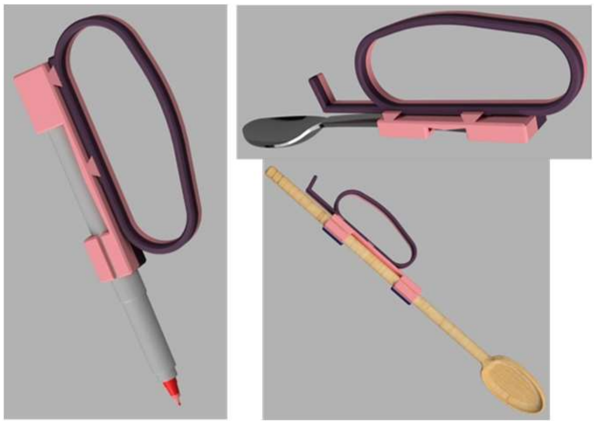


Cost of plastic: **40¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:1086395

Universal Cuff Utensil Holder



Cost of plastic: **50¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3492411

Doorknob Lever Adapter

Cost of plastic: **$1.52**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:640852

C-Clamp Threaded Mounting Adapter

Cost of plastic: **15¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3541114

50mm Piko Button Camera Mount

Cost of plastic: **10¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3197435

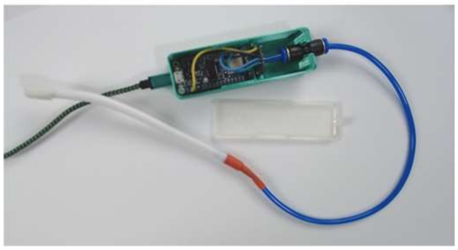
[Lateral Leg Support for Wheelchair](https://www.thingiverse.com/thing:2257895)

Cost of plastic: **63¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2257895

Sip and Puff Interface



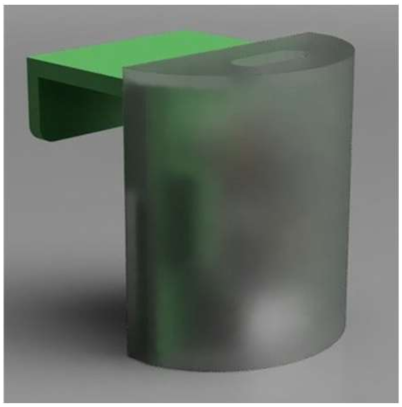
Cost of plastic: **36¢**

Volksswitch.org

The People's AT

https://www.thingiverse.com/thing:3458117

Little HandRaiser Housing

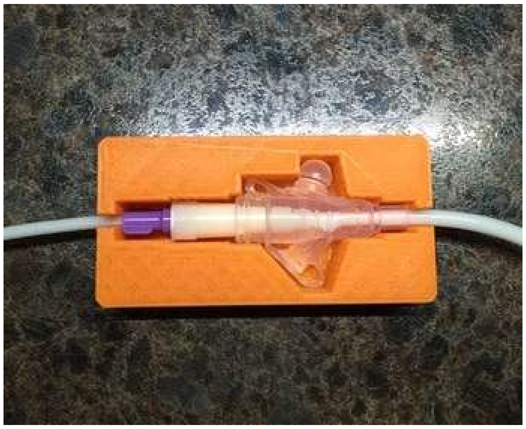


Cost of plastic: **15¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3172905

Feeding Tube Holder



Cost of plastic: **77¢**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2804715

Urinary Catheter Carrier

Cost of plastic: **$2.62**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:3299750

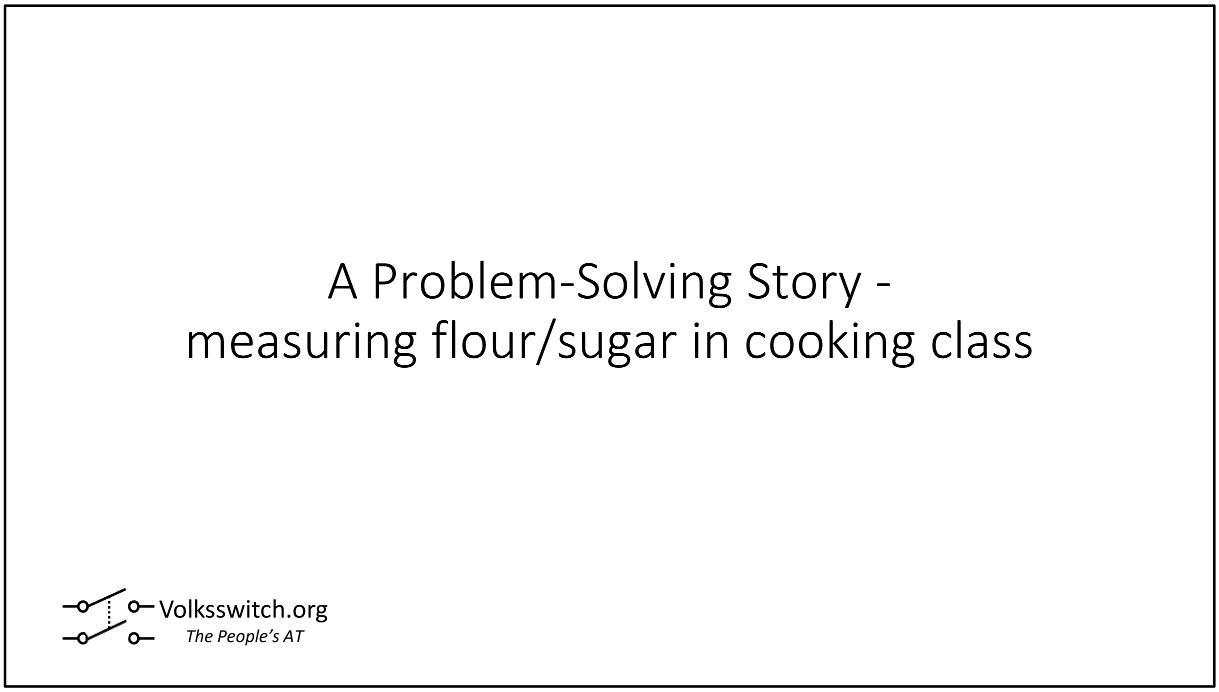
Urinary Sampling Pocket Holder

Cost of plastic: **$2.22**

Volksswitch.org
The People's AT

https://www.thingiverse.com/thing:2849882

Here's a compilation of some of the best sites to visit if you're looking for AT designs.
The first two sites are repositories of 3D models in general. You'll need to search specifically for assistive devices, but they have hundreds of designs.
The remaining sites focus on assistive technology.
If you get into modeling AT, I would encourage you to post your designs at least at Thingiverse and Makers Making Change to share with others.



Downloading and printing free AT designs is one thing but think of the possibilities available to you when you have your own personal design and manufacturing capability.
Let me tell you a story…

Last year I attended a cooking class at a facility in Colorado that serves adults with physical and developmental disabilities.

A young woman was asked to come to the front of the class, given a bag of sugar, a scoop, a large bowl, and a glass measuring cup, and asked to scoop out 2 cups of sugar and put it in the large bowl.

She never successfully completed the task.

I thought, later, about how difficult the task is. It's difficult to manipulate the scoop inside the bag. As you look down on the glass measuring cup all the writing is backwards. If you overfill the measuring cup, how do you get the right amount of sugar back in the bag.

It occurred to me that there's another baking ingredient that is actually very easy to measure. Baking powder. That's because the baking powder container comes with a special shelf that makes measurement as simple as: choose the correct size of measuring spoon, scoop up a heaping amount of the powder, then scrape the top of the spoon against the shelf. Excess powder falls nicely back into the can.

Is there a way to replicate this process with sugar or flour that normally come in 5 lb. bags?

Here's what I came up with.

We can easily get measuring cups that hold a specific amount of something when filled to the top.

I needed a way to store the sugar in a container that I can add a lip to.

I discovered a plastic storage container for shoes. It will easily hold 5 lbs of sugar. It also has a lip at the front, top edge of the box that can be used to scrap off excess sugar.

The problem with the box is that the drawer can be pulled out too far and then you run the risk of the sugar falling behind the drawer when scraped.

I needed a way to stop the drawer when it was in just the right position for the scraping step.

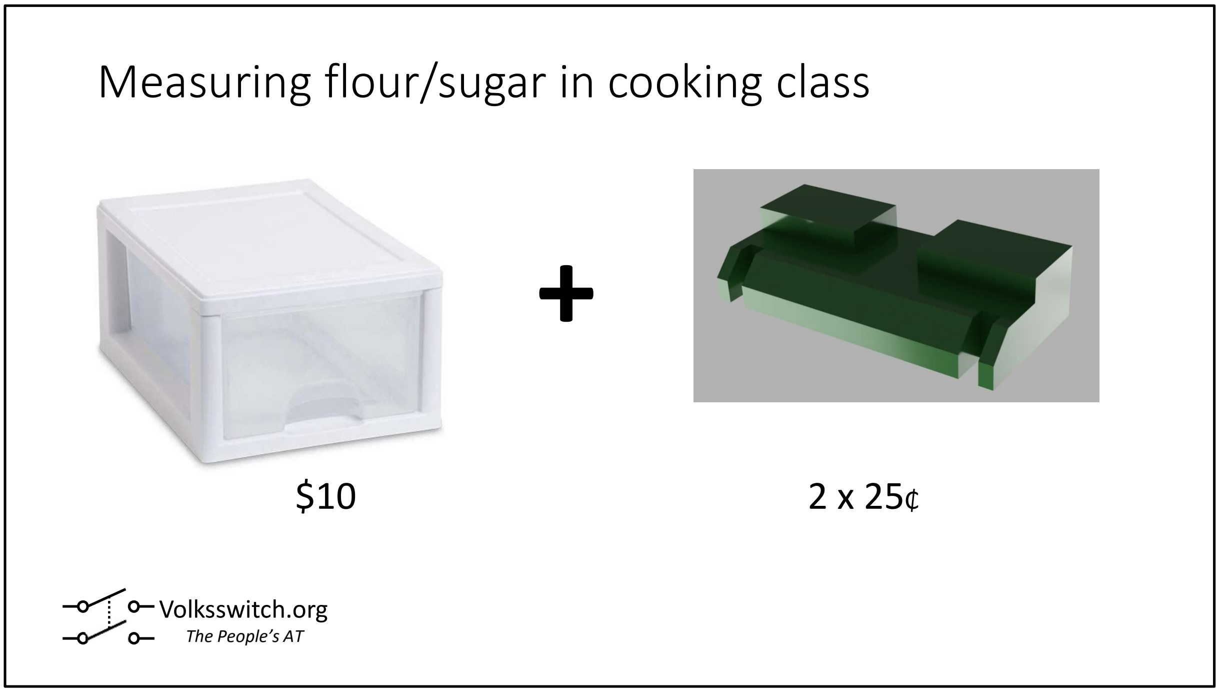
I took the box apart and saw that it had channels in the bottom where I could mount a pair of stops.

I broke out a ruler and my CAD software and soon came up with a design for a pair of stops that would fit securely in the channels.

Reassemble the box and it works perfectly.

Measuring out the correct amount of sugar is now as simple as choosing the proper measuring cup and counting the right number of scoops.

The point of this story is that when you have your own design and manufacturing capability, you're free to focus on changing the task itself rather than training and training on a confusing task.



How much does this solution cost?

Ten dollars for the shoe box and 50 cents for the stops.

I hope I've at least piqued your interest in what's possible with a 3D printer.

3D-Printed Keyguards

Volksswitch.org
The People's AT

Well what's the quickest and easiest way to get there?

I believe the answer is 3D-printed keyguards.

What is a Keyguard?

- A keyguard is a plate which sits over a keyboard or touch screen, with spaces that a user can put their fingers or a pointer through to hit the keys.
- Users who have trouble with fine motor control often find that keyguards help them to hit the key they're aiming for.
- Users who have weakness or fatigue that makes it difficult to hold up their arm can rest their hand on the keyguard while pressing keys.
- Keyguards can make a big difference to a user's accuracy and ability to hit the part of the screen they're aiming for.

-Courtesy of ATMac

Volksswitch.org
The People's AT

I'm sure that many of you are already familiar with keyguards.

- For those people who aren't, a keyguard is a plastic plate that sits on top of a keyboard – or now, much more often, a tablet. The plastic limits access to the tablet to only those places where openings have been cut in the plate.
- Keyguards help people with fine motor control more effectively interact with the app on their tablet.
- They also allow people who are easily fatigued to rest their hand on the tablet without triggering some action within the app.
- They can make a huge difference in a user's productivity.

How Many Keyguards Do I Really Need?

- **<u>As a therapist</u>** you will need a set of evaluation keyguards. These keyguards will need to support each of the tablets and cases you recommend, each of the apps you recommend and each of the app configurations you recommend.
- If you only recommend 2 different tablets, each with two different cases, running 2 different apps in 4 possible configurations you will need **2x2x2x4 = 32 evaluation keyguards**. If 25% of those are lost or broken over time, you will need an additional 8 keyguards for a total of **40 evaluation keyguards**.
- **<u>As an individual</u>** using a tablet with a keyguard, you will need a keyguard for each app you use and additional keyguards as your skills improve or decline.
- What about the development of new tablets, cases, and apps?
- *How many would you need if you could reduce the cost by 99%?*

Volksswitch.org
The People's AT

How many keyguards to you need?

That will depend on the number of tablets and apps you will use or recommend; how many ways the apps can be configured, and how many tablet cases you may use, now and in the future.

- If you only recommend two different tablets, each in two different cases, running two different apps, and four different configurations for those apps, you will need 2 times 2 times 2 times 4, or 32 evaluation keyguards. If a quarter of those break or are lost over time, you'll need an additional 8 keyguards for a total of 40.
- Users will need new keyguards as their skills improve or degrade over time.
- And there are bound to be new tablets, cases, and apps in the future… I can hear what you're thinking - even though I recorded this two months ago! You're thinking that there's no way you could possibly afford 40 keyguards. So that's simply crazy.
- Would it be crazy if you could cut the cost of a keyguard by 99%?

Evaluation Keyguards printed for Imagine! Colorado –

2 tablets, 2+1 Cases, 1 AAC App, 4 Configurations

Volksswitch.org
The People's AT

I designed and printed evaluation keyguards for an SLP at Imagine Colorado.

They support 2 different tablets, one of which could be in two different cases. Just one AAC app – Go Talk Now, and 4 possible layouts.

She needed a total of 10 keyguards to perform evaluations.

How Much Does a Keyguard Cost?

- A Commercial Keyguard

KEYGUARD ASSISTIVE TECHNOLOGY

TouchChat Keyguard

Final Cost: $71

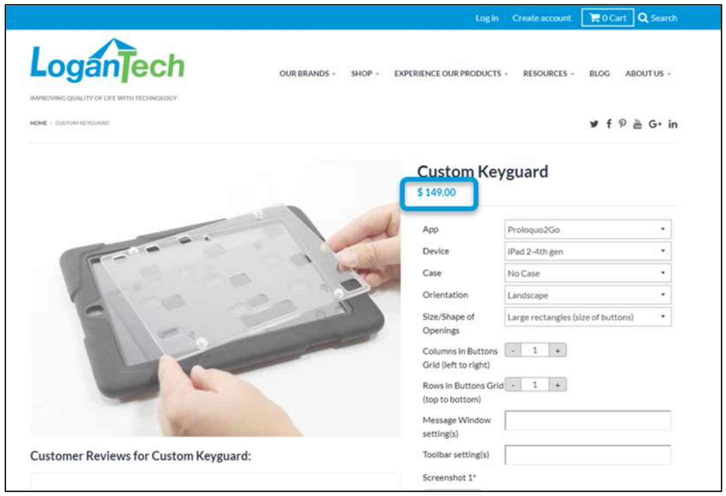
Volksswitch.org
The People's AT

How much does a commercially produced keyguard cost?

Here's a page from the Keyguard AT website. Keyguard AT is the largest producer of laser-cut keyguards in the US and possibly globally.

I purchased a keyguard from them for TouchChat running on an iPad 2 and the final cost was $71.

The Cost Could Be Much More than $71



Volksswitch.org
The People's AT

LoganTech sells keyguards for their systems and this one costs $149.

What if I design the keyguard myself and have it 3D-printed?

Volksswitch.org
The People's AT

So, what if I designed and 3D-printed that TouchChat keyguard myself?

How hard is it to design a keyguard?

Volksswitch.org
The People's AT

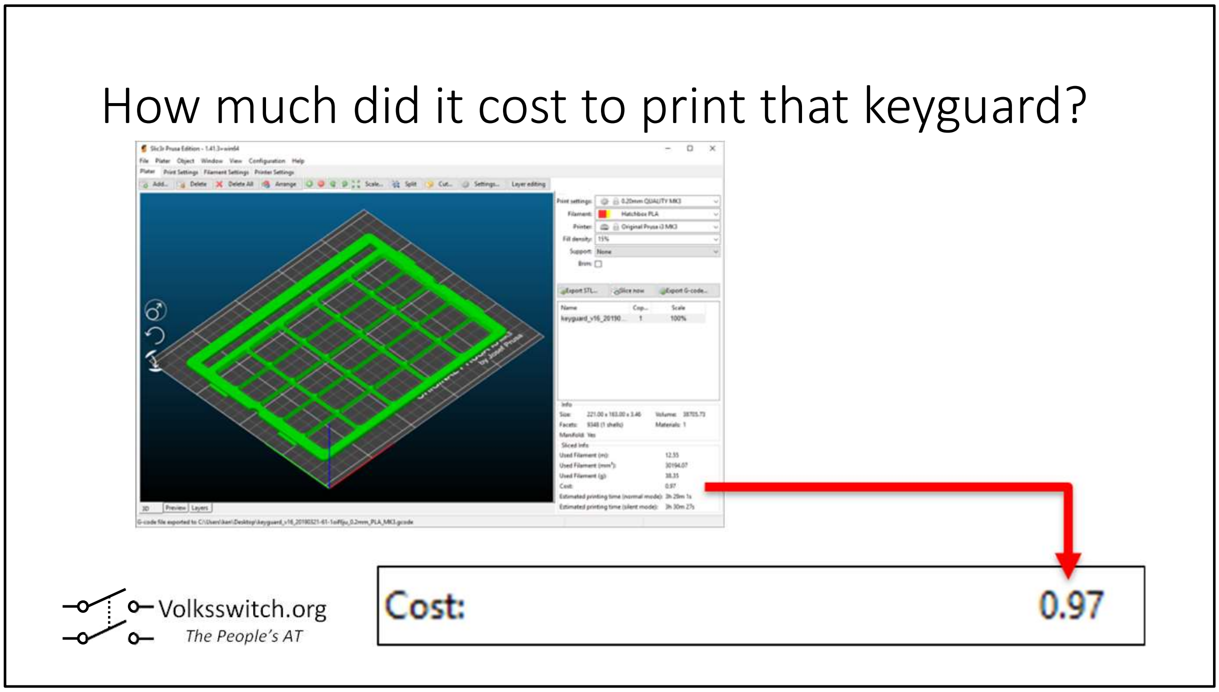
First, how hard is it to design a keyguard?

Volksswitch created a keyguard designer to make the design process easy.

Is it difficult to 3D-print a keyguard?

Volksswitch.org
The People's AT

And, how difficult is it to print a keyguard?

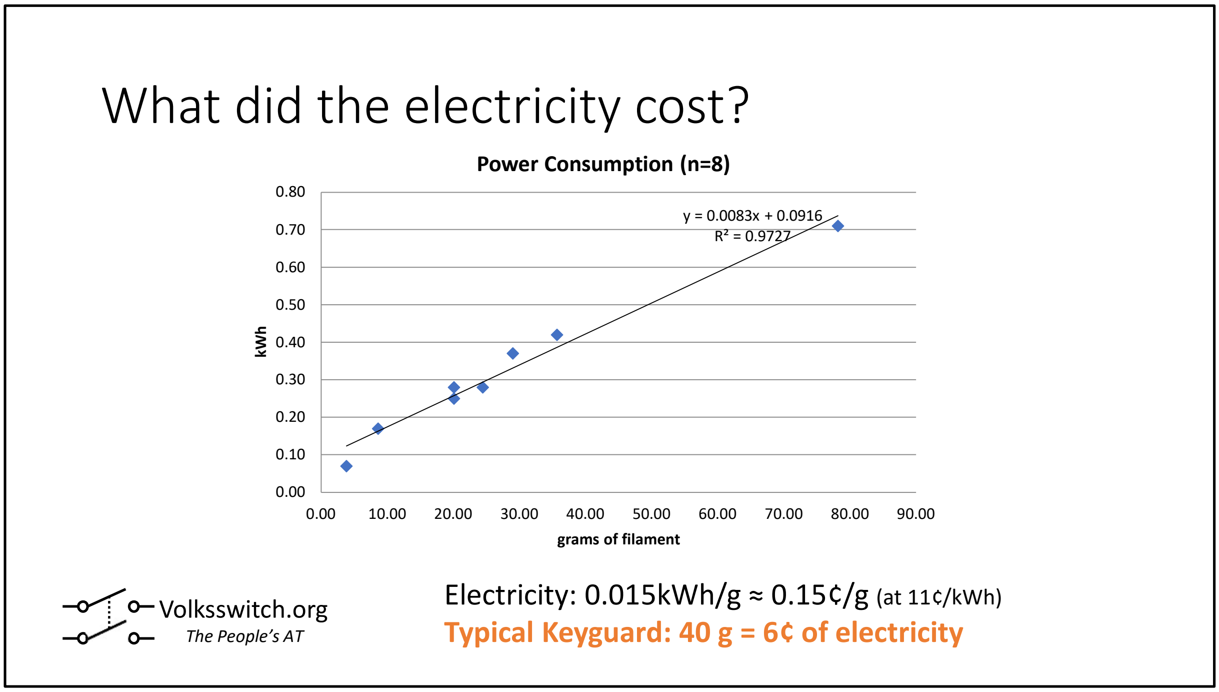


How much did it cost to print the keyguard? That depends on how much plastic filament was used.

This is a screen capture from the slicer software.

If you tell the software how much you pay for a kg of filament, the software will tell you how many grams of filament your print will require and calculate the cost of filament for you.

In this case, the keyguard cost me 97 cents.



How much electricity did I use?

I printed several keyguards in different sizes and looked at the amount of electricity that was used.

The more filament required by the keyguard the longer the print will take and the more electricity will be used.

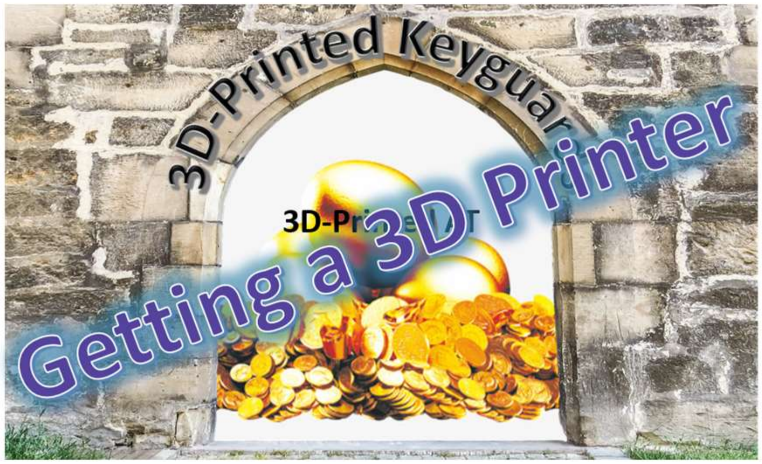
The bottom line is: a typical keyguard will use something in the vicinity of 40 grams of filament which translates to 6 cents of electricity. I think that means you can basically ignore the electrical costs.

Hands-on with some 3D-printed keyguards

Volksswitch.org
The People's AT

Let's take a look at the kinds of keyguards that are possible to create with the Volksswitch designer.

Can I Afford a 3D Printer?



Volksswitch.org
The People's AT

Have I created some excitement for you around the idea of getting a 3D printer? Then let's take a look at some options.

How much does a 3D Printer cost?

Build surface:
300 x 300

Artillery (Evnovo) Sidewinder X1: $450

Build surface:
250 x 210

Prusa i3 MK3S: $749 (kit),
$999 (assembled)

Volksswitch.org
The People's AT

A high-quality 3D printer may be much more affordable than you think.

I've owned several 3D printers over the last 3 years and here are my current two favorites.

The first is the Artillery Sidewinder X1 which sells for around $450. The second is the Prusa i3 MK3S which you can get in kit form for $750 and fully assembled for about $1000. (By the way, I highly recommend assembling your printer from a kit when you can. What you learn in the process will make you much more confident addressing issues in the future that you will inevitably encounter.)

The Sidewinder has a 300 mm by 300 mm build surface while the Prusa has a 250 mm by 210 mm build surface. If you plan to be creating keyguards with your printer, I recommend that you purchase a printer with a build surface that is at least 250 mm on one dimension.

Both of these printers are more than capable of printing keyguards. The Prusa is the highest rated consumer grade printer and it's my go to printer for my day to day work.

How can I justify purchasing a 3D printer?

- If you need to invest in keyguards, the cost differential between commercially purchased keyguards and 3D printed keyguards, is sufficient to justify purchasing a 3D printer after 5 to 10 keyguards.
- With a 3D printer you can explore the full range of free pre-designed AT.
- Based on this information can you put together a business case, a grant proposal, a bake sale?

Volksswitch.org
The People's AT

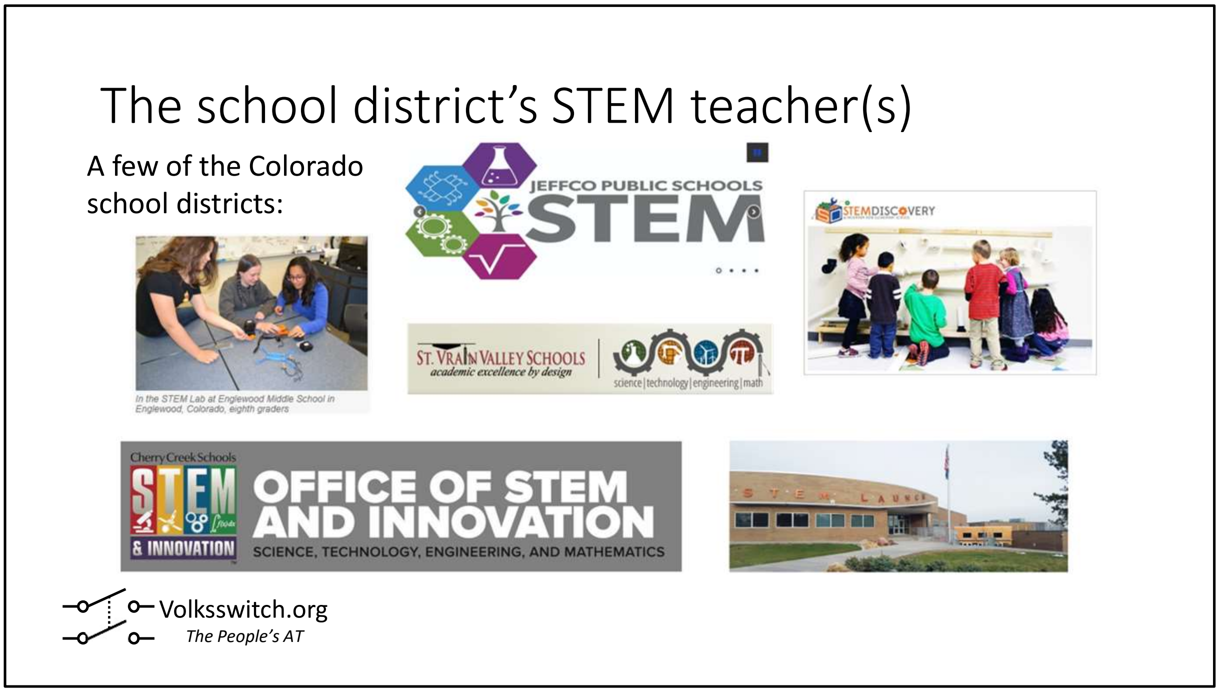
Can you justify purchasing a 3D printer?

- If you save, on average, $90 with every keyguard that you print rather than purchase, you can justify the cost of a 3D printer if you need as little as 5 to 10 keyguards.
- Once you have a 3D printer, you can begin to explore the full range of free, pre-designed assistive technology along with designing and printing your own solutions – which could lead to even more cost savings.
- How difficult would it be to use this information to put together business case?

*Are there any ways to obtain 3D-printed AT without a 3D printer?

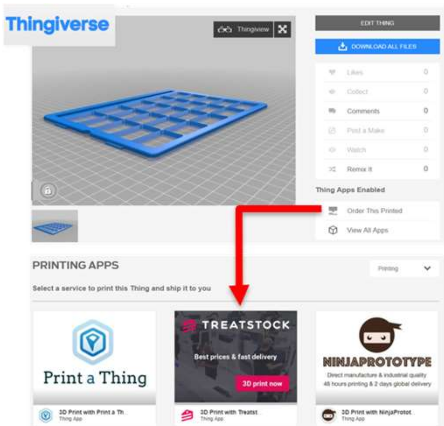
Volksswitch.org
The People's AT

What if the barrier is still too great or maybe you're not ready to make that kind of commitment? How can you get access to 3D-printed AT without a 3D Printer?



If you're employed in a school district, or even just a member of a school district, many districts offer STEM and STEAM programs. Those middle school and high school classes often have 3D printers that are sitting mostly idle. You can give those teachers and students a reason to dust off those printers and CAD software to produce devices that will change people's lives.

Online Printing Services



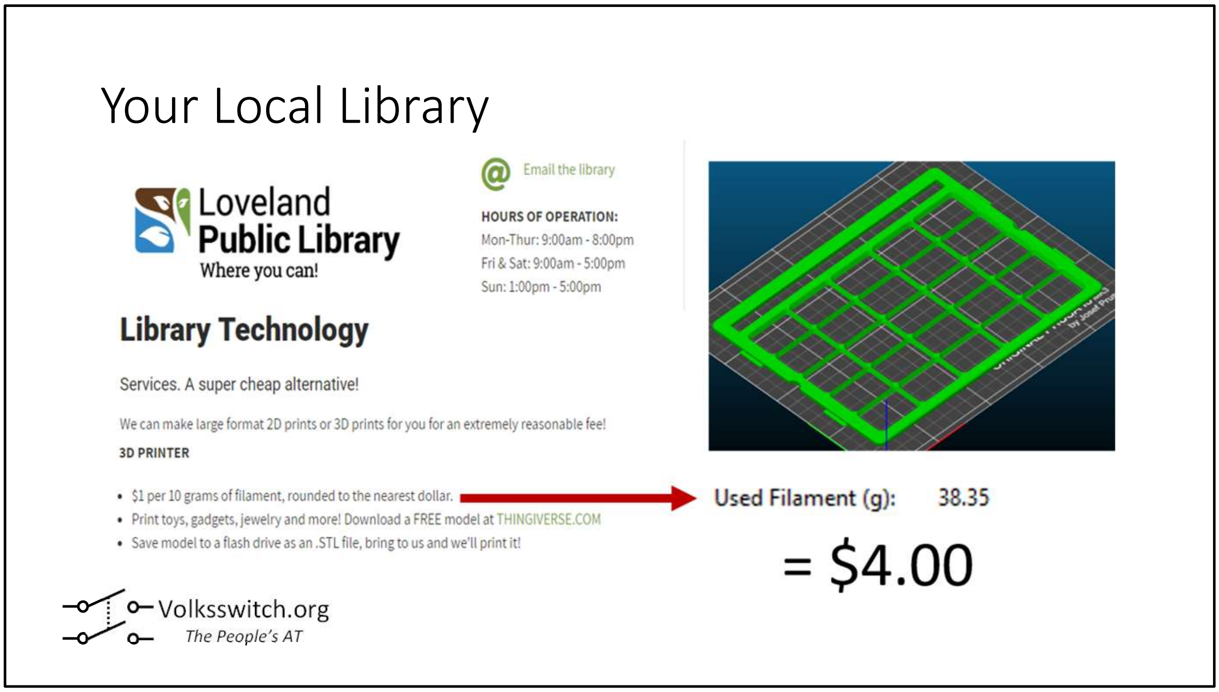
Keyguard AT *$71*

Print a Thing $23 ($47 savings)
TreatStock $17 ($50 savings)
NinjaPrototype $20 ($51 savings)

Volksswitch.org
The People's AT

There are several online companies who will print your design. Thingiverse provides easy submission of designs to 3 different services.

I sent my TouchChat keyguard design to all three to find out what they would charge. The prices vary somewhat but, on average, represent a 2/3 savings over purchasing the same keyguard from Keyguard AT.



You also may have a local library with a 3D printing service. The Loveland Public Library is a few miles from me, and they'll charge you just 10 cents per gram to print a design that you email to them. Remember that my slicer program told me that the TouchChat keyguard requires 40 grams of filament.

That's a total of $4.00 for a keyguard and I didn't have to purchase or maintain the printer nor did I have to purchase and store the filament.

3D-Printing Facebook Groups

(29) Active Groups Dedicated to Generic 3D Printing:

3D printing, 3D Printing Stls, 3D Printing RC, 3D Printing Miniatures and Terrain, **3D Printing Useful Things!**, Functional 3D Printing, 3D Printing For Beginners, 3D Printing Club 3DPC.tech, 3dfigureprints.com 3D Printing Models STL, 3D Printing Geeks, The Tabletop 3D Printing Guild, 3d printing things, 3D Printing, Creality CR-10s 3D Printer User Group, 3DHeals: 3D printing in Healthcare, 3D Printing - Show & Tell, 3D Printing For Everyone, 3D Printing For Christmas Light Enthusiast Group., Forward 3D printing, Anet A6 3D printer (RepRap Prusa i3), 3D Printing Egypt, XYZ Da Vinci 3D Printer Users Group, Dazz3D Printing Group, 3D Printing United Kingdom, 3D Printing Malaysia, 3D PRINTING PHILIPPINES, 3D Printing South Africa, 3D Printing Australia, Bristowne 3D Hobby Prints, St. Louis 3d Printing Society

(26) Active Groups Dedicated to the Prusa line of Printers:

Prusa 3D Printer Owners, Original Prusa i3 MK3 Support and Discussion, Prusa i3 mk3 users group, Original Prusa i3 MK3 Print Showcase, Anet A6 3D printer (RepRap Prusa i3), Prusa Prints, Geeetech Prusa i3, Prusa Community Useful Products, Geeetech Prusa 3D Printer, Prusa MK2S Owners (post/ask Anything, Uncensored), FLSUN 3D PRINTERS DELTA PRUSA I3 & CUBE, Original Prusa i3 MK3 Makers, U3dprintshop 3d printing community, 3DHeals: 3D printing in Healthcare, RepRap Prusa i3 3D Printer Support Group, Anet prusa i3 3D printer Malaysia (Official), Anet A8 y Prusa i3 en español, impresión 3D, Original Průša i3 Mk2/S/MK3/MMU komunita, Estado51PRUSA, Prusa Bear Argentina, ESTADO PRUSA (ESTADIDAD AHORA), Stampanti 3D Anet e Cloni Prusa i3 - Stampa 3D Italia, Oryginalna Prusa i3 MK1/MK2/MK3 Polska, TEVO Tarantula Prusa i3 Deutsch, die ORIGINAL-Gruppe ;-), Imprimante 3D - Anet A8, clone Prusa, impression 3d Prusa i3 anet a8 fr, Prusa I3 Portugal

(33) Active Groups Dedicated to the Artillery line of Printers:

Artillery Sidewinder X1 3D Printer Owners Group [Official], Artillery Sidewinder X1(EVNOVO)/mod/fix international group, Artillery Sidewinder X1 works show, Artillery Sidewinder X1 3d Printer, Artillery Sidewinder X1, Artillery Sidewinder X-1 Files Only, Artillery 3D Printer Sidewinde X1r, Artillery Sidewinder X1 & Genius FR Francophone imprimante 3D, ARTILLERY Sidewinder X1 3dES España/Spain, Artillery (Sidewinder X1, Genius, etc.) Aide Francophone (imprimante 3D), Artillery Sidewinder X1 Grupo de propietarios Español, Artillery Sidewinder X1 3D Drucker für den deutschsprachigen Raum, Artillery Sidewinder X1 PTBR Português, Artillery Sidewinder X1 & Genius - Deutsche Gruppe, Artillery Sidewinder x1 Ultimate Mod, Artillery Sidewinder X1 & Genius Italia New Generation - © Official Group, Artillery Sidewinder X1 3D Printer België / Nedereland, Artillery Sidewinder X1 pour les nuls Aide et conseils, Artillery sidewinder x1 , Genius , Entraide Amélioration Familiale, Artillery sidewinder x1, Artillery Sidewinder X-1, Artillery Sidewinder X1 3D Drucker Germany, Artillery Sidewinder X1 Middle East Group, Artillery GENIUS 3D Printer Owners Group [Official], Artillary Sidewinder & Genius BEGINNERS Group, Artillery Sidewinder X1 Australian Support, Artillery (Evnovo) SX1 / Genius - FR, Artilerry Sidewinder PT, Artillery Sidewinder/ Genius 3D printing beginners (Noobs), Artillery Sidewinder X1 - Deutschland - Österreich - Schweiz, ARTILLERY SIDEWINDER ARGENTINA, Artillery Sidewinder 3D Printer Owners Group Philippines, Artillery Sidewinder X1 Deutsche Gruppe, Artillery Sidewinder X1 Polska (SWX1)

Volksswitch.org
The People's AT

This eye chart is a listing of Facebook Groups that focus on 3D printing in general, the Prusa line of printers, and the Artillery line of printers.

A majority of the people in these groups are excited about 3D printing as a technology and their own 3D printer but they've tired of printing Yoda heads and Baby Groots. Their shelves are full of decorative items and they're wondering if that's all there is to this technology.

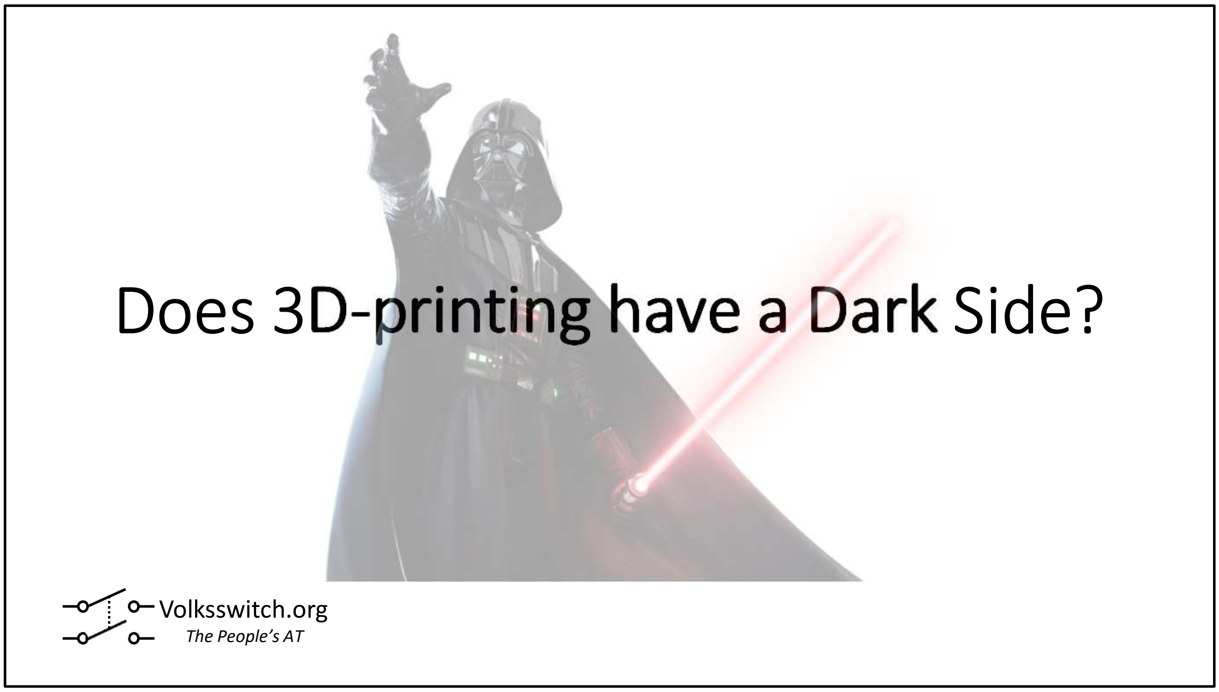
If you post to a few of these groups and describe your need, I guarantee you'll hear from someone who is dying to finally use their printer to create something of real value. You may need to reimburse them for the filament and postage but, then again, you may not.

Join a Parent's Group and Pool Resources

Volksswitch.org
The People's AT

Are you a member of a parent's group? Could the members of the group pool their resources and purchase a printer and filament?

I suspect that every parent's group harbors a father who'd love to do the research, purchase and house the printer and become an expert in its use.



I wouldn't be honest if I didn't admit that I have some concerns about 3D printing, especially 3D-printed assistive technology.

Volksswitch.org
The People's AT

I think the most subtle dark side of 3D printed AT.

It's easy to become overly enamored with the technology and to start to see every problem as having a 3D-printed solution.

What are the Limitations of 3D-Printed AT?

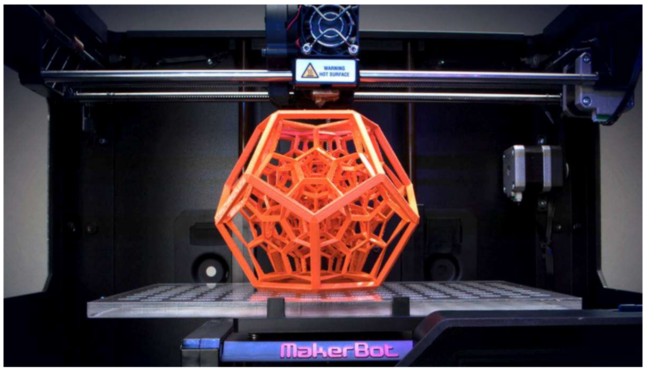
- 3D printing materials have limited strength and temperature/UV stability
- Open-Source designs and devices are unlikely to have undergone extensive testing to validate their safety and effectiveness
- Liability for injury is unclear
- *You cannot create a transparent object*

Volksswitch.org
The People's AT

As you think through possible responses to a need or solutions to a problem, be very clear about all the demands on that solution – especially those related to safety.

- Because consumer-grade 3D printers print with thermoplastics, the devices they produce will always have limited strength and a limited range of environmental temperatures. They may also degrade if exposed to long periods of sunlight.
- Those wonderful, freely downloadable designs you find on the web have probably not been tested with respect to their safety or even their effectiveness.
- If a device should fail and someone should get hurt, it's unclear who's liable – if anyone.
- And because this is a presentation, largely, about keyguards, you cannot create the equivalent of a laser-cut acrylic keyguard in the sense that you cannot produce a transparent 3D-printed device.

What are the dangers of 3D Printing?



- The nozzle can be very hot: 360°F to 500°F.
- The print surface can be hot: room temp to 140°F.
- Some filaments are smelly – ABS, in particular.
- Most filaments produce ultrafine particles and volatile compounds while printing.
- The printer can't see you and may pinch or injure you if you get in the way of a moving part.
- **Just leave the printer alone in a well-ventilated room until it's done printing and has cooled down.**

Most 3D printer owners, who get hurt, cut themselves with the scraper that came with the printer trying to remove prints that are stuck to the print surface.

- Waiting until the print surface has cooled down to room temp can help with print removal.

Volksswitch.org
The People's AT

You may be concerned about the safety of 3D printing. In my opinion, it's a relatively safe technology. Some vendors may make a big deal about 3D printing safety and charge schools thousands of dollars for a "school safe" 3D printer. They do this by putting their printers in cabinets with special fans and filters. These companies typically sell 3D printing systems that lock you into an overpriced filament. Strangely, their printers often represent 3D printing technology that's several years old.

In reality, you can take some simple steps to ensure that everyone remains safe around the 3D printer.

Let's look at the most common safety concerns and how you can deal with them.

- Every Fused Deposition Modeling (or FDM) printer has a heater block that melts plastic filament at temperatures in excess of 200 degrees Celsius – that's twice as hot as boiling water. You may be tempted, on occasion, to use your fingers to wipe away the little bit of plastic that oozes out of the nozzle at the start of a print. Don't! An adult should always supervise young children when they're watching an operating printer. Watching a printer slowly turn an idea into a 3D object can be mesmerizing.

Just keep your hands in your pockets.

- A heated build plate can help a print adhere better to prevent print failures and resist warping. The temperature of the plate can run from room temperature to 70 degrees Celsius depending on the filament type. You probably won't get burned by touching the build plate but it can be uncomfortable. Don't touch the build plate until the print has finished and the build plate has come back to room temperature. The print will come loose from the build plate easier when it has cooled down.
- Plastic filaments come in a variety of formulations. Some are smellier than others. ABS is particularly stinky when printing. It's also hard to print with because it has a tendency to warp. ABS was very popular in the early days of 3D printing but not anymore. Now there are much better filaments that have very little smell and are easy to print with.
- The plastic filaments can release particulates and organic compounds when melted. Again, ABS is a significant offender. You shouldn't experience much of a problem if you stick to filaments like PLA, PETG, and TPU. In fact, for the kind of devices that I've shown you today, these are probably the only filaments you will ever need. You may find that you never need anything other than PLA.
- The print head and build surface move around a lot in the process of creating a 3D object – often quickly. You don't want to get your hands in the path of either moving part. It's not good for you and it's probably much worse for the printer. Just keep your hands in your pockets.
- You may choose to avoid all these issues by locating the printer in a separate room with reasonable ventilation. It's relatively easy to set up a webcam and watch the print progress from the comfort of your computer.

Many Chinese 3D printers come with a paint scraper. Because some filaments stick way too well to the build surface, you'll have to pry the printed object off using a scraper like this. The scrapers are usually very sharp so they can get under the edge of the print. If you're going to get hurt using a 3D printer, it will probably be while you are prying a print loose from the build surface with one of these scrapers.

If you let the build surface cool down completely, most prints will release all by themselves. This is what happens to objects printed on the special build plate material of the Artillery Sidewinder. The Prusa has a special flexible build plate that forces the print to pop off when you flex it.

Some assistive technology is <u>NOT</u> a good match for 3D Printing

-Avoid printing items that could cause significant injury if they fail…

Uncovering Challenges and Opportunities for 3D Printing Assistive Technology with Physical Therapists

- McDonald, Comrie, Buehler, Carter, Dubin, Gordes, McCombe-Waller, Hurst

3.2.2 Designing a Crutch Tip (Figure 3)

Crutch tips are located at the bottom ends of the crutches and support the user's weight and maintain balance while the user is mobile. Due to a high volume of student users, the PT professors' crutch tips frequently go missing and a third of their crutch tips are lost every year. PT professors believed 3D printed crutch tips could replace missing crutch tips on their pre-existing crutches.

Figure 3. (Left) A 3D printed crutch tip installed onto a crutch. (Top Right) Different iterations of 3D printed material to test crutch tips. (Bottom Right) A 3D printed crutch tip in comparison to original crutch tip.

They're wrong! They don't understand the limitations of the technology.

Cost of a commercial crutch tip: $6.60
Cost of a 3D printed crutch tip: $ 1.47
Cost of a fall due to crutch tip failure… ??

Volksswitch.org
The People's AT

Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility, Reno, Nevada, USA — October 23 - 26, 2016
Pages 131-139

I was shocked when I came across this journal article that says "PT Professors believed that 3D-printed crutch tips could replace missing crutch tips on their pre-existing crutches."

A commercial crutch tip costs $6.60. A 3D-printed crutch tip costs $1.47. If the 3D-printed crutch tip fails, how much will that cost?

The bottom line is: never use a 3D printed device in a situation where failure of the device could result in injury to the user.

AT that is a good candidate for DIY & 3D Printing

- It presents rich opportunities for customization
- There is no commercial option, or it represents a significant cost savings over a commercial device
- It doesn't need to support loads greater than 50 lbs. or temperatures greater than 150 degrees Fahrenheit
- It doesn't require transparency or softness and will spend a limited amount of time directly in contact with the user's skin
- It will likely require iterations to fit the individual physically, functionally, or aesthetically
- The device can be modeled as a collection of 2 and 3 dimensional primitives as opposed to purely organic shapes

Volksswitch.org
The People's AT

How can you recognize an AT device that's a good candidate for 3D modeling and printing? Look for these characteristics.

- One of the most important characteristics is that it calls out to be customized. If one size will fit all, then traditional manufacturing techniques can produce thousands of them for pennies. Because the needs of disabled individuals often vary so greatly, assistive technology often requires customization. You should ensure that your design has customization built in. Try to avoid designs that will only meet a single individual's needs. Try to think broader than that.
- Commercial manufacturers of assistive technology have devoted their lives to serving a traditionally underserved community – often on very thin margins. If your design doesn't represent a breakthrough in customization and personalization, or doesn't offer a significant cost savings for families, then you should abandon your plans and go with the commercial device.
- 3D printed plastic devices are stronger than you might think but you shouldn't ask too much of them. You shouldn't expose them to pressures greater than 50 lbs. Also, they

they may be printed at temperatures double the boiling point of water but they will begin to deform at temperatures much less than that. You should focus on devices that can be used at room temperature. Avoid using or storing them in places like the dashboard of your car in summer.

- A 3D print is composed of a series of very thin layers. Even if you use a transparent filament, the final print will be, at best, translucent. Those layers will be visible on all vertical surfaces and can be abrasive when placed against sensitive skin. You can smooth these surfaces by wet sanding them but that will add additional time and effort to the process.
- The 3D modeling and printing process facilitates iteration so the fact that a device will require iteration before it's a good fit is a sign that you're on the right track in choosing this technology.
- 3D modeling tools work with geometric primitives like circles, squares, cylinders, and cubes. If you can visualize your device as a combination of these primitives, then your modeling work will be a lot easier and you'll be able to build in a great deal of customization. You can model organic shapes by taking 3D scans of an object, but that's usually a sign that your model will only meet the needs of a single individual.

How do 3D-printed keyguards stack-up?

- ☑ It presents rich opportunities for customization
- ☑ There is no commercial option, or it represents a significant cost savings over a commercial device
- ☑ It doesn't need to support loads greater than 50 lbs. or temperatures greater than 150 degrees Fahrenheit
- ☑ It doesn't require transparency or softness and will spend a limited amount of time directly in contact with the user's skin
- ☑ It will likely require iterations to fit the individual physically, functionally, or aesthetically
- ☑ The device can be modeled as a collection of 2 and 3 dimensional primitives as opposed to purely organic shapes

Volksswitch.org
The People's AT

I started out by telling you that 3D printed keyguards are your gateway to 3D printed assistive technology. So let's see how well they stack up against these characteristics.

- Volksswitch has created a single keyguard designer that should allow you to create almost any keyguard for tablets. Since there are 10s of tablets, 10s of cases, 10s of apps, each of which can be configured in 10s of ways, sufficient customization had to be built into the designer to support 10s of thousands of possible keyguards.
- A 3D printed keyguard can cost from 1/3rd to 1/100th as much as a commercial keyguard. As such, it can make it possible for an SLP to have on hand all the keyguard variants that they need when evaluating the abilities of an individual. They can be produced in a rainbow of colors and support mounting methods that are simply impossible when starting with a simple sheet of acrylic.
- Keyguards rest on the surface of a tablet. That means that they have no special strength requirements. If you step on one and break it, you will likely have broken the tablet as well and you'll have bigger problems than a broken keyguard. In any event, replacing the keyguard will only set you back a few dollars.

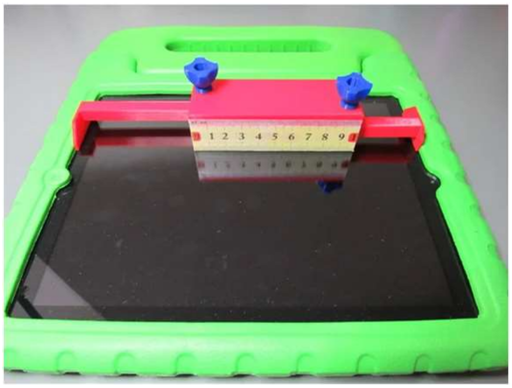
- They are typically used in home and school environments so they're rarely exposed to extreme temperatures.
- While we often think of keyguards as transparent, because we're used to seeing keyguards cut from sheets of acrylic, transparent keyguards can create visual problems for their users as light from the tablet refracts through internal faces of the keyguard. So an opaque, 3D printed keyguard will often be preferred over a transparent one.
- Additionally, a user may place their hand on a 3D-printed keyguard but not for an extended period.
- When you're designing the first instance of a keyguard – especially if you're working with someone in another location – you'll probably need to give them multiple drafts of their keyguard that they'll use to test for effectiveness before settling on a final specification.
- Finally, a keyguard is literally a rectangular block of plastic with holes cut in it. Note that with 3D printing you don't actually cut holes. Instead, you lay down plastic everywhere but where the holes should be.

Wrapping Up

Volksswitch.org
The People's AT

Time for some final thoughts.

Easy Measurement Tool



Cost of plastic:

Volksswitch.org
The People's AT

If you're planning to create some 3D-printed keyguards, two of the most important measurements are the height and width of the opening in the case. Unfortunately, it's very hard to take these measurements accurately with a ruler.

We've created a 3D-printable tool, our Easy Measurement Tool, specifically designed for this purpose.

How much does it cost?

If you email me and request an Easy Measurement Tool, I'll send you one for free.

Questions?

Send an email message to **ken@volksswitch.org** to ask follow-up questions and make suggestions.

Volksswitch.org
The People's AT

At this point in the presentation I'd normally open the discussion to questions from the audience. Since that won't be possible, I want to encourage you to send me your questions. I really want you to be successful so don't hesitate to contact me.

Thank You For Attending!

- **CEUs**
  - **IACET CEUs:** 0.1
  - **ACVREP CEUs:** 1
- **Handouts**
  - These slides, including an embedded transcript, are available at:
    https://www.closingthegap.com/conf-presentation/3d-printed-keyguards-your-gateway-to-3d-printed-assistive-technology/

Volksswitch.org
The People's AT

Finally, don't forget to apply for the CEUs you've earned.

You can also get a copy of the slides from this presentation from the CTG website. I've embedded my comments for each slide in the PowerPoint slide notes.