The Effectiveness of Commercially Available Teeth Whitening Products

Year 9 Science Research Project

Jayden Pak

Acknowledgements:

I would like to thank my dad who provided me with the resources to complete this project. Additionally, I would like to thank the staff for contributing enthusiastically to this project. And also to my, brother and mum for their continuous support.

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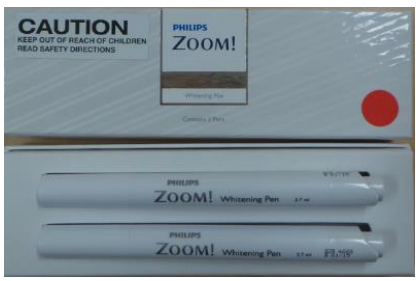


-Abstract

Advertisers are always touting more ‘chemically enhanced’ and effective teeth whitening toothpastes and the toothpaste industry has expanded due to demand. But which whitening toothpaste is the most effective and are company-based claims a case of commercial injustice or the truth? This project looks at which commercially available tooth whitening product is the most effective when tested on subjects and consequently, answers the question of whether tooth whiteners are effective at all. My hypothesis was that the *Philips Zoom! Whitening Pen* would whiten the teeth by more shades in comparison with the other products. 10 subjects and 5 products were chosen. Each product was used on 2 subjects. Subjects brushed their teeth every day, morning and afternoon. Every week for 5 weeks, the shade of the teeth was recorded. The products tested included *Philips Zoom! Whitening Pen, Macleans Extreme Clean Whitening, Colgate Advanced Whitening, Oral-B Complete Extra White and Colgate Total.* The experimental results showed that there was no significant difference in shade between all the products and that they did not affect the shade of the teeth very much (less than 2 shade improvement). Conclusions that can be drawn from this experiment is that the products tested do not make a significant difference to the shade of teeth and that improvements may only be small when using such products. (1 shade or less).

-Introduction

For the last few years, we have witnessed a significant expansion in the industry of cosmetics. With thousands of procedures performed world-wide, it is safe to say that the importance of “personal appearance” has taken a substantial toll to the marketing industry. One industry that has significantly developed in the past decade is the “Cosmetic Dentistry” industry. Teeth-based cosmetic procedures have gradually increased in popularity and as a result has expanded dentistry into a larger commercial market. “Cosmetic Dentistry is very popular because your smile is one of the most important expression and eye-catching feature of your face.” (Wynne, 2009) Much like the motives of other cosmetic businesses, cosmetic dentistry aims to “provide the patient with an attractive appearance” (Byrd, 2002) and enhance the visual appeal of one’s gums, teeth and bite. Cosmetic Dentistry consists of many practices including teeth reshaping, false teeth (bridges), gum lift and bite adjustments but the most common procedure performed is *Teeth Whitening*. Performed by hundreds of dentists worldwide, it is possibly the most efficient and effective procedure that can improve one’s visual appearance. According to a survey hosted by the American Dental Association and Colgate, teeth whitening is the ‘fastest growing part of dentistry’. Maintaining a high procedural success rate, the convenience of teeth whitening is more popular than ever before. This popularity has created a path for manufacturers to create DIY products. But to many consumers, the results of these products are beyond them. Do they really work? Which ones? How many more shades do your teeth improve by? Is it worth it?

The answer lies within the chemical ingredients. No two products are the same in terms of the chemicals contained within the product. Each product contains different chemicals that are each used for individual reasons. The amount of variety in whitening products goes to show that there is no ‘secret recipe’ when whitening your teeth. No company knows the best combination but all claim to be the most effective compared to other products. Though products may have their differences, there are two main chemicals which can be found in most professional products and only some DIY products. These chemicals are Hydrogen Peroxide and Carbamide Peroxide. These two chemicals tend to be the only active ingredients and are very effective for bleaching purposes. Oddly enough, these peroxides are not contained within whitening toothpastes, which begs the question. What is contained within whitening toothpastes that effectively ‘whitens’ your teeth?

As the popularity of teeth whitening has grown, the demand for DIY whitening products has continued to expand far beyond expected. “The tooth whitening market has evolved into four categories: professionally applied (in the dental office); dentist-prescribed/dispensed (patient home-use); consumer- purchased/over-the-counter (OTC) (applied by patients); and other non-dental options.” (ADA). Large varieties of products have entered the commercial market, expanding the product range and allowing many consumers to whiten their teeth at home. Products such as whitening strips, gels and tray-based teeth bleaching systems have become available to those not wanting to spend their budget on In-office treatments. The popularity of these DIY products have been proven in recent statistics. According to BU Today, Americans reportedly drop $1.4 billion annually on non-prescription teeth whitening products.

I have chosen to explore this topic of discussion, in order to understand a current essential factor in general dentistry. The information that is learnt from this experiment will have a beneficial place and conventional use in ‘marketing justice’ within society. We can also learn which combination of constituents is the most effective and why.

-Background Information

Before reading this scientific report, having good, detailed knowledge of the background information will enable you to understand the processes and chemical equations happening within this experiment.

Each tooth comprises of a hard outer layer that protects the tooth known as the enamel, and an inner dentin layer. The enamel is made up of microscopic hexagonal rods called “hydroxyapatite crystals. Food and beverages, prominently coffee, contribute to the creation of another layer of foreign material on the enamel known as “pellicle film”. This film can be removed using regular toothpaste with mild abrasives. A discolouration problem arises when the pellicle film amasses over years and starts to seep into the enamel. This makes it practically impossible to clean stains by brushing. (Barlow, 2012). Teeth discolouration can be classified in 3 groups: Extrinsic, Intrinsic and age-related discolouration. (Colgate, 2013) Extrinsic discolouration occurs when only the outer layer (the enamel) is stained. These types

of stains can be caused by coffee, juice, wine or other types of drinks and food. Intrinsic discolouration is when the inner structure of the tooth (the dentin) is darkened or has a yellow tint. This can be caused by many different factors including having too much exposure to fluoride at a young age. (Colgate, 2011) The last type of discolouration is age-related. Over time, the dentin within the structure of the tooth begins to naturally yellow. This is because the "enamel that covers the teeth becomes thinner and the dentin begins to show through. (AACD, n.a.)

No two whitening products contain the same chemicals but, there are two common ingredients that most teeth whitening products utilise. These two ingredients are Carbamide and Hydrogen Peroxide. These two chemicals are the main active ingredients and the main reason why your teeth are whitened. (Opalescence, 2012) Chemically, Carbamide Peroxide is $CH_6N_2O_3$. It breaks down into Hydrogen Peroxide and Urea in an aqueous solution. When broken down, the Hydrogen Peroxide acts as a bleaching agent while the urea acts to remove stain bonds on the teeth (ADA). Carbamide Peroxide is generally found within dental office and store-stocked teeth whiteners making up 15 to 35% of the total ingredients. DIY home products generally contain 10%, hence the reason why the result is much less profound. Hydrogen Peroxide's chemical formula is H_2O_2 and is "an effective bleaching agent that can penetrate enamel to bleach intrinsic stains" (ADA). It can be found separately from Carbamide peroxide in whitening products. When Hydrogen Peroxide oxidises, the active ingredient in the solution breaks down, allowing oxygen to enter the enamel and dentin, thereby bleaching the teeth to a lighter colour. (greenfacts, 2014) "The concentration of these peroxides in over-the-counter products differs greatly from the amount found in professional whitening products and procedures." (toothpasteandwhitening.com).Typically, the higher concentration of peroxides a product has, the more effective the results are.

Whitening toothpastes tend to not contain either of these peroxides. According to the Los Angeles Times, studies show that whitening toothpaste rely on abrasives to scrub off stains left from coffee, juices, cigarettes and food. (Woolston, 2011) Abrasives are substances, generally minerals, which are "capable of polishing or cleaning a hard surface by rubbing or grinding" (dictionary.com). Common abrasives found in whitening toothpastes include calcium carbonate ($CaCO_3$), silica (SiO_2) and Aluminium Oxide (Al_2O_3). The toothpaste should be abrasive enough to also remove plaque but not enough to damage the tooth enamel. (howstuffworks, 2009) As opposed to peroxide-based products, in which the whitening effect is produced by a chemical improvement within the product; whitening toothpastes produce a whitening effectively only by the way of removing debris off the external surface of the teeth (dentalpictureshow.com). Tooth whiteners in toothpastes contain mild abrasives which only have the ability to clean stains on the enamel and no deeper. They are used to slightly whiten the appearance of the teeth, while still keeping prices low for customers. (toothpasteandwhitening, 2014)

There is no one standard system used by dentists to determine the exact shade and colour of ones teeth, though there is one commonly used tool known as a shade guide. The common shade guide divides the shade of white on teeth into four categories: A (reddish brown), B (reddish yellow), C (gray) and D (reddish gray).

Within each category are different levels of darkness, which provides a scale detailed enough to be used to identify a shade of white on teeth. (Colgate, 2003) Professional whitening “can occasionally improvement tooth colour nine or more shades but the majority of people who whiten their teeth see an improvement of between two and seven shades.” (Colgate, 2003).

Aim

To investigate which commercially available tooth whitening product is the most effective.

Hypothesis

That the *‘Philips Zoom! Whitening Pen’* would provide the highest increase in shade out of all the products

Materials

- 2x Colgate Advanced Whitening ($5.15pp)
- 2x Oral-B Complete Extra White ($6.50pp)
- 2x Macleans Extreme Clean Whitening ($5.50pp)
- 2x Colgate Total (non-whitening) ($1.97pp)
- 2x *Philips Zoom! Whitening Pen* ($22.49pp)
- 10x manual toothbrushes (same product)
- 10 subjects (no requirements)
- Degudent Shadepilot

Method

1. Participants were asked for approval for experiment to commence with them as subjects
2. 10 participants were chosen; 2 participants for each product
3. 2 participants were allocated *Colgate Total* (control)
4. 2 participants were allocated *Philips Zoom! Whitening Pens*
5. 2 participants were allocated *Colgate Advanced Whitening*
6. 2 Participants were allocated *Oral-B Complete Extra White*
7. 2 participants were allocated *Macleans Extreme Clean Whitening*
8. Participants were taught to brush using short, gentle strokes in a circular motion on teeth.
9. Teeth were brushed daily, day and night, for 4 minutes, for 5 weeks
10. Whiteness of teeth was calculated every week for 5 weeks using Degudent Shadepilot
11. Results were recorded in table, graph using the center shade as a reference point

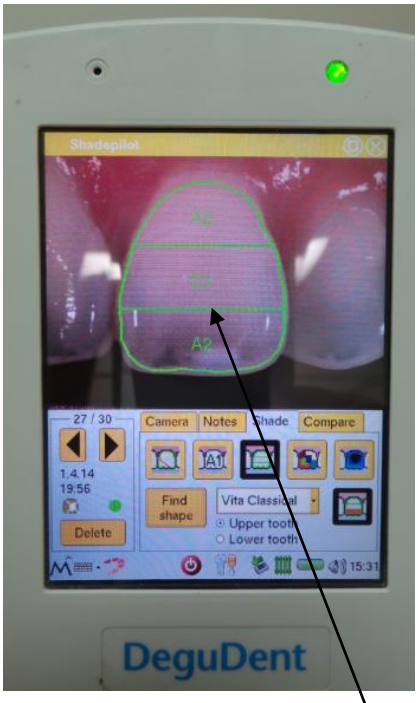
Variables

Independent Variable: Different Whitening Products
Dependent Variable: Whiteness of Teeth
Controlled: Amount of Time
Type of Toothbrush (Manual)
Amount of Toothpaste (pea size)
Repetition: 2 subjects per product

Risks and Precautions

- Avoid professional teeth bleaching direct contact with skin; may cause chemical burns
- Do not swallow toothpaste
- Excessive bleaching leads to teeth weakness and sensitivity; irritation on gums
- If bleaching, consult your local dentist first
- Follow steps from product
- Excessive bleaching may cause ‘bleachorexia’ (An unhealthy obsession with whitening one's teeth)

-The Degudent Shadepilot



Experiment Reference Point

The Shadepilot™ works through a digital camera linked to an LED spec- trophotometer.

Shadepilot™ will analyse your patients tooth shade in different variances by recording the average and/or the overall tooth shade.

Product Information

1. Colgate Advanced Whitening

Ingredients: Sodium Fluoride (1450ppmF), Ingredients:, Aqua, **Hydrated Silica**, Sorbitol, Glycerin, Sodium Bicarbonate, PEG-12, Aroma, Sodium Lauryl Sulfate, Carrageenan, CI 77891, Sodium Fluoride, Sodium Saccharin, Polyethylene, Limonene, CI 42090

Abrasive: Hydrated Silica

Claim: *"Whiter Teeth in 14 days"*

"For White Teeth So Healthy They Shine"

"Clinically Approved; Whiter Teeth"

2. Oral-B Complete Extra White

Ingredients: Aqua, Sorbitol, **Hydrated Silica**, Sodium Lauryl Sulfate, Cellulose Gum, Aroma, Zinc Citrate, Carrageenen, Sodium Fluoride, Sodium Saccharin, Hyroxyethylcellulose, Copernicia Cerifera Cera, Sodium Citrate, Stannous Chloride, Cl 77891, Silica, Limonene, Cl 42090.

Abrasive: Hydrated Silica

Claim: "Whitens Teeth"

3. Macleans Extreme Clean Whitening

Ingredients: Water, **Hydrated Silica**, Sorbitol, Glycerin, PEG-6, Sodium Lauryl Sulfate, Flavour, Xanthan Gum, Titanium Dioxide, Cocamidopropyl Betaine, Sodium Fluoride, Sodium Saccharin, Limonene, Linalool, Cl 77492, Cl 73360.

Abrasive: Hydrated Silica

Claim: "Whitens Teeth"

"Whitening variety helps maintain whiteness of teeth"

4. Philips Zoom! Whitening Pen

Ingredients: Water (Aqua), **Hydrogen Peroxide** (5.25%), Carbomer, Glycerin, PEG 60 Hydrogenated Castor Oil, Ammonium Hydroxide, Flavor (Aroma), Sodium Saccharin, Etidronic Acid, Potassium Stannate

Chemical: Hydrogen Peroxide (5.25%)

Claim: "Keep your teeth white without a mess. Anytime, anywhere!"

"Your smile stays bright and white"

Results

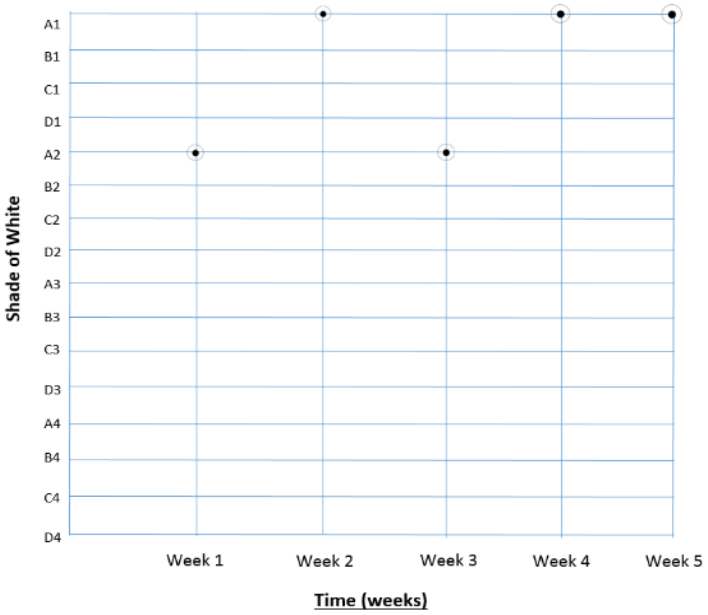
Shade of Teeth using 5 products over 5 weeks

Subject	Product	Partaker	Week 1 (24/2/12)	Week 2 (3/3/14)	Week 3 (10/3/14)	Week 4 (17/3/14)	Week 5 (24/3/14)
A1	Colgate Advanced Whitening	D.M	B2 A2 B2	B2 A1 A1	B2 A2 A1	B2 A1 A1	B2 A1 A1
A2	Colgate Advanced Whitening	C.C	D2 D2 A2	D2 D2 B2	D2 D2 B4	D2 D2 D3	D2 D2 B2
B1	Oral-B Complete Extra White	L.P	A2 A2 A3	A2 A2 A2	A2 A2 A2	A2 A2 A3	A2 A2 A3
B2	Oral-B Complete Extra White	J.C	A2 A1 A1	A1 B1 A1	A1 A3 A1	A2 A2 A1	A2 A1 A1
C1	Macleans Extreme Clean Whitening	Je.K	A3 A3.5 A3	A3 A2 A2	A3 A3 A2	A2 B2 A2	A2 C1 A2
C2	Macleans Extreme Clean Whitening	J.K	A3 A2 A3	A3 A3.5 A3	A3 A3.5 A4	A3 A3.5 B2	A3 A3.5 B3
D1	Professional Whitening Product	M.C	A2 A1 B2	A2 A1 C1	A2 A1 C1	A1 A1 C1	A1 A1 C1
D2	Professional Whitening Product	Y.M	A1 A1 A2	A1 A1 A2	A2 A1 A2	A1 A1 A2	A1 A1 A2
E1	Plain ToothPaste	A.C	C1 B1 A2	A1 A1 A2	B2 A3 A4	C1 A4 B2	C1 B1 B2
E1	Plain ToothPaste	Ju.K	A1 A1 B2	A2 A2 A2	A2 A2 A2	A2 A2 A2	A2 A2 A2

-'Colgate Advance Whitening' Results

Subject A1

Whiteness of Teeth using '*Colgate Advanced Whitening'* after 5 weeks of application



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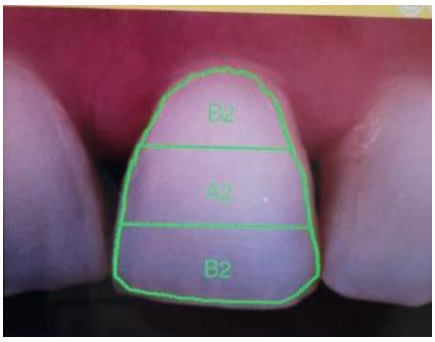

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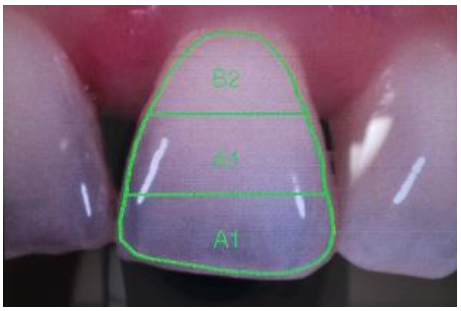
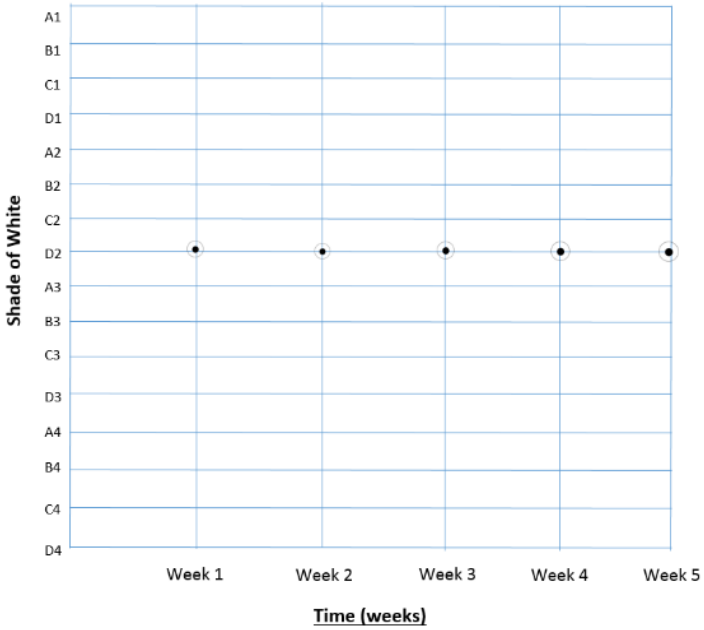


Subject A2

Whiteness of Teeth using '*Colgate Advanced Whitening'* after 5 weeks of application



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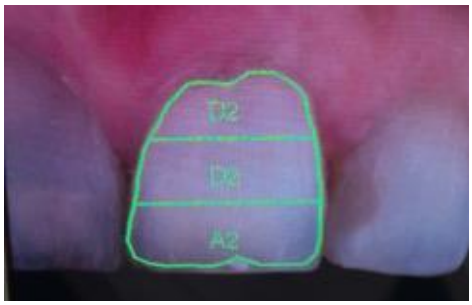

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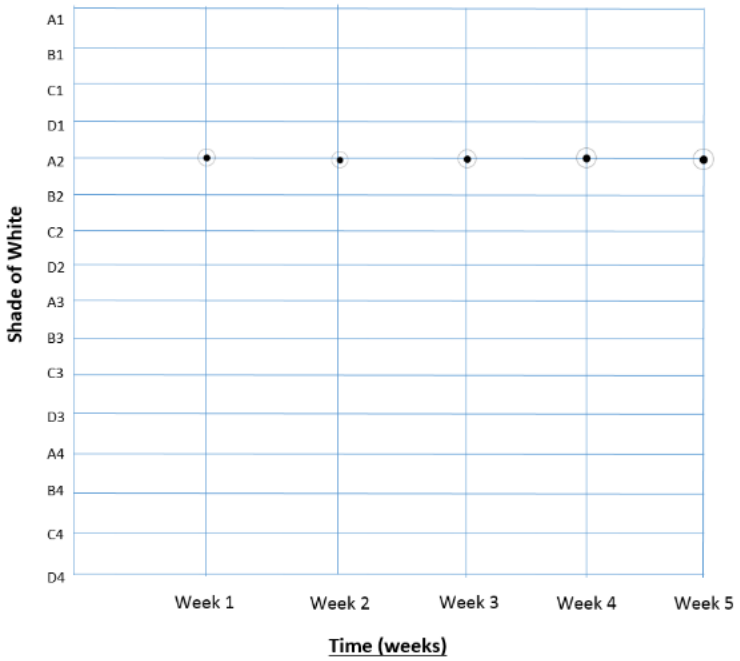
-'*Oral-B Complete Extra White*' Results

Subject B1

Whiteness of Teeth using '*Oral-B Complete Extra White*' after 5 weeks of application



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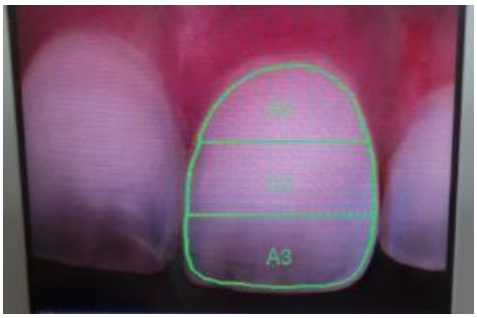

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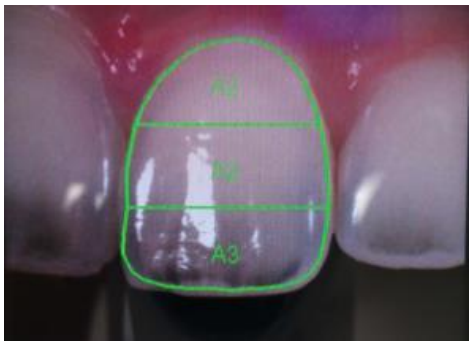
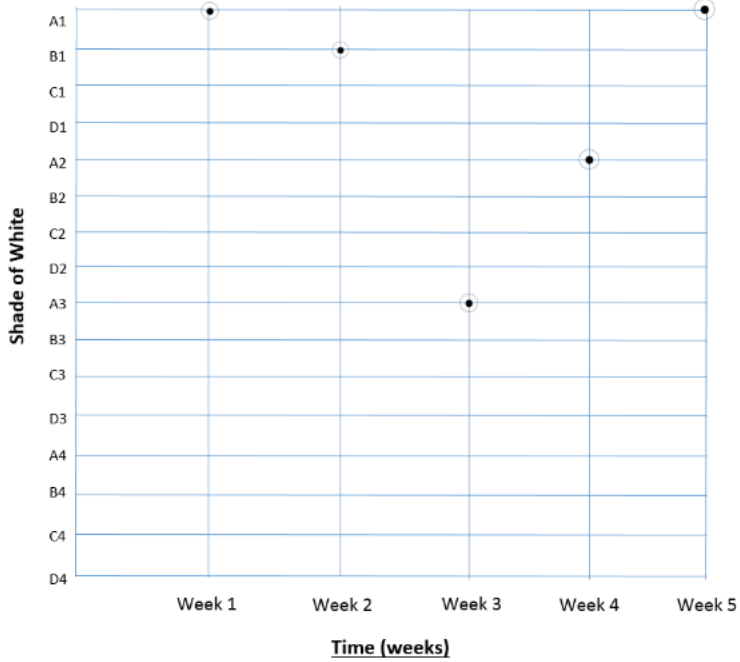


Subject B2

Whiteness of Teeth using '*Oral-B Complete Extra White*' after 5 weeks of application



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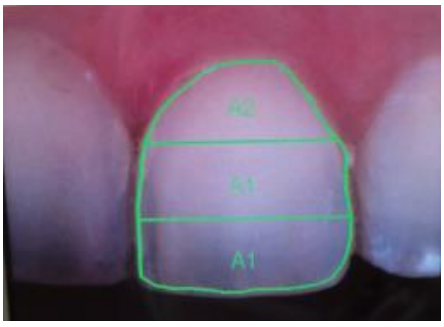

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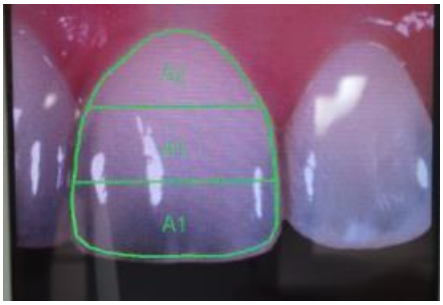
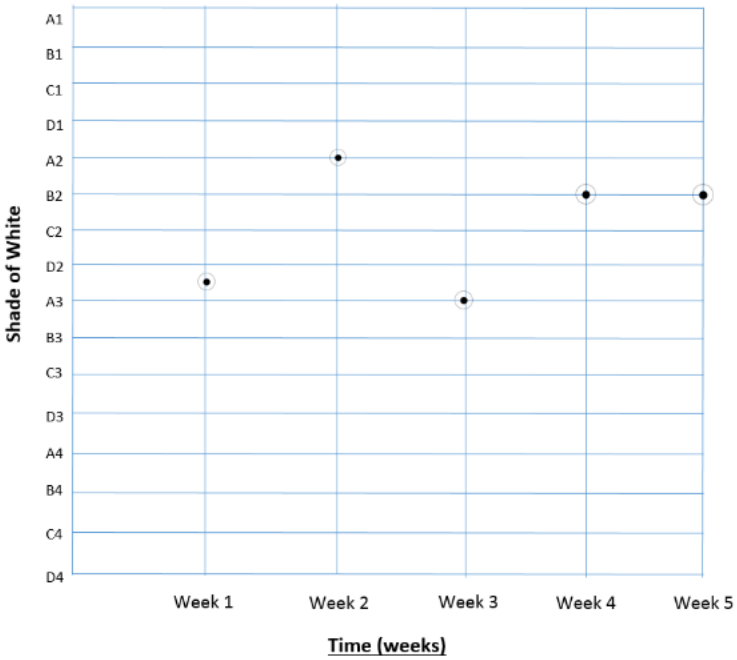


-'*Macleans Extreme Clean Whitening*' Results

Subject C1

Whiteness of Teeth using '*Macleans Extreme Clean Whitening*' after 5 weeks of application



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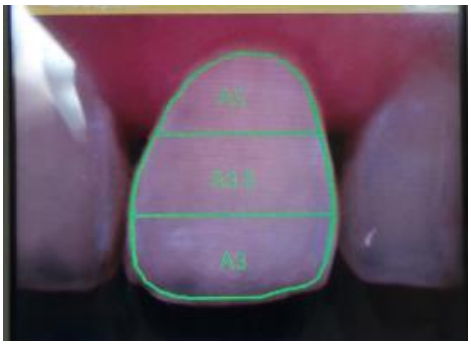

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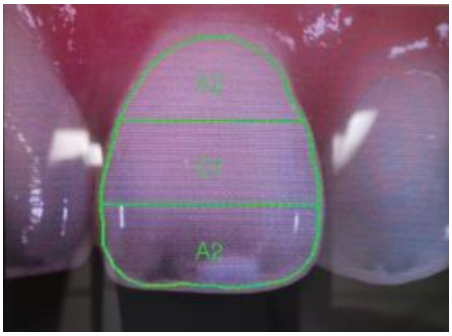
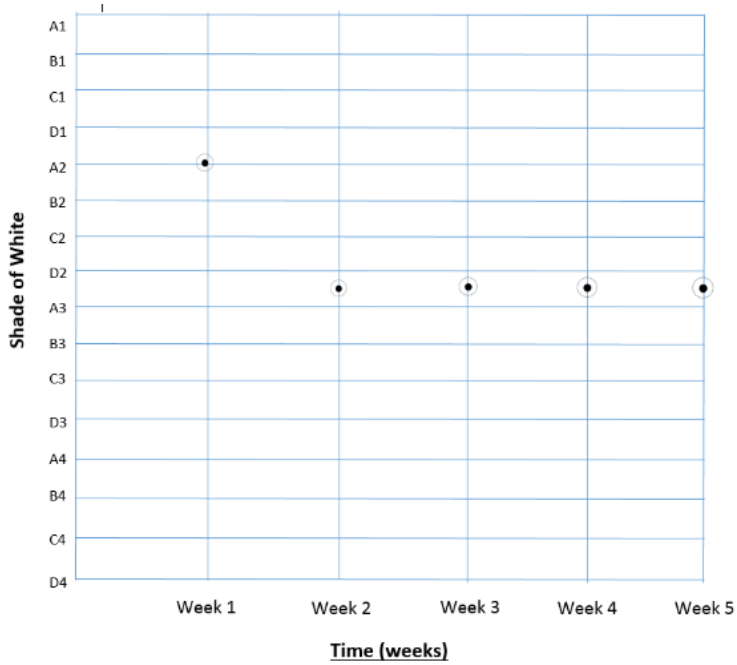


Subject C2

Whiteness of Teeth using '*Macleans Extreme Clean Whitening*' after 5 weeks of application



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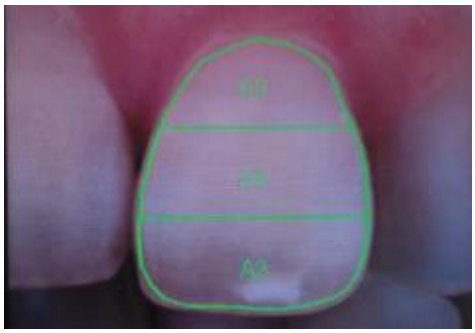
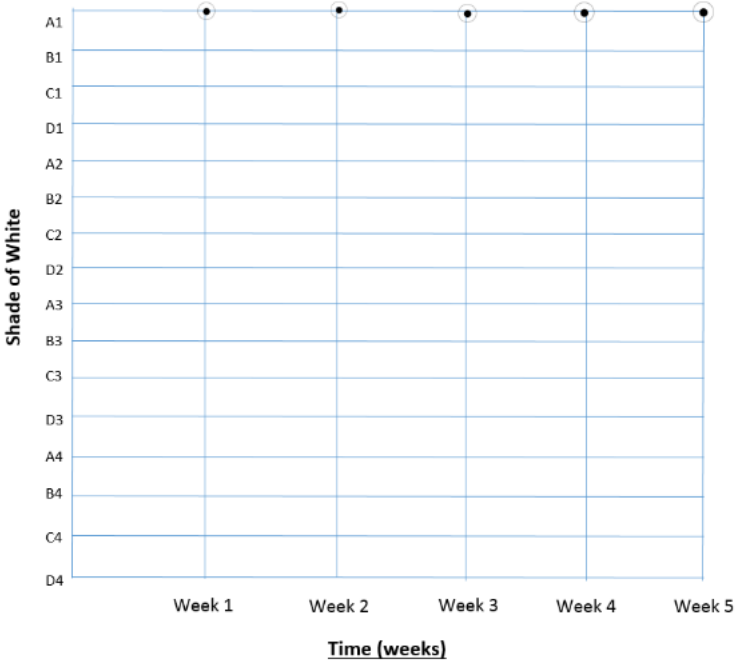


Last Week

- *'Philips Zoom! Whitening Pen'* Results

Subject D1

Whiteness of Teeth using '*Philips Zoom! Whitening Pen'* after 5 weeks of application

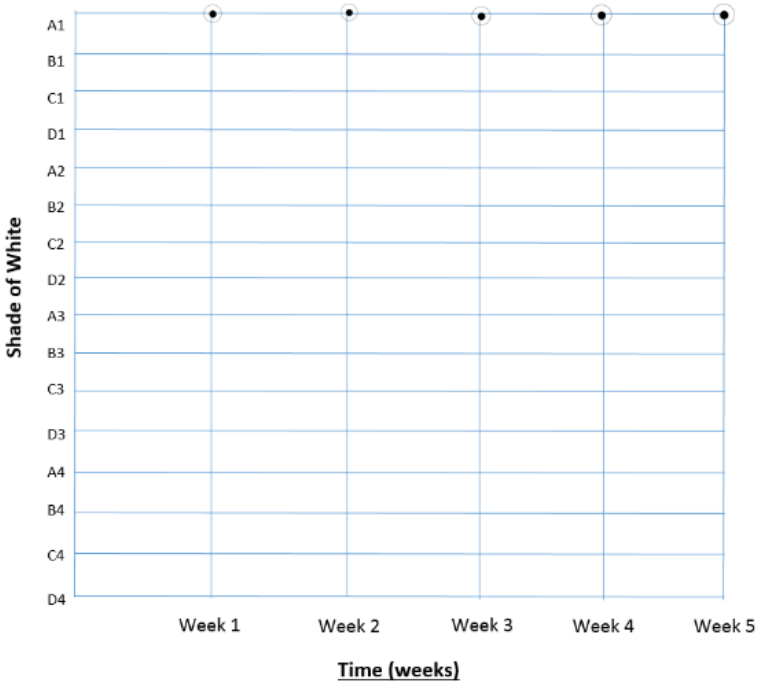


First Week

Last Week

Subject D2

Whiteness of Teeth using '*Philips Zoom! Whitening Pen'* after 5 weeks of application



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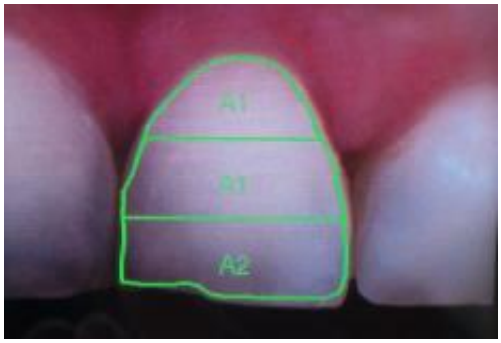

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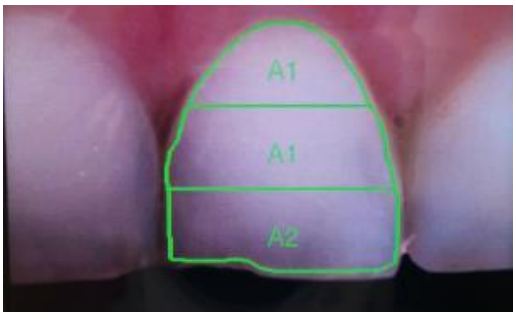
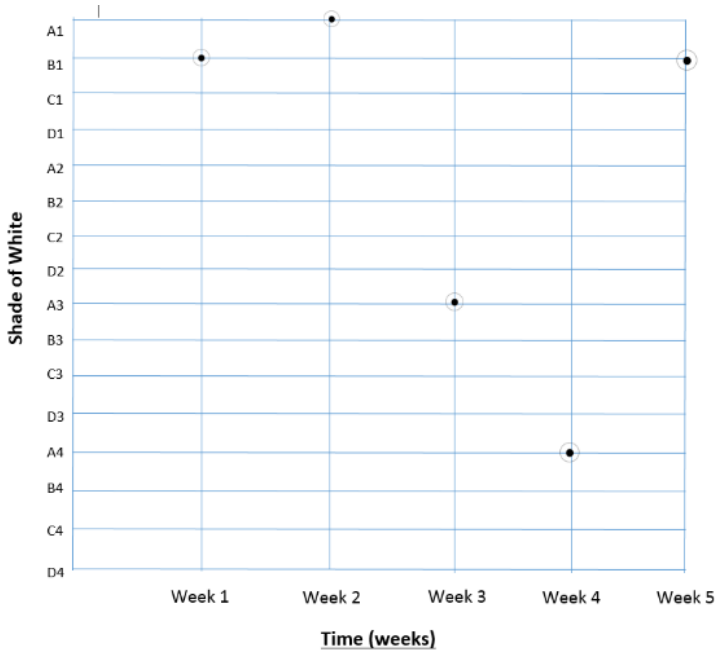


-'Colgate Total' (Non-Whitening) Results

Subject E1

Whiteness of Teeth using '*Colgate Total*' (non-whitening) after 5 weeks of application



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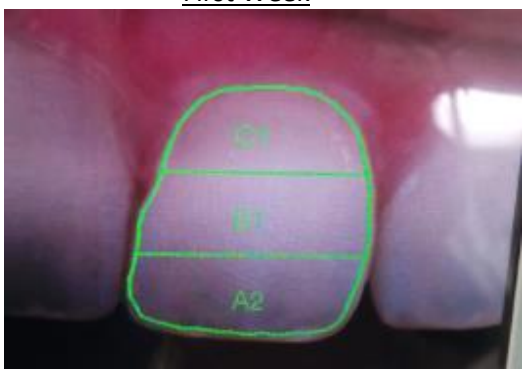

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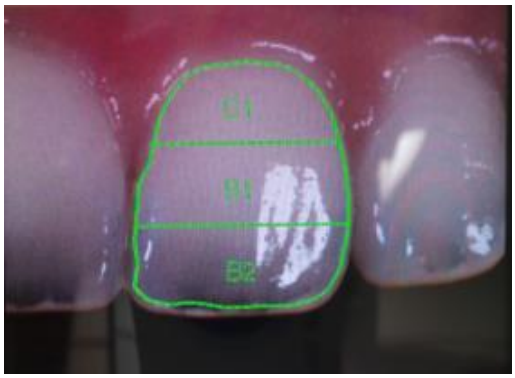
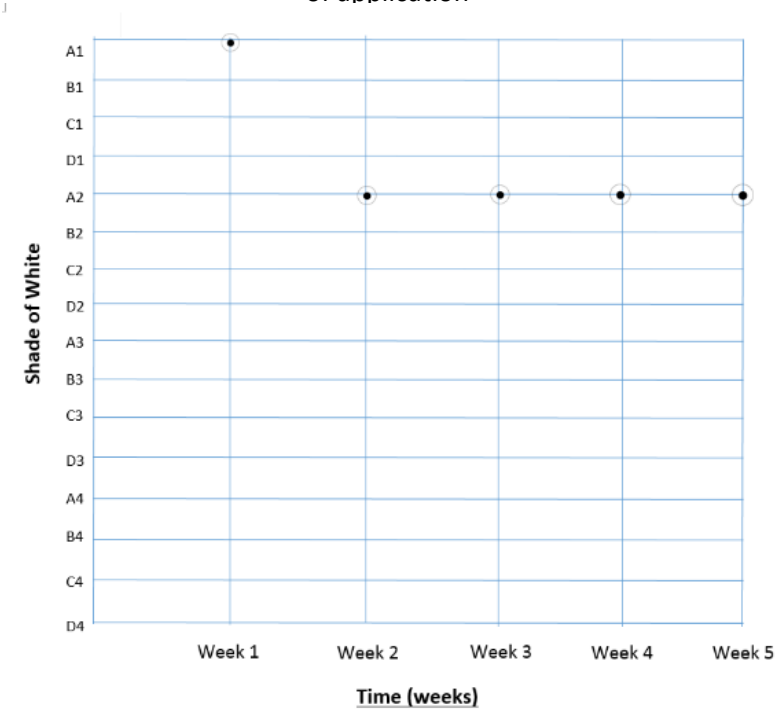
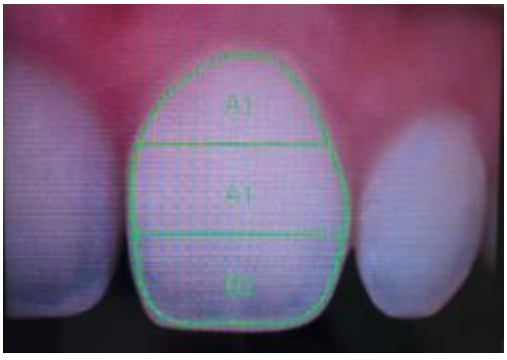


Subject E2

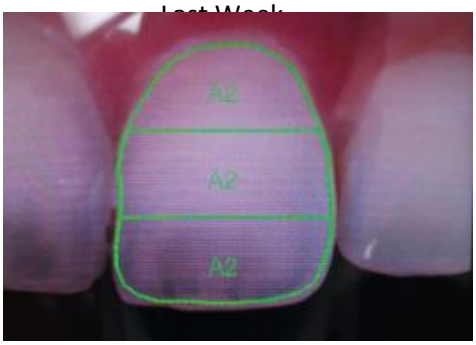
Whiteness of Teeth using '*Colgate Total*' (non-whitening) after 5 weeks of application



First Week



Last Week



-Discussion

Subject Number
Shade

The purpose of this investigation is to investigate which commercially available teeth whitening product is the most effective which also answers the question of if they are effective at all. The hypothesis of this experiment is that the *Philips Zoom! Whitening Pen* would produce the best result because of the presence of hydrogen peroxide within its range of ingredients. In this investigation, the results show that there was no significant improvement to the shades of the teeth on the first week to the last week. A majority of the improvement in the teeth whiteness was shown through a decrease in shade colour, mostly likely due to the impacts of daily lifestyle and tooth stainage. The two subjects of the '*Colgate Advanced Whitening'* maintained their teeth shades between *A1* and *A2* (5 shades). Subject **A1** observed a mixture of inclines and declines in shades while Subject **A2** remained at a constant *D2* shade. The two subjects using *'Oral-B Complete Extra White'* contained their shade between *A1* and *A3* (9 shades) and followed the same trend as the *'Colgate Advanced Whitening'* Results. One subject stayed consistent at the *A2* shade while the other witnessed increases and decreases in shade. Subjects using *"Macleans Extreme Clean Whitening"* followed the same trend as the other products. The teeth remained between *A2* and *A3* (5 shades). Subject **C1** observed inclines and declines but overall the product improved the tooth by 1 shade; Week 1: *A3.5*, Week 5: *B2*. Both the subjects using *'Philips Zoom! Whitening Pen'* had a consistent shade throughout the whole experiment (**A1**). The subjects of *'Colgate Total'* (non-whitening) had the most shade variation out of all the products. The shades remained between *A1* and *A4* (13 shades) with Subject **E1** having the most variation of all the results.

These results may have occurred due to the ingredients found within whitening toothpastes. Abrasives within these products are only designed 'to polish teeth not to permanently whiten them.' (howstuffworks.com, 2014). Whitening toothpastes only remove surface stains and debris, therefore overall improvements never exceed 1 to 2 shades (sharecare.com, 2013). They only have the ability to create a temporary look or help sustain shades after professional whitening.

The results of this experiment are not very reliable; the type of brush that was used by all the subjects was the same but there was a chance that some subjects may not have applied their product every morning and evening. Not applying the product one night or morning can possibly affect the results in a negative way and may lead to a misleading result. Also, the subjects may not have all applied the same amount of their products to their teeth which may slightly affect the results.

The results did not show a clear trend between the final shade and the products. Although the product with Hydrogen Peroxide maintained a consistent A1 shade, the other products had interesting results. While one subject had a consistent shade, the other subject would have a mixture of high and low shades. This variation is most likely the result of every-day living, with certain foods and drinks containing the potential to produce stains. A subject's diet may potentially be a contributing factor to the mixed results.

A few problems were encountered during the experiment. One of them being that the instructions on the *'Philips Zoom! Whitening Pen'* packaging stated that users should not consume food or drink thirty minutes after it has been applied. With subject's most likely consuming food or drink thirty minutes after applying, it became clear that the results from the *"Philips Zoom!"* experiment may be invalid and may not display the full potential of the product.

This experiment could be improved if the results were recorded daily therefore the more slight increases in shade can be recorded therefore resulting in a more accurate and precise experiment. Another improvement would be to not make subjects that have the highest possible shade, use the "most effective" products i.e. *'Philips Zoom! Whitening Pen'.*

This experiment can be extended by using a larger variety of products with varying amounts of peroxides and different abrasives. More subjects would allow for a more valid and averaged result. In this experiment, the time period was 5 weeks. In future experiments, it would be more beneficial if the time period was extended, possibly, to a term or longer.

Conclusion

My hypothesis was that the *'Philips Zoom! Whitening Pen'* would produce the highest increase in shades compared to the other products. The experimental data did not support the hypothesis. The results showed that there was no significant improvement in the shade of teeth after using them for five weeks. There were only three overall increases but only by one shade. It can be seen that the abrasives found within toothpastes are not very effective while the peroxide-based product showed a consistent shade. As a result, further studies must be taken to gain a more valid result. If the experiment was to be performed again, a wider variety of products would be used as well as a longer time period in order to expand the validity of the results. Through this report, facts about these whitening toothpaste have been revealed. This knowledge allows people to grasp 'commercial justice' when it comes to really getting what you paid for.

Images

Scanning the Results
of Subject E1

Scanning the Results
of Subject C1