3-D Printed Molecules for Chemistry Education

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Background

Visual learning tools have proven to be extremely beneficial in an education environment by assisting in the development of a student's comprehension skills. Three dimensional objects can offer a different exposure method compared to a typical 2-D illustration[2].

In general chemistry classrooms, VSPER theory has proven time and again to a challenging topic for many students. The orientation of bond angles and over-all alignment of the molecule is essential for understanding this topic. Students often struggle with conceptualizing this material due to its complexity. By producing simple yet accurate models, students will be able to examine the molecule in its entirety rather than being limited to a dimensionless model[1].

3-D printing offers an efficient and effective approach to generate these objects[3].

Objectives

- Generate a simple 3-D model molecule (i.e: Methane) on a mount that permits the molecule to be interchangeable.
- Write a SOP for future students.
- Generate a model that extends beyond a molecule (i.e: exterior of a virus cell membrane)
- Identify a software program that allows for building unique designs with the capability to print via Cura.

Materials and Software

- LulzBot Taz 3-D printer: single and dual extrusion for more complex builds.
- Polylactic acid (PLA) and Polyvinyl alcohol (PVA), were the two filaments used as building materials. PVA was used only for the support as needed. Due to the filament being soluble in water, it was removed from PLA with relative ease. Both materials were extruded at 185°C.
- Free CAD software offers a vast number of tools for building unique models that can be upload into Cura. Cura is the connector program for the LulzBot and the desktop computer.

Results:

Free CAD was used to draw a sample flag-pole design base structure. The program offered a variety of tools with extensive design opportunity. A molecule from the Avogadro program was able to be imported. Challenges arose when merging the base and molecule that resulted to outsourcing to Tinker CAD. The first test prototype model was uploaded to Cura. Cura confirmed both objects were flush with another and could proceed to printing. A physical model was unable to be product due to numerous issues arising with the LulzBot Taz. A standard operating procedure is complete and available in PDF format.

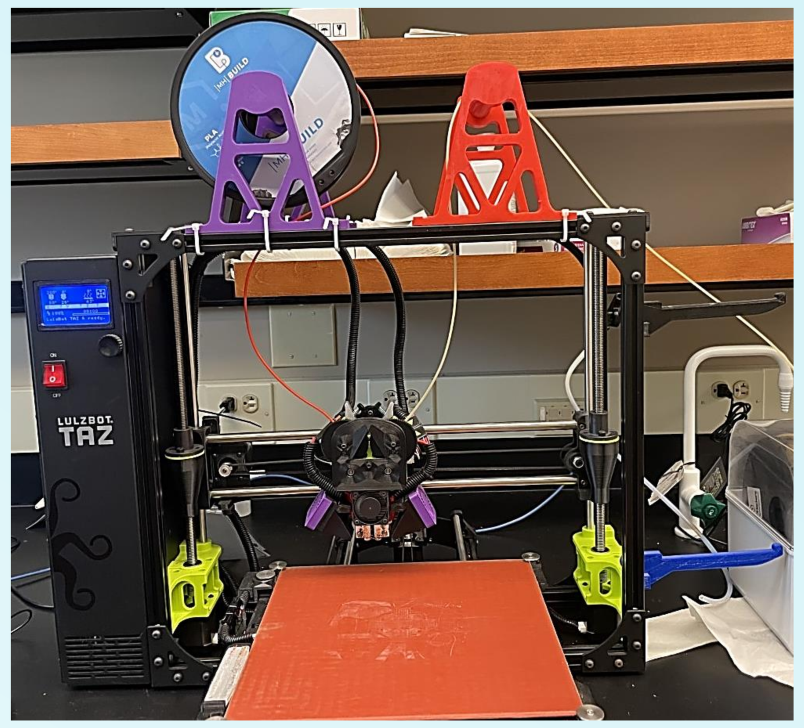

Fig. 1: LulzBot Taz printer

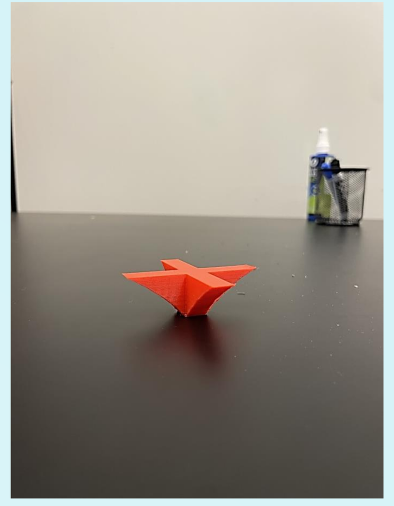

Fig. 7: Overhang test print

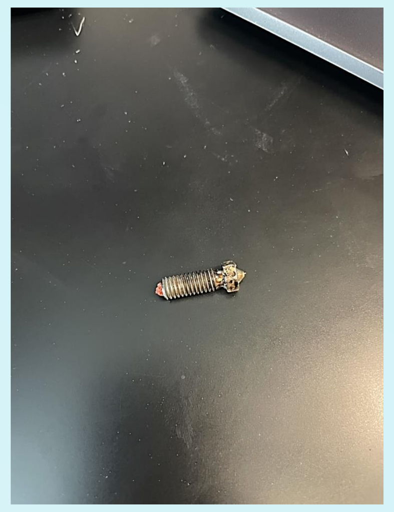

Fig. 8: Clogged hot end nozzle.

Progression

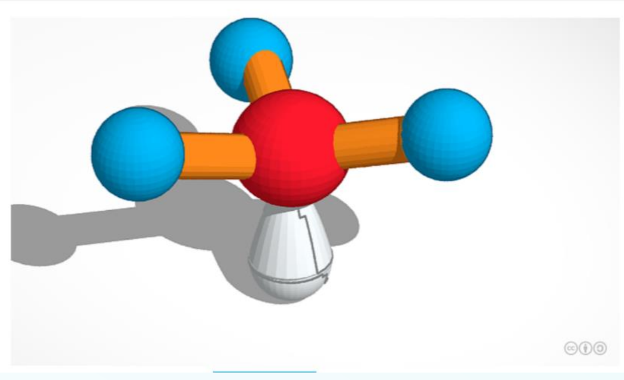

Fig. 2: Sample Model in Tinker CAD:
First program used to generate a sample model. The interface was easy-to-use yet lacked capabilities of complex design.

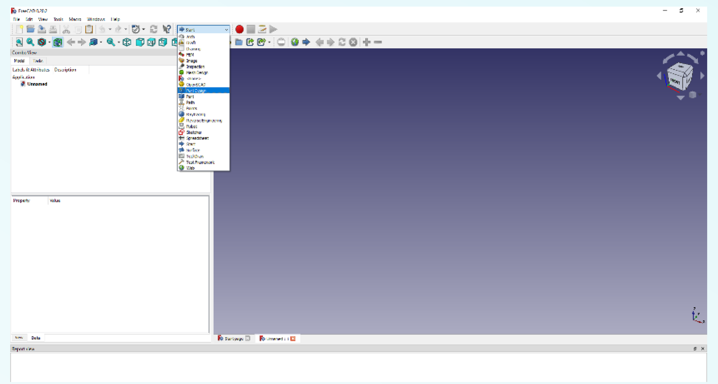

Fig. 3: Free CAD interface:
Selected due to the vast number of tools and workbenches available.

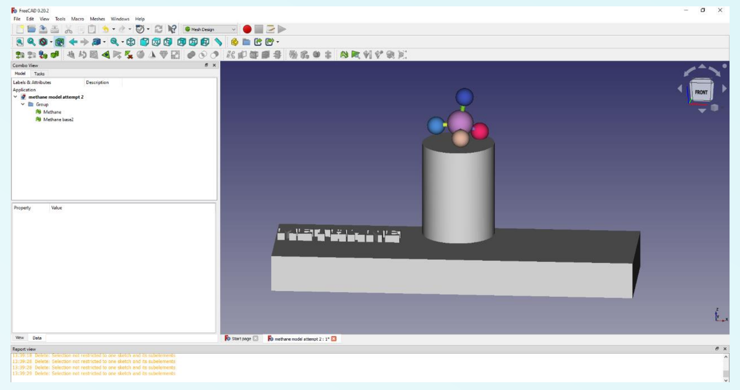

Fig. 4: Sample molecule uploaded into Free CAD: The two models failed to merge as one. The ability to edit the molecule was lost upon importing.

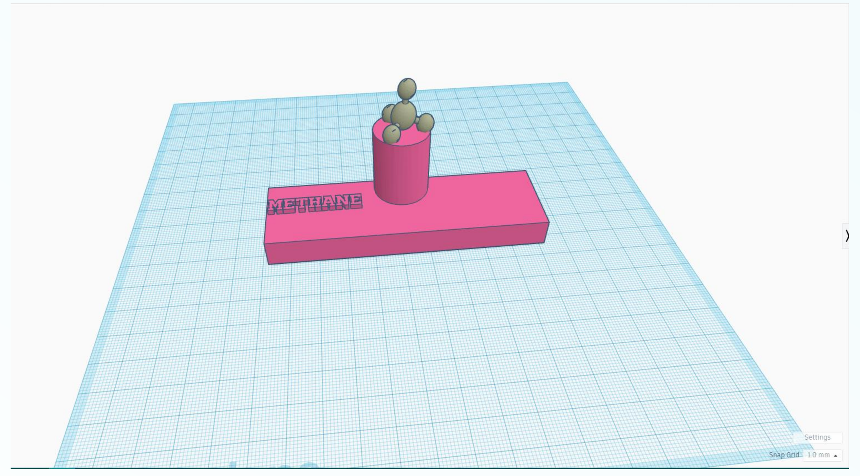

Fig. 5: Tinker CAD interface:
Tinker CAD allowed for simple adjustments that were needed for the model. The base and molecule were able to be fused as one utilizing these tools.

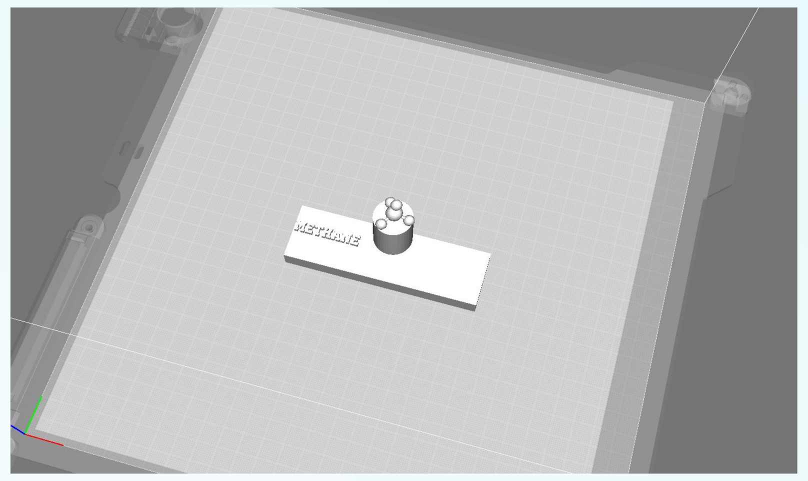

Fig. 6: Methane Model imported to Cura:
The molecule is flush with the base and is ready for printing.

Discussion

The test model has not yet been printed due to a malfunction that occurred during the check-point tests for the LulzBot printer. This obstacle compiled with a clogged nozzle that extended to the hot end and a blown fuse have also delayed printing. New nozzles and hot end have been obtained. Utilizing an Ultimaker printer is currently a short-term solution for printing the model while the LulzBot is being repaired. However, ultimately the goal is to printing using the dual-extrusion method from the LulzBot.

Free CAD software has proven to be a very complex program in which its tools will need to be further investigated. A better understanding of Free CAD can minimize the number software programs required to import a model into Cura. This is a crucial step in creating a user-friendly method of 3-D printing for all areas of education

References

[1] Gilbert, J.K., Boulter, C.J., Rutherford, M. Explanations with Models in Science Education. Developing Models in Science Education. Springer, Dordrecht. **2002.** DOI: 10.1007/978-94-010-0876-1_10.

[2] Dhanapal, S.; Wan, E. A Study on the Effectiveness of Hands-on Experiments in Learning Science among Year 4 Students. *International Online Journal of Primary Education* **2014**, 3, 1, 29-40.

[3] Waseem, K.; Kazmi, H. A.; Qureshi, O. H. Innovation in Education--Inclusion of 3D-Printing Technology in Modern Education System of Pakistan: Case from Pakistani Educational Institutes. *Journal of Education and Practice*, **2017**, 8, 22-28.