

MEMO

TO: *Name(s) removed for privacy*

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SUBJECT: Module 3: Iterative Design Final Memo

Introduction

Not all picture frames are created equally. Though the presented picture frames in Module 3 varied in shape and size, all had the same requirements. Explicitly mentioned were the dimensions of the frame and the software needed to complete it. The frame had to be designed using only original files made in SolidWorks Software. The files then had to be converted into MakerBot files so the design could be printed in polylactic acid filament in under 9.5 hours. In addition, the frame had to fit on the 10.5 in. x 6.5 in. print bed, be able to lay flat so that the print wasn't interrupted by the parts falling over or rolling away, and could not exceed a thickness of 0.75 in. In addition, the frame was required to stand between a 60°-80° angle, with the stand part printed separately so that it could be attached and detached. On the frame, the group and section numbers also had to be extruded to indicate which group it belonged to. The frame needed to hold a 3" x 5" picture and be under 75 g. Of course, the picture needed to be visible, so the frame could not cover more than 1/8 in. on any side. And, in order to be a functional frame, it had to be able to hang on a nail in the wall. Moreover, the frame had to have a theme that called to mind the University of Notre Dame.

One needed to implicitly infer that the picture frame had to be able to hold a picture. Thus, there had to be some overhang that allowed photo to stay in place in the picture opening. The parts of the frame that bridge cannot be excessively tall or else the support for the bridge becomes clustered and hard to take off. Similarly, if the slits for the picture in the frame were too

thin, the printer would fill these in with support, blocking off the slits. A raft had to be used on the print bed in order to stop the print from curling. Also to avoid curling, the temperature had to be adjusted to 205°F. Once these requirements, implicit and explicit were fulfilled, the frames were made.

The first frame was centered upon a unique shape and its Irish design. This frame is thick in order to compensate for two complex nail holes for hanging vertically and horizontally. However, in order to account for mass which was 117.8 g. some major extruded cuts are taken out from the back, as seen in Figure 1.

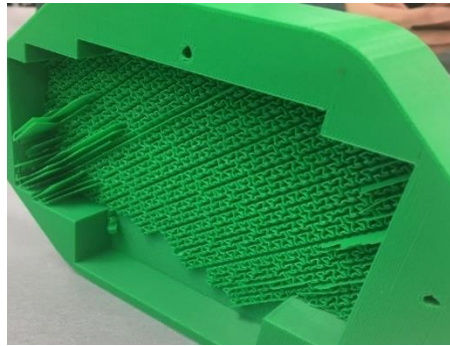


Figure 1. Frame with Backing Cut Out

The frame is shaped like an octagon with fileted corners, and on each edge was placed a four-leaf clover, which can be seen in Figure 2.

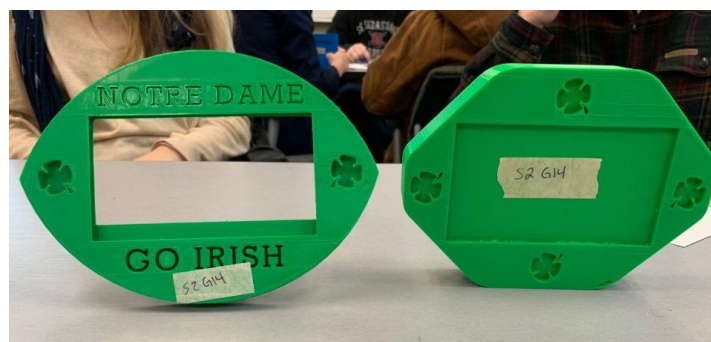


Figure 2. First Frame (Right) and Final Frame (Left)

There is no slit on the frame for the photo to be inserted, but there are overhangs to keep it in place. In these overhangs, the 3D printer built in support material that could not be removed. Overall, this frame has an interesting shape and design element that captures attention but has some major design flaws like being too massive, having too much excess material, and lacking functionality.

The second design (seen in Figure 2) improves upon the initial design greatly. Primarily, the thickness was reduced below the required 0.75 inches, cutting the mass in half, down to 57.28 g. Next, the back of the picture opening was cut out, but overhangs keep the picture in place. These overhangs align with the picture slots on both sides of the frame which were made with enough space for the overhang support material to be excavated, visible in Figure 3.

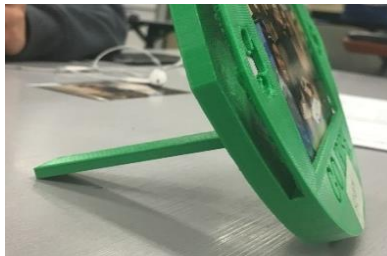


Figure 3. Frame Slot

The design team changed the shape to a Notre Dame football and added the words “Notre Dame” and “Go Irish” along the edges of the frame. The number of four-leaf clovers are reduced to two, each on either side of the picture opening. A flat bar topped with two pegs is the stand, which can fit into the back of the frame, visible in Figure 3. This allows the frame to stand up at a 70° angle, an additional feature to the nail hole still available in the back for hanging the frame on a wall. This frame achieves a good balance of everything: mass, dimensions, and design; and it couldn’t look better on the mantle of a Notre Dame engineer.

Analysis and Implementation: Testing, Feedback, and Changes

After Demonstration Day 1, Group 14 received feedback on their first iteration design from the Notre Dame bookstore and students in other EG10111 sections. The main components evaluated were the frame's ability to hang on the wall, the execution of the Notre Dame theme within the design, the ability to insert the picture into the frame, and the frame's overall potential of being bought by a customer. These components were judged on a numerical basis with short commentary about changes that should be made and parts that should be kept. In Table 1 below, the numerical feedback given by peers for the first design is organized:

Table 1. Summary of Peer Feedback Numerical Questions

Statement	Group Average (1-5)	Group Standard Deviation	Section Average (1-5)
The frame is easy to hang on the wall.	3.4	0.89	3.5
The frame is easy to stand up.	N/A	N/A	3.8
The frame's theme is clearly based on ND.	3.6	0.87	4.0
The picture can easily be inserted into the frame.	2.0	0.89	3.4
I would purchase this frame.	2.0	0.91	3.1

Once the feedback was examined, it was clear that many changes needed to be made for almost every component of the frame due to the relatively low scores received. The ratings given for the frame's theme were the least varied, while the preference to buy the frame was the most varied. However, many of the criticisms about the frame given in the commentary portion were consistent, with the frame's thickness and lack of ND theme being the most prominent criticism.

In addition to the peer feedback, the bookstore representatives also mentioned that the cost of the frame should be lowered and that the design should be reworked to incorporate the Notre Dame theme more. Both the peer and bookstore feedback were prioritized when redesign ideas were being made for the second iteration. The goals of the new changes centered on

reducing the frame's thickness, mass, and print time to meet the specified requirements, which inherently decreased the cost of production. Other redesign goals were to make the frame based more on the Notre Dame theme as well as figuring out a better design configuration to insert to the picture into the frame. Specific changes to the frame are detailed in Table 2 below with the outcomes produced by these changes:

Table 2. Summary of Design Change Outcomes

Design Change	Outcome
To reduce the frame's mass, the back surface behind the picture area was removed completely. Extruded cuts were made into the back edges of the frame to make it hollower.	The frame's mass was reduced from 117.80 g. to 57.28 g. which was below the 73.0 g. specified.
The shape of the picture frame was redesigned to look like a football, and "Notre Dame" and "Go Irish" were included in addition to the shamrocks on the original frame.	The theme of the frame became clearly based on Notre Dame, and the design was voted Section 02's overall best frame.
Slits were added to both sides of the frame and the width of the slit edges were made thicker.	The picture was able to be easily inserted into the frame from both sides and was also able to stay in place.
Almost 60% of the backside of the frame was cut because the frame was too thick and took too long to print.	The thickness of the frame was reduced from 1.2 in. to 0.5 in. which was below the 0.75 in. maximum thickness requirement. The print time was also reduced from 650 mins. to 520 mins, which was below the 570 mins. requirement specified for Demo Day 2.

Once these changes were made, the second iteration frame was ready for Demonstration Day 2. The new frame passed all the evaluations that tested fit, function, and form and the new design was also able to stand independently at a 70° angle, which was not attempted in the first iteration. To add, Group 14's design was voted as Section 02's overall best frame by another EG10111 section occurring during the same class period.

Final Comparisons and Recommendations

The mean mass of a frame for the class is 55.01 g and the standard deviation for the class data is 10.45 g. The mass of the new frame for Group 14 is 57.28 g. Is it a little greater than the mean for the class, yet it is still within one standard deviation from the mean. The histogram providing the distribution of masses for all of the picture frame masses in the course is presented in Figure 4 below.

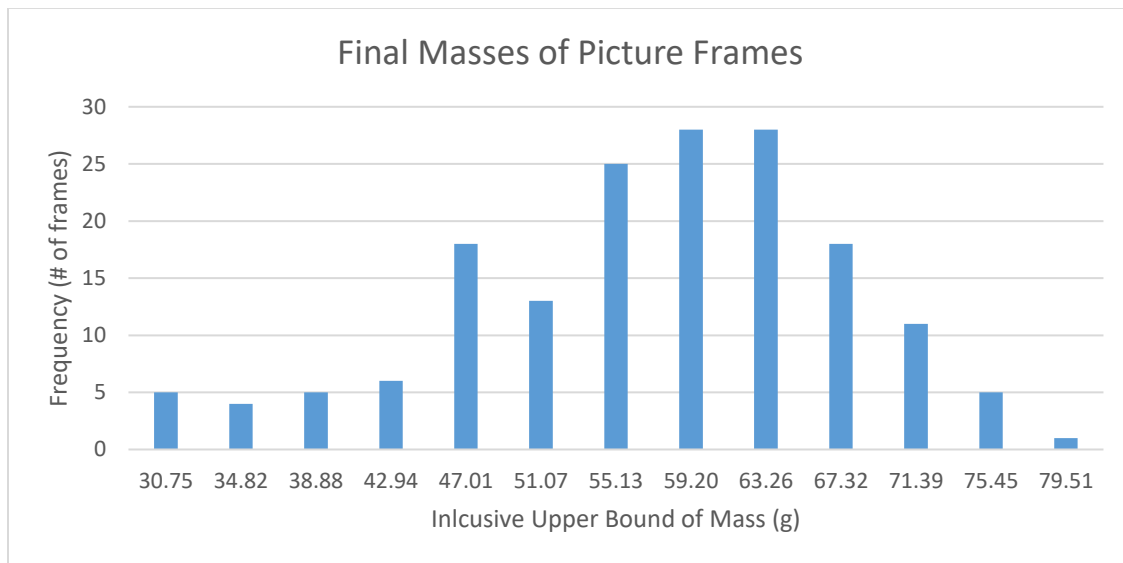


Figure 4. Histogram of Final Masses of Picture Frames

In future prototype development, the group would work on making the stand piece more stable. It is easy to connect the stand piece to the frame, however, when placing on a surface, it takes several seconds to stop bouncing from side to side.

Group 14 would also work further to decrease the mass of the frame to be more consistent with the mean mass of the class. The thickness of the frame can also still be decreased to make the frame more appealing, and both of these changes would reduce the material needed, print time, and overall cost of producing the frame.