HIGH SCHOOL EDITION
Journal of Student Research
Volume 11 Issue 1 (2022)

The True Effectiveness of Dry-erase Erasers

Nathan Hong[1] and Danilo Tadeo[1#]

[1]Yongsan International School of Seoul
[#]Advisor

ABSTRACT

Sparked by the interesting observation of the correlation between the omnipresence of dry-erase erasers and their low usage, research to test the actual effectiveness of dry-erase erasers was conducted. Alternatives of relatively similar effectiveness and use were selected to be tested against the dry-erase eraser, with 'effectiveness' determined by the percentage erased of an equal, constant drawing. The almost completely automated experiment design was made with the intentions of minimizing human influence and error. Using the collected data, the four "other candidates" (candidates excluding the dry-erase eraser) were group in pairs to perform multiple two-sided t-tests to determine whether the means of % erased were statistically different. Because they were not, the comparison with the dry-erase eraser was held with a collective alternative variable, which was just the averaging of the values of the other candidates. This one-sided t-test yielded convincing evidence of a more significant mean percentage erased for the dry-erase eraser, upholding its stance as a valuable item.

Introduction

While dry-erase boards are commonly used in schools and classrooms, their eraser counterparts are not. Even with their single-functionality and ubiquitous presence, people rarely go out of their way to pick up and use one. Instead, nearby tissue or human palm usually comes into play more often than not and serves its purpose reasonably well, despite the unavoidable stain.

These dry-erase erasers are usually layers of felt capped with a styrofoam cover. Nothing too fancy, considering its $1.75 price tag. However, from personal experience, most alternatives mentioned earlier rival the effectiveness of the dry-erase eraser--keeping in mind that its only function is to erase whiteboards. Nevertheless, when additional options such as socks, gloves, towels, remover pads, and magic erasers come to light, the "market" for erasing whiteboards seems too deep with too much competition for the traditional dry-erase erasers.

So what exactly is the point of these designated, specific, single-use, and specially-designed objects? Are they easier to use? This research aims to find the reason for the continuous production of these items, whether they hold any significant, advantageous value to the average consumer, and a potential alternative should one exist.

Objectives

This study aims to determine the actual effectiveness of the dry-erase erasers compared with the other alternative erasers commonly used. Specifically, to descriptively quantify the percentage erased ability of the different erasers and statistically compare the significant difference between these percentages.

Methodology

Data Collection

The eraser candidates tested in this experiment were (a) dry-erase erasers, (b) tissues, (c) magic erasers, (d) towels, and (e) socks displayed in Figure 1. Next, a 4 cm by 4 cm square was lightly carved out on a decently sized whiteboard for the colored drawing. Erasers were made to be larger than the square drawing to eliminate the potential disadvantages of an eraser's varying shapes and sizes.

A uniform 4x4 square was colored in by hand, pictured at a constant height, angle, and lighting, and processed through a color proportions identifier software[1] to make sure it said approximately 100% black (as the marker used was black). It was purposely done to ensure that each eraser was erasing the same amount of "drawing" on the whiteboard. Upon checking this condition, the eraser was lined up just outside the square drawing on the whiteboard and received a total of 1.4 grams in weights on top to recreate similar pressure applied by a human hand when erasing. The mass of 1.4 grams was determined by measuring the weight of a hand erasing a drawing on a scale. The various weights that showed up on the scale were recorded and averaged to attain an approximate force representative of a human erasing.

Figure 1. Display of eraser candidates only to judge based on their erasing capabilities as textures

A cup with an approximately uniform shape holds the weights equally to distribute the downward force applied to the object. Furthermore, to minimize any additional low force that could alter the effectiveness of the eraser and variability in its horizontal course over the square, a programmed Lego Mindstorms EV3 with constant speed and direction to push on the item parallel to the board recreate the action of erasing without human intervention. A small arm-like component was attached to the front of the EV3 to ensure that it did not run over the drawing during the push. This small arm-like component is longer than the length of the square, which enabled it to push the eraser without physically intruding within the drawing space. The code was also programmed for the EV3 to move back to its original position before going too far.[2]

[1] https://labs.tineye.com/color/

[2] Link to video of experiment in action

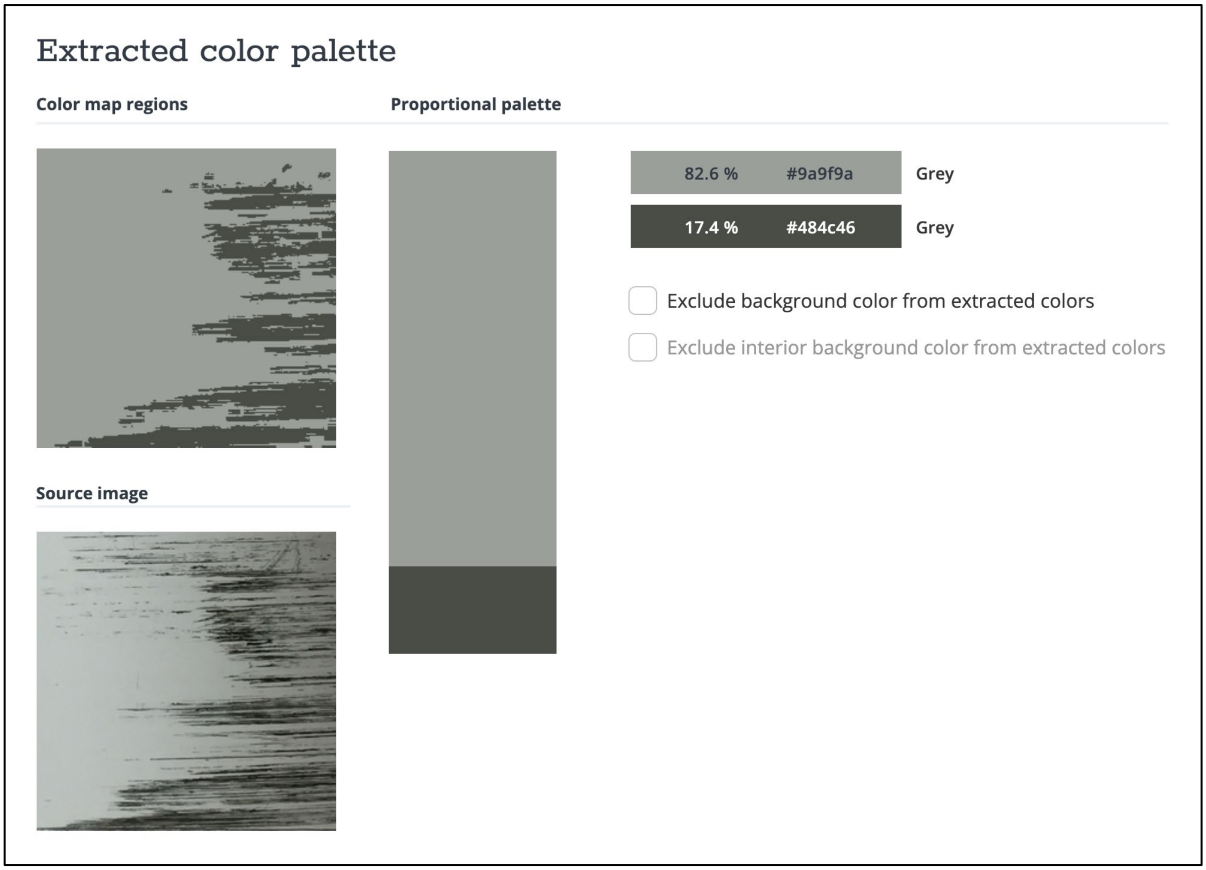

Figure 2. Color Proportion Identifier Software in Action

Once the entire eraser passed through the square, it was removed from the whiteboard. The drawing was retaken with the same height, angle, and lighting and run through the color proportions identifier software. The new percentages of black and white that remained were recorded in the data table. The transition from image to data is shown in Figure 2. The bottom left panel is the original image taken of the whiteboard, and the top left panel is its converted digital image in the program. The program then analyses the top rendered image to give the proportions in black and white. However, it is displayed as light grey and dark grey due to lighting on the right side, resulting in 17.4% of the square area remaining unerased in this example. After each trial, the board is thoroughly washed, and the program is reset. The process was repeated with all the alternatives 20 times each to collect the desired data. The setup of the entire experimental process is captured in Figure 3.

Volume 11 Issue 1 (2022)

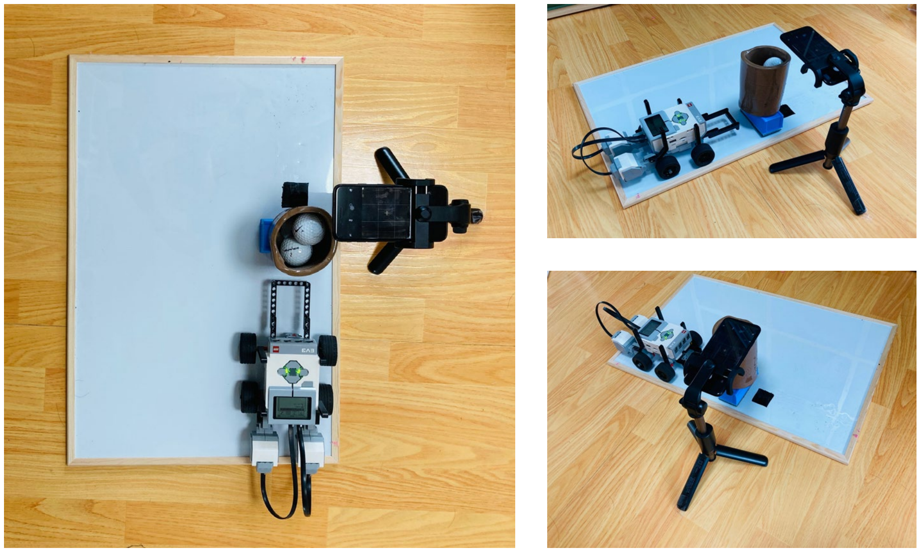

Figure 3. Experimental Setup

Descriptive Statistics

In both Figure 4, the dry-erase eraser can be seen to have generally greater values that can be seen with a relative distinction to the other alternatives. Though it is a rough estimate, the significant difference within the scatter plot implies a possible hypothesis to be made for the case of dry-erase erasers.

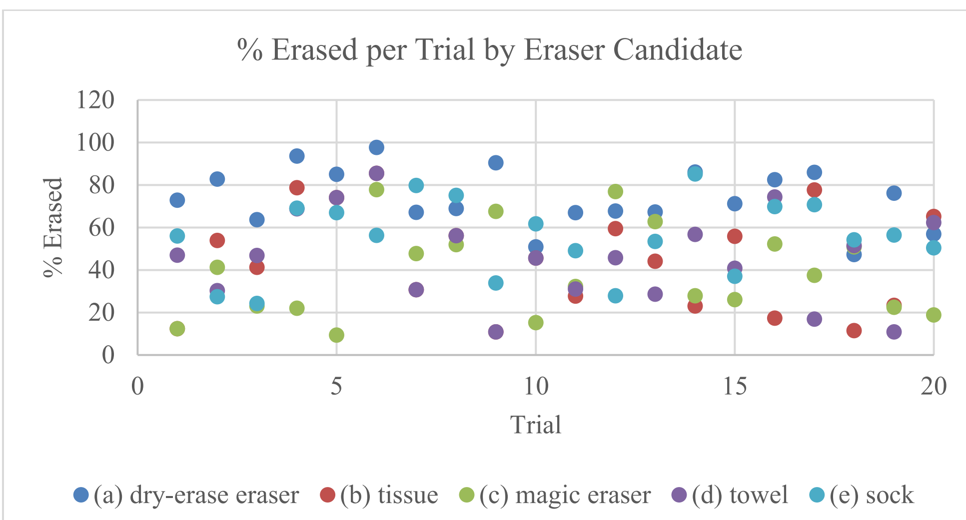

Figure 4. Dot Plot Distribution of percent (%) Erased

More easily comparable data displays in the boxplots shown in Figure 5 are not heavily skewed and have no outliers. The mean of dry-erase erasers is 74.1--the greatest out of the five--and the standard deviation, *SD,* is 13.85, the smallest out of the five, once again, pointing to a more significant % erased in general.

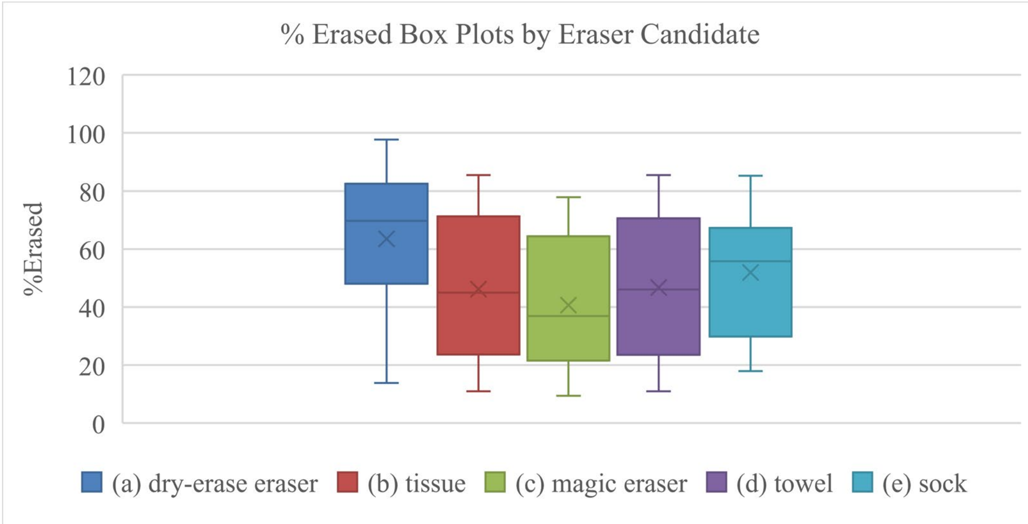

Figure 5. Box Plot Distribution for % Erased

Inferential Statistics

A two-step process with multiple two-sample t-tests was conducted to determine whether the dry-erase eraser was indeed the best option to erase. First, to determine which of the four alternatives erasers was the most effective, or at least to determine which could be eliminated, 6 ($_4C_2$) two-sided two-sample t-tests were conducted to verify whether any of the four alternatives were statistically different from each other. Then, the "winners" of this first step would go on to be compared (averaged out if multiple) with the dry-erase eraser in a one-sided two-sample t-test.

The null hypothesis is that the two means are statistically equal. (H_0: $\mu i - \mu j = 0$). The alternative hypothesis is that the two means are statistically different. (H_a: $\mu i - \mu j \neq 0$). The following conditions were checked before conducting the statistical test.

1. Random: We randomly selected each candidate of eraser from the store by mentally labeling each with a number and using a random number generator to choose one.
2. Independent: We assume that the alternatives and the dry-erase eraser will not affect the performance of the others. And because there are thousands of identical eraser candidates in production, our one of many passes the 10% condition.
3. Average: All five distributions of the dry-erase eraser and alternatives do not show strong skewness or outliers. And because they are roughly symmetrical, it is assumed that the sampling distributions are approximately standard.

Table 1. Two-sided Two-sample t-tests for Alternatives

i, j	t	p-value	df	conclusion/winner
(b), (c)	0.817	0.419	37.356	Fail to Reject H_0
(b), (d)	-0.139	0.890	37.305	Fail to Reject H_0
(b), (e)	-1.557	0.128	34.898	Fail to Reject H_0
(c), (d)	-1.028	0.311	37.999	Fail to Reject H_0
(c), (e)	-2.639	0.012	36.888	Reject H_0
(d), (e)	-1.534	0.134	36.950	Fail to Reject H_0

However, because there was no convincing evidence to conclude that all four of the alternatives were statistically different, as shown in Table 1, there was no 'best' alternative and none to exclude from the comparison with the dry-erase eraser. Thus, the four options were pooled together and averaged, creating a new variable--"(z) collective alternative" --with a new average and variance compared to the dry-erase eraser. The mean and standard deviation of the (z) collective alternative are 46.2 and 21.276 listed in Table 2, and more minor and more significant than (a) eraser, respectively.

Table 2. Summary Statistics of (a) dry-erase eraser and (z) collective alternatives

Material	AVG	MIN	Q1	Q3	MAX	Range	Med	SD
(a) dry-erase eraser	74.1	47.3	67.2	85.3	97.7	50.4	72.1	13.852
(z) collective alternatives	46.2	9.4	27.9	62.5	85.5	76.1	47.5	21.276

Note: p=.00000000339 and df=44.314

The null hypothesis is that the two means are statistically equal for the one-sided t-test with the dry-erase eraser and collective alternative, H_0: $\mu_a - \mu_z = 0$. The alternative hypothesis is that the mean erased of the dry-erase eraser is greater than that of the collective alternative, H_a: $\mu_a - \mu_z > 0$. The same conditions are checked and verified. The one-sided t-test with the dry-erase eraser and collective alternatives was calculated as shown below.

$$t = \frac{(\bar{x}_a - \bar{x}_z) - (\mu_a - \mu_z)}{\sqrt{\frac{{s_a}^2}{n_a} + \frac{{s_z}^2}{n_z}}} = \frac{(74.1 - 46.2) - (0)}{\sqrt{\frac{13.852^2}{20} + \frac{21.276^2}{80}}} = 7.144$$

Conclusion

Since the p-value < 0.05, the null hypothesis was rejected. Thus, we have convincing evidence that the mean percentage erased for dry-erase erasers is more significant than its alternatives and can conclude that dry-erase erasers are a statistically significantly superior alternative to erase whiteboard drawings.

Future Studies

The two most difficult points to address in the experiment design process were how to reduce human error when erasing and how to define what a "more effective" eraser was. Overall, the efforts to minimize human error in the experiment design process were successful, with the different contraptions and mechanisms working sufficiently well. And the solution to a standard of erasing (the color proportion identifier program) also worked reasonably well, helping to keep the testing conditions constant and converting image data to numerical percentages.

There were, however, sporadic cases of the program not identifying narrow streaks or minor blemishes of the drawing, ultimately excluding them from the erased rates. Yet, they did not alter the data drastically, as they were infrequent and negligible. In the future, however, better software would greatly benefit the testing process and yield more accurate data and results. In addition to simply expanding the range and scope of other options, I would like to test the specific relationships between varying forces' and erasing effectiveness for future studies.

References

Conderman, Greg, Val Bresnahan, and Laura Hedin. "Promoting active involvement in today's classrooms." Kappa Delta Pi Record 47.4 (2011): 174-180.

Duchaine, Ellen L., Katherine B. Green, and Kristine Jolivette. "Using response cards as a class-wide intervention to decrease challenging behavior." Beyond Behavior 20.1 (2011): 3-11.

Henry, David, Julie Henry, and Stephanie Riddoch. "Whiteboarding your way to great student discussions." Science Scope 29.7 (2006): 50-53.