

3D Printing

Desktop 3D printing technology is becoming more accessible in schools due to its increasing affordability. 3D printing technology allows students to turn their digitally designed models into physical objects. Educational 3D printers generally use additive manufacturing technology by depositing printing material layer by layer. 3D printer works with the technology specifically called Fused Deposition Modeling (FDM). During the printing process, the smart extruder melts the filament to form the layers which will later turn into a physical object. In 3D printing, filaments are similar to ink in traditional printing and the smart extruder is similar to a hot glue gun. We used Polylactic Acid (PLA) filaments because it meets safety standards in educational settings. It is made of corn and smells like pancakes when it melts. It is safe to use PLA filaments in classrooms unlike other filaments such as oil-based plastic filament called Acrylonitrile Butadiene Styrene (ABS) because it helps to meet ventilation requirements for closed spaces (Makerbot Education 2015; Kaya et al. 2017).

We used a 3D printing slicing software, which transforms a digital 3D design into a format that 3D printers can interpret by slicing the 3D design layer by layer. This free software allows users to see an animated preview of the printing, change settings to optimize the printing, real-time monitor the printing process with cameras, and informs the user about the length of the printing process (Makerbot Education 2015). This app is capable of handling STereoLithography (.STL) file format, which is the most commonly used file format in 3D printing (Kaya et al. 2017).

We strongly recommend that teachers visit the [Thingiverse](#) website as they integrate 3D printing into their science and engineering instruction. Thingiverse is an online educational community organized around educational applications of 3D printing. It includes hundreds of free NGSS aligned science and engineering lessons integrating 3D printing. Thingiverse files should be downloaded with the STL option which is a common file extension that works for most 3D printers. In Thingiverse, teachers can form focus groups to share best practices and troubleshooting techniques in 3D printing. Teachers can also share their own lesson plans in the Thingiverse environment.

References

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- Makerbot Education. 2015. MakerBot in the Classroom: An introduction to 3D printing and design. Makerbot Education.

- Horejsi, M. 2014. Science 2.0. *The Science Teacher* 81 (4): 10.
- Kaya, E., A. Newley, E. Yesilyurt, and H. Deniz. 2019. Improving Preservice Elementary Teachers' Engineering Teaching Efficacy Beliefs With 3D Design and Printing. *Journal of College Science Teaching* 48 (5): 76–83.
- Kaya, E., A. Newley, E. Yesilyurt, and H. Deniz. 2017. *Improving Pre-service Elementary Teachers' Engineering Teaching Efficacy Beliefs through 3D Printing* (Work in Progress). Poster presented at the 2017 American Society for Engineering Education Pacific Southwest (ASEE PSW) Section. Tempe, AZ, USA.
- Mersand, S. 2015. 3D Printer Guide. *Tech & Learning* 36 (3): 22–25.

Materials List

Material Name	Quantity	Picture
Scissors	5	
Fishing Line	3(various size)	
Tri-Fold Project Display Board	10	
Craft Knife	3	
Duct Tape	2	
Electrical Tape	3(various colors)	
Meter Stick	5	

Rubber Band	3(assorted sizes)	
Graph paper notebook	10	
Ruler	5	
Pencil	10	
Pen	10	
Crayons	3	
Eraser	5	
Velcro	2	
Brass Fasteners	5	

Peer Review Rubric

	Basic	Satisfactory	Master
Ease of use	Mechanical grabber was hard to use while picking up the objects. ☐	Mechanical grabber was relatively easier to use but lacked a few parts to pick up some objects easily ☐	Mechanical grabber was easy to use while picking up the objects in a systematic way. ☐
Reliability	Mechanical grabber failed to pick up the objects ☐	Mechanical grabber picked up most of the objects ☐	Mechanical grabber picked up all the objects in a consistent way ☐
Aesthetics	The mechanical grabber is acceptably attractive ☐	The mechanical grabber is attractive ☐	The mechanical grabber is extremely attractive ☐
Portability	Mechanical grabber meets some of the portability constraints ☐	Mechanical grabber meets most of the portability constraints ☐	Mechanical grabber meets the portability constraints. ☐
Storage Space	Mechanical grabber failed to fit in a mailing tube with the dimensions of (LxWxH=62cmx8.5cmx8.5cm) container. ☐	Mechanical grabber fit in the container with the dimensions of (LxWxH=62cmx8.5cmx8.5cm) container but took most of the space. ☐	Mechanical grabber easily fit in a container with the dimensions of (LxWxH=62cmx8.5cmx8.5cm) container. ☐
Suggestions for Improving the Overall Design			

Needs Analysis

[illegible]