DEVELOPING A PROJECT BASED 2-8 FABRICATION CURRICULUM

Kris Swanson, Innovation Specialist
Pine Crest School
Co-Creator of Young Makers Lab
ABOUT KRIS

➤ Innovation Specialist at Pine Crest School, Boca Raton FL

➤ Palm Beach County Public Schools for 21 years

➤ 5th grade teacher

➤ Science Lab teacher

➤ Planetarium Director

➤ District Technology Specialist

➤ Co-Creator / Co-Owner of Young Makers Labs

➤ Autodesk Tinkercad Ambassador
Project difficulty can be tailored to a student's abilities and interests, so 3D printing can be used for all ages. Products can be selected from pre-defined models, downloaded from the Internet, or created from scratch. Younger students can build printable objects by simply drawing them with graphical software while older students can build more complex designs with mathematical equations.

Working in project groups will add communication and teamwork skills to the learning mix. Group members can contribute based on their individual strengths and feel that they're part of a team contributing to a common goal.

Some teachers have used 3D printing to fabricate models and visual aids for their chemistry, math, and biology courses. In the process, they have discovered that while the visual models add to the clarity of the lessons, they also draw students into the printing technology that created them.

In both education and real-world settings, 3D printing is also flourishing in areas like art, fashion, jewelry design, lighting, music, and architecture.

Three school experiences, below, will show the value and effectiveness of 3D printing for all grade levels.

Harnessing Natural Enthusiasm

Although the fun of 3D printing may first capture the attention of elementary school students, the technology quickly leads to more ambitious classroom exploration. Kris Swanson, Planetarium Resource Teacher at Poinciana Elementary STEM Magnet School in Boynton Beach, FL, has seen the excitement. "The kids are simply mesmerized by the process—watching a thread of plastic turn into a thing, especially when that thing is something that they designed."

Swanson uses 3D printing to help students visualize the world. "One of the challenges of teaching engineering and design to elementary-aged students is getting from an abstract idea or even a 2-dimensional drawing to an actual object in the real world," he said. "My challenge is to help them make their ideas real. 3D printing is a powerful tool to help do that."

He purchased a MakerBot Replicator 3D printer in 2011 with a STEM grant, and members of his after-school engineering club served as guinea pigs to figure out how to use the machine. One of his biggest challenges was determining which CAD software was most appropriate for his 8- to 10-year-old students. He settled on Tinkercad, a free program with an easy-to-use interface, and found a Tinkercad tutorial to guide his students through their first printing project of making nameplates for their cubbies. After that, some of the girls moved on to designing jewelry, while the boys gravitated more towards spacecraft. "This year, we just got experience with the printer," he explained. "Next, my plan is to integrate the printer into 4th- and 5th-grade geometry units and to complete some engineering projects with them."

Building Toward High School

3D printing has been used in middle schools to give students a technical foundation to take advantage of opportunities they'll encounter in high school. Peter Grimm, an industrial technology teacher at Southview Middle School in Edina, MN, focuses his students' energies with design competitions. One of his first projects was a challenge to improve the usability of automobile cup holders, and the winners were rewarded by having their design printed.

The response of his students has convinced him of the value of 3D printing for teaching physical concepts. "Giving students the ability to hold a functional model of their design work makes engineering real," he said. "It is one thing to create a solution using 3D software. It's quite another experience to actually manipulate the mechanism you designed."
ABOUT PINE CREST SCHOOL

➤ PK-12 Independent School with campuses in Ft. Lauderdale and Boca Raton, Florida.

➤ Started an Innovation program three years ago to offer new experiences to students, both inside and outside of standard curriculum.

➤ 3 Labs with 3d printers, laser cutters, CNC, vinyl cutters, sewing machines, standard power and hand tools and more.
THE PROMISE OF DIGITAL FABRICATION

➤ Give students the ability to construct things that they don’t have the dexterity / skill to make with their own hands or with power tools.

➤ More quickly and easily iterate parts for projects.

➤ Share with and learn from others.
QUESTIONS WE ASKED . . .

➤ What do we want kids to be able to create with Digital Fabrication devices?

➤ What is realistic for kids at different grade levels to design and create with Digital Fabrication machines?

➤ What software is appropriate at what grade levels?

➤ What types of fabrication machines are appropriate at what grade levels?

➤ What types of projects are appropriate at what grade levels?
# BACKWARDS DESIGN TOWARDS PROFICIENCY

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G7-8</td>
<td>Design &amp; fabricate functional 2D and 3D objects that can fit together, fit into other objects, and move.</td>
</tr>
<tr>
<td>G6</td>
<td>Design &amp; fabricate functional 2D objects that have desired form and function.</td>
</tr>
<tr>
<td>G5</td>
<td>Design and fabricate 3D objects to scale that accurately model ideas and systems.</td>
</tr>
<tr>
<td>G4</td>
<td>Design and fabricate 2D objects to scale that accurately model ideas and systems while continuing to develop basic building skills.</td>
</tr>
<tr>
<td>G2-3</td>
<td>Introduce 2D and 3D design and fabrication while focusing on developing basic “hand-crafted” design and building skills.</td>
</tr>
</tbody>
</table>
What experiences do students need to grow towards proficiency using Digital Fabrication?

- Conceptualize, design, and create digital files for an object to be 3d printed or fabricated in another way.
- Design stable, realistic items.
- Design parts that fit into or connect to other parts or existing objects.
TWO PROJECTS / STORIES

➤ 4th and 5th Grade Set Design
TWO PROJECTS / STORIES

➤ Weather Station Display Base
1: INCREASE OPPORTUNITIES FOR PK-5 TO DESIGN AND BUILD IN 3D WITH SIMPLE MATERIALS.

➤ Keva Planks
➤ Rigamagig (regular and JR)
➤ Paper
➤ Cardstock
➤ Craft Materials
➤ Chipboard
➤ Cardboard
➤ LEGOos
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<tr>
<th>Grade Levels</th>
<th>Materials</th>
<th>Tools</th>
<th>Processes</th>
<th>Be able to...</th>
<th>Develop -&gt; Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>PK-K</td>
<td>• paper</td>
<td>• scissors</td>
<td>simple mechanical adhesives</td>
<td>• build a box / cube</td>
<td>• simple sketch</td>
</tr>
<tr>
<td></td>
<td>• leds / batteries</td>
<td>• tabs</td>
<td></td>
<td>• create simple circuit</td>
<td>• oral</td>
</tr>
<tr>
<td></td>
<td>• straws</td>
<td>• clamps (fingers, tape)</td>
<td></td>
<td>• bind soft materials</td>
<td>• showcase</td>
</tr>
<tr>
<td></td>
<td>• pipe cleaners</td>
<td></td>
<td></td>
<td>• Build a stable structure, without limited materials</td>
<td>• iterate</td>
</tr>
<tr>
<td></td>
<td>• foam sheets</td>
<td></td>
<td></td>
<td>• mechanical / adhesive understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Yarn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• strawbees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>• chipboard</td>
<td>• hand drills</td>
<td>• masking tape / clamp</td>
<td>• build hinges</td>
<td>• shows details</td>
</tr>
<tr>
<td>2</td>
<td>• sewing / fabric</td>
<td>• clamps</td>
<td>• cable ties</td>
<td>• simple machines</td>
<td>• labels parts</td>
</tr>
<tr>
<td>3</td>
<td>• craft sticks</td>
<td>• sandpaper / sanding blocks</td>
<td>• adhesive - hot glue</td>
<td>• measure &amp; cut accurately</td>
<td>• discusses material choice</td>
</tr>
<tr>
<td></td>
<td>• wire / electrical components for circuits</td>
<td>• wire cutters / strippers</td>
<td>• duct tape</td>
<td>• integrate light</td>
<td>• reflect on choices</td>
</tr>
<tr>
<td></td>
<td>• duct tape</td>
<td></td>
<td>• binding posts</td>
<td>• develop an understanding of structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• thin acrylic / gels</td>
<td></td>
<td>• tacky glue</td>
<td>• build a stable structure with limited materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• cardboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• little bits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>• wood</td>
<td>• drill press</td>
<td>• wood glue</td>
<td>• design and craft motors and lights into builds</td>
<td>• orthographic drawing</td>
</tr>
<tr>
<td>5</td>
<td>• Acrylic</td>
<td>• power drill</td>
<td></td>
<td>• Integrate builds with physical computing projects</td>
<td>• designing templates</td>
</tr>
<tr>
<td></td>
<td>• nuts/bolts and assorted hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>• PVC</td>
<td>• x-acto knife</td>
<td>• super glue</td>
<td>• create a jig to make a job easier and more exact</td>
<td>• share projects through online</td>
</tr>
<tr>
<td>7</td>
<td>• Metal rods and tubes</td>
<td>• box cutters</td>
<td>• epoxy</td>
<td>• create 2 view drawings and use them to make a 3D object</td>
<td>portfolios</td>
</tr>
<tr>
<td>8</td>
<td>•</td>
<td>• Power sanders (rotary, belt, hand)</td>
<td>• Spray Paint</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2: INCLUDE OPPORTUNITIES TO APPLY MEASUREMENT SKILLS IN AS MANY PROJECTS AS POSSIBLE.

➤ Include quantity and measurement as requirements in projects starting with Kindergarten

➤ Require projects to fit within certain size and material limitations
3: CREATE OPPORTUNITIES FOR STUDENTS TO CREATE MATHEMATICAL / ARTISTIC CREATIONS BY INTEGRATING FABRICATION WITH MATH AND COMPSCI

➤ Cooperative practices with Computer Science and Math teachers to include projects created with:
  ➤ Scratch and ScratchX
  ➤ Turtle Art
  ➤ Turtlestitch
  ➤ Tinkercad Codeblocks
  ➤ OpenSCAD

➤ Fabricate with:
  ➤ 3d Printers
  ➤ Silhouette Cameos (plot)
  ➤ Laser Cutter
  ➤ Embroidery Machine
4: Make Fabrication a standard tool that students can use in iLab and classroom projects

➤ Full Class / Grade Level projects used to integrate direct instruction in Tinkercad / Illustrator / Fusion360 (beginning in G4)

➤ Open projects where students:
  ➤ Use what they have learned from direct instruction
  ➤ Learn more from online tutorials “prescribed” by iLab Specialists
2D SOFTWARE TOOLS / INSTRUCTION

K-3  iPad Based Drawing Apps

G4-5  Fab@School Maker Studio

G6  Fab@School Maker Studio
     Tinkercad
     Adobe Illustrator?

G7-8  Adobe Illustrator
     Fusion 360
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>2-3</td>
<td>Tinkercad</td>
</tr>
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Classroom Integration with “Opportunistic Instruction”
Project-Based with Prescribed Tutorials
Grade 7 2D3D Design and Fabrication Class:

Illustrator (Basics of Vector Design) -> Fusion360 (Focus on Parametric Tools)

Independent Machine Use - 3d Printer, Laser, Cameo, AxiDraw, CNC
Q&A

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