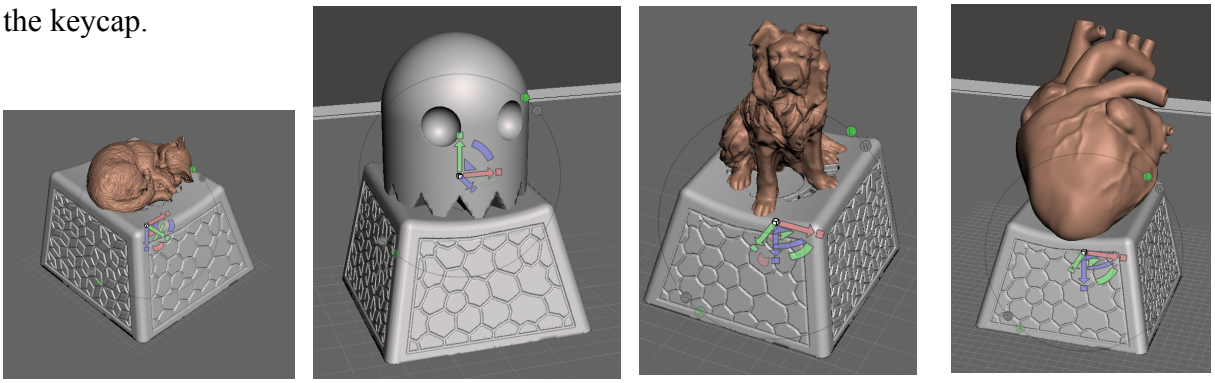
Group 8 Design Project Final Product

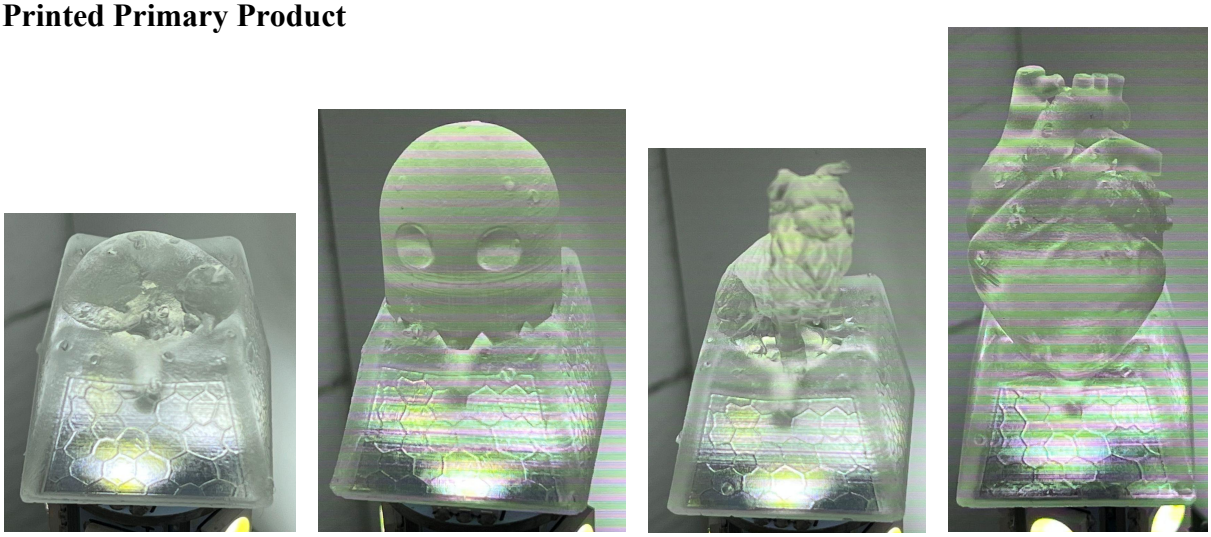
Final Product Choice

For the final product we improved on our implementation of custom keycaps where the quality and complexity of this design has changed from its first couple implementations. This involved updating the scale and orientation of the print within the PreForm slicing software in order to scale the quantity of these prints over the course of several iterations. A main focus of improvement regarded the UV post curing process to ensure the keycap would maintain a solid connection to the keyboard. A subsequent focus was to increase the complexity of these keycap designs to further exploit the additive manufacturing approach to products. The texturing and customizability of these keycaps have appeal within the gaming community and potentially wider appeal to the enthusiast keyboard community with the addition of figurines appended to the keycap.



Figures 1 - 4 (left to right): CAD models of figurines appended to existing textured keycap.

Printed Primary Product



Figures 5 - 8 (left to right): Detailed images of successful keycap prints.

During this final design phase, methods to improve quality and quantity of these printed keycaps were investigated. The first challenge was to remove the build up of residual resin that formed on the print and for this different printing orientations were investigated. In subsequent prints the UV post curing process was analyzed with different printing scales and UV post curing durations and temperatures. Lastly the complexity and quantity of these prints were scaled up to understand how the production process would compare to the conventional manufacturing process.

Once the foundation of a refined and satisfactory keycap was created, the final set of prints focused on the customizability of the keycap. The final set of prints as seen in the figures above appends 3D models downloaded from Thingiverse (Ghost, Heart, Cat, Dog) to the base keycap using a software tool called Meshmixer. This outlines the concept that a user can upload any 3D model, such as a point cloud of their pet (such as the case in the Sleeping Cat model), and have it printed out in a keycap for them to use. During this process numerous challenges were encountered regarding control of the quality and dimensions of the key cap. These issues were honed out over the course of several iterations and a few compromises were made to ensure the keycap reliably fits on the keyboard.

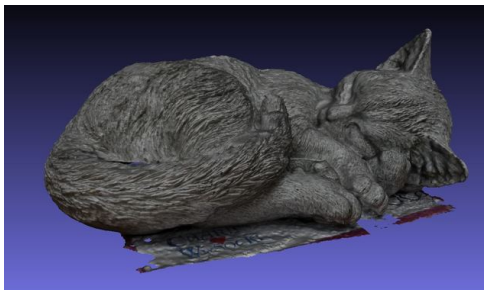


Figure 9: 3D model of a sleeping cat created with photogrammetry by Lightfizz on Thinigverse

Analysis Summary, Retrospective

Cost and Market Fit

The product of a customizable keycap has the qualities of a successful product with its high level of detailing and design flexibility. These features open the possibility to command a high selling price (somewhere within $4 - $25) and secure an adequate profit margin with relatively low production cost per keycap, estimated below:

$$Production\ Cost = \frac{\$149.00}{1\ Liter\ of\ Resin} \times \frac{0.1\ Liters\ of\ Resin}{1\ Print} \times \frac{1\ Print}{30\ Keycaps} \approx \$0.50\ per\ Keycap$$

Along with the competitive production cost, the ability for users to upload their own stl files that can be appended to the keycap allows for a level of personalization that would increase its value to the customer.

Challenge #1: UV Post Curing

The greatest challenge in this product was to retain the model's dimensions specifications during post processing steps such as UV curing as the dimensions of the connector to the keyboard switch is critical to a functional keycap. In addition, the bending experienced during the post curing process was avoided by keeping the supports on, contradicting the instructions provided by TechSpark. With the as printed dimensions without any UV post curing, the keycap fits on the keyboard switch however enough shrinkage occurs during the post curing process that the keycap connector deforms to a point where it does not fit on the keyboard anymore. Our initial presumption was that uniform shrinkage occurred and the simplest solution would be to uniformly scale up the printed model in the PreForm slicing software.

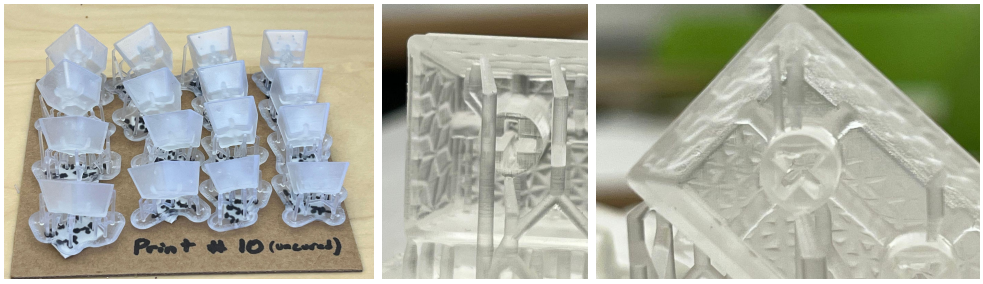
This theory was tested with an initial set of shift keycaps of varying scales 1.000, 1.010, 1.020, and 1.025 (Print #12). With the uncured set of shift keycaps, the 1.010 and 1.020 keycaps fit well into the keyboard. Once the keycaps were cured only the 1.020 scale shift keycap seems to fit into the keyboard. This is most likely due to the fact that the UV post curing process makes the keycap less ductile and more brittle. We also noticed that the connectors for the cured keycaps would shatter if not a perfect fit whereas the connectors for the uncured keycaps would be pliable enough to bend.

Figure 10: Shift Keycaps at varying scales (top row is cured, bottom row is uncured).

With this knowledge, we scaled up the production process to create a batch of over 30 turkey keycaps with a scale of 1.020 and applied a UV post curing treatment. This shrank the keycaps to the desired dimensions however we had difficulty fitting the keycap without its connector shattering. Thus in the following prints we investigated finer scale control of the print and came to a conclusion that the UV curing process was not uniformly shrinking the key cap connector, leading to an improper fit no matter how it was scaled. Therefore, we made a compromise to skip the UV post curing process as the tradeoffs of greater hardness were not significant enough to warrant further investigation.

Challenge #2: Resin Build-Up

Another challenge was to compensate for the resin build up towards the top of the keycap that was primary due to the perpendicular build direction. For this a set of prints were angled at 15 degree increments along the X and Y axis in order to determine which set of angles would be the best to print at. In our initial findings changing the X and Y rotation of the part just slightly is significant enough to remove the residual resin collected on the top of the part. However, changing the Y axis rotation resulted in the "+" portion of the connector curing incorrectly such that it formed more of a "x̄" instead of a "x" at a 45 degree Y rotation angle, as seen in figure 12. This issue along with the small footprint pushed us towards using a 15 degree X rotation for our future prints.



(left to right) Figure 11: Array of prints angled at 15 degrees, Figure 12: Connector close up at Y rotation of 0 degrees, Figure 13: Connector close up at Y rotation of 45 degrees.

Process Mistakes

For this project a majority of the mistakes were made during the fabrication process rather than the design process. The CAD design process was relatively seamless as the designs

matched that of our specifications. However a majority of the issues arose during the process of turning the designs into real world products, mainly through the use of the Form2 SLA printer. One large mistake was the assumption that the fabrication process would be relatively straightforward as all that was required to print was the sliced stl file provided to the printer. With the aforementioned challenges that we encountered, it is now apparent that the process to transition from design to physical product requires significant iterations in order to fabricate a proper product. This underestimation of the challenges and knowledge required to create a detailed and quality product with additive manufacturing lead to the majority of the time allocated to this portion of the project.

Effective Procedures and Future Advice

The team did a fantastic job delegating tasks amongst ourselves such that the iterations between designs were fast and efficient. Many iterations went into measuring the mating dimensions of the keyboard and changing the process parameters of the part in order to achieve a strong initial product that would serve other iterations with different designs. Because of this, the group set itself up for having a smooth sailing future when printing products that have new designs. The group also benefited a lot from continuously working on the project and constantly making improvements as opposed to waiting until a new part of the project was assigned. This gave our group the benefit of not having to work up until the deadline or feel rushed and continuously putting out updates to our project. This is the advice we would give other groups in the future, to continuously make small improvements to the design and process.