

# Disposable dermatoscope

*by* Andrew Evan Sims

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# University of Wales Trinity St. David

DISPOSABLE DERMATOSCOPE  
MAJOR PROJECT  
MX600417

Andrew Sims P147955 | BEng Mechanical and Manufacturing Engineering | 29/4/2019

### Declaration of Authenticity

This thesis is the result of the author's original research. It has been composed by the author and not been previously submitted for examination which has led to the award of degree

Signed:

Date:

### Acknowledgements

I would like to thank Graham Howe for first putting me onto this very interesting project. Graham's assistance in this process has been instrumental in helping this gain momentum and become a reality.

Thanks are due as well to Dr. Steve Fielding whose medical knowledge and perspective proved an invaluable resource.

Finally, thanks to everyone at UWTSD Swansea from the lecturers and technicians to the cleaners and canteen staff. They're all a credit to the institution and keep up the excellent work.

### Abstract

Dermatoscopes are devices a dermatologist would use to inspect the skin for moles and abrasions. This paper focuses on manufacturing methods and processes pre-design stage with the aim of devising an outline for manufacturing a cost effective dermatoscope that people can use at home.

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## Project proposal

### 0. Reasons for the relevance of the project

Since the birth of NHS in Britain in 1948 it has provided free health care to the people of Britain. Now, 70 years on and with the population of Britain nearing 70 million, the NHS is under enormous strain to provide care within a reasonable time frame.

The figures reveal the sheer magnitude of the task facing them, net operating expenditure for the year ending 31 March 2018 was £108,148,525,000.

([www.england.nhs.uk](http://www.england.nhs.uk), 2019)

The sheer size of this organisation across the United Kingdom means it needs dedicated and hard-working professionals to carry the burden. A recurring theme in recent times is the opinion that the NHS is not only massively under-funded, but in radical need of a shakeup in terms of its operations and processes.

If you look at the entire process from an engineering perspective, from symptom all the way through to treatment, the flow of the system is massively inefficient.

For this piece of work, we will address this issue of lengthy process of diagnosis to treatment, specifically relating to skin lesions and possible melanomas. By reverse engineering the current tool used by medical professionals to diagnose various skin cancers, a dermatoscope, a new, low cost alternative product based on lean manufacturing principles will be proposed.

Statistics from cancer research UK state that there were 15,906 cases of skin cancer in 2015 and 2,285 deaths in 2016. The most salient piece of data however is that 86% of melanoma skin cancers are preventable.

([www.cancerresearchuk.org](http://www.cancerresearchuk.org), 2019)

This innovative new product will hopefully help people here and abroad who don't have access to doctors with sophisticated medical equipment, to cheaply and independently take accurate images of the skin lesions with any smart phone that can be sent to a medical professional to examine. This will not only save the GP's and NHS the time and

money of checking these people and buying expensive dermatoscopes for surgeries. Once the specialist dermatologist has seen these images, they can quickly deduce what's the next course of action, if any. On a larger scale this could also help people in developing countries, especially tropical nations who don't have national or access to healthcare at all to check themselves to alleviate any concerns or, accelerate the treatment process.

This development will:

- Cut out the need for GP's to inspect skin lesions
- Save the NHS time and money
- Send images straight to skin specialists
- Accelerate treatment for cancer positive people
- Allow those in parts of world where healthcare isn't widely available to check their skin
- Improve awareness of skin cancer and its forms

In this country using the NHS your GP will inspect your skin lesion with a dermatoscope and if he suspects a possible melanoma, they'll recommend you to a specialist dermatologist for the next step. However, the first step of diagnosis can be unnecessarily long and just to get an expert's opinion.

### 1.The problem statement

Most dermatoscopes are very expensive and are made by high end medical brands such as '*Dermlite*' and '*Skiary*' and can go for prices into the thousands of pounds. This prospect has been identified and exploited by a few companies as they strive to create a cheaper alternative. However, they still haven't utilised certain theories and business strategies to create a product that does a 'good enough' job for a valuable price. Their products are in the middle ground if you like and do not really offer anything more than slightly better value for money than leading brands. What we have acquired is a Dermlite HUD patient dermatoscope that is a phone attachment for £65 pounds. Our goal is to manufacture a phone attachment with a polarized light source and magnified lens for a R.R.P of about £15 that can be used with any smartphone's camera, to take photos of skin lesions to send onto medical professionals. This concept will cut out unnecessary strain on our health service and hopefully make its way into developing nations where healthcare is poor. In order to find weaknesses with this model we must see what qualities it has and how it can be made cheaper as our goal is to go after the lower markets.

In order for us to gain an insight of how to best develop a product that delivers large sales and profitability, we will utilise several prominent theories in manufacturing, business and product design to give us our best chance of a successful product by positioning us well in the market.

## 2. Value steam mapping

A value stream is a process by which a company or organisation deliver to the customer what they desire. This includes including the necessary steps of design, production and delivery to them. According to Dr J. R Thomas, a ten-year member at the institute for manufacturing at Cambridge University, VSM is a detailed analysis of process efficiency and gives the greatest depth of analysis after process mapping and activity mapping alone.

(Thomas, 2019)

As Martin 2014 explains, "The roots of value stream mapping can be traced to a visual mapping technique used at Toyota Motor Corporation known as "material and information flows". "We learned that Toyota's focus on understanding the material and information flow across the organisation was a significant contributor to its ability to perform at consistently high levels.

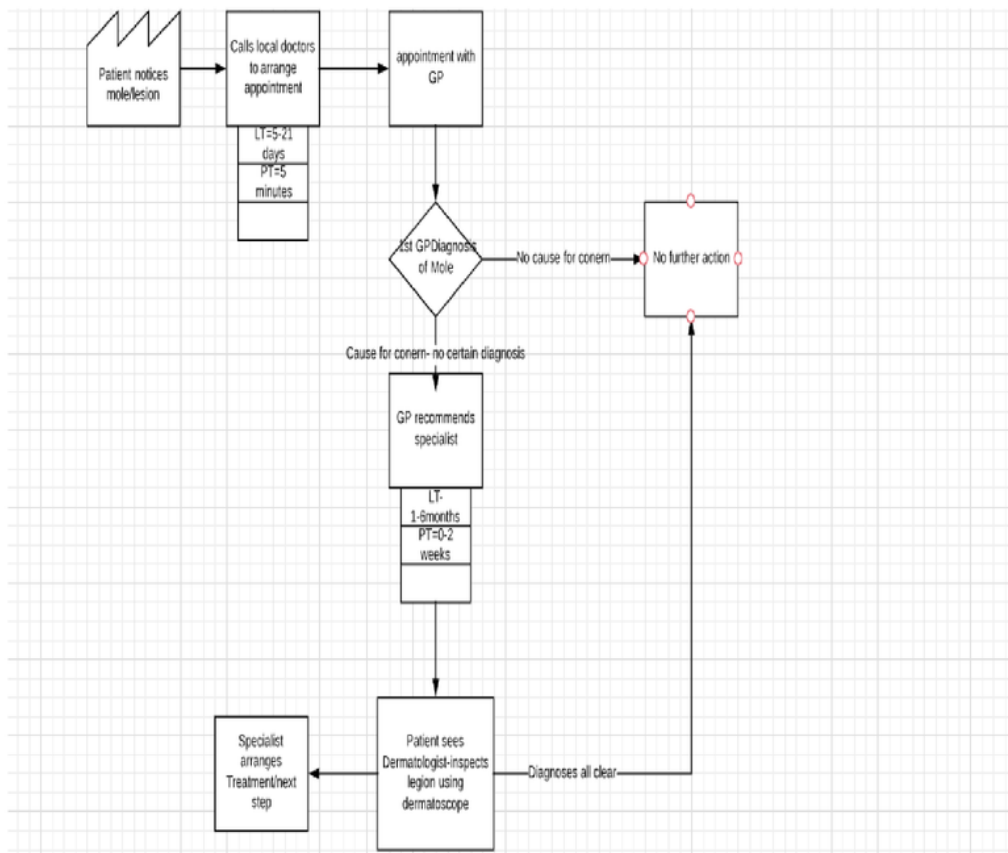
(Martin, 2014)

Although our current problem of shortening the total time taken to be diagnosed needs to be mapped to be truly understood, it is not a business model that produces a product, i.e. the production of dermatoscopes, and therefore we must look at the process in terms of waste in its many forms.

### Why do we map processes?

In order to understand where improvement can be made in a system or process, it must be broken down into each individual action or step. By presenting the system as each subsequent step we can see what input leads to a successful output.

### The current process



Through mapping we can immediately see the problems with the system. If our product can skip these stages and go straight from “patient notices mole/ lesion” to “specialist treatment” then we have fulfilled our goal.

### 3. Disruptive Innovation

Disruptive Innovation – *“Transforms a product that historically was so expensive and complicated that only a few people, with a lot of money and a lot of skill, had access to it”*  
– Clayton Christiansen

Clayton Christiansen is Professor of Business Administration at Harvard Business school and considered by many to be the top pioneer on innovation and growth in business.

His first book, The Innovator’s Dilemma received the Global Business Book Award as the best business book of the year (1997); and in 2011 The Economist named it as one of the six most important books about business ever written.

This definition of DI is exactly what we’re trying to achieve in this project. To design a ‘good enough’ dermatoscope so that members of the public can take clear photographs of skin lesions with their own smart phone and send them to a third-party medical professional for a swift diagnosis. Dermatoscopes doctors use do a job but cost hundreds. Once the technology of alternatives catches up with the present products and gains a foothold in the lower markets then the disruptors are on the winning path to defeat the incumbent businesses.

*“In order to maintain profits and handicap competitors should companies make better products that they can sell for more to their best customers, or make worse ones that would ruin their margins but sell more? Is it better to focus on the most profitable customers or make greater numbers of a “good enough” product? Incumbent businesses or industry leaders always struggle to realise there is profit in going down the chain. Big businesses often fail not through poor management but through an inability to realise this fact.”* – The Innovators Solution

### Disruptive Innovation Modelled

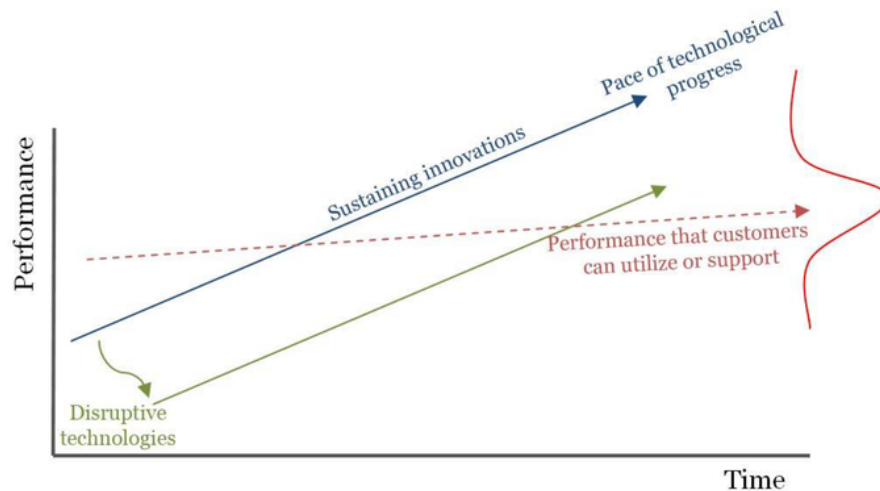


Figure 1

The three lines on this graph paint the picture very well. Firstly, the dotted line represents the technology that the consumers can utilize. In this instance we're limited because they're very un-common, expensive and usually only doctors have would them or access to them. This isn't strictly a straight line but imagine many roughly on the same course, illustrated by the red distribution curve. This is because there will always be people who are happy with the lower limit and some unhappy with the upper limit. However, this very premise is one we intend to exploit for our gain. The blue line (sustaining innovations) is the trajectory of improvement that incumbent business' develop in order to keep up with demand for better products. They utilize advances in technology and style to provide the best products they can for their customers.

What this really shows is that the advancement of technologies always outpaces the ability of the customer to use it. Therefore, a company that prioritises the latest and greatest and tries to sell the best products for the highest profits to the best customers will always go beyond what's necessary. A good example Christiansen uses is the chip inside computers for keyboards. Some people can type so fast their computer can't keep up so they need faster processing, but this is usually unique to a small number of exceptional typists when most people type at an average speed. The disruptive

innovation however offers a product that isn't actually any better than anything on the market but less expensive and simpler to appeal to new or less-demanding customers.

(C.Cristensen, 2003, pp. 31-35)

Dermatoscopes doctors use do a job but can cost up to £1000's. Once the technology of alternatives catches up with the present products and gains a foothold in the lower markets then the disruptors are on the winning path to defeat the incumbent businesses. This is exactly what we want to achieve. Christiansen devised a "litmus test" on shaping ideas to be disruptive.

### Shaping ideas to be disruptive: Three litmus tests

#### 1<sup>st</sup> set – Whether it can become a new market disruption?

- Is there a large population of people who historically have not had the money, equipment, or skill to do this thing for themselves, and as a result have gone without it altogether or have needed to pay someone with more expertise to do it for them? –
  - ✓ Enormous target market, especially people in 3<sup>rd</sup> world countries with no access at all to healthcare.
- To use the product or service, do customers need to go to an inconvenient, centralized location? -
  - ✓ Doctors surgeries or hospitals can take weeks and eventually months to be fully diagnosed.

#### 2<sup>nd</sup> set – Explores potential for low end disruption

- Are there customers at the low end of the market who would be happy to purchase a product with less (but good enough) performance if they could get it at a lower price? –
  - ✓ Not strictly tested or known but there is no low end of the market as the only people who would buy dermatoscopes are healthcare organisations and medical professionals for top prices. Our low-end product would be strong in its own category.
- Can we create a business model that enables us to earn attractive profits at the discount prices required to win the business of these overserved customers at the low end? - ✓ same as previous point, new market but currently next to impossible to buy your own product.

3<sup>rd</sup> set - Once an innovation passes the new-market or low-end test, there is still a third critical question

- Is the innovation disruptive to all the significant incumbent firms in the industry? - ✓ It's a product that doesn't have a massive market now but would disrupt the few that do produce, high quality, highly priced components.

#### 4. Porters 5 forces

Following on from disruptive innovation Porter's 5 forces of competition focuses on how your business is susceptible to attack from rival companies. Designed by Michael Porter in 1979, to analyse a potential industries and likelihood of profitability, its become a prominent tool in business strategy. (www.mindtools.com, 2019)

*"The collective strength of these forces determines the ultimate profit potential of an industry"- Michael Porter.*

(Porter, 2008)

**Figure 1. Porter's Five Forces Model General Framework**

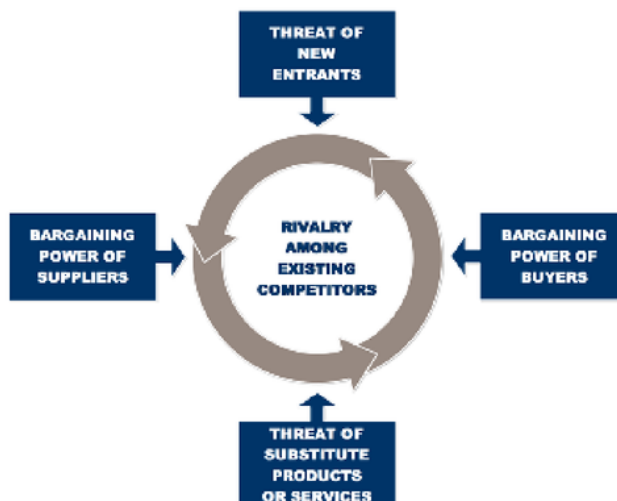


Figure 2

In order to sustain profitability of our dermatoscope we must recognise and respond to the competition. If you don't keep tabs on your rivals and investigate how they can damage your business and profitability. These 5 forces will vary in influence across different product markets due to the nature of demand e.g. In air travel, rivalry is intense between dominant producers like Airbus and Boeing and the bargaining power of the airlines that place huge orders for aircraft are strong, while the threat of entry, the threat of substitutes, and the power of suppliers are miniscule. (Porter, 2008) However, Porter explains that you must have a solid grasp of which factors apply to you and how to deal

with them if you want to be successful. I will list them and then contextualize them to our product and discuss possible solutions and how Porter's article in the Harvard business review, suggests countering them.

1. Competitive rivalry

This looks at how many competitors you have and their strength. Who are they and how does the quality compare to your product? Where rivalries are intense, companies are always trying to undercut one another to attract customers.

This market however doesn't have any bargain basement equivalents so will stand alone in this category, this should lead to large profits and control of the market. This is exactly what Porter suggests by investing in products that hugely differ from competitors' offerings.

2. Supplier Power

This deals with how much power the supplier has over us in terms of upping their production costs. Most dermatoscopes are manufactured by large medical companies who charge large amounts due to the precision and quality of their instruments but still they are made of basic materials. Our suppliers are vast and the product can easily be mass produced across the world as it will consist of nothing more than a plastic mould with some lights, a polarized lens and a magnifying lens. Standardising our products specifications will mean more ease of movement between vendors.

3. Buyer/Customer Power

How easy will it be for customers to drive the prices down? Do we have a small number of customers who hold or the power or large amounts meaning you hold all the power?

Our model is a disruptive innovation. Under this very premise we know how important it is for companies to develop innovations that threaten their very own

products as if you don't then someone else will. Once developed it will be imperative to try and disrupt the product both in both directions, i.e. cheaper and more expensive alternatives with greater or less function but same value. Owing to it being as cheap as possible, the customers won't be able to threaten elsewhere as it won't exist, for now at least. That brings us on nicely to the next force.

4. Threat of substitution

Can customers find an alternative way for doing what your product offers? How easy would it be for them to devise and prepare a cheaper substitution that can weaken your position in the market and inhibit profits?

Again, this is a disruptive innovation so the product will do a job to a standard that's not currently available but due to the simplicity of our premise, the threat of substitution is high as its easily replicable. We will have to look at a unique design and the prospect of a patent.

5. Threat of New entry

New entrants to a market will always try to bring something new to the market and this therefore puts a cap on the profit to be made as someone will always do it cheaper and companies price match each other to stay afloat. The threat of new entry depends on the barriers that inhibit newcomers to the industry and the retrospective action of the already present businesses. For this particular market, threat of entry is high, but we must ensure our product is as cheap as possible.

*"It is the threat of entry, not whether entry actually occurs that holds down profitability"*

(Porter, 2008)

## 5. Value Analysis & Value Engineering

In order for us to deliver a successful product that disrupts the current dermatoscope market, we need to address value. Value in manufacturing is all about delivering the greatest amount of function for the lowest cost

I.E.

Value = Function ÷ Cost

Value analysis and value engineering are two powerful tools for analysing products in terms of value by either increasing the function, lowering the costs or both. Value analysis is concerned with existing products and Value engineering with new.

It is vital to employ VE before any investment in the product because upto 80% of the costs are locked in at the design development stage.

([www.advice-manufacturing.com/Value-Analysis](http://www.advice-manufacturing.com/Value-Analysis), 2019)

This backs up the 10:100:1000 theory in terms of cost first proposed by George Labovitz and explained to me by Dr. J R Thomas that states as material and information moves through the processing system, the cost of correcting an error multiplies by ten.

([www.dqglobal.com](http://www.dqglobal.com), 2019)

If we correctly use VE we can identify a problem in our own area and easily correct it before it gets to the customer and needs to be recalled and corrected at huge financial and disreputable cost to the business. VE of new products follows similar guidelines to VA but is performed late on in the development stage of the new product so we will come back to that later

VA focuses on existing products and using a functional analysis, evaluates the product in numerous areas like cost, ease of assembly, function and others. Once broken down into these functions the cost is addressed as well as the value to the buyer.

In order to better understand the current, low-end dermatoscopes on the market, we'll now break down our "Derm-lite HUD iPhone SE/5/5S" product into its component parts and functions to see where we can improve them.

## 6. Skin cancer theory

Arguably the largest health crisis we face as a species today is that of cancer. A condition of many different forms with no direct cure for any of them remains a mystery to medical professionals the world over. The rise in skin cancers today are attributed to many factors. Mass emigration of fair-skinned Europeans in the last two centuries to warmer climates i.e. the Americas, Australasia, rising global temperatures and hedonistic recreational exposure to the sun and lifestyle choices are to name but a few. Twenty years ago, skin cancer was the 27<sup>th</sup> most common cancer in the U.S but now the 7<sup>th</sup> and as well in the UK, about 1800 people died of skin cancer each year.

(Agnew, 2005)

### What is cancer?

Our body and its various parts are comprised of cells. These cells are all uniquely different, e.g. brain cells, lung cells etc. These cells are constantly growing, dying, replacing and multiplying. Cancer occurs when normal cells in the body become abnormal due to mutations the genetic code in the D.N.A of the cell.

([www.worldwidecancerresearch.org](http://www.worldwidecancerresearch.org), 2019).

Cancer starts when these gene changes cause the cells to multiply too much and they become a growth called a tumour. Once the tumour reaches the size of a grain of sugar, it requires its own blood supply. It sends out chemical signals which hijack the body's blood vessels, supplying it with nutrients and oxygen allowing it to grow. As the primary tumour is now connected to the blood supply, cancerous cells can break away and be spread through the blood around the body (metastasize) causing further damage.

([www.cancerresearchuk.org/about-cancer/what-is-cancer?](http://www.cancerresearchuk.org/about-cancer/what-is-cancer?), 2019)

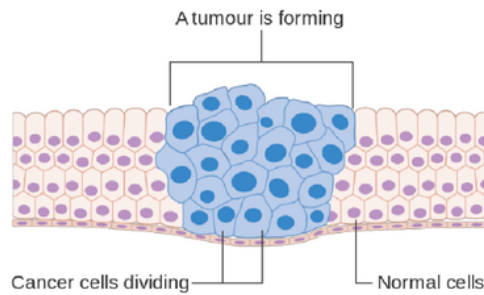


Figure 3

### Skin cancer

Most people understand prolonged exposure to the sun can have a very damaging effect on the skin but it's the main modifiable risk factor in developing skin cancer.

(Crocetti, 2015)

There are 5 main groups of cancer depending on the type of cell they start in. Skin cancers belong to the carcinomas, meaning they originate from skin or tissues that line internal organs. These are the most common type of cancer and makes up 85% of all cases in the UK.

([www.cancerresearchuk.org/about-cancer/what-is-cancer?](http://www.cancerresearchuk.org/about-cancer/what-is-cancer?), 2019)

Benign lesions on the skin are common and do appear in young adults and often stay for years without changing or disappear over time. It's very uncommon for these to turn malignant but it can happen. There are many types of common moles and tags which we see everyday and usually < 6mm in diameter.



**Junctional Nevus**



**Intradermal Nevus**



**Compound Nevus**

*Figure 4*

## 1. Malignant melanoma

The main characteristic of a malignant melanoma is change especially enlargement and changing pigmentation. Sun exposure is involved in at least two thirds of these malignancies. The main malignant melanoma type is Superficial spreading melanoma making up about 80% most frequently seen on men's backs and women's calves. These are easy to identify and there are many simple checks to analyse their severity.

The ABCDEF criteria and Glasgow checklist can easily identify concerning traits the melanoma has and is still a vital tool although particular emphasis places on the "E for Evolving" criteria.

(Abbasi, 2004)

| ABCDE Criteria                                                                             | Glasgow 7-Point Checklist |
|--------------------------------------------------------------------------------------------|---------------------------|
| A – Asymmetry                                                                              | 1. Change in size*        |
| B – Irregular borders                                                                      | 2. Change in shape*       |
| C – Multiple colors                                                                        | 3. Change in color*       |
| D – Diameter >6 mm                                                                         | 4. Diameter $\geq 7$ mm†  |
| E – Evolving (with respect to size, shape, shades of color, surface features, or symptoms) | 5. Inflammation†          |
|                                                                                            | 6. Crusting or bleeding†  |
|                                                                                            | 7. Sensory change†        |

\*Major criteria.

†Minor criteria.

Figure 5

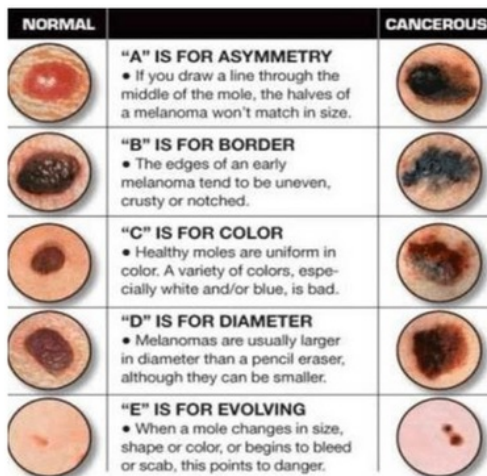


Figure 6

If our product can deliver 100% repeatable images of lesions, the customer will be able to keep track of their changes, if any, and take appropriate action.

## 2. Basal cell carcinoma (BCC)

This form develops mainly on the face and are not as easily diagnosed as melanomas are as they don't really look like moles but often more translucent, pearly nodules containing capillaries that enlarge. Clinical assessment is usually enough for diagnosis but it's often complicated to determine exactly which BCC the person has as there are many, so our product isn't ideal for this sort of lesion. A biopsy is usually required for successful diagnosis. However, the potential for metastasis is small and even when it's a giant BCC, there are very few reported cases of lymphatic metastasis so it's not as primary concern as self-diagnosis of melanoma.

(Agnew, 2005, pp. 40-46)

## 3. Squamous Cell Carcinoma (SCC)

This also develops on sun-damaged skin on the areas with highest UV exposure all over the body in males and females. Most commonly, people have Bowen's disease which can lead to a SCC. A red/pink crusty patch roughly resembling psoriasis or eczema on the skin and is easily treatable.

(<https://www.nhs.uk/conditions/bowens-disease/>, 2019)



*Figure 7*

Keratosis is the umbrella that a lot of benign crusty, yellow skin lesions fall under but these develop into SCC's. Diagnosis of an SCC is often made clinically or by biopsy if there's suspicion of invasive malignancy. Treatments are usually non-surgical but there are still low risks of metastasis even in non-sun exposed regions. This type of skin cancer could use our dermatoscope for diagnosis but it's not as urgent as a suspicious melanoma and more than likely, is something less sinister and a trip to the doctor should alleviate any concerns.

#### Key Points

- Melanoma usually manifests itself as a changing existing pigmented lesion. It's by far the most grievous of all the cancers but usually the easiest to distinguish. Early detection is key to avoiding further growth and risk of death.
- There are many types of BCC but they usually share the main characteristic of being a whitish, pearly nodule that grows very slowly. As there are many types, a biopsy may be necessary for exact diagnosis but often a clinical examination is sufficient.
- Invasive SCC usually occurs in an area of existing keratosis and a biopsy is often required for diagnosis.
- Melanoma is the highest priority to diagnose early and that's what we should focus our impetus on with this project.

(Agnew, 2005, pp. 51-62)

## 7. Polarised light

Dermatoscopes usually all have a light source attached or near the lens to illuminate the skin under inspection. What separates them however is their ability to use polarised light. Light, usually referred to as visible light, is simply electromagnetic radiation that our eyes can see due to its frequency. Visible light is no different from any parts of the electromagnetic spectrum it's just we can see it at wavelengths 400-700 nanometres.

When light travels its electric fields are travelling in all directions. Most people know polarisation from sunglasses or photography because it blocks out any unwanted light or glare, to give a clearer image. What's happening here is that the electric fields that were travelling in all directions have now been limited to one single plane, meaning all would-be reflected light has been removed.

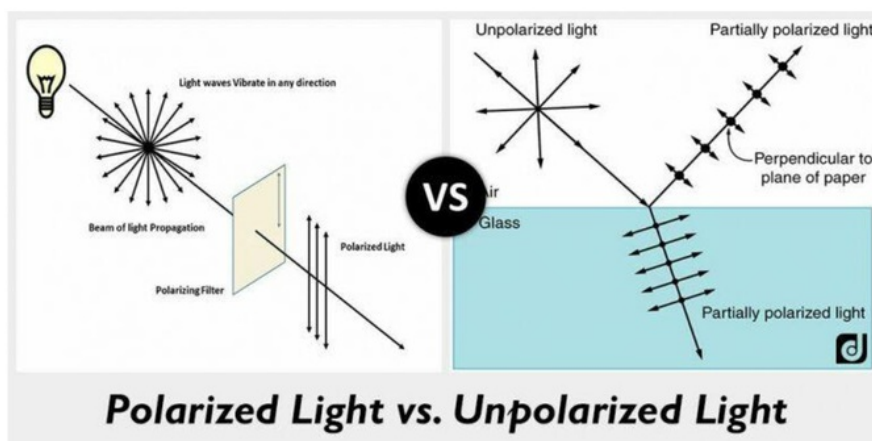


Figure 8

If we want to ensure we have the clearest image we must use a filter which will give us p-polarised light (light which has an electric field direction parallel to the plane of incidence) and design our spacer at Brewster's Angle. Brewster's angle takes advantage of a naturally occurring phenomenon as seen above whereby the angle of incidence of the light hits the material, that light comes back polarized. From looking at the design of the DERMlite it looks like that's what they've tried to achieve as it's roughly the critical Brewster angle of water, 53 (skin) and glass, 57 (lens) respectively.

(Abrahamowitz, 2019).

Why this been done however remains a bit of a mystery because polarisation can be achieved with a polarising filter which are widely available online in all sizes.

Polarised and non-polarized do complement each other and both have desirable qualities but for our design, we want to focus on the detection of malignant melanomas which polarised light is better for. Melanin looks sharper and darker and it shows blue nevi in a lesion more clearly.

(Benvenuto-Andrade, 2007)

Its also imperative that we design a product that harnesses this possibility for clearer more accurate images to get the edge on our market rivals.

## 8. Functional Analysis

By running a functional analysis, we can see many things i.e. How much does each function cost and also, how valuable is that function to the customer in the end? This will allow us to only include vital components and functions into our design and maximizing value for the customer.

Even though a product has a specific purpose, it can be broken down into many constituent functions required to achieve its sole purpose.

As we can see the product is made up for four constituent parts.

- A) The lens attachment- this includes 2 LED's, a battery and USB charge port for the battery.
- B) The adjustable rack stick (male)
- C) The port for the rack to clamp the phone (female)
- D) Clip for part 1 to sit on the rack



Figure 9

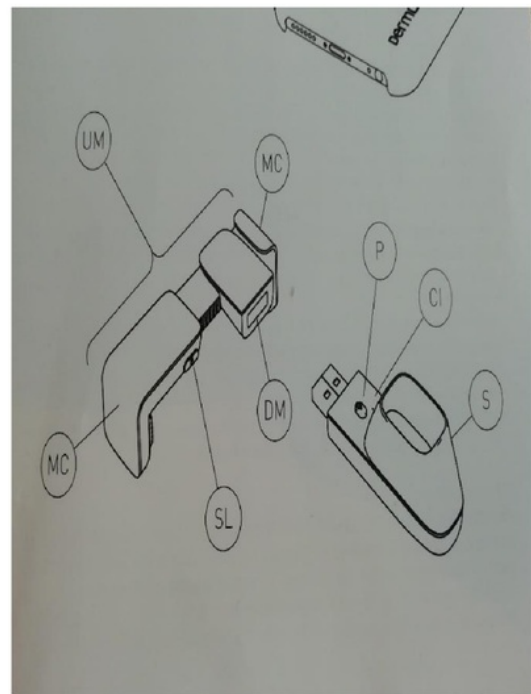


Figure 10

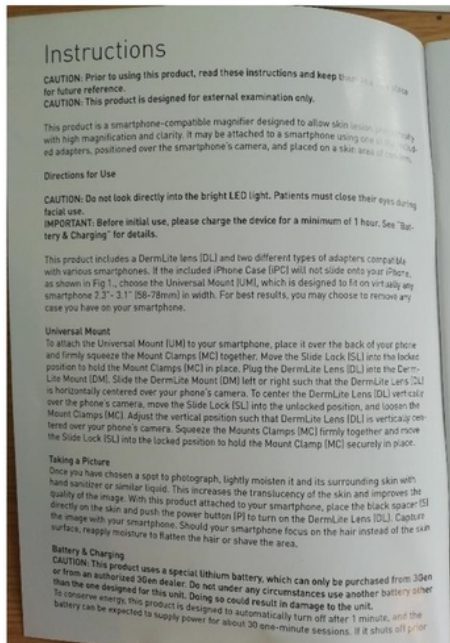


Figure 11

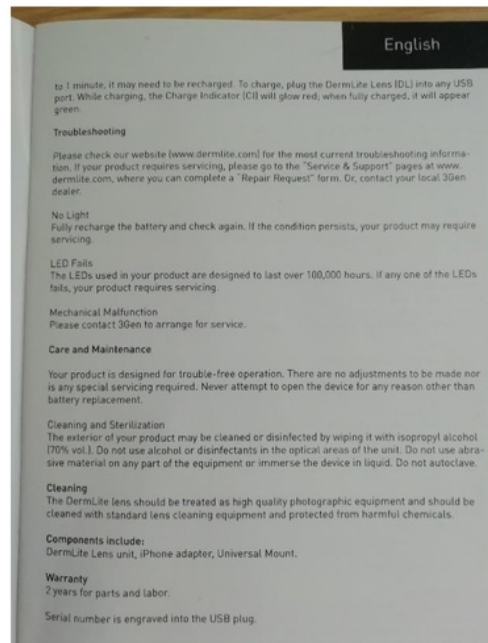


Figure 12



Figure 113

Its important to note that there are no screws, fasteners or nuts with this assembly. Everything is clued or clipped together which will save costs but mean once it breaks, it is not designed to be fixed

#### Part A) ( lens/LED housing)

From figure we can see that (A) has the Spacer (S), power button (P) and Lens ( DL, it says CL on the picture but it must be a mistake as it's not in the book and on another picture its labelled as DL)

Bill of materials for each component

#### A) Dermlite lens piece

- USB charge port with special lithium battery- unique to 3Gen dealer (Purchased part; PP)
- White top and black bottom (printed or most likely injection moulded)
- Attached Spacer (S)
- 2 LEDS' (PP)
- Small black ring around visual hole for lens (printed)

#### B) Dermlite mount

- Black side (printed/ moulded)
- White side with hole through for rack to slide (printed/ moulded)

2 Parts make the universal mount for the phone but we'll look at them individually.

#### C) Mounting clamp with rack

- White side with rack (probably printed due to detailed rack for B) to slide on for positioning.
- Black side
- Soft rubber for gripping phone

#### D) Mounting clamp

- Main white side with holes for rack to fit into (IM)
- Black casing

- Soft rubber grip
- Black toggle lock switch for locking rack into correct position for image capturing

From studying the whole component there are only 2 of the same part once and that is the rubber grips on C and D so therefore, 13 different parts, including 2 LED's, make up the finished dermatoscope.



Figure 14

#### Positives of this design

- The rack feature means it will fit any phone width and can be placed to line up with the phones camera lens on most models.
- It lights up the lesion for you and the 2 LED's next to each other provide increased illumination.
- Its easily charged in any USB port
- There are no screws, fasteners or nuts with this assembly. This saves on cost and assembly time

#### Negatives of this design

- Far too many different parts to be produced to complete finished product
- Excess material leads to more expense in manufacture

This is the major flaw in this design and can be addressed in many ways. Bob Eberle developed the acronym of "SCAMPER" to get ideas going of how to look at these parts

- i. **Substitute**
- ii. **Combine**
- iii. **Adapt**
- iv. **Modify/Magnify/Minimize**
- v. **Put to other uses**
- vi. **Eliminate**
- vii. **Reverse/ Rearrange**

(Childs, 2014)

We need to massively reduce the amount of parts, especially moving ones, and there's many ways to do this to be looked at later.

- It requires the phone and device to have power. Its no good if its dead as it becomes useless
- As stated in the handbook, the batteries are unique to 3Gen and that makes them more expensive and will most likely involve a return to have fitted.
- NO polarized filter or lens to reduce surface reflection, instead it promotes the use of contact fluid film
- Doesn't fit all smart phones e.g. Huawei, as it must sit over buttons on the side. There is an alternative sleeve to the mount but that's more production costs we don't want to incur.
- As we can see, there's black and white plastics in the finished product. This might be the same type of plastic but they may be painted in house just for the aesthetic. This can be cut out to avoid expenses.
- It does seem a bit delicate and fragile when fully assembled as it is quite long and not fixed at the top to the camera. This could be altered by having a larger or largest part as the base or fixing it at the top as well as the sides.

## 9. Design for Assembly

If our product is to successfully disrupt the current dermatoscope market then we must first look at what the competition is. By looking at what our competition have come up with and trying to see how they went about their design we can learn from them but reverse engineer and try to simplify and consolidate components parts.

When completing this design for assembly we must focus on our two main aims.

- 1) Simplify the product so that the cost of assembly is reduced.
- 2) Improve quality and reliability whilst also reducing production equipment and number of parts.

Earlier we mentioned SCAMPER and is perfect for our design. From looking at this design of the DERMlite one major flaw we saw is its lack of rigidity and strength when gripping the phone. Due to its sliding rack its not the most accurate and to gain a clear image of a lesion the lens must be held also next to the phone's camera.

This had lead to the conclusion that our model will be one extruded base made to fit the phone exactly, in this instance, the most popular phone out there being an Apple iPhone 8 plus. This has been chosen as it's the latest generation of iPhone and they're guaranteed to sell well so we have the largest target audience.

Design features we must incorporate.

- Reduce the multiple parts to one base clamp- This can be easily and cheaply manufactured using an injection mould. This will incorporate parts B, C and D by removing the movable rack, two side grips on the universal mount.
- Do not incorporate LED's or exclusive battery - The DERMlite's 2 LEDS opposite do provide a better illumination for the lesion but this light is not polarised. To gain a better clarity of picture, it says in the handbook to use apply a gel to the epidermis but this relies on having some to hand to use the product which takes a lot away from its durability. Using the iPhone already existing light (seen below) we can have one strip across the phone horizontally (Injection Moulded) with a hole large enough for the phones lens and light to be seen.



Figure 15

- Similar Spacer to dermlite - However ours will not contain LED's, just a 10X lens and polarising film on top. The light from the phone will be sufficient and with the polarising filter and the newest camera on the market in the phone, image quality will be guaranteed.
- Magnifying lens quality – The iPhone 8s has a sufficient camera and zoom capacity but this Dermlite doesn't have a particularly good lens or even state what it is. Most dermatoscopes have a 10X zoom lens and this is what we must include in our design. The image below was captured using it and although the mole itself was <3mm, most possible melanomas we know exceed 7mm, but the image magnification is very poor and would not allow for accurate diagnosis.

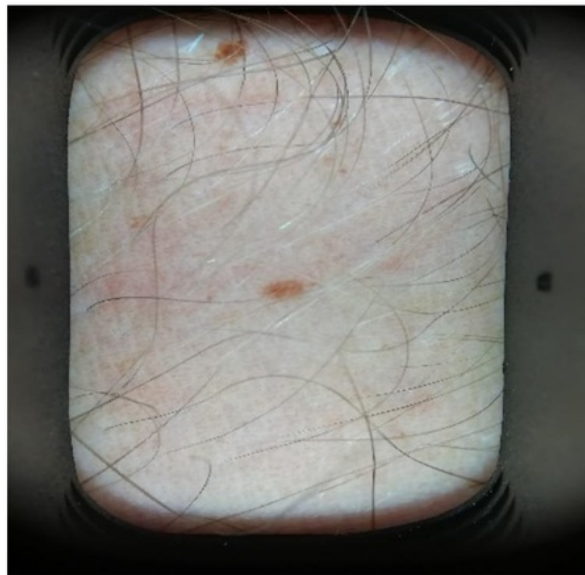


Figure 16

#### Predicted Costs of manufacture

- Injection mould of mount roughly 80mm x 10mm x 5mm – for small designs were looking at about £1000 for the mould but we are saving costs on tooling and material as the mould is tiny as well as production costs as it would not take long.
- Injection mould of spacer inc. 10x lens and polarized lens- polarized lens can in many shapes we'd have to see how it would fit but its possible to get an A4 sheet of it for £9.60

The production of 1 unit will probably cost around £10-£20 but its an assumption and we must design and manufacture before we can evaluate again and lower costs.

(//www.3dhubs.com, 2019)

(www.amazon.com/Polarizing-Film-Sheet, 2019)

## 10. Conclusions

The aim of this project was to investigate the necessary processes and procedures before production to ensure a successful end product. By studying the best current alternative product out there we have seen the faults in its design and the approach its manufacturers have taken.

Through studying breakthrough theories, strategies and aids available to us in the world of manufacturing, we have proposed a new design for an existing product. This will not only will do the job better, but through combining and reducing components, generated a better value product which will attract a new target audience and open up disruptive markets. This research has been backed up by all relevant sources listed in the bibliography.

## 11. Further Work

The next stage is to prototype and model using 3D printing just to gain an insight of its functions. Once the 2 components are manufactured and lens manually inserted, we'll test the accuracy and durability of the product. Once this using the techniques we've presented here, VAVE, DFA etc. greater refinement and a better idea of cost and necessary features/limitations etc.

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