COOPERATIVE EXTENSION
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# 3D Printing Insect Models for K-12 Education

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## Introduction

In recent years, 3D scanning and printing technologies have advanced and become more affordable, creating new opportunities for expanded use of this developing technology. At the Tennessee State University Nursery Research Center (TSUNRC), 3D printed insect models have been a cost-effective alternative to traditional preserved insect specimens for educating students on invertebrate biology and agricultural pest insects (**Fig. 1**).

***Figure 1.*** *3D printed and painted educational models of insects (and one arachnid). Models and photo by author, 2024.*

## Educational Goals

The TSUNRC entomology program regularly volunteers for educational outreach events with local schools and clubs, bringing display cases of pinned insect specimens as well as 3D printed models for students to view and discuss (**Fig. 2**). Our primary goal at these events is to increase student interest in entomology, to encourage their awareness of the insects around them, and to teach them to recognize beneficial insects and invasive pest groups such as imported fire ants, Japanese beetles, and spotted lanternflies.

## Advantages of 3D Printed Models

While real, preserved insect specimens are a valuable learning tool for entomology and critical at higher levels of education for studying insect anatomy and identification, these specimens take significant time to collect and prepare. Combined with the expense of the properly-sealed pinning boxes necessary to preserve them long-term, preserved insect specimens are a valuable and limited educational resource. Any handling of the specimens reduces the

lifespan of a preserved insect so great care must be taken to protect them from damage, especially when children are learning from them. When working with K-12 students, the only way to ensure specimen safety is to keep the insect specimens within the glass-covered boxes.Although students get to see and learn from real and tangible examples, they do not get a literal ‘hands-on’ experience from the pinned insects.

***Figure 2.*** *Research center staff (Nadeer Youssef, left, and Alfred Johnson, right) display specimen cases and 3D printed models during an elementary student program. Photo by author, 2024*

3D printed models have three benefits for scientific outreach. First, they are more durable than museum specimens. Thus, the printed models are much more suitable for passing around a classroom, allowing young children to handle them. It also allows students to view the insect from all sides and see anatomical features that are not visible in pinned insect specimens. The printed insect model can also be resized to any dimension that fits within the bed of the particular 3D printer, allowing the creation of sturdier models but also enlarging small features to be easily visible. While 3D printed models can also be damaged, particularly models of insects with thin, easily broken limbs and antennae, they can be cheaply and easily reprinted, whereas rare insect specimens may be irreplacable.

**Types of 3D Printers**

Presently, there are two main types of 3D printers available at low cost to the general public – fused deposit modeling (FDM) printers, which use a heated nozzle to build up layers of melted plastic and form an object, and stereolithography (STL) resin printers, which use a pool of resin that cures under ultraviolet light and an LCD screen that projects ultraviolet images to build layers of cured resin during object formation.

The FDM printer type uses plastics that are typically less expensive and/or stronger than the UV resin used by STL printers, but FDM printers have lower resolution and are less effective at printing small or more finely detailed models (Figure 4). This issue can be resolved if the printer is run very slowly with a fine nozzle tip, but this results in prints that take multiple days to complete.

On the other hand, the STL printers have the ability to capture small details and can complete complex, irregular models in a matter of hours (**Fig. 3**). However, many UV resins can become brittle and degrade over time when exposed to sunlight. The uncured resin can also be hazardous, causing dermatitis with skin contact and lung damage if the vapors are inhaled for extended periods.

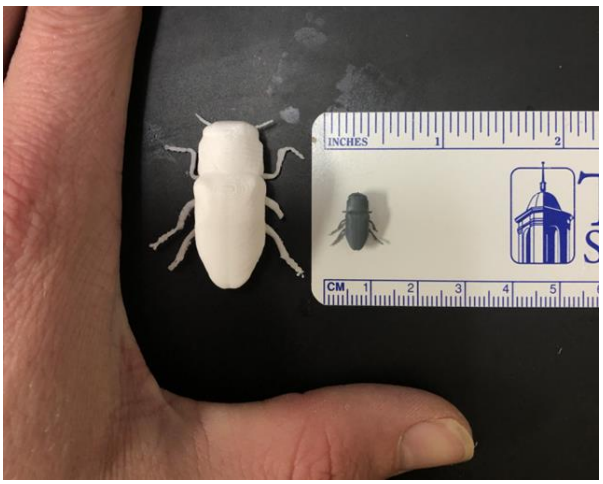


***Figure 3.*** *Minimum scale test prints from FDM (left) and STL (right) printers - note the partial right middle leg on each due to printing error. Photo by author, 2024.*

**Printing Process**

After the purchase and setup of the printer, the next step in creating a 3D printed object is to find or create a digital model file. There are many online resources (**Table 1**) with large collections of premade 3D model files by artists and institutions, many of which are under a creative commons license that allows them to be used for free.

**Table 1. Online resources for 3D printing model files**

| Name | Digital Model costs | Link |
|---|---|---|
| Thingiverse | Free | https://www.thingiverse.com/ |
| Sketchfab | Free and paid available | https://sketchfab.com/ |
| Smithsonian 3D | Free | https://3d.si.edu/ |
| Printables | Free and paid available | https://www.printables.com/ |
| Creality cloud | Free and paid available | https://www.crealitycloud.com/ |
| Cults 3D | Free and paid available | https://cults3d.com/ |

If you need custom models, such as models of insect species not available online, you may need to invest in a 3D scanner and a digital sculpting software tool such as Blender (https://www.blender.org/features/sculpting). It can take years of training to become a skilled digital sculptor, but even if you only plan on making prints from pre-made open-source models, familiarizing yourself with the basics of 3D digital sculpting and downloading a free sculpting tool like Blender can be useful for re-orienting, re-sizing, and repairing model files. After downloading or creating a model file, a slicing program will be required to automatically support

any hanging parts on the model and slice the file into layers to create the final print file. A slicing program should also be able to perform simple tasks such as re-orienting, re-sizing, and repairing model files. Many 3D printers come with propriety slicing software.

All 3D printers require some maintenance and leveling before printing which takes about 5 to 10 minutes, but minimal supervision is required during printing. Actual print time depends on the size and complexity of the model being printed. A basic insect model the size of your palm can take 6 to 10 hours while large or intricate models may take as much as 24 to 36 hours.

Once the printing process is complete, the object will require additional work to be considered a finished product. Support structures must be cut from the base of the model and at this point will be a single color and likely have some visible irregularities created by the printing process such as layer lines and stringing. The surface irregularities can be reduced by sanding with a fine grit sandpaper. Once sanded, the plastic surface will readily accept acrylic paint for detailing. For models that will be handled frequently, a coat of clear sealant such as decoupage or resin is recommended to protect the paint from flaking (**Fig 4**).

***Figure 4.*** *Creation process for the beetle larva of a roundheaded borer 3D print. Left to right - initial scan image and data (Revoscan 5 software), finished digital file after cleanup and detail sculpting (Blender software), unpainted print of the model, and the final print after sanding, painting, and sealing. Note that the sealing process gives a shiny appearance to the model. All images by author, 2024.*

**Costs of 3D Printing**

There are many high end and expensive options available for 3D printers today, including high speed, multi-color, and composite metal filament compatible models that cost thousands of dollars. However, if your goal is simply to convert a digital 3D model into a single-color object less than one foot on a side within one to two days, there are many commercially available FDM and STL printers that cost less than $300 and will do everything you need. Printers also require a few tools for adjustment and maintenance, but these vary by model and printer type and are typically included with the printer. The STL printer type also requires a solvent (isopropyl alcohol or similar) to clean excess resin from printed models, a rinse station that washes the prints in this solvent, and an ultraviolet light to guarantee complete resin curing. The primary recurring costs for operating a 3D printer include replacement parts and filament/resin. Some components on FDM and STL printers have limited lifespans and can deteriorate in less than a year with heavy printer use, and resin and filament consumption depend entirely on the size and number of models being printed. Most replacement parts cost $1–$5, with the most expensive around $50. One kg (2.2 lb) of filament or resin, which can produce dozens of models, typically costs around $30.

Software is required to prepare models for 3D printing. There are paid slicing software options as well as free open-source versions. Paid software offers more options, automation of many basic functions, and results in cleaner prints. Software licenses for slicing programs are included with many printers. If you plan to design your own model files, 3D sculpting software will be necessary and free open source and professional paid versions are also available (Table 2).

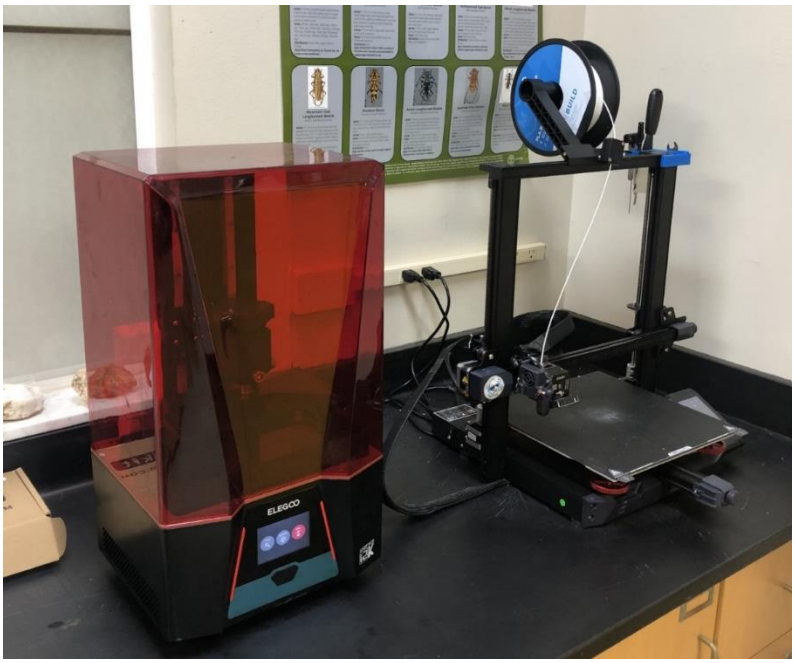


***Figure 5.*** *TSU Otis Floyd Nursery Research Center's Elegoo Saturn STL printer (left) and Ender 3 S1 FDM printer (right). Photo by author, 2024.*

**Table 2. Estimated costs associated with 3D printing**

| Method | Required Equipment | Estimated Cost (USD, as of 2025) |
|---|---|---|
| FDM Printer | Printer | $160-$900+ |
| | Filament | $7-$27/lb |
| | Tools (nipper, wrench set, etc.) | $15-$50 (free with some printers) |
| | Replacement parts | $5-$30/year |
| | Slicing software | $0-$150/year (free with some printers) |
| | 3D sculpting software | $0-$1,000+/year* |
| STL Printer | Printer | $200-$600+ |
| | Resin | $10-$22/lb |
| | Tools (nipper, wrench, etc.) | $15-$50 (free with some printers) |
| | Replacement parts | $30-$60/year |
| | Slicing software | $0-$150/year (free with some printers) |
| | Wash station | $50-$170 |
| | Wash solvent | $10/lb |
| | UV light/curing station | $30 |
| | Protective equipment | $40-$80/year |
| | 3D sculpting software | $0-$1,000+/year* |

*3D modeling software can be used to create or edit model files for FDM and STL printers, only one is required for both printers.

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For additional information, contact your local nursery specialist at:

**Tennessee State University, Otis L. Floyd Nursery Research Center**

472 Cadillac Lane McMinnville, TN 37110
https://www.tnstate.edu/agriculture/nrc/
931-259-4824

## Precautionary Statement

Users should follow manufacturer's directions for safely using 3D printers. Filament printer hot ends operate in excess of 200° C and can cause burns or fires if used improperly, monitor while in use and consult manufacturer's instructions before use. Resin printers produce toxic volatiles and should be used in ventilated locations according to manufacturer specifications.

## Disclaimer

Use of trade, brand, or active ingredient names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others that may be of similar and suitable composition, nor does it guarantee or warrant the standard of the product. The author(s) and Tennessee State University assume no liability resulting from the use of these recommendations. The manufacturer's directions for use should be followed for safe use of 3D printers.

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