

Dream, Design, Fab! Engaging Youth with Digital Fabrication

Museum of Science and Industry, Chicago



Association of Science-Technology Centers(ASTC)
Annual Conference
October 18-21, 2014

Dream, Design, Fab!

Engaging Youth With Digital Fabrication

Museum of Science and Industry, Chicago

ASTC Conference - October 19, 2014



Introductions

- Matt Chalker
 - Fab Lab Program Coordinator
- Dan Meyer
 - Fab Lab Manager
- Rabiah Mayas
 - Director of Science & Integrated Strategies

Session Goals

- Discuss MSI's digital fabrication program models
- Share recent experiments in non-digital making
- Discuss challenges and opportunities
- Ask questions when you have them
- Play a little 😊
- Use some of your text messaging plans...

Note Concurrent Session:

Making Space for Innovation – Sampling of Making and Tinkering

*What is your primary
interest in museum-based
makerspaces?*

*What burning question(s)
do you have for this session?*

Makerspaces are Everywhere!

(just a snapshot!)



Makerspaces in Science Centers (also just a snapshot!)



THE LAWRENCE
HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY



Makerspaces and Learning

- Support connected learning and HO-MA-GO
- Safe spaces for failure, iteration and collaboration
- Connections with NGSS and workforce skills
- Interest/hobby-driven access
- “maker” label not resonant with some populations
- Challenging to measure impacts and learning

Museum of Science and Industry, Chicago



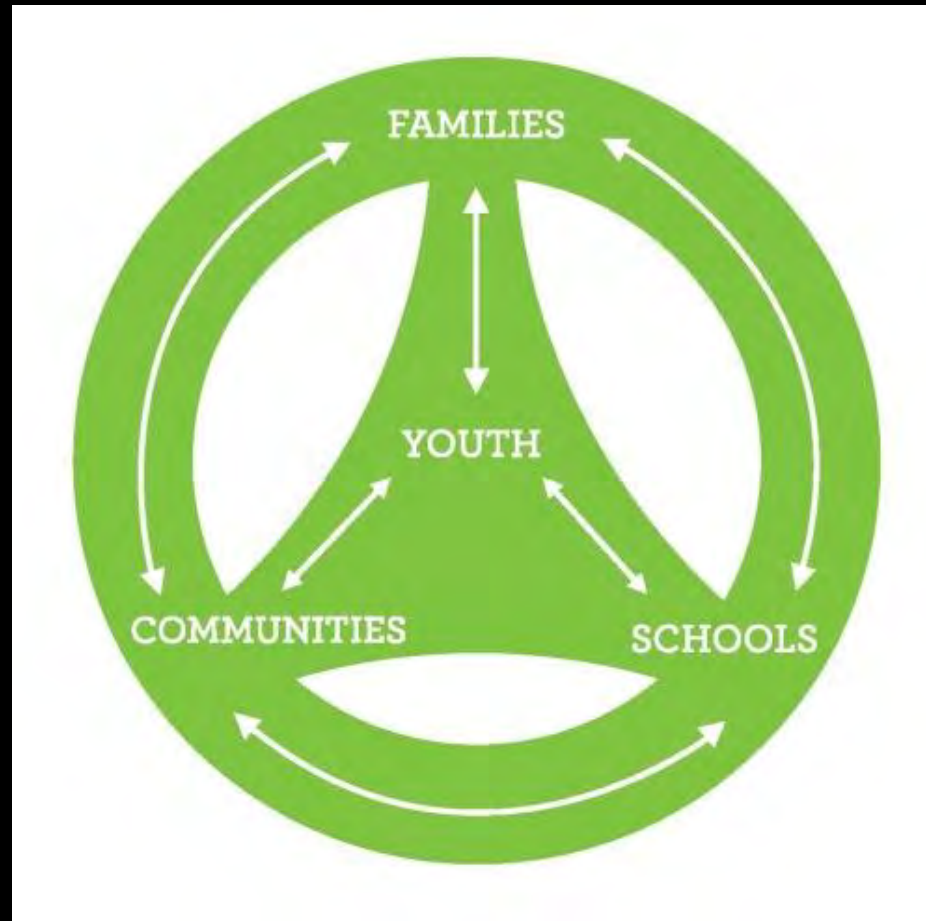
*To inspire and motivate our
children to achieve their
full potential in the fields
of science, technology,
medicine and engineering.*

MSI Strategic Priorities

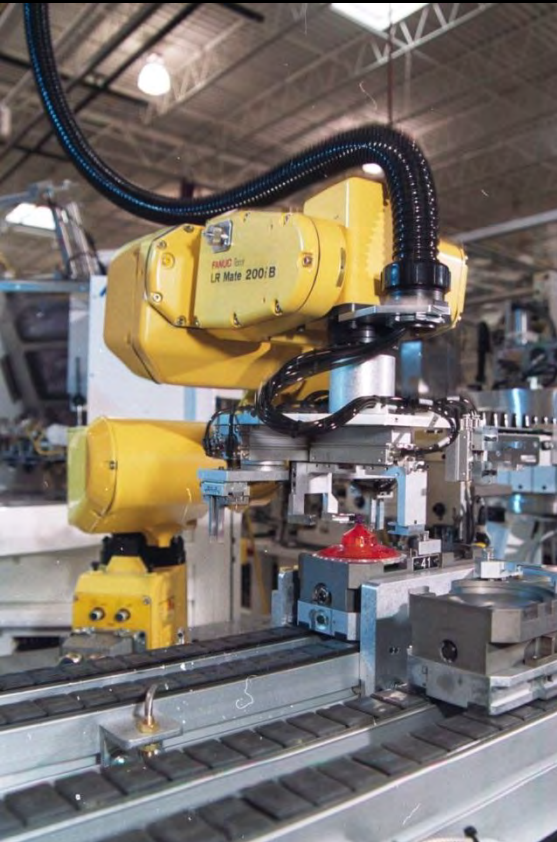
- Transformative Exhibitions
- Guest Experience
- Education and Public Engagement
- Digital Engagement



Center for the Advancement of Science Education (CASE)



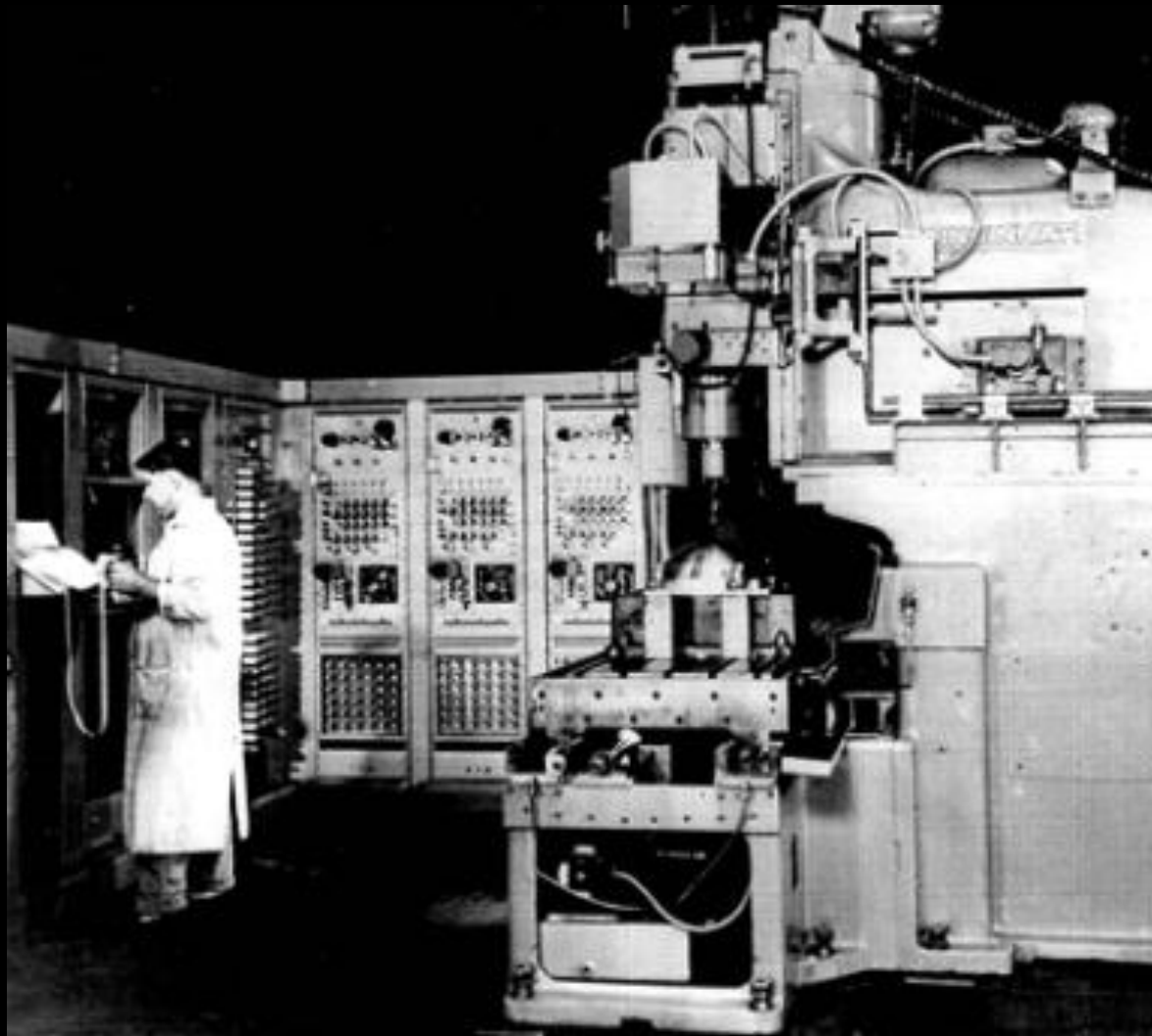
ToyMaker 3000

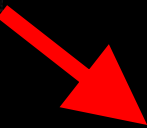
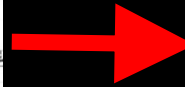
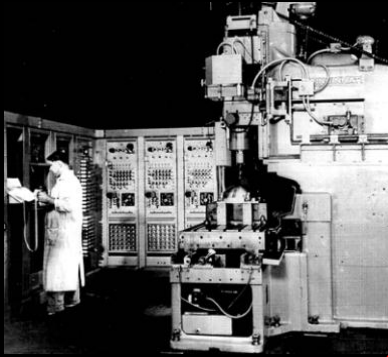


We Got a Fab Lab! (2007)

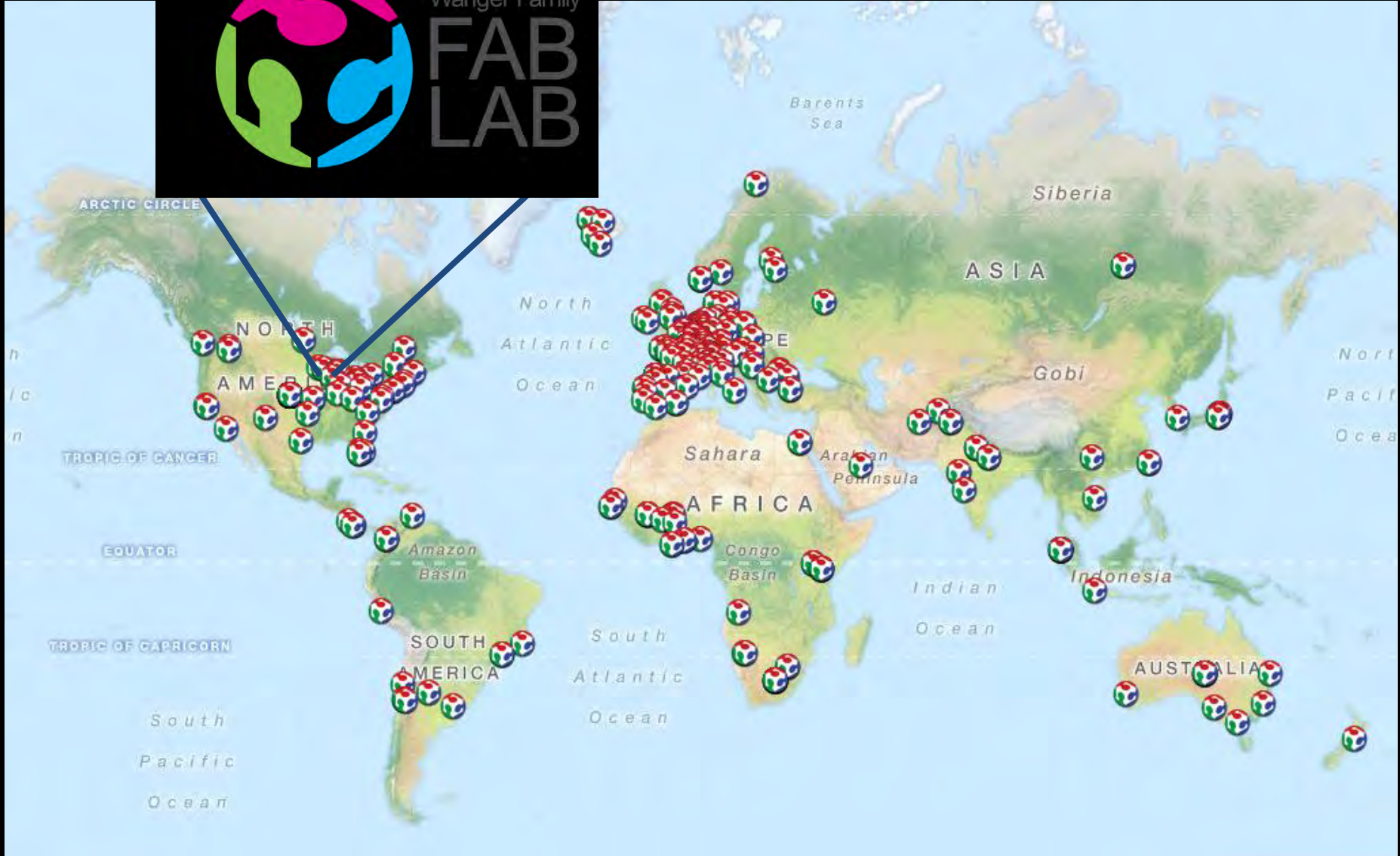


History of Fab Labs





Global Fab Lab Network



Wanger Family Fab Lab



Fab Lab Priorities

- Empower youth to maximize their unique creative potential to innovate their world and the future.
- Provide youth with access to the tools of innovation, through project-based, peer-mentored, youth-driven approaches.



Fab Lab Inventory



Make It

- 2D subtractive - laser cutters; vinyl cutters
- 3D subtractive – milling machines (3)
- 3-D additive – 3D printers
- Electronics and circuitry

Design It

- 2D and 3D design software
- Fab Lab polycom
- Design circle



Fab Lab Guest Workshops





Fab Lab Feedback

I want you to know that this lab is one of the greatest places I've ever been. I love it!

-Alyssa ♡



Thanks so much!

I made a model of my head! It was awesome.

Thanks!

★ ★ ★ ★ ★ -Carrot★

Fab Lab Student Programs



- Semester-long engagement
- Project-based teamwork
- Boot camp: Skills development
- Project session: youth-driven solutions



Fab Lab Summer Camps



- Week Long, Half day
- Specific topics
- Middle and High School



Fab Lab Special Programs

- Offsite events
- Training
- Tours/special



Innovation Studio



Innovation Studio



Idea Walls



14 50 12

Innovator Gallery

MARK DEAN ELECTRICAL ENGINEER

HAVE YOU EVER PLUGGED A KEYBOARD OR MOUSE INTO A PERSONAL COMPUTER (PC)? OR USED A PC WITH A COLOR MONITOR? IF SO, THEN YOU'VE USED SOME OF THE TECHNOLOGY DEVELOPED BY ELECTRICAL ENGINEER DR. MARK DEAN.

WHILE WORKING AT IBM IN THE 1980S, DR. DEAN AND HIS COLLEAGUE DENNIS MOELLER DEVELOPED A NEW TECHNOLOGY THAT ALLOWED DEVICES LIKE PRINTERS AND MONITORS TO BE PLUGGED DIRECTLY INTO COMPUTERS. HIS WORK ALSO LED TO THE DEVELOPMENT OF THE COLOR PC MONITOR AND THE FIRST 1-GHZ PROCESSING CHIP, WHICH ALLOWED COMPUTERS TO PERFORM ONE BILLION CALCULATIONS PER SECOND. DR. DEAN EARNED A PH.D. IN ELECTRICAL ENGINEERING FROM STANFORD UNIVERSITY AND IS NAMED ON MORE THAN 25 PATENTS.



Innovator Gallery

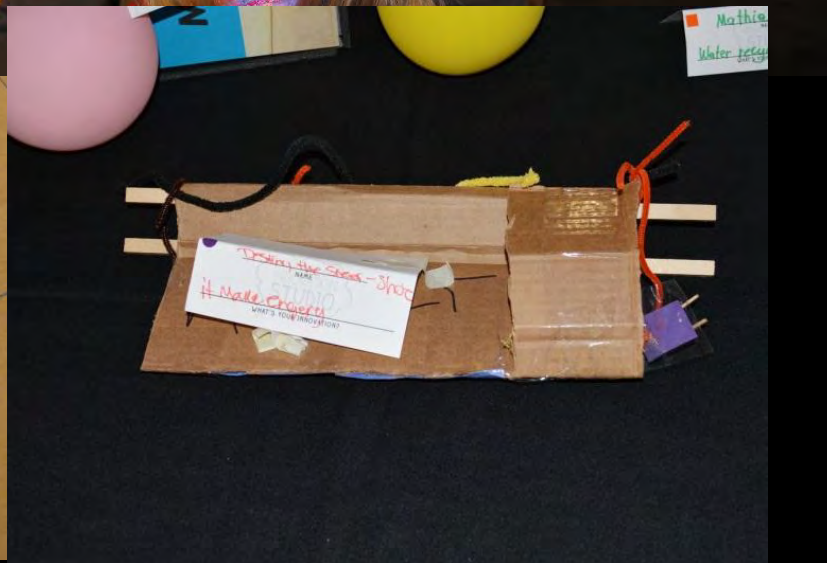
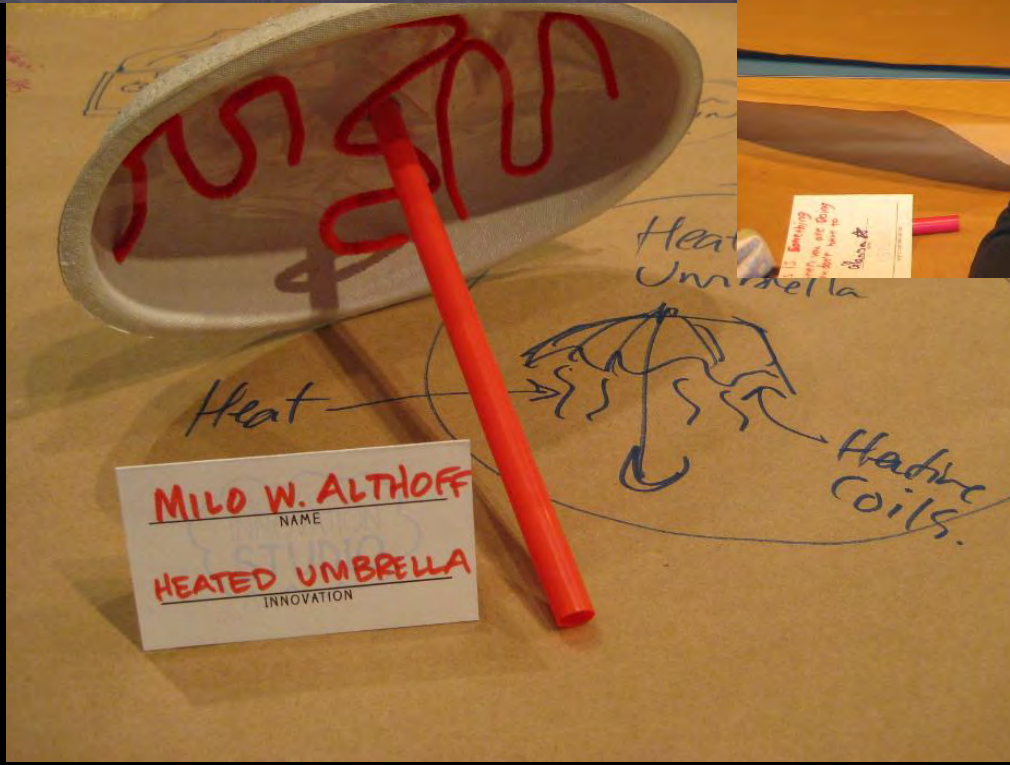


URSULA BURNS
CORPORATE EXECUTIVE

HAVE YOU EVER MADE A PHOTOCOPY OR BOOKED A PLANE TICKET?
If so, you've used tools built on the technology
developed by Ursula Burns and her team at Xerox.

Ms. Burns, Xerox's first female CEO, is a trailblazer in
technology. She's also a woman who's not afraid to
take risks. In 2010, she led the charge to create
Xerox's first female CEO. She's also a woman who's
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also a woman who's not afraid to take risks.





Innovation Studio Feedback

“The innovation studio is a very good idea...its basis is the scientific method and how it intersects with creativity to form innovation!”

“It’s a great way to learn how to innovate!”

“It was so fun to make all the things, and if they didn’t do what you wanted them to, you just tried again!”

“This was the most inspiring part of our day.”



BREAK TIME!

Staffing and Volunteers

- Staffing structures
 - guest/staff ratios
 - Expertise/background
- Volunteers
 - 15 Active
 - Background and skills
 - Recruitment + management process



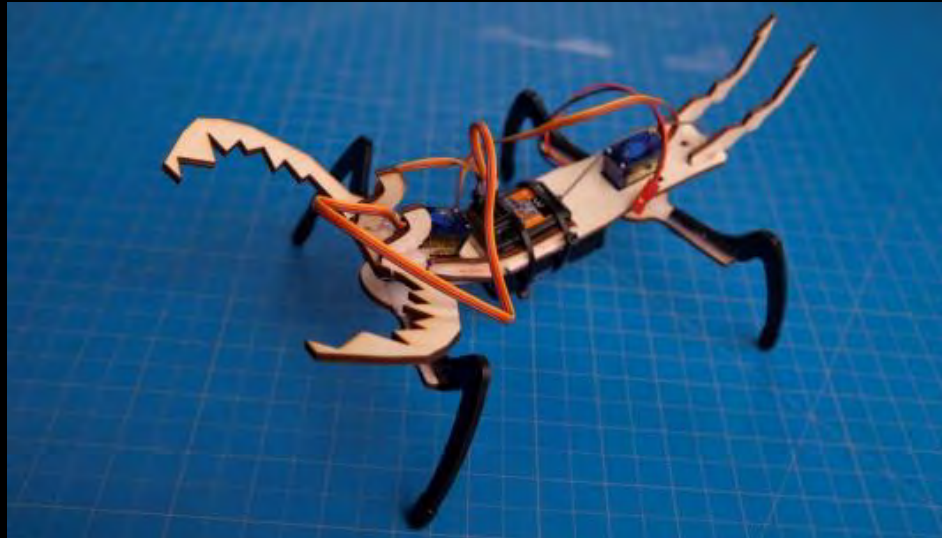
Managing Guest Expectations

- Ticketing
- Staff/guest ratio
- Young children and chaperones
- Welcoming diverse skill levels



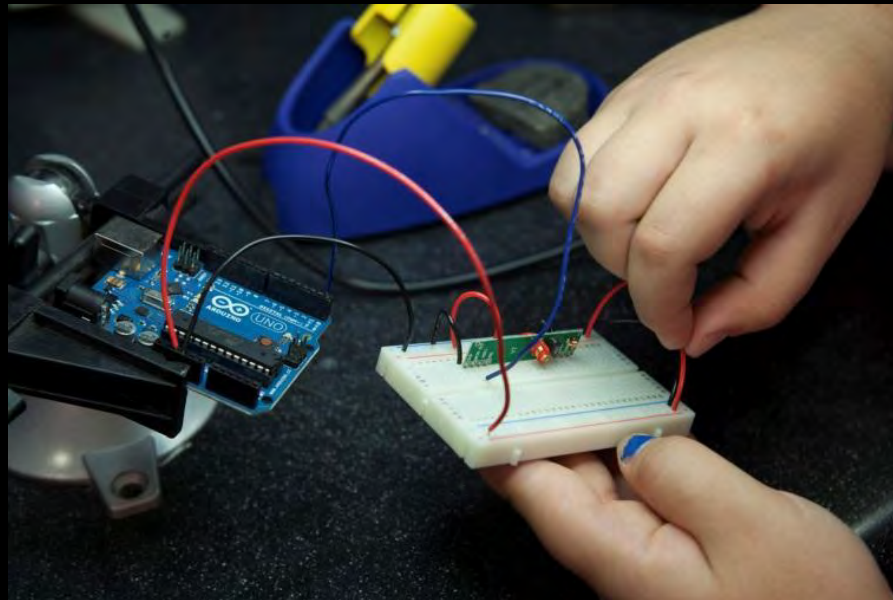
Structure and Constraints

- Discrete learning goals for each experience
- Scripted workshop guides
- Predictable time, materials usage, item size
- Ongoing program iteration



In-Lab and Post-Visit Extensions

- Open-source software at home/school
- Process handouts
- Connections to other makerspaces
- Fabrication-related career exposure



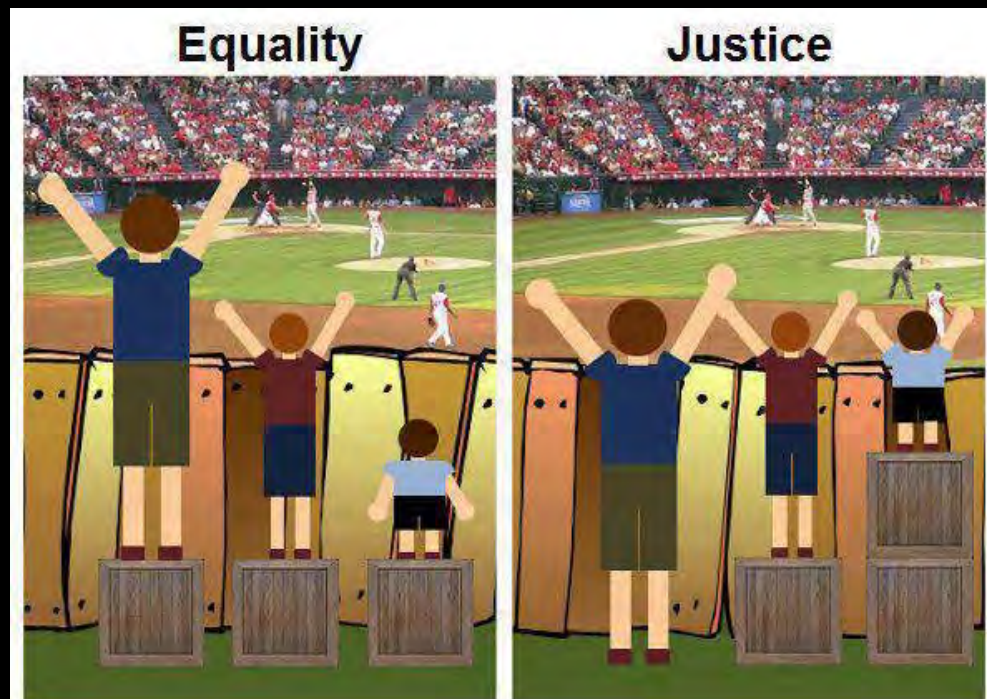
Key Relationships

- Other makerspaces (local, national, global)
- Local makers, designers and engineers
- Schools and classroom teachers
- Youth-to-youth and youth-to-guests
- Internal – IT, Legal, Guest Experiences



Access and Equity Considerations

- Fee vs. Free
- Transportation support
- Staff and volunteers
- Social, learning and physical challenges



Evaluation and Research

Key Questions:

- Who is visiting the Fab Lab and why?
- What effect does participation in the Fab Lab have on youth participants?



Fab Lab Participants

- Similar to general guests in most categories: age, race, ethnicity, engineering attitudes, DIY behavior
- Median income in Fab Lab attendees one quartile higher than general guests:
 - \$64,554 - \$104,086 vs. \$39,736 - \$64,553



Summer Camp Youth

- No changes (compared to control group) in:
 - Engineering habits of mind
 - Design knowledge
- Modest but significant increase in:
 - Engineering interests
 - Engineering attitudes
- Follow-up studies in school year youth programs

What's Next?

- Local capacity building and traveling Innovation Studio
- Expand suite of revenue-generating programs
- Field trip programs
- More HO and MA opportunities
- Continued Fab Lab evaluation and research



*Which demonstration would
you like to see at the end of
this session?*

Discussion / Q&A

Let's Stay in Touch!

Visit us!!

Let us come visit your space

Share program ideas and materials

Collaborate on research studies

Participate in the ASTC CoP

Email us:

fablab@msichicago.org

Thank You!



museum of
science+industry
chicago

3D Print Yourself

Overview: Guests will experience 3D scanning and printing in a condensed time frame. They will enter the lab and scan their heads with an Xbox Kinect. The program facilitators and volunteers will guide the guests through the process of preparing the files for 3D printing. Finally, the guests will operate Makerbot Replicator 2's, with goal being to complete this whole process, from guest walking in the door to out of the lab with their 3D print in under an hour.

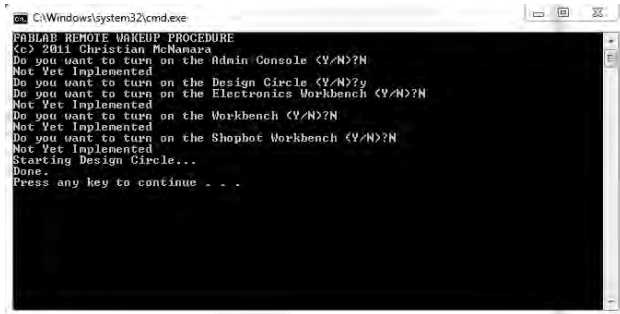
Workshop time: 30 minutes prep, 45-60 minutes workshop time, 15 minutes cleanup

Target Audience: Grades 6-12, Adults. Maximum of 6 participants. Younger groups require at least 1 chaperone for every 4 youth (chaperones can participate and make their own designs too!) No children under the age of 6, they cannot sit still enough for a quality scan to be made

Staffing: At least two staff members are needed for this workshop, three staff members or highly qualified volunteers are preferred.

Before the Workshop

1. Turn on the lights in the lab (103* on the keypad)
2. Make sure the lab is clean and in order (can be done while waiting for computers to boot)
 - a. If there are loose objects sitting on the tables, workbenches or design circle, move them to the red tag area (the built in wall shelf to the right of the main entrance)
 - b. If the floor looks dirty, sweep and/or vacuum
 - i. The broom is in the closet to the right of the Shop-Bot and the Flammable Materials cabinet
 - ii. The vacuum is on the floor below the red tag area
3. Turn on the podium computer (2 Min)
 - a. It will give you a power button failure (only visible once the projector is turned on) that is related to the extended button on the top of the podium. Press F1 to continue bootup.
 - b. Login either as Administrator or Fab (pw: fab)
4. Open the Jabber video conference software through the start menu and mute outgoing sound.
5. Open up the utilities folder shortcut on the desktop and double click on the wakeup utility shortcut on the desktop and double click on the wakeup utility. Respond with Y to every line.:



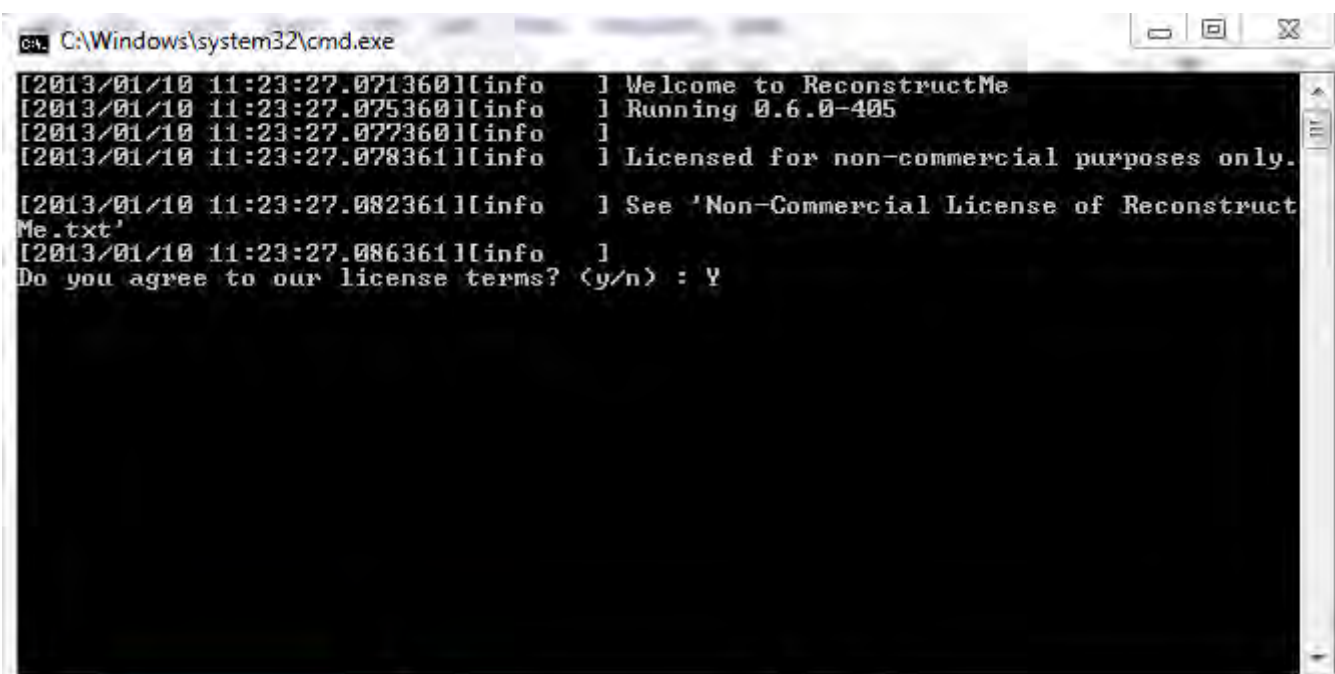
6. Wait for every computer in the lab to turn on. Take note of any that do not turn on or display error messages and report them to the other lab staff. (2 min)
 - a. If the computer is needed for any of the following steps, attempt to manually turn it on. Otherwise leave the computer off.
7. Open the live infrared video software on the third computer around the design circle (labeled) (1 min)
8. Open Google Chrome on the remaining computers around the design circle (3 min)
 - a. Click the link for the VNC software in Google Chrome
 - b. Connect to 192.168.16.30 (computer with the infrared camera attached)
 - c. The password is fab
 - d. Maximize every window
9. Move the tables to the edges of the rubber floor
10. Move the MakerBot cabinets to the center of the open space
 - a. Arrange them in a horseshoe pattern, facing the center
 - b. Put the spare cabinet in the center of the circle with the 3D printed objects demo box in the center
11. Power on every MakerBot (currently 6 in total)
 - a. Make sure every bot has Bright Green PLA filament loaded and is extruding
 - b. Scroll to utilities: Change Filament: Load. The extruder will heat up and start running. As long as filament extrudes everything is good. If filament does not extrude, switch to Unload and follow the directions on the screen. Trim off the end of the filament and reload it.
 - c. Return the MakerBot LED color to White
 - d. Return the MakerBot menu to "Build from SD"
12. Pull out the etch a sketches from the drawers and set them next to the printers.
13. Clear all of the SD cards in the yellow box on the podium
14. Take the Kinect Scanners out of the rolling cabinet by the projection screen
 - a. Plug their power into the power strip below the computer closest to the podium in the design circle
 - b. Plug one USB into the first computer in the design circle
 - c. Plug the other USB into the podium computer
 - d. Plug the others into the first and last computers around the design circle
 - e. Put swivel stools at every location

Gathering and preparing guests

1. Be finished with the physical preparations of the lab at least 10 minutes before the workshop is scheduled to begin.
2. If there are 6 or guests waiting in front of the doors for the workshop, let them know the workshop will be starting on time.
 - a. Make sure they understand the lab will take approximately 60 minutes
 - i. If that doesn't work for their schedule, tell them about the upcoming workshops
 - b. Make sure all youth are old enough to participate in the workshop.
 - i. If anyone is too young, tell the parents/chaperones that previous testing has shown that we simply cannot produce good scans or prints from young children
 - c. Use your personality to get them excited about the lab!
 - i. Examples could include: "Are you ready to be designers/engineers/use the 3D printers today?!"
 - ii. Emphasize how this will be their chance to be creative and make something cool using advanced equipment.
 - iii. The dialogue about using robots at home/work is great, continue with that.
3. If there are not enough people for a full workshop, have one facilitator go out on the museum floor to recruit groups
 - a. Make sure the people on the floor and in the lab each have radios to call back and forth and make sure the workshop does not go over capacity.
 - b. The people on the floor should bring sample keychains with them to demonstrate what guests can make in the lab
 - c. Approaching groups in the rotunda or above the escalators seems to be the best locations
 - d. Emphasize that the workshop is free, that they get to be designers and make something on the 3D Printers that they can take home and keep
4. The cap of 6 participants is critical in this lab. Everyone who walks in the front door will want to be printed, so count parents and chaperones. We only have enough physical capacity on our printers for completing 6 prints in one hour.
5. Once you have enough people for the complete lab (or the scheduled start time arrives) move onto starting the lab.

During the Workshop

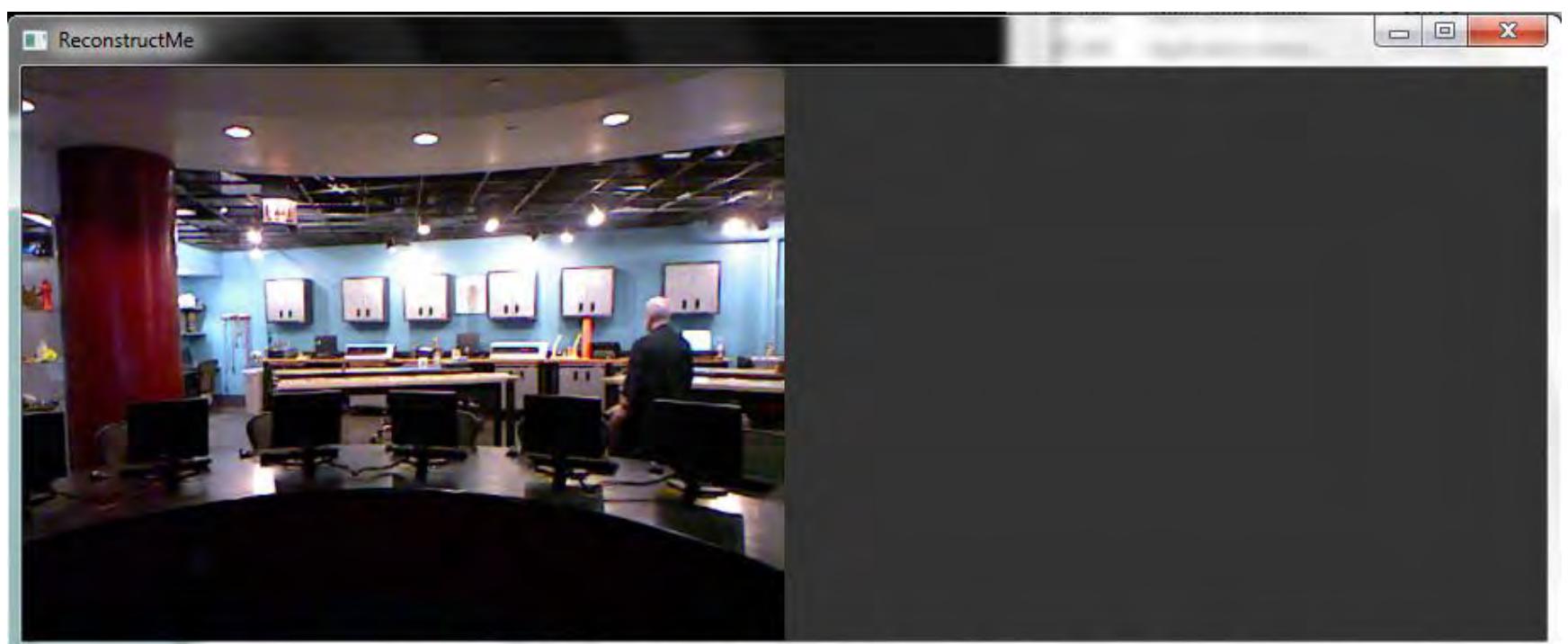
1. When the lab is scheduled to start, return to the front door and pass out Golden Tickets to the first 6 names on the sign up list. If someone is not there, pass the remaining tickets out to the people on the standby list.
2. Have the guests gather in the lab, between the trash can and the design circle (2 min.)
 - a. Once all of the guests for the session are in the lab have one of the volunteers close the door and run the rope across the entrance to prevent more people from wandering in after the start.
 - b. Introduce yourself and the other facilitators/volunteers/helpers
 - c. Give everyone a moment to take in the room
 - i. Quickly describe some of the machines, but hold the stars of the show (the 3D printers!) till the end
 - d. Explain the general procedure for the lab. While we're doing every step we will explain exactly what's going on and how this works. Please ask questions whenever they arise!
 - i. First we will 3D scan everyone up here in the design circle
 - ii. Once we finish scanning, everyone will prepare their scans for printing
 - iii. Then everyone will operate a printer to make a miniature bust of their heads!
 - iv. At the end, you'll get to keep the miniature bust of yourself that looks like the sample in your hand! (Have a sample of yourself printed in the same colors and at the same scale.)
3. While the lead facilitator is explaining the schedule, the second facilitator can take statistics for the attendance of the lab. The best place to do this is in the 3D printing alcove.
4. Transition everyone to the design circle
5. Lift up the Xbox Kinect attached to the podium and ask if anyone has seen one before or knows what it is
 - a. Affirm correct responses and give them a sticker
 - b. Explain that it's just a normal Kinect, we haven't hacked it at all, simply plugged it into our computer and use a bit of FREE software to let them talk to one another
6. Open up ReconstructMe
 - a. The shortcut is on the desktop, "Start ReconstructMe.bat"
 - b. Press y and enter to accept the terms and conditions



```

C:\Windows\system32\cmd.exe
[2013/01/10 11:23:27.071360][info ] Welcome to ReconstructMe
[2013/01/10 11:23:27.075360][info ] Running 0.6.0-405
[2013/01/10 11:23:27.077360][info ]
[2013/01/10 11:23:27.078361][info ] Licensed for non-commercial purposes only.
[2013/01/10 11:23:27.082361][info ] See 'Non-Commercial License of Reconstruct
Me.txt'
[2013/01/10 11:23:27.086361][info ]
Do you agree to our license terms? (y/n) : Y
  
```

- c. The live video window will then open



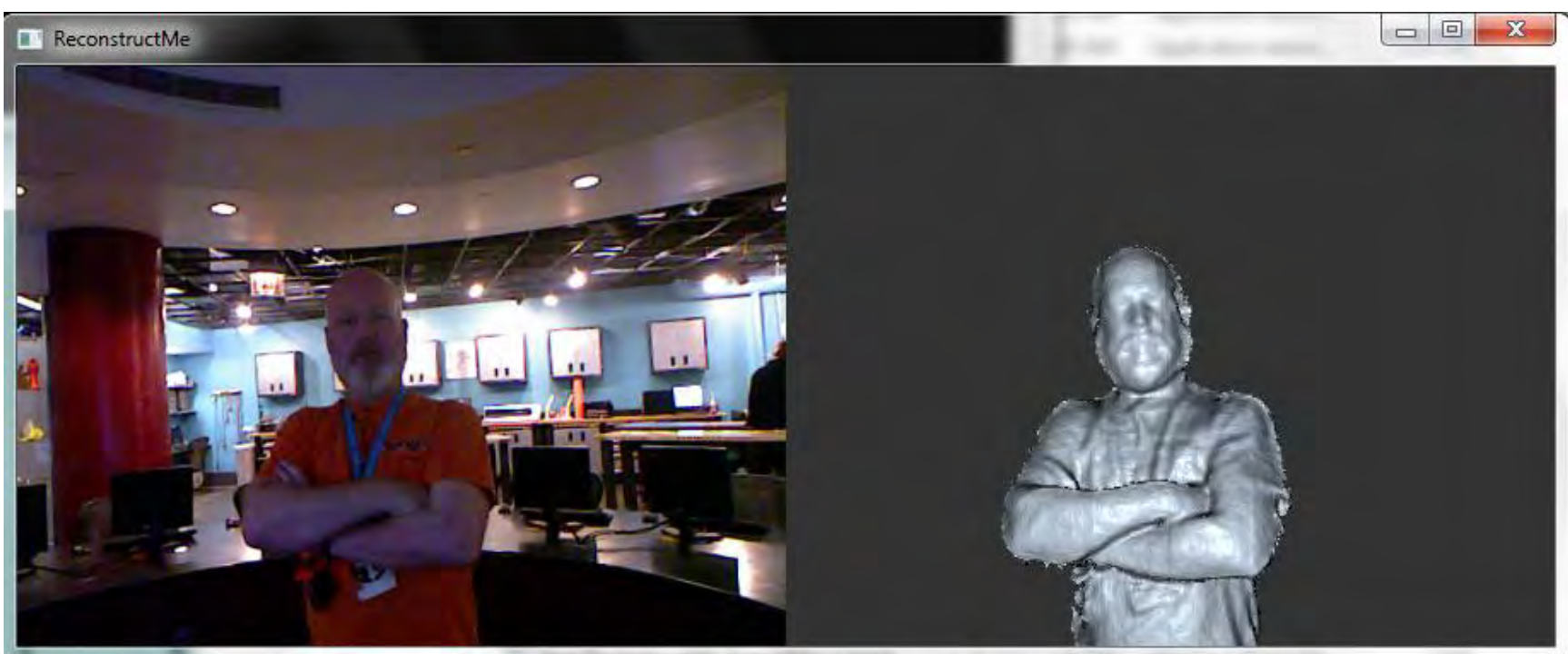
7. Ask if anyone knows how the Xbox Kinect works
 - a. Describe the three windows on the front of the Kinect
 - i. The one in the middle is straightforward, just a traditional video camera (move around the Kinect so everyone can see themselves on the big screen)
 - ii. The one that looks a little red is shooting out a bunch of infrared lasers
 - iii. The other one on the end is an infrared camera, our eyes can't see infrared light, but it can.

- b. The Kinect hooked up to the third computer in the design circle has its lasers and video camera blocked off, so all it can do is see infrared light
 - c. Ask the guest sitting at that computers' name
 - d. Say what's going on is everyone is looking as Person X's screen right now, so we're all seeing the infrared camera on this Kinect (hold up the infrared camera Kinect.)
8. Ask the other facilitator to come up to the center of the circle to sit in the swivel chair and be scanned
- a. Point the infrared Kinect at the other facilitator, while pointing the scanning Kinect away
 - b. Say "Right now you shouldn't be able to see the other facilitator on your screens"
 - c. But if I point those infrared lasers at them (point scanning Kinect at them), they should show up on screen with a bunch of little dots all over them
 - d. The Kinect knows where those dots are supposed to be, so if we move around in 3 dimensions we disrupt the pattern, which the Kinect can recognize to make a 3D file. Pretty cool, right?
 - i. This is kind of like a motion capture suit, with all of the ping-pong balls
 - e. The trick is that it can only make a scan where the dots hit, so if you have bad posture, keep your chin down, etc, it won't get any information and there will be a hole there.
9. Explain to guests the two jobs of scanning, the scanner and the scannee.
- a. The scannee has to rotate around in the chair while holding still like a statue
 - i. You can make a monster face or smile or whatever, as long as you can hold that face for a minute or two
 - ii. Posture is very important, roll your shoulders back, hold your seat and look up to where the ceiling meets the wall so the dots can get under your chin
 - iii. Don't chew gum, talk or laugh while being scanned. Also don't turn your head to look at the screen
 - iv. If you are wearing glasses and want them to show up, we can put tape over the lenses, otherwise they will disappear
 - b. The scanner needs to hold the Kinect very level and keep the scannee in the frame
 - i. When the scannee completes one full circle, slowly raise the Kinect vertically while rotating it to view down on top of their head.
10. There are 3 keyboard commands available during a scan: "p" for starting or pausing a scan, "r" for restarting (during a pause) and ESC for exiting the live scan window

```

C:\Windows\system32\cmd.exe
[2013/01/10 11:23:27.071360][info ] Welcome to ReconstructMe
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Me.txt'
[2013/01/10 11:23:27.086361][info ]
Do you agree to our license terms? (y/n) : Y
Do you agree to our license terms? (y/n) : y
[2013/01/10 11:24:22.559534][info ] Starting sensor
[2013/01/10 11:24:22.561534][info ] Testing OpenNI driver backend
[2013/01/10 11:24:28.065849][info ] Preparing environment for Device Quadro 60
0
[2013/01/10 11:24:28.133853][info ] Using default settings.
[2013/01/10 11:24:29.955957][info ] Press 'p' to reconstruct/pause recording
[2013/01/10 11:24:29.958957][info ] Press 'r' to reset volume
[2013/01/10 11:24:29.961957][info ] Press 'ESC' to stop recording
  
```

- a. When the facilitator is in their ready pose, hit "p" on the keyboard and have them begin turning. The live data being captured by ReconstructMe will be displayed on the right of the video window.



- b. After they complete one full revolution, slowly fill in the holes on the top of their head and under their chin.
- c. When the scan is complete press "p." You can now spin the scan on the right around to show any remaining holes and the 3D nature of the data.
- d. After completing the demo press ESC to return to the command line dialogue.
- e. Press 'y' to save the data.

```

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[2013/01/10 11:24:29.955957][info ] Press 'p' to reconstruct/pause recording
[2013/01/10 11:24:29.958957][info ] Press 'r' to reset volume
[2013/01/10 11:24:29.961957][info ] Press 'ESC' to stop recording
Save content? (y/n) : y
  
```

- f. **IMPORTANT:** Save the file as “guestsname.stl” Appending the .stl on the end of the file is critical, without it, there are several time-consuming steps to convert the file format from the default of .ply to .stl (which is what is required by our printers.)
 - i. Fun fact for the guests! Ask if anyone knows what .stl stands for. It is short for either “Surface Tessellation Language,” “Standard Tessellation Language,” or “Stereolithography”
 - ii. Ask if anyone knows what Tessellations are. Explain that they are repeating shapes that cover a surface, sort of like hexagons with a honeycomb or squares with a checker board. We just tessellated the other facilitator into thousands of little triangles.

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C:\Windows\system32\cmd.exe
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[2013/01/10 11:24:29.961957][info ] Press 'ESC' to stop recording
Save content? (y/n) : y
Filename (string) : patricksample.stl
  
```

- g. “Once you hit enter to save the content do NOT close the window, ReconstructMe takes several moments to generate the .stl file and move it to the network drive. Only close the window by letting the process complete and pressing any key.”

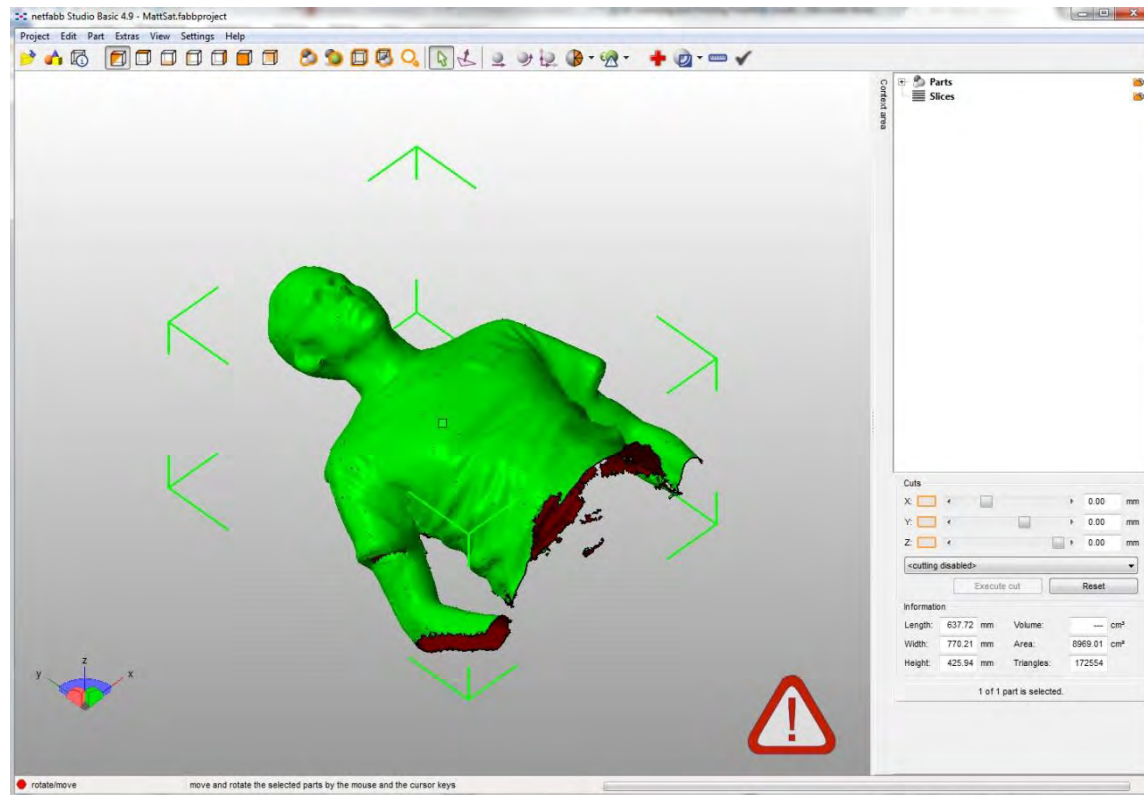
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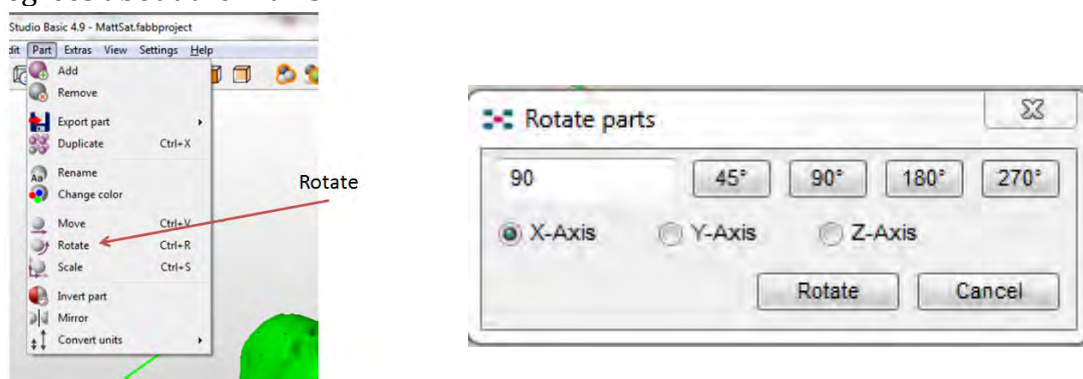
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Me.txt'
[2013/01/10 11:23:27.086361][info ]
Do you agree to our license terms? (y/n) : Y
Do you agree to our license terms? (y/n) : y
[2013/01/10 11:24:22.559534][info ] Starting sensor
[2013/01/10 11:24:22.561534][info ] Testing OpenNI driver backend
[2013/01/10 11:24:28.065849][info ] Preparing environment for Device Quadro 60
0
[2013/01/10 11:24:28.133853][info ] Using default settings.
[2013/01/10 11:24:29.955957][info ] Press 'p' to reconstruct/pause recording
[2013/01/10 11:24:29.958957][info ] Press 'r' to reset volume
[2013/01/10 11:24:29.961957][info ] Press 'ESC' to stop recording
Save content? (y/n) : y
Filename (string) : patricksample.stl
[2013/01/10 11:27:40.015828][info ] Content saved as patricksample.stl
[2013/01/10 11:27:40.680866][info ]
[2013/01/10 11:27:40.681866][info ] Thanks for using ReconstructMe!
[2013/01/10 11:27:40.685866][info ] Visit us http://www.reconstructme.net
C:\ReconstructMe\patricksample.stl
1 file(s) moved.
Press any key to continue . . .
  
```

- 11. Once the demo is completed, proceed to have the remaining guests scan one another at the three scanning stations by operating in teams. (10 min)
 - a. Have facilitators and volunteers operate each station to assist and coach the guests through the exact procedure above. Particularly young and older guests often need special attention.

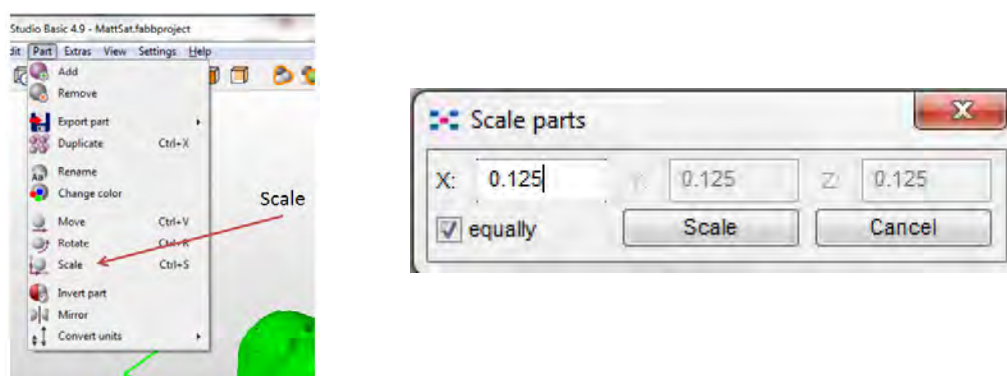
12. Once the guests are scanned, have them return to their seats to begin preparing their files. (10minutes.)
13. First close out of the infrared camera
 - a. Have everyone EXCEPT the person at the infrared station press the escape key.
 - b. Close the window by clicking the red X in the upper right corner
 - c. Say yes, you really want to leave this page
 - d. Once everyone is logged out, have the person at the infrared computer close out by pressing the escape key
14. Have everyone open netfabb studio (the blue and pink checkerboard on the desktop)
 - a. Do all of the below procedures on the facilitator scan you created during the demo
 - b. Bring in your scan by going to Part: Add and finding your name
 - i. Emphasize the guests to not move their scans around or click anywhere with their mouse, the orientation of the model is very important.





- c. “The Kinect wants us to start the scan pointing down on your head, which is inconvenient, so we come in laying on their backs, rotate them so they stand upright by opening the rotate tool (in Part:Rotate) and selecting rotate 90 degrees about the X-axis”

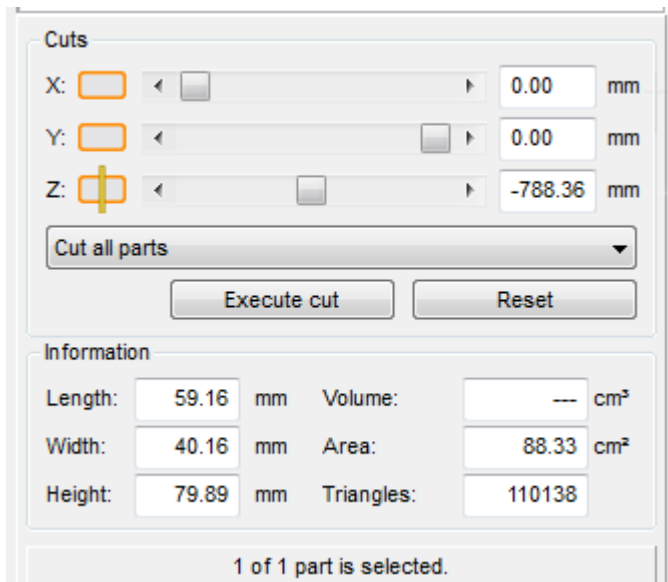


- d. “The 3D scan coming from the Kinect is approximately life size, which is much too big for our printers and the amount of time we have. We will be doing 1:8 scale prints in this workshop. To scale the print down, open the scale tool (in Part: Scale) and selecting a scale factor of 0.125 (equally in all axes.)”

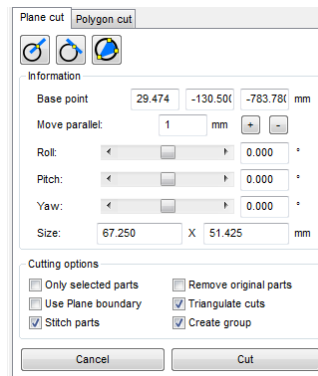
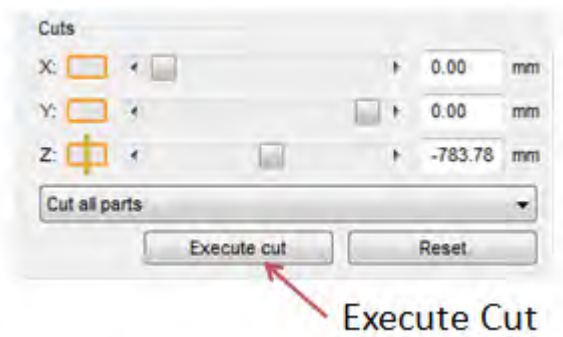


- e. Zoom in on the scan using the scroll wheel or clicking on the zoom to parts button 
- f. Explain what takes time in 3D printing
 - i. “In general, it’s the amount of plastic we use, but we’ve already shrunk you down and the software will make you hollow later on”
 - ii. “The next thing is actually how tall it is because we get set up as layers”
 - iii. Ask if you were printing a model of the Eiffel Tower or a Pizza, which would take longer
 1. Correct! The Eiffel Tower!

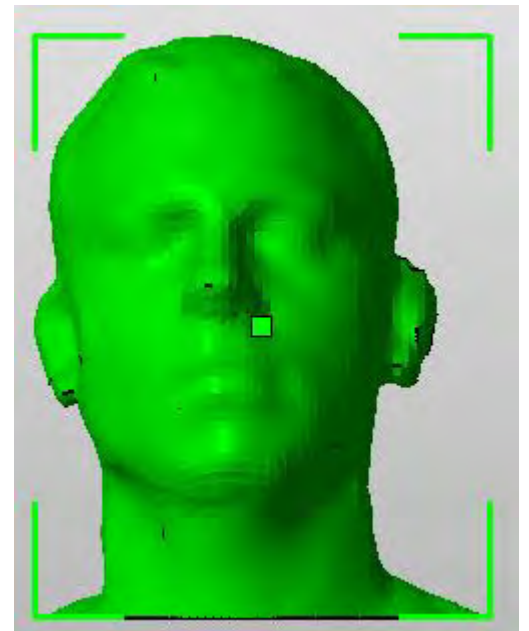
- g. “So, to save time we must now slice the scan”
 - i. “First, look head on at the scan by clicking the wire box with an orange front.” 
 - ii. “Generate the cut plane with the sliders on the right of the screen. Cut only in the Z-Axis. The cut plane will appear as a blue ring on the green scan.”



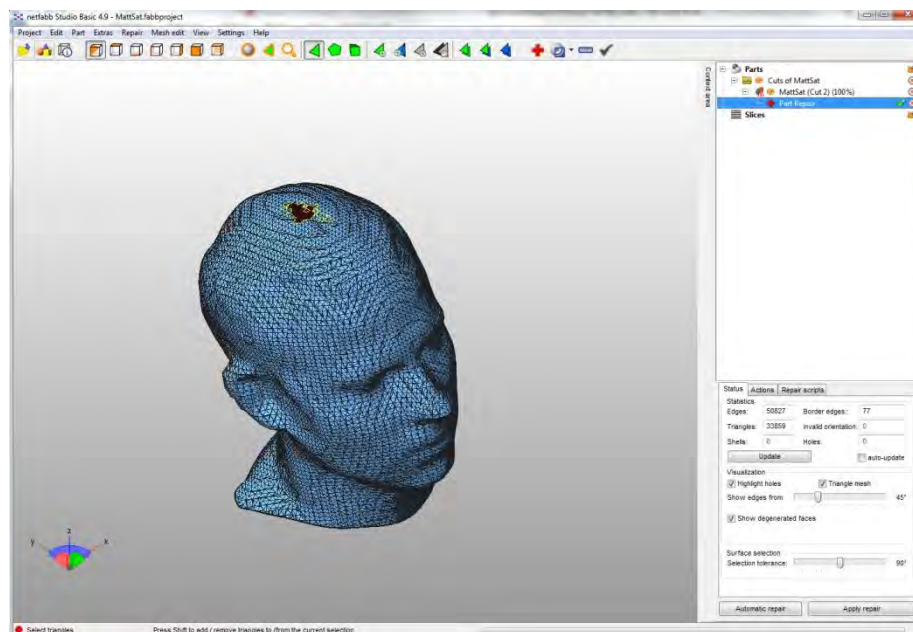
- h. “To get the best compromise between saving time and making a good looking print, set your cut line to just about where your neck is turning into shoulders”
- i. When the cut plane is in a good spot, press the execute cut button below the cut sliders. This brings up a new menu, click Cut in the bottom right corner.



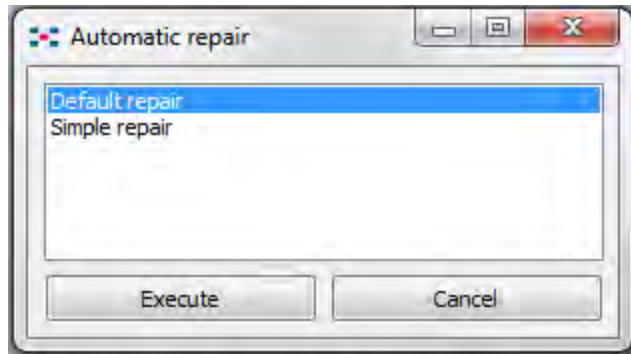
- j. “The scan is now two separate parts. Click on the lower part and press delete. Select yes, you really want to remove that part.”
- k. Ask if anyone has any holes in their heads.
 - i. We need to fix those holes, so just as in real life, we go to first aid
 - ii. Click on the Red Cross repair button



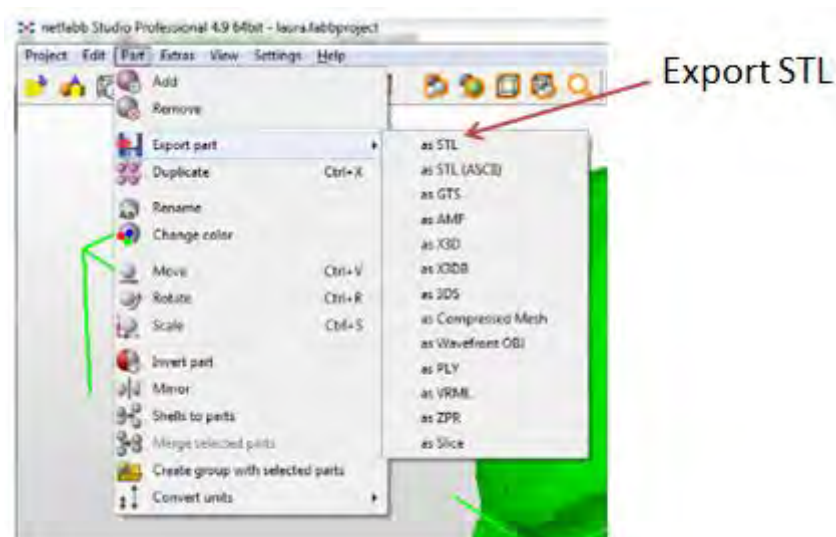
- l. Netfabb now is showing the model with all of its triangles.
 - i. Ask “Can anyone remember what the triangles are called”?
 - 1. Reward/remind everyone about Tesselations
 - ii. “The holes in the scan are highlighted by yellow circles”
 - 1. “We need to close those holes, otherwise the printer will come across them and not know what is going on, it will think the file is done and stop printing.”



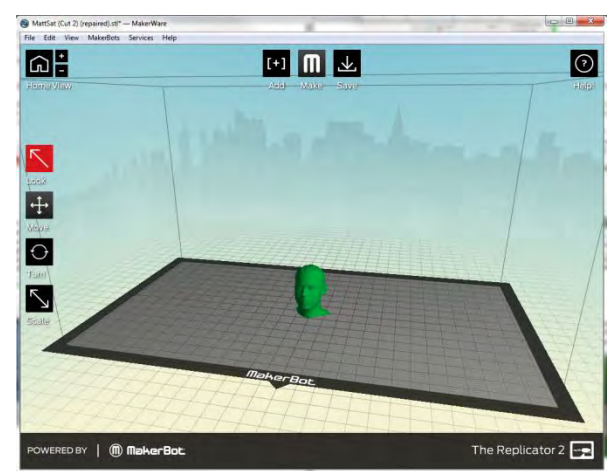
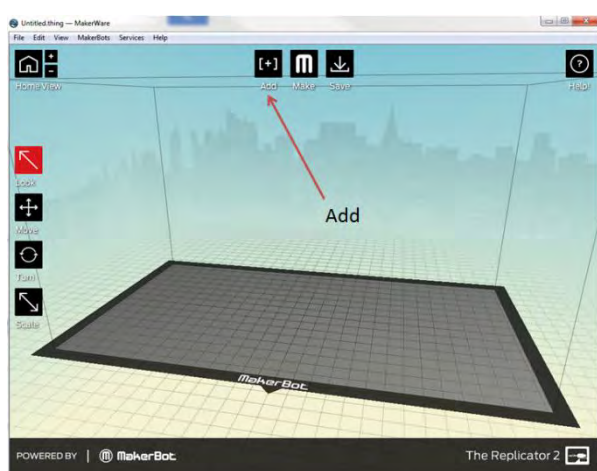
- m. “Click on the automatic repair button in the bottom corner.”
 - i. “This brings up another dialogue, simply click on the execute button.”



- n. “The holes are no longer highlighted, but the repair has not been applied yet. Press apply repair and remove the old part. Generally the exclamation point in the corner of the screen will disappear, but it is ok if it does not.”
- o. “The file is now prepared for printing and can be exported. Open Part:Export part: as STL”

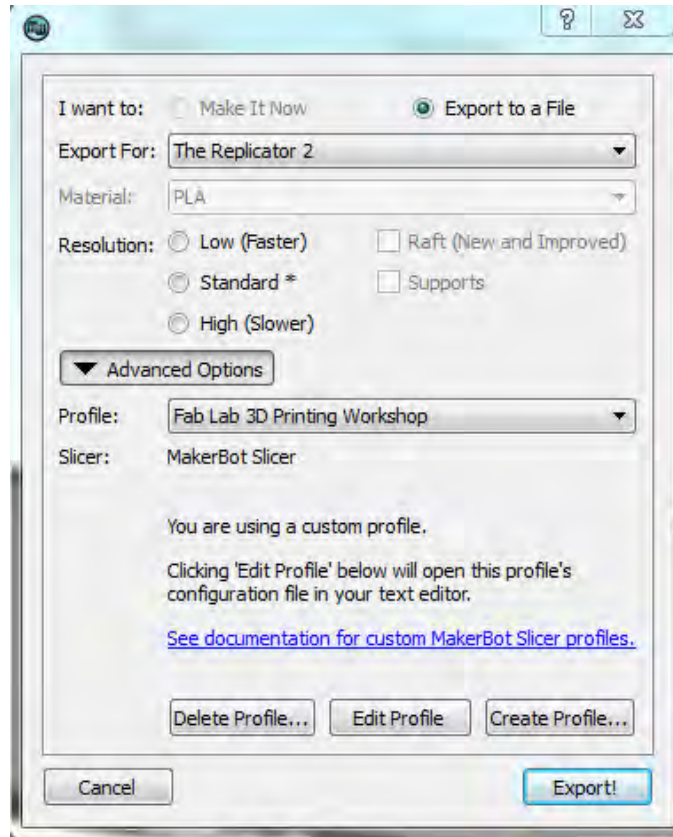


- p. “Save the file in the same spot, with the new name assigned by Netfabb. If a window comes up with a big red X, simply click export.”
 - q. “Minimize this software, there is a small chance we’ll have to return to it.”
15. “We have now finished the CAD portion of the workshop, we’re now moving onto the CAM portion in which we’ll get the machines moving.”
- a. “Open MakerWare on your desktops. It is the blue circle with a big MW in the center”
 - b. “What we see on the screen is a representation of the inside of a MakerBot. What we need to do is take your head and put it on the plate (demonstrate with physical models.)”
16. “Press the Add Button (big plus sign) at the top”
- a. “Find the file named after you, but with (cut 2)(repaired) added on the end”

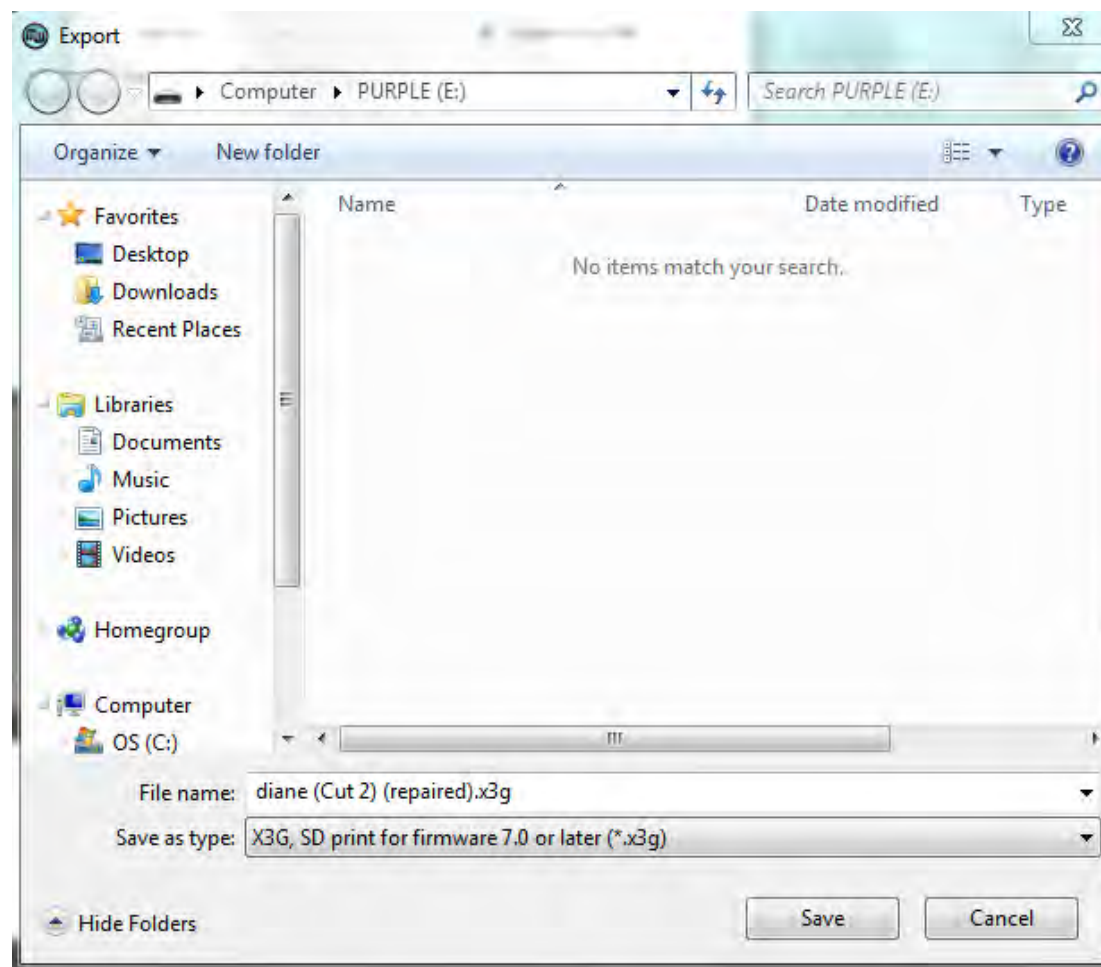


- b. Ask the guests if we want to move the object to the platform?
 - i. Yes!
- c. OPTIONAL: If you have more people than printers, form design teams and have the lead person add their partner to a plate
- d. “So now our heads are on the plates, but our printers don’t understand triangles, they understand loaves of bread and slinkies, stacks of slices. We need to slice our files and do something called “generate toolpaths.” “
 - i. “Unfortunately, our printers are not connected to the computers, we have to create what is known as a “sneaker net.” That’s where we put the file onto a removable drive and physically carry it to a new place”
- e. Pass out the SD cards plugged into the USB sticks
 - i. Don’t let the guests choose colors, just pass them out
 - ii. Have the guests plug them into the dongle beneath their monitors
 - iii. If a window pops up asking you to open the drive, just close the window

- f. “We’re now prepared to make our heads, so let’s click Make It (the big M) to get going.”
 - i. Have everyone check to see if “Fab Lab 3D Printing Workshop” is selected under Profile
 - ii. If so, click Export



- g. “Make sure the saving location is says Computer/Some Color (depending on the drive)”
 - i. “If so, click save “



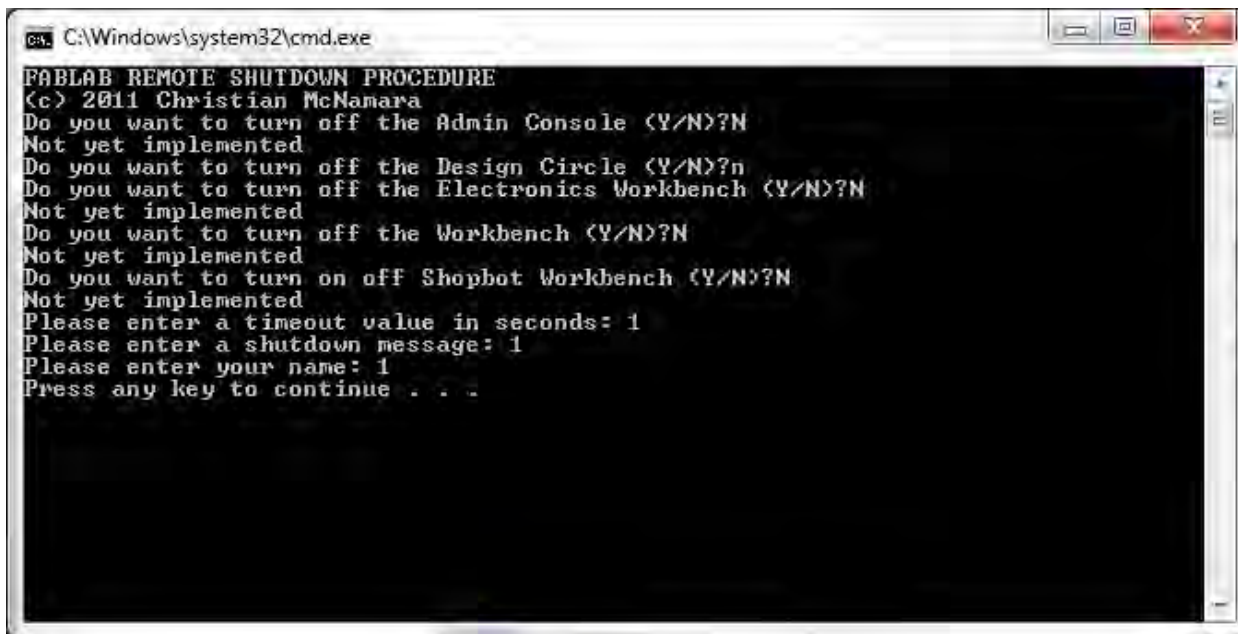
- h. “Once all of the little red activity bars are finished, eject the drive by clicking the green checkbox in the bottom of the screen and pull out the stick. Then, pull the card out of the side of the stick, hold onto the card and give me the stick.”
17. “Now, stand up and head back to the 3D printers, choose one to sit at. The colors on the printers and the colors on the cards mean nothing, they are just a way for us to keep track of things.”\
18. Transition to the other facilitator, who will lead the backend of the workshop.
 - a. The printing time will vary a little bit for each group, depending on the size of your slicing and the number of features you include. Normally this will be between 20 and 30 minutes.
 - b. From this point on, all of the dialogue is for the second facilitator, the first is helping guests.
19. “The first thing we need to do is get familiar with our MakerBots.”
 - a. Hold up the laminated card representing the front panel



- b. “The first thing we notice is the big red M, this is like an enter key”
 - c. “It has four arrows around it to navigate through the menus to the left on the LCD Panel”
 - d. “Behind the red M on the side of the machine there is a slot, insert your SD card with the number facing you. Press down until it clicks sort of like a ballpoint pen.”
20. “Now we load your file”
- a. “The M button is very sensitive, so lightly tap it once”
 - b. “If you see your name, tap a second time to get the MakerBot moving!”
21. “At this point the MakerBot is “zeroing its axes” which simply means it’s figuring out where the head and build platform are relative to one another.”
- a. “Since the machine is moving we want to direct your attention to the safety warnings on the front bottom left of the machine.”
 - b. “The first is a hand having a bad time since it’s caught in some gears.”
 - c. “The second is a hand being burnt.”
 - d. “You should see on the front of your machine a number increasing slowly to 230 C, that means it’s heating up to 230 degrees Celsius. Does anyone know what that is in Fahrenheit?”
 - i. ~450F
 - e. “So, this is a long way of saying please don’t stick your hands in the machines while they are operating. It is potentially like sticking your hand in an oven, only the hot elements are moving around.”
22. “Once the machines are at temperature you’ll see the extruder move to the corner and draw a small diagonal line on the platform.”
- a. “This is sort of like it clearing its nose. It’s getting rid of any debris that might be in the nozzle.”
 - b. Hold up the hot glue gun. “Has anyone ever used one of these?”
 - i. “Yeah? Well these machines are just like a hot glue gun, just a lot more precise. Instead of your hand squeezing a trigger to pull glue, a motor pulls filament off of a roll on the back. You can see your neighbors’ on the machines across from you.”
 - c. “At this point you should be making some squiggles in a back and forth pattern.”
 - i. “It’s making a raft, which is a special feature to prevent delamination.”
 - ii. Use the clean and birdnested bowl to explain why rafts are important.
23. “Now the rafts are done, you should be making funky little loops, which are the layers for your neck.”
- a. Use the laser cut layers and the hot glue gun to describe how the extruder moves around.
 - b. “This is sort of like an etch a sketch”
 - c. “So we have a challenge for you, in 30 seconds try to draw a perfect circle on your etch a sketches”
 - i. Give the winner a sticker
24. “There are four total motors on these machines. The first pulls the filament through, the second two are like the knobs on your etch a sketch, they move the extruder around. Where do you think the fourth one is?”
- a. Explain how layers work and the Z-motor operates with the laser cut stack.
25. “Ok, so this is all fun using the printers like a high-tech portrait studio, but what are some of the practical aspects of 3D printing? To show you, we’re going to play a game, Name that 3D printed object!”
- a. Tailor the objects you pull out of the crate to your audience and the amount of time available. A good general order is
 - i. Meteorites – Copying/outreach/education
 - ii. Mars – Alternative education methods
 - iii. Tooth/jawbone – medical applications
 - iv. Yoda(s) – Art, Film, digital manipulation of files
 - v. Bracelet/Wrench – Different printing methods, Space
26. Once most of the prints finish, wrap up the game and instruct everyone in how to remove the heads from the build plates.
- a. “The heads are designed to break away from the raft, so simply reach in and pull on your head gently till it breaks. Be careful not to pull our MakerBot on the ground!”
 - b. If someone’s head isn’t releasing, remove the build platform and use the spatula to get it off.
27. Conclude the workshop
- a. “It was great having you all visit the lab today, but we want to make sure you can continue your adventure in digital design and rapid prototyping.”
 - b. Pass out the 3D printing handout
 - c. “This sheet has all of the software we used today listed on it, the best part being that they were all free! So you can continue when you go home.”
 - d. “We also include a few other 3D design software packages and printing services, so if you don’t want to only design but continue making, the service is there for you!”
28. “Thanks for coming to the lab, enjoy the rest of the museum!”

After the Workshop

1. Remove all of the rafts from the plates with spatulas and return the plates to the machines.
2. Prepare for the next workshop
3. If you have other work in the lab, allow the volunteers to work on personal projects for ~1 hour (as scheduled by Lab Manager,) but if you have to leave, make sure no one is in the lab unattended
4. If you are leaving for the day, turn off all the computers by running “goodnight.bat” from the podium computer
 - a. Answer Y or N as appropriate for computers that need to be shut down
 - b. Make sure all of the computers shut down, if any are missed, manually shut them down



```

C:\Windows\system32\cmd.exe
PABLAB REMOTE SHUTDOWN PROCEDURE
(c) 2011 Christian McNamara
Do you want to turn off the Admin Console (Y/N)?N
Not yet implemented
Do you want to turn off the Design Circle (Y/N)?n
Do you want to turn off the Electronics Workbench (Y/N)?N
Not yet implemented
Do you want to turn off the Workbench (Y/N)?N
Not yet implemented
Do you want to turn on off Shopbot Workbench (Y/N)?N
Not yet implemented
Please enter a timeout value in seconds: 1
Please enter a shutdown message: 1
Please enter your name: 1
Press any key to continue . . .
  
```

5. Turn off the projector using the remote on the podium
6. Check the lab for any trash or personal items left behind by guests
7. Make sure everything else is tidy in the lab (leave it cleaner than you found it!)
8. Check the workshop sign, adjust it to reflect the next scheduled workshop
9. Lock the front doors

General Timeline and Goals

Time (min)	Goal (What the guests will accomplish/receive)	Steps/Action (What the facilitators will do)
-5-0	Intro, Know Schedule, Get Excited	Talk to Guests at rope, explicitly inform them about workshop using precise language
0-2	Gather themselves, take in the room	Introduce general lab, guide guests to design circle
2-25	Scan themselves and prepare the files for printing	Demonstrate scanning, guide guests in software
25-30	Operate machines to start prints	Explain how to load SD cards and operate machines
30-50	Print heads, learn about 3D Printing	Explain how 3D printers work, observe machines to make sure prints aren't failing, play name that 3D printed object
50-60	Wrap up and get out	Remove heads from plates, pass out notes sheet, thank guests for coming



YOU CREATED A 3D OBJECT

SOFTWARE

You scanned yourself with a Microsoft Xbox Kinect with ReconstructMe (reconstructme.net) to create an STL (Surface Tessellation Language) file. You used NetFabb Studio (netfabb.com) to repair the 3D model. Then you sent the file to MakerWare software (makerbot.com) to prepare the 3D files for printing.

HARDWARE

Your head was printed on a MakerBot Replicator 2 3D printer. Check out msichicago.org/whats-here/fab-lab/ to see a video about how it works.

HOW IT WORKS

3D printing uses Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) concepts. CAD creates and manipulates a 3D object on a computer. Models can be created on a computer from scratch, downloaded from the Internet or scanned with a 3D scanner.

CAM prepares a 3D object for printing by slicing the 3D model into thin layers. The printer then stacks the layers on top of each other by “drawing” each layer with melted plastic.

RESOURCES

3D PRINTING WEB SITES

Thingiverse (thingiverse.com): For sharing 2D and 3D objects.

Shapeways (shapeways.com): For sharing, buying, and selling 2D and 3D objects.

Ponoko (ponoko.com): European-based web site for sharing, buying, and selling 2D and 3D objects.

FREE 3D DESIGN SOFTWARE

Autodesk 123D (123Dapp.com): Suite of various 3D applications.

Sculptris (pixologic.com/sculptris): Software for sculpting 3D files from scratch.

MeshMixer (meshmixer.com): Software for manipulating 3D files.

MeshLab (meshlab.sourceforge.net): Software for processing and editing 3D files for printing.

SketchUp (sketchup.com): 3D modeling software for professionals.

Sketchup-STL (github.com/SketchUp/sketchup-stl): Plugin for exporting STL files from Trimble SketchUp.

3D PRINTING LOCATIONS IN CHICAGO

Harold Washington Library (chipublib.org/branch/details/library/harold-washington)

Southside Hackerspace Chicago (sshchicago.org)

Edgewater Workbench (edgewaterworkbench.com)

Pumping Station: One (pumpingstationone.org)

The 3D Printer Experience (the3Dprinterexperience.com)



ABOUT THE WANGER FAMILY FAB LAB

The Wanger Family Fab Lab at the Museum of Science and Industry, Chicago is a modern workshop for computer-based innovation, design and fabrication that allows you to dream up, design and make almost anything you can imagine using cutting-edge software and equipment. MSI's Fab Lab is one of hundreds of such labs worldwide. Fab Labs began as a community outreach program of the Center for Bits and Atoms at the Massachusetts Institute of Technology and have spread worldwide.

Visit us at msichicago.org/whats-here/fab-lab/ to learn more about the lab and to keep up to date on our workshops. We can be contacted at FabLab@msichicago.org. If you're not from the Chicago area, visit fab.cba.mit.edu to see if there's a Fab Lab near you.

CENTER FOR THE ADVANCEMENT OF SCIENCE EDUCATION

The Wanger Family Fab Lab is part of the Museum's Center for the Advancement of Science Education (CASE), which was created to help realize our vision to inspire and motivate all children to achieve their full potential in the fields of science, technology, engineering, and medicine. CASE programs extend the content of the Museum's exhibits through strategies that empower teachers, engage the community, and excite students and Museum guests.



Boot Camp - Summary

Short Summary: Fab Lab boot camp is an intensive series of workshops in which participants learn a new Fab Lab process, including both software and machinery, during each return visit. The MSI Fab Lab boot camp is based off the Fab Academy created by Fab Central at MIT. If the number of visits permits, boot camp ends with personal project time in which the participants can demonstrate and practice their new skills.

Workshop time: 90-120 minutes, 4-10 visits.

Target Audience and Capacity: Ages 12-18

Materials and Equipment: The exact set of processes and materials depends on the number of visits the group will have in the lab. The software covered includes vector graphics through Inkscape, raster graphics through GIMP and 3D files through Sketchup, netfabb and/or ReconstructMe. The minimum hardware covered includes the Epilog 35 Watt laser cutters, the Roland GX-24 vinyl cutter and the MakerBot Replicator 2 3D printers. During the most extensive boot camp sessions, participants will learn effectively every tool and process in the lab.

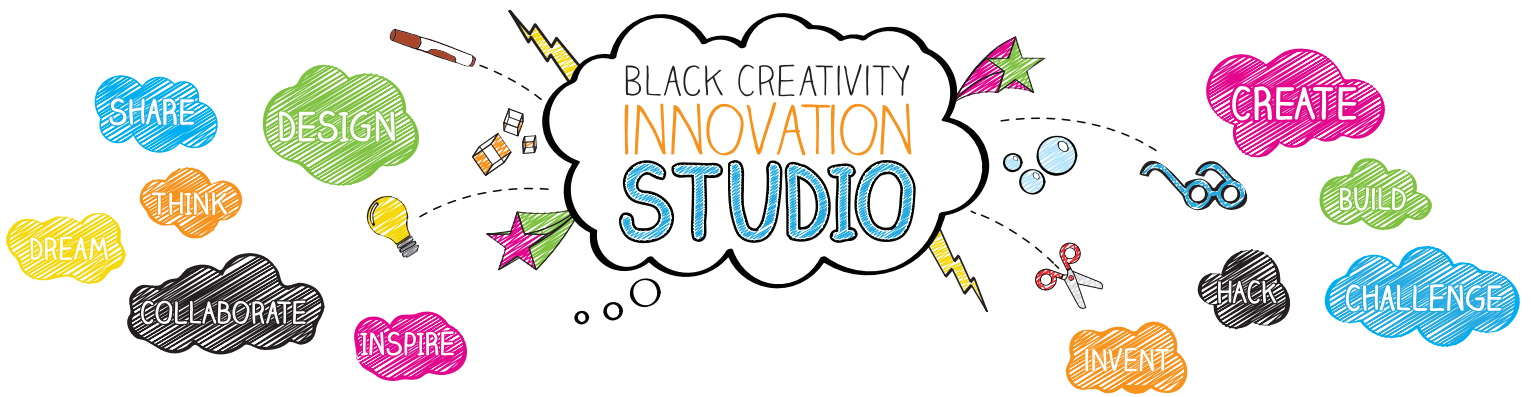
Learning Goals: By the end of Boot Camp, guests will:

- Have a personal experience with multiple computer controlled machines
- Understand there are computer controlled machines that can make things
- Be able to design and make items completely of their own invention
- Have a fundamental skill set in a variety of design software
- Understand the general operation of a number of computer controlled machines, what differentiates them and what makes them similar.

Educational Standards: Boot Camp, in part, fulfills the requirements for the following standards:

NGSS – 3-5-ETS1-2, MS-ETS1-3, HS-ETS1-3.

AAAS Project 2061 – 8B/M2,M3,M4,M7,H1; 12C/M5,H1; 3A/E3,E4,H1 ;3B/M1; 3C/M8; 1C/M6



CHALLENGE: SAFE CYCLING

Chicago is becoming one of the most bike friendly cities, but it's still important for drivers to be aware of cyclists. Following the innovation process and using the materials and tools found in the Innovation Studio, design a new item that can protect bicycle riders either by making them more noticeable or some other method.

BACKGROUND

Bicycling.com recently ranked Chicago as the fifth best city in the country for biking. The City of Chicago has a plan to have 645 miles of bike path installed by 2020, which will result in bike accommodations within a half mile of every Chicagoan. Chicago also has a bike-sharing program to give residents and visitors easy access to bikes.

Biking provides health benefits from exercise. In addition, the European Cycling Federation has found that an increase in the number of people biking significantly reduces emissions of greenhouse gases.

Encouraging additional biking is positive, but increasing the number of cyclists on the road also increases the risk of bicycle-motor vehicle collisions. Even with dedicated bike lanes and improving awareness of drivers, the safety of cyclists is an important consideration and can always be improved.

KEYWORDS

Kinetic energy
Carbon footprint
Emissions
Safety
 $F=MA$

EXISTING INNOVATIONS

- Reflective clothing, gear and bicycle parts
- Evolution of bike helmets
- Lighting systems for bikes and riders
- Freewheel or freehub allows pedals to be stationary while wheels are still turning
- Bicycle bell or horn
- Rear-view mirrors for bikes or helmets
- Rear-view mirrors on motor vehicles
- Improved tires
- Use of hand signals or signaling devices
- Bike holders on CTA buses allow riders to take their bike on the bus where it's not safe or convenient to ride



THINGS TO THINK ABOUT

- Have you ever avoided using safety gear because it was uncomfortable, and/or looked bad? What and/or how would you change it to make it better?
- What if you made something you could wear?
- What if you made something for the bike?
- What if you made something to get people's attention?
- Have you ever had a close call on a bike? Would something have prevented that?
- Can you imagine creating something that would make it easier to obey traffic laws when riding?

STEPS TO INNOVATION

1. **Observe** – Identify the problem or challenge. Look at the circumstances surrounding the issue and record your initial thoughts.
2. **Brainstorm** – Generate new ideas, approaches and solutions. Take other people's ideas and continue their development. Collaborate as a group to come up with a variety of ideas.
3. **Prototype** – Create a first, rough version of the design or idea.
4. **Experiment** — Solicit and receive feedback on prototypes, test it out, and record observations and new ideas.
5. **Modify** – Take information gathered during the experiment phase and update the prototype. Continuously iterate or change prototypes into progressive solutions
6. **Launch** – Share the ultimate solution with the targeted user.

LEARN MORE

Bicycling.com city rankings

www.bicycling.com/ride-maps/featured-rides/5-chicago

City of Chicago Streets for Cycling Plan 2020

www.cityofchicago.org/city/en/depts/cdot.html

Ride the City bike maps

www.ridethecity.com/chicago

European Union Study on Cycling Emissions

www.theguardian.com/environment/2011/dec/12/cycle-like-danes-cut-emissions

Divvy bike sharing program

divvybikes.com/

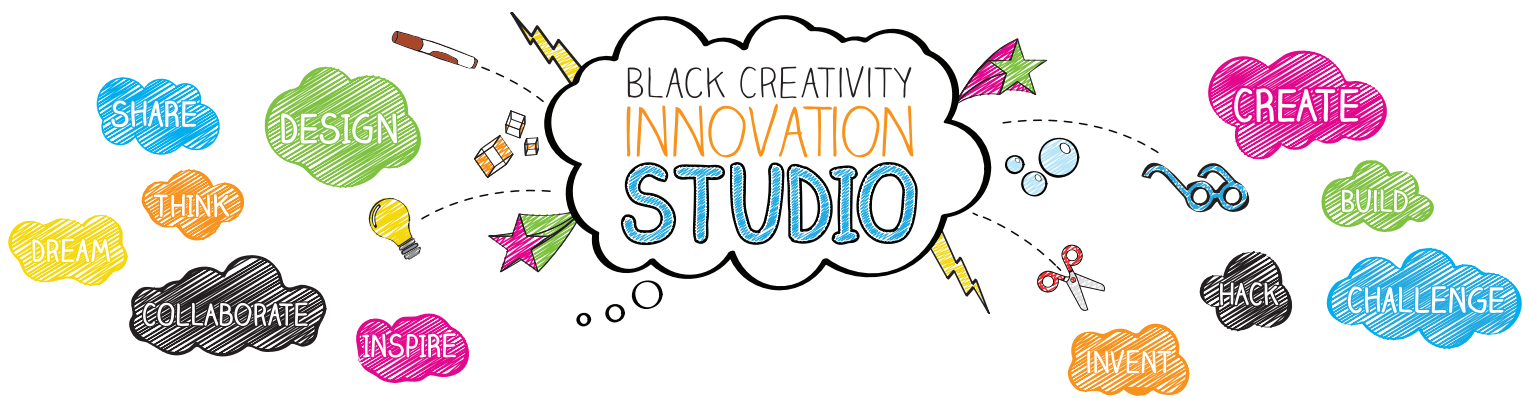
The Art of the Bicycle exhibit at MSI

www.msichicago.org/whats-here/exhibits/art-of-the-bicycle/

BLACK CREATIVITY MISSION

To inspire African American children to pursue educational opportunities and careers in the fields of science, technology, medicine and engineering through programs and events that encourage children and their parents to utilize the Museum of Science and Industry as a resource for exploring and discovering their inventive and creative genius.





CHALLENGE: REDUCE FOOD WASTE

Forty percent of the food produced in America is never eaten. It spoils or is thrown away. Following the innovation process and using the materials and tools found in the Innovation Studio, invent something to reduce this waste or design a purpose for the waste.

BACKGROUND

Food waste in America is estimated to be between 40 and 50 percent. According to the Environmental Protection Agency, more than 36 million tons of food is wasted annually. This includes food that spoils in transit or at the store, food that goes bad after purchase but before being eaten, and prepared food that is not eaten but thrown away. In developing countries where food storage is basic and pest infestations are common, food waste can be even higher.

With so many causes of food waste, this is a complicated problem without a single solution. Many small innovations can combine to create significant improvements.

KEYWORDS

Conservation
 Recycling
 Preservation

EXISTING INNOVATIONS

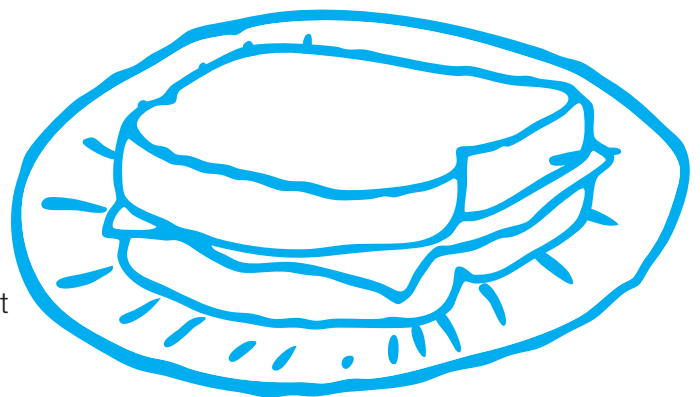
- “Spoiled” food app <http://technical.ly/philly/2012/09/24/spoiled-app-to-avoid-wasted-food-wins-lean-startup-machine-philly-2-honors/>
- Kitchen compost container

THINGS TO THINK ABOUT

- What are some ways you can tell food has gone bad?
- What are some types of preserved foods you eat regularly?

STEPS TO INNOVATION

1. **Observe** – Identify the problem or challenge. Look at the circumstances surrounding the issue and record your initial thoughts.



2. **Brainstorm** – Generate new ideas, approaches and solutions. Take other people’s ideas and continue their development. Collaborate as a group to come up with a variety of ideas.
3. **Prototype** – Create a first, rough version of the design or idea.
4. **Experiment** – Solicit and receive feedback on prototypes, test it out, and record observations and new ideas.
5. **Modify** – Take information gathered during the experiment phase and update the prototype. Continuously iterate or change prototypes into progressive solutions
6. **Launch** – Share the ultimate solution with the targeted user.

LEARN MORE

Food waste study

www.huffingtonpost.com/2012/08/21/food-waste-americans-throw-away-food-study_n_1819340.html#slide=1194117

Global and American food waste

http://endhunger.org/food_waste.htm

Reducing food waste from the U.S. EPA

<http://www.epa.gov/foodrecovery/>

The Your Appetite area of YOU! The Experience exhibit at MSI

www.msichicago.org/you

BLACK CREATIVITY MISSION

To inspire African American children to pursue educational opportunities and careers in the fields of science, technology, medicine and engineering through programs and events that encourage children and their parents to utilize the Museum of Science and Industry as a resource for exploring and discovering their inventive and creative genius.

