Comparing the Structural Integrity of Papier-Mache with Different Composition

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Abstract

Papier-mache has been a commonly used crafting method to solidify a recycled project. Although it is very common to use said method, there is very little research on the best usage. My research exploring the scopes and limitation of papier-mache answers the question of what the best usage is. The different components I tested were toilet paper, cardboard, newspaper, and office paper on top of 4 different mask bases (armatures) that underwent 3 different tests to determine their best physical properties. The weight test was measuring all 4 masks in grams with toilet paper coming out to be the highest and office paper being the lowest. The next test I conducted was dropping each mask from 10 feet high and recording any loose material, dents, or damage. The final test I did was a water test where I then submerged each mask in a bowl of water for 30 seconds and recorded any loose material, bubbles, or softness. The way that I would quantify my results was through a personalized ranking system of 1-4. At the end of my experiment, my hypothesis stating that cardboard will have the greatest properties against physical damage was incorrect. I came to the conclusion based on their ranks, that newspaper and office paper have the best resistance and durability for a papier-mache project due to their physical properties being thin and light weight.

Keywords: papier-mache, physical properties, mask, rankings

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Introduction

In my experiment, I will be testing the different materials possible to make the most resistant papier-mache mask. The materials I will be using have been previously tested by other craftsmanship, but have not conducted an experiment to test their structural integrity. The reason for my experiment resides from my past experience with making masks and the simple fact that mask making is something that I like to do and is completely different to other experiments, due to it being resourceful at its core. “By reusing the materials that are used in the manufacture of products, recycling eliminates the need to acquire new raw materials, such as the fossil fuels that go into many plastics.” (Richman et. al., 2025) The importance of my experiment resides within the fact that something that is considered trash and making it into a work of art is not more normalized and used more often within households than it should be.

Materials

The way that I will make the armature is from aluminum and masking tape. The only thing that will change is the composition that will vary with each mask: newspaper, office paper, cardboard, and toilet paper.

Methods

My hypothesis is that if we compare toilet paper, cardboard, newspaper, and office paper then cardboard will have the strongest physical durability. My null hypothesis is the opposite, stating that the different composition of papier-mache will not change or affect the materials physical properties. The independent variable is the type of material used and the dependent variable was the resistance to various tests. The different materials used for comparison were: newspaper, office paper, cardboard, and toilet paper. The tests I used during my experiment were:

weighing them, a 10ft. drop test, and a 30 second water resistance test. The mask armature, type of glue, and type of water will all remain constant for all four masks. I then have controlled variables which are the armatures, mixture amounts, and the design of the mask. The main method I will be using in order to quantify my results will be a personalized rankin

Procedures

My procedures will be the same with all four masks. I will start with gathering all my materials listed above and making the paste. I will soak the newspaper, office paper, toilet paper, and cardboard in water overnight in order to break down the material. After that, I'll strain it and add school glue, water, and flour as needed. Once my mixtures are done, I will then make an aluminum foil base (armature) coated with masking tape to hold the shape of a mask. After that, I will then put over either of the mixtures to cover the whole armature. The process will then repeat with all four compositions and then set to dry. I will then measure all masks and conduct a drop test from 10 feet high and a water test by submerging them in water for 30 seconds. All these tests will help me finalize my findings of which composition allows the mask to have greater resistance against physical and liquid damage. In the end, I will take into account all my results and give them a rating which will quantify my results.

Figure 1: The picture above demonstrates the papier-mache bowls (toilet paper, cardboard, newspaper, and office paper.) Beneath the pictures are the mask armatures.

Results

My results are shown in the tables below. While conducting the drop test, all masks were ultimately successful in surviving a 10 foot drop. On the other hand, the water test was the one with the greatest physical impact. As they all underwent 30 seconds under water, the newspaper and the office paper had the greatest durability and stability after submerging. The toilet paper and egg cartons demonstrated effects of very weak resistance against the water and broke apart very easily.

Rating System
4- Mask showed signs of advanced durability against impact. Demonstrated no loose material or dents.
3- Mask showed signs of great durability against impact. Demonstrated minimal loose material or dents.
2- Mask showed signs of weak durability against impact. Demonstrated big amounts of loose material or dents.
1- Mask showed signs of extremely weak durability against impact. Had great amounts of loose material or dents.

Figure 2: This data table demonstrates the ranking system I used to grade the performance of the drop test on the masks.

Rating System
4- Mask showed signs of advanced resistance while being submerged. Demonstrated minimal bubbles, no softness, and armature held place.
3- Mask showed signs of great resistance while being submerged. Demonstrated minimal bubbles, slight softness, and slight softness in armature.
2- Mask showed signs of weak resistance while being submerged. Demonstrated bubbles, various bubbles, and slight soggyness in armature.
1- Mask showed signs of extremely weak resistance while being submerged. Demonstrated constant bubbles, softness, and soggy armature.

Figure 3: This data table demonstrates the ranking system I used to grade the performance of the water test on the masks.

	Weight (Grams)
Toilet Paper	124.7
Cardboard	96.4
Newspaper	113.4
Office Paper	90.7

Figure 4: This graph represents the type of masks and the weight that was measured in ounces and later converted into grams.

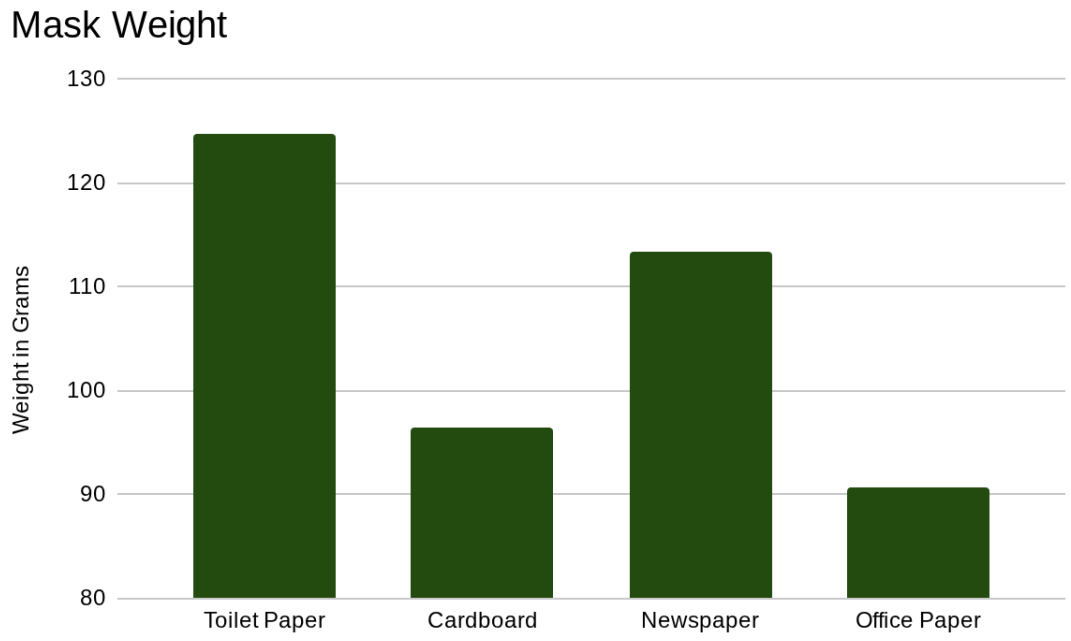

Figure 5: My graph demonstrates a more simplistic translation. The toilet paper had the greatest weight while the office paper had the least. The result of this is from the transformation of paper to mache: how the ripped up pieces of paper react to each other with glue and flour.

Damage Status	Drop Weight	Loose Material	Dents	Rating
Toilet Paper	Heavy	No	Yes	3
Cardboard	Heavy	Slight lifting	Yes	2
Newspaper	Heavy	No	No	4
Office Paper	Light	No	No	4]'\

Figure 6: The data table for my drop experiment shows a detailed explanation of the factors that come into determining the rating. As shown on my data table, the loose material and dents were both present in the toilet paper and cardboard masks, making their rating score lower than the lighter masks.

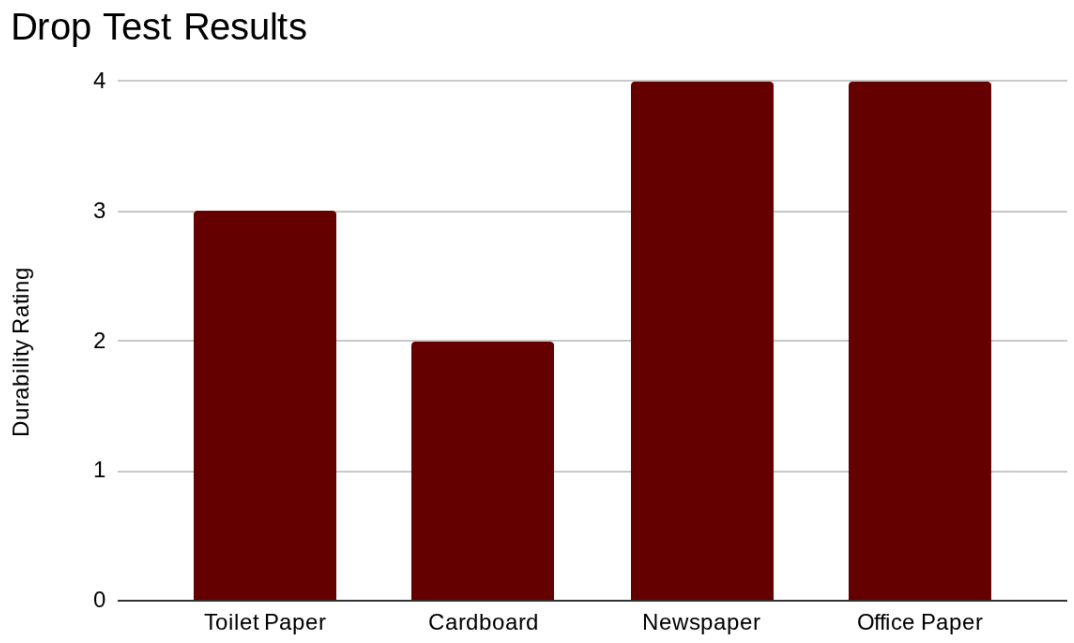

Figure 7: The first test I conducted was the drop test. All masks had positive outcomes, newspaper and office paper having the highest score due to them being lighter, therefore, not having such an impact when it hit the ground.

Water Damage	Loose Material	Bubbles	Softness	Rating
Toilet Paper	Yes	Unconstant	Extreme	1
Cardboard	Yes	Constant	Lifted	1
Newspaper	No	Minimal	Minimal	3
Office Paper	No	Minimal	Minimal	3

Figure 8: For my last test, my results were much more apparent. The toilet paper and cardboard reacted much more negatively than the newspaper and office paper.

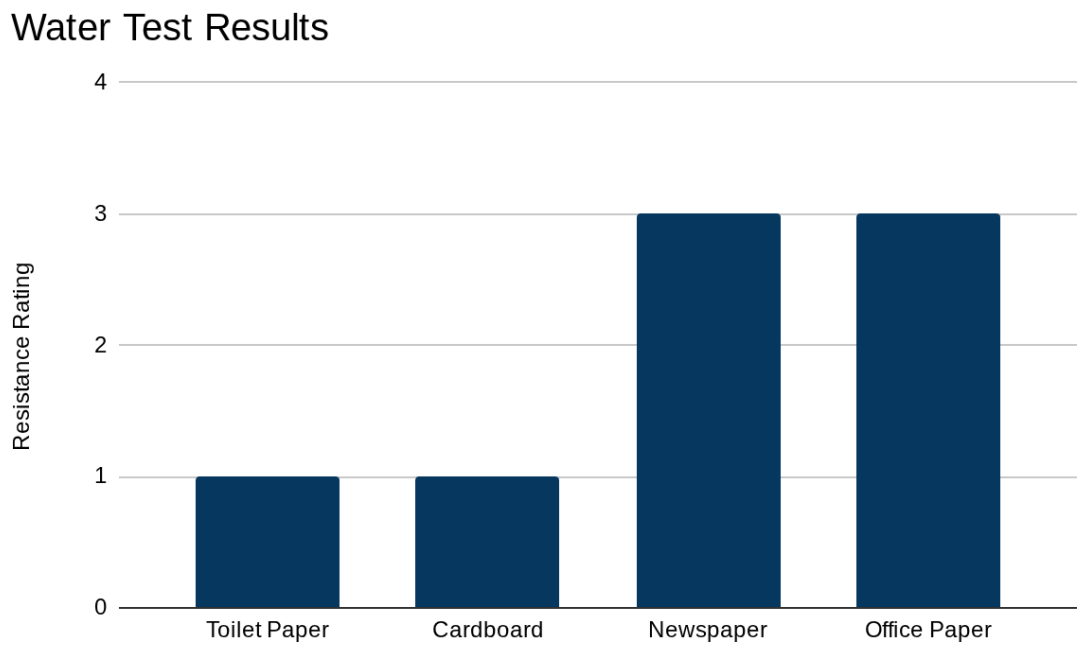

Figure 9: My water test results can be shown in this graph which visually demonstrates the difference between the masks. The toilet paper and cardboard is shown to have the same low rating while the newspaper and office paper are constantly rated higher due to their combined resistance against water.

Conclusion

The goal of this experiment was to test the highest durability of papier-mache masks under different tests, with the outcome of cardboard having the highest durability. The results of my experiment were not supported by my hypothesis. Based on the results, it is clear from my drop and water data tables that the newspaper and the office paper, having an equal and higher score of 4 and 3, have the greatest durability. The results did not support my hypothesis. The conclusion I drew from this was the fact that since they both are much more dense and bulky, the papier-mache pieces clung onto each other and not the armature when submerged under water. The newspaper and office paper had the best outcome from this experiment because they were a thinner and a less dense mixture which were able to cling onto the mask much better. To summarize, lighter materials for masks are more favored under harsher conditions than thicker

materials. The cardboard and toilet paper, being a much thicker and clumpy material than office paper and newspaper, performed the worst.

Discussion

This study has raised important questions about the implications of mask making. With this experiment, the answer of which material is best suited for the papier-mache project can be found. In order to fully encapsulate the results of my experiment, the science behind it must be understood as well. A study from Gale states, “Stronger bonds between atoms make them more difficult to separate and, in general, stronger chemical bonds result in greater hardness, higher melting and boiling points, and smaller coefficients of expansion.” (Lerner et al., 2005) This relates to my project by giving an understanding of how chemical bonds affect the physical properties of things. Closely related to how the type of paste I use for my independent variable in my project will affect the different types of materials used for the masks. The adhesive, being one of the most important aspects of papier-mache, surrounds us universally as well. The UXL Encyclopedia of Science states, “Any time one reattaches a handle that has broken off a cup, pastes a photograph into an album, or tapes a message to a friend’s door, the person is using an adhesive.” (Blackwell et al., 2015) Another question that my experiment has piqued was the use of other materials. What would happen if any other materials were used for the same purpose? “...papercrete is lightweight, a good insulator (up to R-2 per inch), holds its shape even when wet and is quite strong.” (Soldberg et al., 2000) Doing another experiment with the same question with different concrete and paper components can come out of this project. In relation to my results, an article from HackSpace provides support stating, “Colombian artist Daniela Batalla’s Kilele Head mascot, for the 2020 St Kitts Festival, uses a combination of paper pulp, newspaper,

glue, paint, and improvised props to brilliant effect…" (Pi, 2022) The usage of newspapers for papier-mache projects is universal.

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