



# Product Design – The Shell Shack

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PORTFOLIO – CHARLIE LYES

CENTRE NUMBER – 62451

CANDIDATE NUMBER - 9108

# STRAND 1 – EXPLORE

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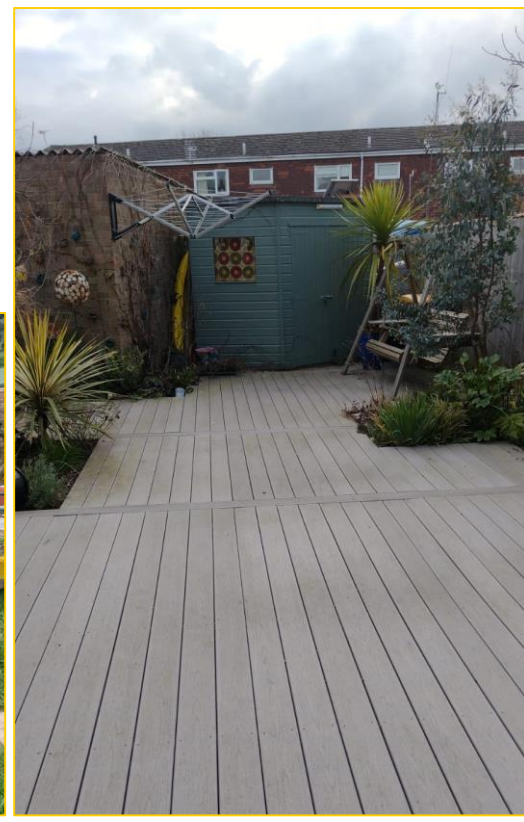




## - Potential Product Locations -

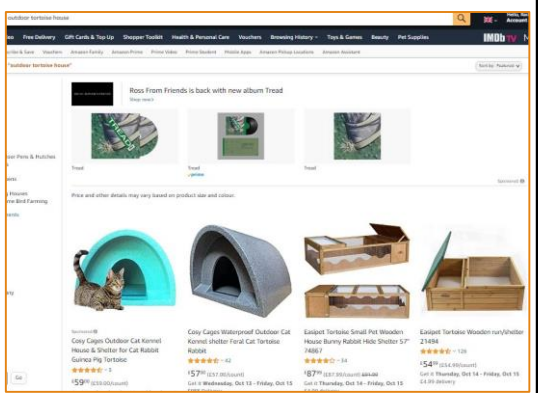
Before making a informed decision on stakeholders and clients, I conducted a small survey where I contacted some local residents of several nearby towns and villages and gathered photos of their gardens and outdoor living areas to get a wide variety of locations that my product would have to be able to adapt and fit to. As you can see from below all these gardens are different and have their own needs and wants, equally due to the different environmental factors, this means that more care must be taken in weather proofing the product to suit all, such as:

- The terrain: some gardens will be grass/lawned, some will be decked, some will be stone so the bass of the product must be able to cater for all of this.
- Water: some gardens are denser than others so have different drainage capabilities so the product must be able to protect against this.
- Pets: some gardens have nosy pets so the product must be secure against them.



I have conducted some secondary research into existing products that could potentially fit the needs and wats of my end users however there is a big gap in the "SELF SUSTAINABILITY" & "LONGLIFE" of these products, equally there aren't any existing products that are naturalistic or innovative.

**Amazon.co.uk: outdoor tortoise house**  
<https://www.amazon.co.uk/outdoor-tortoise-house>  
 I was very surprised with the variety of products on amazon - I thought there where a few innovative design shapes, but none however would meet the needs and wants of my end users. But could potentially have some beneficial shapes to them.



## - Existing Products -

**Tortoise Outdoor House on eBay - Earth's Largest Marketplace**  
<https://www.ebay.co.uk>  
 Ad Free Shipping Available. Buy on eBay. Money Back Guarantee!  
 Fill Your Cart With Color - Make Money When You Sell - Returns Made Easy - World's Largest Selection

I love these products - I thought that the uniqueness of the designs are great and very innovative they could just be more self sustaining with heat or water.

**Tortoise | Pets At Home**  
<https://www.petsathome.com/shop/en/pets/merch-groups/mg-083>  
 Sep 21, 2021 · Tortoise | Pets At Home

CLICK LINKS TO WEBPAGES!

This website - pets at home - is probably the most known supplier in the UK - they do have a better variety of housing that does include some of the basic needs e.g., heat built in however this too lacks some features such as outdoor use as it couldn't sustain a living animal in it aswell.

**Trustpilot**  
 TrustScore: 4.6 | 16,768 reviews

Showing our 4 & 5 star reviews:

- On time every week an... (17 reviews)
- Goods can quick and w... (40 reviews)
- Easy to use website (15,798 reviews)

Zoo Med Tortoise Play Pen Outdoor Enclosure: £94.61

Zoo Med Tortoise House 910x810x305mm: £131.28

**Outside Tortoise Enclosures - UK's Most Trusted Reptile Shop**  
<https://www.reptilecentre.com/tortoise/enclosures>  
 Ad Selection Of High Quality Outdoor Enclosures, Suitable For Your Pet Tortoise. Get Free Next Day Delivery When You Spend £79+ Before 12pm. Shop Now!

This website who claims to be the no.1 tortoise retailer in the UK however the houses lack the basic needs of the animal - I could potentially develop these ideas into something that would suit my user needs, overall, I think that these products would be more suited for a domesticated animal like a rabbit or Guinea pig. So would need changes to suit a tortoise.

Using this secondary research, it is evident that there is definitely a gap in the market for a self sustained reptile outdoor house, although there are similar products that fit some of my criteria needed online there is not one that fits the whole thing. So, I will do some primary research in local pet shops and see if I can find any products that I can use for inspiration to my own one.

**Primary Research:**  
 After completing some secondary online research to see the leading online retailers for tortoise health and care I have decided to conduct some primary research in local pet shops, Blakes, Pets @ Home, Notcutts Garden Centre. I will do a similar process to the online research in which I will observe the current products on the market and see if there is indeed a gap for my own one and whether I can use current products as inspiration or adaptations for my design process.



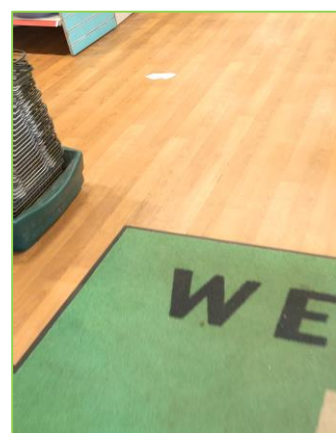
I visited Pets Corner in Didcot to conduct some primary research to see what products and components that are preexisting could I incorporate into my reptile housing project. I will be looking for products that can provide basic needs such as heat, water, comfort, security.



These products give me a good inspiration to incorporate NATURALISM into my design to allow the reptiles to feel more comfortable in their hereditary and natural habitats so mimicking that with either external products or making rock features is clearly desired by market.



At Pets corner there were also several preexisting pet enclosures and cages with evidentially will not be sufficient for the self sustained product that I am investigating, this shows that there is indeed a gap in the market for a self sustained reptile enclosure. Equally this shop also is a supplier of certain heat elements that are required for the health of the animals such as heat mats and bulbs as well as thermometers and heat regulation equipment.



I also visited the Pet shop chain Pets at Home as I thought that getting some primary research from a big chain business would likely yield better and more comprehensive results. I looked for the same basic needs:



Pets at home I found to be very helpful in market research for my product, they supplied a larger and more comprehensive range of heat equipment and pet security such as locks, equally they supply a larger range of heat bulbs that means the design can vary to fit the different shapes of bulbs. I also love the again use of recycled wood and rock effects which from an ethical standard allow the animals to thrive in a happier location which is the end goal.



I was slightly disappointed by the lack of outdoor reptile runs and houses as I do need some inspiration by the lack does show that there is room for me to make one as the pets at home products double as rabbit and guinea pig houses which do not fit the criteria.



Finally, I decided that it would be best to visit a final third pet shop to see if that there would be any other interesting products or techniques that I could apply to my designs or research. The results are as follows below:



Notcutts yielded the same results with heat and security as pets' corner and pets at home, however they gave me further insight in water and comfort as they supply animal water filters that would be beneficial in working as water

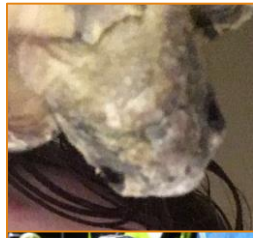


Filtration system which kills bacteria and filters dirt which would help the animals, equally they supply soil substrates with enriched calcium which would be useful in lining the base of the pet shelter when it is complete to allow for a good amount of nutrients from the calcified soil, it would also appear to be more homely to their ancestral living conditions



**Conclusion:**  
In conclusion it is evident from my primary and secondary research that there is indeed a gap in the market for a self sustained reptile house that is sufficient in heat, water, comfort & security, it is clear that I need to consult some potential stakeholders to find interest in my project. From both online and I store research I can see that although there are some similar products available, such as pre existing external runs and homes, there are however no sustained ones or the products that exist have very basic functions and are in no way desirable or long lasting.

## - Primary Users & Stakeholders: -



### Client Profile:

- Name: Frank
- Age: 5
- Occupation: He's a Tortoise...
- Needs:
  - Heat
  - Clean water
  - Lighting
  - UV - From the Sun
  - Insulation
  - Shade
  - Food

Frank will be the primary user for this project and it will be centred round his own needs, there will have to be special precautions put in place though to ensure he is safe to use the product. It will also need to have a long life due to tortoises life span and growth rate meaning it will need to be large.

### Client Profile:

- Name: Andrew Lyes
- Age: 48
- Occupation: RAF Aircrewman
- Needs:
  - Safe secure space for pet.
  - Needs to have the ability to be self sustaining.
  - Have the product be moveable.
  - Have the product be lightweight or collapsible
  - Insulation
  - Shade
  - Food
  - Most importantly will need to have a naturalistic design.

Andy will ultimately be the stakeholder and the primary user of the product, his needs are very similar to the tortoises needs as he needs the pet to remain safe and happy in its new environment. **He ALSO REQUIRES THE PRODUCT TO BE "A HOUSE OR VIVARIUM SORT OF PRODUCT"**



### Client Profile:

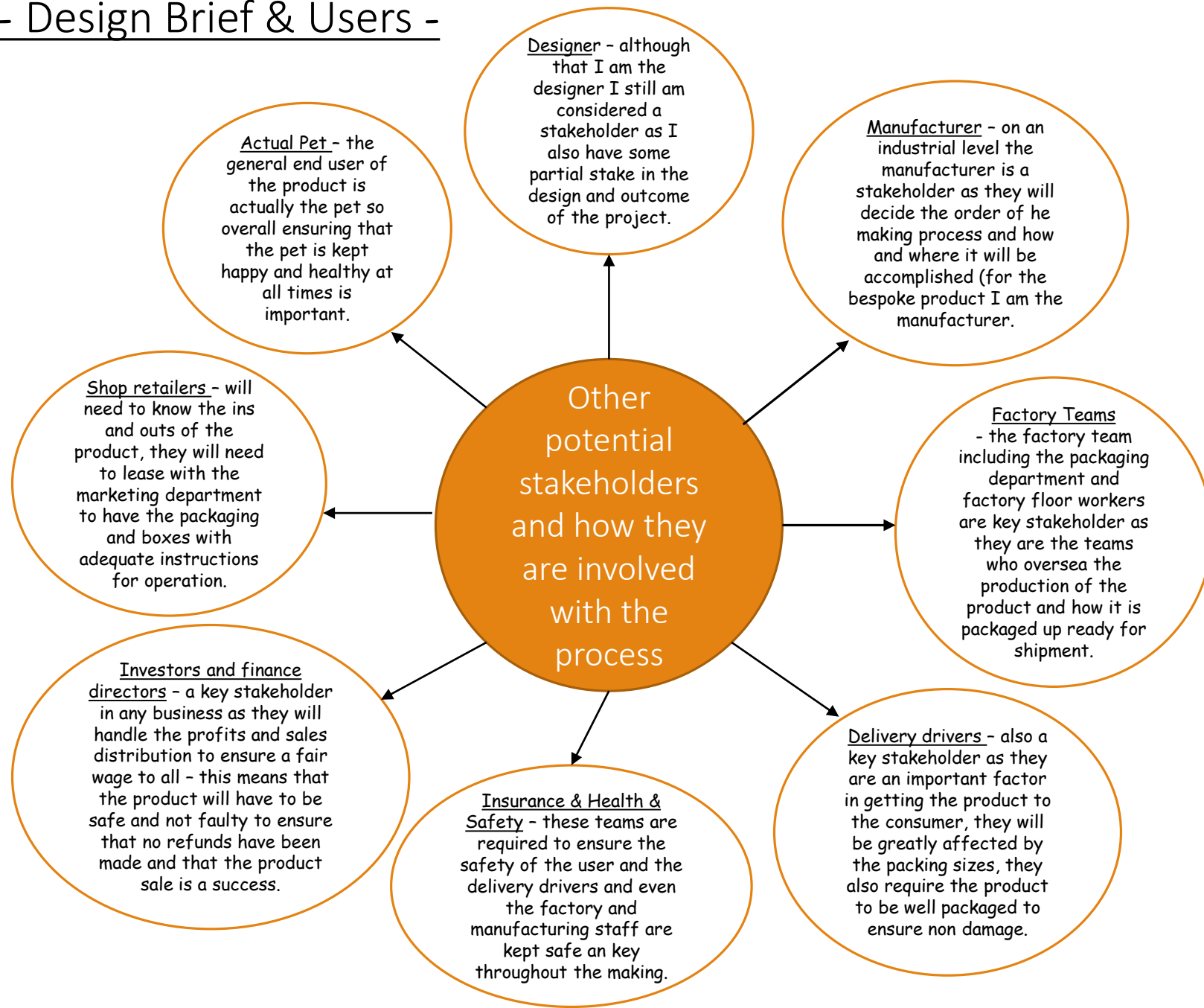
- Name: Martin Turner
- Age: 50
- Occupation: Carpenter
- Tortoise: Zippy, aged 11, 30cm long, Eastern Hermann's Variety
- Needs:
  - Some form of window to allow the tortoise to have a natural source of light as opposed to UV lamp.

Martin wants an outdoor pen that is moveable and insulated whilst remaining waterproof, he wants it to be slightly raised of the floor and needs a covered area and possible roaming area with a large collapsible run.



In order to have a successful product I will centre the design ideas around the needs and wants of the stakeholder and end users of my product. From my design brief/context and the response from my stakeholders I need to now come up with some suitable designs/ideas for reptile housing as this the product that is sort after. How ever it would be more prudent for me to invest my time into some research both primary and secondary for my project.

## - Design Brief & Users -



### Final Design Brief:

To begin my project I started off by exploring problems with reptile housing in todays society - more specifically outdoor housing, I concluded that there was a gap in the market for a reptile house that is too some extent self sustaining with heat, water etc. further research online greatly proved my point. After gaining, contacting and meeting with a few stakeholder/end users they have given me a list of criteria that they want included in their designs, ultimately for me it is important to consider the sustainability of the product and the durability and making sure that it is as eco friendly as possible by using a variety of materials and joining methods. Equally it will be important to consider the marketability of the product on an industrial scale.

### Next Steps:

I now need to conduct some primary research into local pet venders and contact some zoos and/or focus groups to get some feedback/inspiration for my product on a larger scale. Equally I will need to "touch bass" with my users and get their opinions on what materials I should use after I conduct a thorough investigation into the different types of materials I could potentially use.

# - In Depth Interviews With My Clients -



Initial interaction with client martin turner, I introduced myself and explained the product concept I was looking to make and asked whether he would want a "stake" in the product and if he and Zippy his tortoise would want to be a client of mine! From our initial chat it is clear the Martin has an indoor vivarium to sustain his tortoise's health but is looking for an outdoor project of sorts for the summer months when Zippy can live outside. So I now have a second client to use.

Hello Charlie, greetings from Kenya. I love the research you have done in the materials and I think the choices you have made for wood over metal and then the potential use of clay and fiberglass is very impressive. I am especially impressed with the in depth detail you have made for the research into the specific technologies needed for the tortoises health. I would want a heat mat to be used rather than a heat bulb due to its price and ease of replacement.

As requested I have come up with a list of specifications for the product which I need you to follow they are:

- Naturalistic in looking
- Sufficient Heat Source
- Sufficient access to clean water
- Easily moveable and well balanced
- Design must lightweight
- Long lasting
- Design must be cost effective

Please do send me your designs when you have produced them and I will be back in the country for a little while so I am available for some more handwritten notes and a comprehensive chat if needs be.

Keep at it!

Andy Lyles

[andyosandy234@gmail.com](mailto:andyosandy234@gmail.com)

Reply Forward

Hi Charlie, thank you so much for considering me to be a part of your coursework and product. I do have a tortoise and his name is Frank and I am looking for a natural looking house that can go in my garden for the summer months when the weather is hot.

Unfortunately I am in Kenya for the next couple of months so will be available for contact on occasion so please keep me in the loop with any and all developments of the project and I will see what I can help with.

I do believe that the product I am looking for is not currently widely available for sale as I am looking for a fairly self sustained with a heat source and windows for a nice view.

Keep me updated with any developments you have.

Many thanks.

Andy Lyles

[andyosandy234@gmail.com](mailto:andyosandy234@gmail.com)

Reply Forward



This client will be the primary user of the product and he has provided me with some helpful starting points for the product, he has also agreed to continuously give me feedback for my product, equally what Andy is looking for is a product that can complete these following criteria point:

- Naturalistic in looking
- Sufficient Heat Source
- Sufficient access to clean water
- Easily moveable and well balanced
- Design must lightweight
- Long lasting
- Design must be cost effective

This shouldn't be difficult to accomplish so I will now get to work designing and researching and gathering comments and feedback from various clients such as Andy & Martin to ensure that the best possible product for the clients and their tortoises!

**M Turner**  
to me

Tue, Jan 4, 11:02 AM (7 days ago)

Hi Charlie,

Happy New Year to you. I only just picked up your e-mail so I will have a look at it tonight when I get home from school and will send you over some initial feedback.

I assume you have a tortoise (otherwise a really random, weird project to choose!!!), what type do you have? We have a female Hermann's called Zippy and she is about 11 years old.

More than happy to give feedback as your project progresses. I recently finished making a new Vivarium for Zippy which actually fits under my son's bed; I'll send you a photo.

Mr T

After our second interaction it is clear that Martin wants a slightly different set of features and specifications for his use of the product, he wants the same warm and waterproof and naturalistic compound and then he would also like me to look into the outside of the product and design a form of enclosure which again will also need to be naturalistic looking.

**M Turner**  
to me

Thu, Jan 8, 10:05 AM (3 days ago)

No probs Charlie, I forgot to take photos yesterday before it got dark and am out taking down Christmas lights for the next couple of days in Thatcham which is where Mr Holden lives so it may be at the weekend I take photos.

Don't forget that all your design ideas are good and all get your marks even if the design completely changes so keep going with all the different ideas until you finally nail one that you think ticks most boxes (which should be your parents ones as they will no doubt be funding any prototype you might be doing!!!)

Because of what your parents want, it may be worth doing your design with two elements: design the warm, waterproof, natural looking 'home' and then design the compound to go around the 'home'. Look at things like wind turbines and solar panels to make it more eco friendly as well, and even storage batteries that harness the power generated for after dark. Mains is easiest but this shows you are thinking.

Better do some proper work now!!

Mr T

**M Turner**  
to me

Wed, Jan 5, 9:08 AM (6 days ago)

Hi Charlie,

First of all well done as you have clearly already put a good chunk of effort into your folder work so keep it up. I didn't realise initially that you were designing an outdoor vivarium for tortoises. You have done a fairly good mood board addressing lots of key issues. Below are my thoughts as a client/tortoise owner combined with my practical knowledge from being a Product Design technician:-

Most importantly I do not think you can actually get a heat bulb that you can use outdoors as they would need to be IP68 rated (which basically means they are waterproof). As tortoises are cold blooded and come from hot climates they are usually only put outdoors when the weather is 18degrees or higher so only tend to be outdoors for three or four months a year. This does vary a bit with species. This fact alone I think might impact your design quite a lot. As your design prototype can be a bit theoretical you can maybe use some poetic licence to invent some sort of heater that would be suitable for outdoor use as this would mean that a tortoise could spend more of the year outdoors (like when I sit under a patio heater at the pub!!!)

So - I would want an outdoor pen that can be moved around the garden so the grass does not get too spoiled in one particular area. It would have a waterproof shelter that is insulated and slightly off the ground so my tortoise (Zippy) could burrow into the straw to keep warm on a colder day and the straw would be dry. Also, a covered area where fresh food and water could be placed. The sides of the pen would need to be a minimum of 250mm high so that Zippy could not reach the top as she would try to climb out and would fall backwards onto her shell and would not be able to turn back over again. I would also want it to be quite large so that she has a good area to roam around in but I would like it to be collapsible so that I could store it in the shed or garage over winter when it is not in use. If you are keen to design a vivarium that can be used inside and outside then how about this for a thought. Make the vivarium a suitable size for indoors (I think the average minimum space you need to provide for a healthy tortoise is about 1000mm x 800mm) and make it using a lightweight material that is waterproof so it can be carried outdoors easily for the warmer months. Design it so that a portion of one of the vivarium walls (or a whole wall) can be detached. You could then have a separate, much larger pen that securely joins onto the vivarium so you have the existing warm and waterproof shelter with the addition now of a large outdoor space for the tortoise to explore. This outdoor pen part could be made up of waterproof lightweight panels that simply slot together and you can buy more or less to make the area bigger or smaller depending on the size of your garden. I have built a basic outdoor pen which I will photograph and send you a picture of as an idea. I hope this all helps and does not make your job harder!!! Photos will follow.

Mr T

P.S. Details for my Client Profile are: Martin Turner, aged 50(though I look much younger!!!), occupation carpenter(best not to put that I am anything to do with Product Design teaching). Tortoise name is Zippy, aged 11, 30cm long, Eastern Hermann's variety

This interaction with Martin proved very helpful as it allowed me and him to get more firmly on the same page and to establish the actual form of product that I am wanting to make, Martin's enclosure ideas have now got some more specifications that he wants it to have, with some ideas for the sizes and the idea for collapsibility which would be beneficial for the product. Also he wishes for the product to be moveable which is also beneficial as my other client also wants the product to be moveable. He is also looking for the outdoor pen to be made of a waterproof material and to also be lightweight, also the housing would need to have a flat inside to ensure that zippy does not flip over.

# - Key Research From Outsider Expertise-

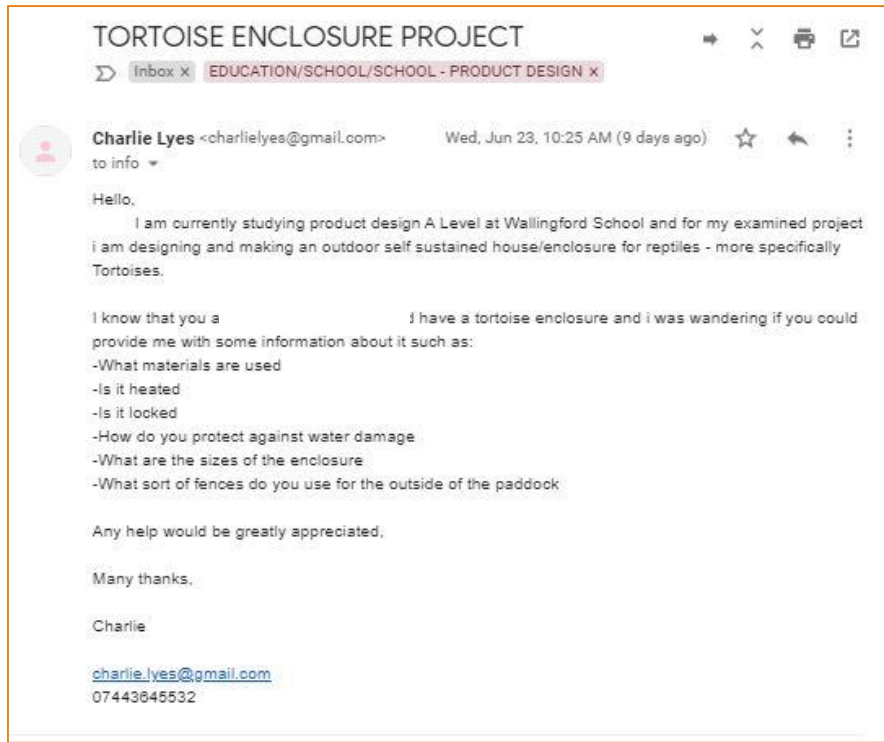
## - Primary Users & Stakeholders: -

After meeting further with my end users, I conducted a survey to see which key criteria the end users wanted me to do some more research in and then I plotted these results in a mind map. Some of which I planned to anyway however I believe that some of these questions/research could be easily answered by contacting some zoos and getting their professional opinions on the subject at hand.

To ensure that I can get a professional opinion on some of my questions and researched I reached out to two prestigious local zoos that both house reptiles and giant tortoises - obviously, this would be my product on a much larger scale however I thought that it would be the same principal just smaller. This led me to contact:

- Crocodiles of the world
- Cotswold wildlife park

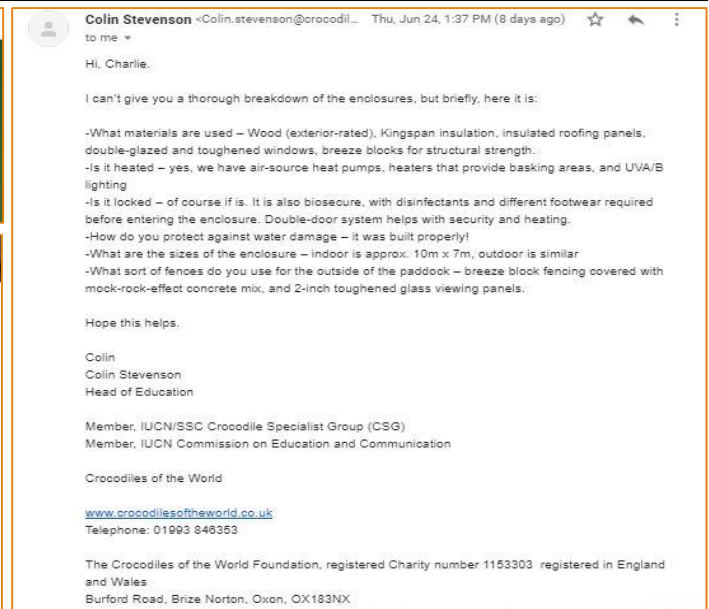
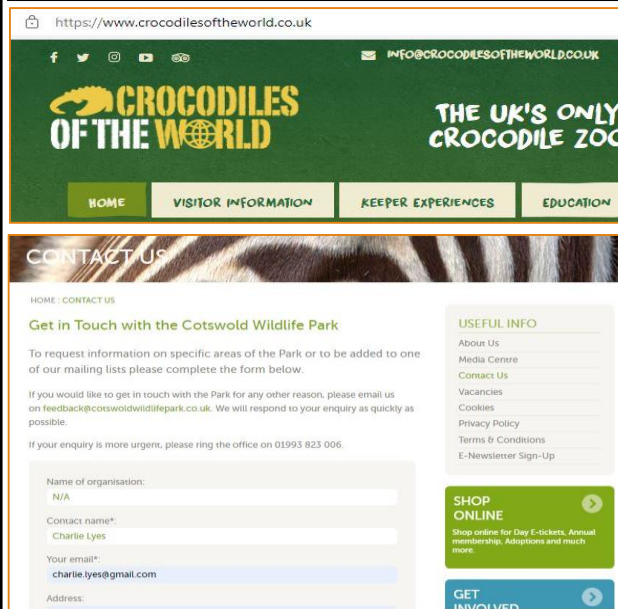
I sent them both the same email as I have seen that they have very similar circumstances with regards to animal & design (I have visited both zoos to obtain some design ideas!)



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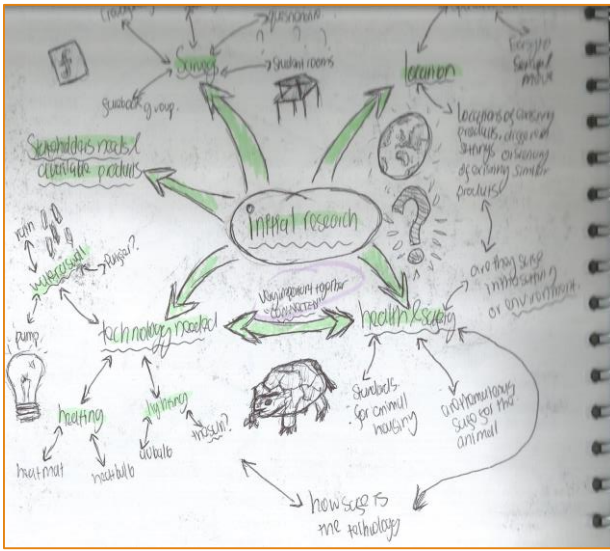


I was grateful to one of the zoos - responding with some insightful comments and help with my project and I will use his advice with my design process! Unfortunately, Cotswold wildlife park was unable to respond to my request. This was crocodiles of the worlds response which I will look in depth into now.

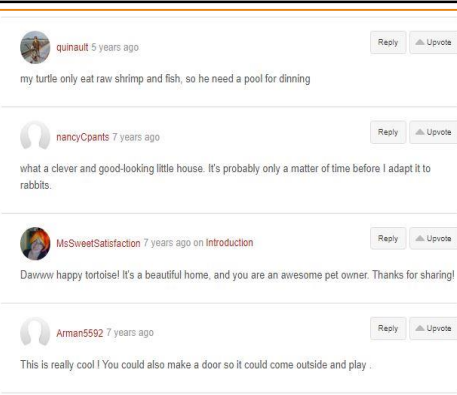


Now this information from "Crocs" was so good and useful and helps with some more of the end users queries about research, for example; "Is it heated?" there response was obviously YES and they explained that they use heat pumps and have use of insulation which ticks the box of my end users needs and wants, unfortunately they where unable to comment on how they protect against water damage so I will have to do some more research into that - I'm thinking of using rubber seals and marine plywood. Crocodiles of the world's comment about their use of materials was inspiring and extremely interesting, I especially like the fact that the roofing panels and double-glazed windows etc. were great and something that I want to include in my designs. All in all, the end user queries/questions have pretty much been answered - the only thing that is most puzzling to me is to find a veneer finish that is suitable for reptiles as some of the materials that I may use could perhaps give of some toxic fumes which is unethical to have the pets living in an unsafe environment. (SEE LEFT TO GET RESPONSE FROM ONLINE EXPERT RESEARCH)

**Next steps:**  
Use the response from end users and outsider research (zoo's) to produce a list of materials that could be used for the product.



In order to get a further marketability and some more feedback on my product I joined the facebook group "Tortoise owners of the UK" that has 23k members in it, I asked them this question that is like the one I sent to the zoos but less formal, unfortunately none of the members had attempted to create a product such as mine so I was unable to get an accurate response however this does mean that I can gain some feedback from them when evaluating my product. This was the message:



- Material you need:
- 1) Wood boards
  - 2) Wood screws
  - 3) Spray paint
  - 4) Artificial grass
  - 5) Plastic mesh
  - 6) Acrylic boards (tray)
  - 7) Reptile's lamp

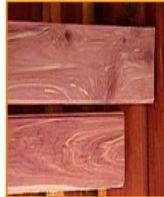
I thought that even though I have already contacted some local zoos and I also contacted an online forum with over 20,000 self proclaimed experts in this field, that it might be equally as beneficial to research all the necessities that are required to make a tortoise comfortable in their living situation and habitat. To conclude the online expert who gives advice to perspective builders concluded that ensure that the tortoise is happy is - Wood screws, Spray paint, Artificial grass, Plastic mesh, Acrylic boards (tray), Reptile's lamp or suitable heat source e.g., matt.

## Timber & Manufactured Boards:

### Softwoods:

#### Pine -

- Softwood so easy to mass grow
- White or pale wood can be stained easily
- Light weight
- Knotted pine is sometimes used for decorative effect
- Quite cheap
- **Not suitable for my product as pine is too weak and does not have much water resistant so would potentially ruin my product.**



#### Spruce -

- Softwood
- Beige colour
- Used in furniture
- Light weight and easy to bend
- **Straight grained so easy to cut one way which could potentially create some problems as I may want to cut it another way and it may be difficult and time consuming.**

#### Red Cedar -

- Dark colour and looks nice on furniture
- Softwood
- Harder to mould and bend than other soft woods because of the close grains.
- **Now I think that red cedar would be lovely to use for the shack due to the fact that it is a self finishing material so would not need any additional chemicals that could harm the animal. It also has nice appearance which is beneficial.**

### Hardwoods:

#### Oak -

- Hardwood is less available but always high quality
- Strong, heavy and durable
- Less expensive than some other hardwoods but still quite expensive
- Has a wide grain so is hard to cut through
- Knotted effects on wood are used in building or furniture for effects.
- **Used for out door cabins and high end furniture. So would be great for my product as it also has a nice appearance ad is self finishing.**

#### Beech -

- Hard, strong and heavy.
- High shock resistance
- Smooth finish makes it easy to polish and clean but can dent easily
- Has a good look to it
- Very nice pale colour and thickness
- Close grained and wide grained
- Not used for knotted furniture as knots are much darker on beech than on oak
- Cheaper than oak but of a lower quality
- **Can be used out side as it has a high water resistance perfect for my product.**

## - Secondary research of Materials & Joining Methods -

### Manufactured Boards:

#### MDF -

- Wood fibers glued together to make panels
- Denser than other woods
- Water absorption
- Internal bond strength is high meaning the wood is strong
- Very easy to snap and flake
- **Good for insulation panels, would be suitable for the insulation for my product however is not waterproof.**
- Standard color of wood.



#### Plywood -

- Thin layers of wood glued together with adjacent layers
- High impact resistance
- Strong for the weight of the product
- Chemical resistance - **beneficial to use since the product will need frequent cleaning.**
- Very good use for building or furniture insulation

#### Flexiply -

- A form of plywood that is easy to be bent into shape and "Moulded" - **beneficial for my NATURALISTIC end user criteria!**
- Bent into shape and then clamped together over the shaped object, if left for enough time shall remain in the shape after unclamped
- Good for shaped furniture or structure - **however I don't have much experience in steam bending or Flexiply moulding.**
- **Can't be used outside which is potentially a problem since my product will be outside, however I could use a varnish or finish that would still protect the animal.**

#### Marine ply -

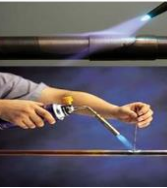
- Thin layers of wood with adjacent layers, with a waterproof sealant in between to prevent water damage
- High impact resistance
- Chemical resistance
- Only plywood that can be used outside
- **The use of marine ply on my product would be greatly beneficial for my end-user criteria as the product needs to be outside which marine ply is suitable for - I'm thinking that it would be useful to have it as a base to my product due to its strength and durability and long-life-ability.**

Equally using marine ply would be beneficial to the response from the zoos about how to keep it waterproof.

### Metals:

#### Mild Steel -

- Made of carbon and iron
- 2.1% carbon bonding which is relatively low in comparison to other metals.
- Very strong
- Quite expensive if mass buying.
- Very strong due to the low level of carbon it contains.
- It has high tensile and impact strength meaning it is less likely to bend or break compared to other materials.
- Soft so can be easily machined to be in a correct shape.
- Very good for welding and brazing.
- **I have used mild steel before and do find it easy to work with.**



#### Metal Joints:

##### Brazing -

Metal is heated up at a steady rate and then flux is applied to stop the metal burning, then a filler material, usually brass rod or pewter, is filled in which bonds the two pieces of metal together. Brazing is cheap but can ruin a piece of work if the flame is too hot or if the brass is melted in the wrong place as this can cause more work to be needed to fix the joints if brazed in the wrong place.

- Less heat required than welding as is a low heat joining method.
- More environmentally friendly than welding
- Weaker joint so could break if force applied.
- Cheaper than welding.
- Less dangerous



**I have experience with brazing through school as it is more viable to use in school than welding, equally I know that mild steel bonds together very well with brass used in brazing, and I have access to a surplus of mild steel in school that I can use for my product if chosen by my end-user.**

##### Welding -

Fusing two of the same metal together using intense heat to melt the area where the metal items are to be joined. VERY DANGEROUS as requires intense heat and does spark a lot so could cause fires.

- Welding requires More energy than brazing
- Less environmentally friendly as produces much carbon dioxide.
- Stronger joint than brazing also wont snap or break.
- Can be done underwater
- More dangerous

**Potentially unrealistic because welding is primarily done on an industrial level and I don't have as much access to it myself so would probably struggle to do it myself in the workshop.**

Timber is something I want to use and from my secondary research into it I have come across some that I would like to investigate further as primary research. I would like to investigate using oak, beech and red cedar, the hardwoods would be for structural purposes as they do fit the bill. The red cedar would be for decorative effects and would possibly be used to line the inside of my product. Plywood is something that I want to use in my product just because of its versatility and strength - marine ply and Flexiply are the two that I would like to focus on the most due to the ability to make a naturalistic shape and form and the fact that marine ply is waterproof so overall has the best properties for a product of mine.

#### Comments:

Good idea to use wood to reduce weight! Maybe consider recycled plastic?

# - Secondary research of animal/structural related equipment -

CLICK LINKS TO WEBPAGES!

## - Heating and UV -

Due to my clients wanting me to include heating and UV light in the product I have done some secondary research into some equipment that I will need to regulate and maintain a constant temperature in the house. I chose to use the websites [Pets at home](#) & [Ebay](#) as when researching existing products and gaps in the market these were the two websites that produced the best results.

Digital Thermometer  
★★★★★ (4)  
£12.89

Very Reasonable price for a crucial bit of equipment.

### Thermometer:

Now this would be a very **beneficial product to install in my product as it will ensure that the house does not get too warm or too cold** and that the user can have a visible prompt of when to change the temperature to best suit the **needs of the animal.**

Arcadia D3 160w Basking Lamp UVB Infra Red E27 Screw Fit (Web Exclusive)  
£45.00

### Heat & UV Lamps:

This bulb would be perfect for the **heat and UV element for my bulb, it has the dual control which would be perfect for maintaining health**, downside is that it is quite expensive.

Exo Terra Daylight Basking Spot 150w  
£9.69

I really think this bulb is **not suitable** for my product - the lack of a heat element to the bulb is a downside - it would be useful for the UV however it is not worth it due to the lack of **heat which takes priority.**

Exo Terra Solar Glo Reptile Heat Lamp UVA UVB Light All In 1 Bulb 80w 120v 140v  
£29.95

This is a definite no - the different wattages in these lamps leads me to think that the **bulbs are unreliable so will constantly need replacing. I will avoid this.**

EXO TERRA LIGHT DOME ALUMINUM UV REFLECTOR LAMP X2 UVB REPTILE LIGHT HOLDER  
£19.99

I like having the lamp in a holder however the use of aluminum shell could lead to the **bulb exploding due to reflection which could be dangerous to the pet.**

Exo Terra Reptile Heat Bulb - Night / Day / Infrared / Swamp Basking Light Lamp  
£7.99 each

These lamps create an interesting contrast as the idea of infrared could be useful if the **market was expanded from tortoises to include other pets like snakes or exotic lizards.**

Habitat Reptile Heat Mat 43 x 28cm 20 Watts Black  
£21.99

Vivexotic Glass Heat Mat Holder (Web Exclusive)  
£18.79

### Heat Mats:

This heat mat is so good - I love the fact that it is **flat and sleek** so can be **hidden under the soil/terrain**, it also takes the need away to **install a bulb and holder** - the only downside is it

The glass tile would help **maintain heat doesn't create UV - so I could regulation. And conduction in habitat. look to use both bulb and mat.**

Homodo Ceramic Lamp Fixture and Mounting Bracket (Online Exclusive)  
£15.75

## - Additional Equipment -

This would only be beneficial if I were to use a bulb - however I could potentially **make my own. Which would be cheaper.**



### Alternate UV Source:

I think its likely I will use the sun because it is **free and a permeant source of heat and UV - so ill likely use this and a heat mat/bulb.**

plastic dog fence window

### Window Acrylic

Through speaking with my clients, they want some form of window in order to see the pet. I thought of the idea to use a dome to keep the product "naturalistic" so I've researched on [Amazon](#) as they have proven effective before in my earlier research on existing products.

POHOVE Dog Fence Window Pet Sight Window Clear View Dome Pet Peek Window Durable Acrylic Dome Dog Window for Backyard Fence, Dog House, Reduced Barking  
£18.99

I really like the idea of using this product - I think that the **size would be great and contributory to the pet** - I did dabble in the idea of making one myself using vacuum forming - however on an industrial scale it would be **more cost effective to use an existing product.** I think that the price is justifiable.

Lovetao Diameter 3.15 inch/80mm w/ 4 Holes Acrylic Dome Flange Clear Plastic Hemisphere Indoor/Outdoor CCTV Replacement Clear Dome Camera Cover Security Dome Camera Housing (3.15...)  
£13.49

Equally the **use of a flange would prove effective when attaching to the shell or frame of my product as no additional adjustments would need to be made. Definitely will use this.**



This dome is a bit trickier - I think that this would be good for the **naturalism of the product** however the size could be a problem since it is very small - I could potentially use it as a **decorative piece in addition to the earlier dome** - potentially on the side, however due to it not being able to **catch as much sun. equally it could be very fragile to handle and to screw/bolt to my product.**

I could use the plastic dome along side the sun as the primary heat/UV source for the product?

## - External materials -



DIY cheap exercise ball pizza oven in 5 mins



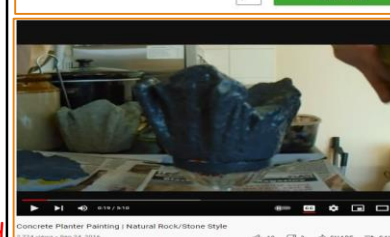
how to make - fiberglass bumper part 1: laying the foam plug - jeep grand cherokee

To keep the **naturalist effect and the durability, strength and weight desired by my end users** I came up with the idea to use **fiberglass sheets** as a way of creating the **rock effect**. The fiberglass when mixed with epoxy resin it hardens and becomes extremely hard however is also **lightweight and strong** which is wildly beneficial. I would use the process that many use when creating "pizza ovens" (example in the video below) - it involves cutting hole in a wooden board and popping in the exercise ball, the ball is then cling filmed to prevent sticking and then is covered in concrete to **retain the ball shape. For my idea I would replace the concrete with fiberglass and layer the sheets to the desired thickness and then the resin would be painted on it would be the same process as the video below regarding fiberglass bumper repair.**

Scola Air Drying Modelling Clay - 12.5kg - Stone  
£8.79

### - Clay & Concrete -

Using clay would be great for the **naturalistic look for my product**, there is the potential to use air drying clay or regular clay however if I used regular clay in order to set it, I would have to put it in a kiln to be fired and therefore would make it all shiny and metallic looking which is **not the design that I am looking for.** Air drying clay also dries much faster and is **more moldable**, therefore I could **easily create the stone texture** as seen in the video here in my product. Equally clay is **lightweight so will not be heavy to move & air-drying clay is fire resistant so will not explode I the hot product** - which is always a bonus to have!



Blue Circle High Strength Ready Mixed Concrete, 20kg Bag Grey  
£7.76

I could also use concrete however there are a couple of concerns with this; **concrete doesn't have as much structure when it is setting so is likely to run** also due to the type of bonds it has, it **dries very hard which is beneficial however it is very concentrated so becomes extremely heavy** which is not what I want as then it will be **harder to move.**

So, this research I believe was extremely beneficial for me, I think In terms of the heat and UV source it would be wasteful using a bulb that is likely to need constant replacing, so I have decided that I would be best to use a heat mat combined with a plastic dome to give the sufficient amount of heat and sun required. I could in theory use both sizes of dome for maximum sunlight. In regard to the structure, I am definitely going to use fiberglass and epoxy resin to create the hard-shell structure that retains heat and moisture. Then I will use air drying clay over regular clay and concrete just due to its versatility and likeness to stone and naturalness. Overall using these materials and products will definitely be in keeping with the naturalism required by my design.

Next Steps: I will start the design process keeping in mind all the technical data and research, I will also gain feedback from all of my designs.

Comments:  
Window idea is great! I like the idea of the sun!

# - Research Client Anatomy & Key Features of Client 1 -



CLICK LINKS  
TO WEBPAGES!

Client: Andy Lyes  
Name: Frank  
Species: Leopard Tortoise

## Pet Needs & Health Requirements

### Lifespan

The leopard tortoise has been known to live to 100 years old both in the wild and in captivity, with most living well over 50 years of age.

### Weight

The leopard tortoises are the second largest species of tortoise in Africa, with the largest being the African spurred tortoise. Their shells are highly domed in shape and can grow to be 10-18 inches in length. Leopard tortoises can weigh up to 45kg, however it is more common for them to weigh around 25kg. Females often grow larger than males.

### Behavior's

As with most tortoises, the leopard variety spends most of their days basking, sleeping, and eating. However, due to the intense heat of their natural habitat in eastern and southern Africa, they also spend a lot of their time staying sheltered under the shrubs and bushes so as not to overheat from too much sun exposure. They are most active at dawn and dusk

Leopard tortoises require a dry substrate like that they would encounter in the wild. Anything too moist can cause respiratory problems or shell rot. Use something like wood chips or a soil-sand mixture with areas of varying humidity so they can move where they feel most comfortable.

### Humidity

A relative humidity of 40-60% is perfect for them, however they prefer a higher humidity at night so you should gently mist their substrate when it's nighttime.

### Heat

Leopard tortoises are highly intolerant of lower temperatures and should not be kept in conditions that are consistently lower than 20 degrees Celsius. For this reason, outdoor enclosures are not suitable in the UK unless a sufficient heat source of variable heat can be provided. Basking areas should be in surplus of 35 degrees.



120mm

190mm



100mm

### Furnishings

Will need plants, logs, rocks, and other furnishings in the tortoise enclosure to encourage them to explore and discover the entirety of the space available to them. A bored tortoise is a stressed tortoise, and this can lead to many health problems.

### Water

Provide a shallow water dish for them to sit in and drink from. Leopard tortoises need water to be able to cool down after a long time under the basking lamp. This needs to be cleaned daily and they must be provided with fresh water to prevent a build up of bacteria however a filter may also be used to maintain the cleanliness'.

### Lighting

Tortoises need UVB light to be able synthesize Vitamin D3 so that they can absorb calcium to grow healthy bones and a healthy shell. UVB lighting should be provided by installing the correct bulbs and keeping them on throughout the day. You can also use a timer so that they turn on and off every 12 hours to mimic the hours of natural sunlight that they would experience in the wild.

Make sure they have a good basking for UV. Without this, and without enough vitamin D3 and calcium in their system, they could develop metabolic bone disease which can be fatal if not diagnosed and treated as soon as possible. Alternatively, the sun can provide this heat and ultraviolet light, if outside another form of heat should be maintained to compensate in the nighttime when the sun has gone.

### Enclosure Size

Due to them being larger tortoises when fully grown, they should be given ample space to be able to explore which is why the recommended size for adult leopard tortoises is around 3m x 3m. Young tortoises could be housed in a tortoise table for a few years, but they will soon need to move into something bigger as they begin to grow. A small enclosure can lead to behavioral problems but can also be a stressor for your tortoise which can be the cause of several health issues however having a smaller enclosure that opens into an open space has proven to be the most beneficial way to house your tortoise, too.

### Care Routine

Due to the high natural temperatures of their habitat in the wild, leopard tortoises do not need to hibernate therefore you must keep their conditions stable all year round. This is vital to their survival, as any lower temperatures will only cause health issues which could be fatal.



This is the kind of filtration system that I would be looking to include into the water feature as it is shown to inhibit bacteria growth. Which greatly benefit my tortoises health as shown by my research into the species.



### Research Conclusions relating to design features:

From my research into the anatomy and health needs of the client's leopard tortoise I have been successful in identifying some specific design features that will need to be incorporated to allow the tortoise to thrive in its new habitat.

- Weight/Length - My Clients tortoise is currently 190mmx100mmx120mm and from my research I have found that the average tortoise of this species will grow to around 380mmx180mmx220mm so therefore the entrance to the habitat will need to be at least 220mm(Wide)x180mm(Tall). The weight isn't particularly an issue as any structure that is competent will hold the weight.
- Lighting/Heat/Humidity - the use of the sun as a secondary heat source and the heated mat as the primary heat source is something that I have already researched into and now I can conclude that these are the two sources of heat that I will be using as otherwise I will have to use some more design processes to incorporate wiring up a UV & a Heated Basking Bulb which is not particularly cost effective. Equally as long as there is a sufficient source of water present then the humidity level should stay between 40% & 60%.
- Water - this is something that was always going to be particularly difficult as there needs to be absolutely no leakage I order to allow the tortoise house to maintain a perfect thriving condition, therefore I will be conducting some research into a pet friendly filtration system that prevents bacteria growth, then designing a suitable water system that prevents leakage should be simple, what may be difficult is ensuring that the water container or bowl doesn't flood which again should not be a difficult fix to make when designing the house.

# - Research Client Anatomy & Key Features of Client 2 -

CLICK LINKS TO WEBPAGES!



Client: Martin Turner  
Name: Zippy  
Species: Herman's

120mm



170mm



150mm

## Pet Needs & Health Requirements

**Lifespan**  
On average, can live up to around 75 years of age but they have been known to live even longer in good conditions.

**Weight**  
Usually, the Herman's tortoise is smaller than other tortoises and generally will weigh on average about 3-4kg and will generally be 6-8 inches in size, with females growing larger than the males. They have strong hind legs and large, thick scales on the outside of their front legs which generally doesn't cause damage to the enclosure. Their claws also help climbing and stability.

**Behavior's**  
Hermann's tortoises hibernate between October and April; however, this can vary depending on the climate. They will hibernate underground, where they are safe from predators, their hibernation means they don't have to worry about food scarcity. During their active months, they will bask in the morning sun and then using the energy to forage and explore. When it gets too hot, they will likely find cover until it begins to cool down at dusk.

**Humidity**  
Most tortoises do well at a humidity of 40-70%, anything out of this range and they can become dehydrated or can develop respiratory issues. Maintaining the humidity by misting the tortoises and their enclosure each day, making sure the tortoise table is not next to a source of dry heat such as a radiator, and providing the correct substrate helps to regulate the required humidity.

**Heat**  
The ideal temperature for a Hermann's tortoise is around 27-30C, and it should never fall below 18C during the day so the temperature in the basking spot needs to be in the upper end of this range. At night, it is acceptable for the temperature to drop, so the heat source can be turned off, but it should never be less than 15C. Reptiles require heat to be able to perform their daily bodily functions such as moving, foraging, and even digesting their food so it's important to monitor the temperatures throughout the day and night using an accurate thermometer, if the tortoise is kept outside in the UK, it can only be during summer months when the temperature is sufficiently high.

**Furnishings**  
Hermann's tortoise enjoy eating succulents so they can be planted throughout their enclosure to break up the space. They don't always like to climb, they are used to rocky environments there can be rocks, logs, for them to explore.

**Water**  
As with all tortoises, the Hermann's tortoise requires a small, shallow water bowl for them to drink from, bathe in, and cool off. They need access to water daily, and it needs to be clean and bacteria free. The Herman tortoise will suffice on natural rainwater/spring water. However, if outside it would probably be best that the water is filtered before drinking.

**Lighting**  
In the wild, Hermann's tortoises will bask in the sunlight and soak up all the UVB rays they need to grow and develop correctly. Therefore, they need to be provided with adequate lighting so that they can do the same in captivity. Without UVB light they cannot synthesize vitamin D3 which helps them to absorb calcium for the development of a healthy shell and healthy bones. A fluorescent UV light can be placed at one end of your enclosure so that the tortoise can bask, get all the rays they need, and then move out of the heat if they need to. A timer can turn the lights on and off automatically, they will need 12 hours of light each day. If the tortoise is living outside in UK weather in the summer, then the 12 hours outside will be sufficiently hot enough to sustain the Herman's heat needs.

**Enclosure Size**  
Hermann's tortoises can live quite happily in a tortoise table or in a garden pen if it is big enough for them to explore, they have enough space as they continue to grow, and you provide them with everything that they need. a tortoise table that is big enough should accommodate them throughout their entire lives, so you don't have to upgrade as they grow.

An enclosure around 2 feet x 4 feet should be more than sufficient but will need larger if there is more than one tortoise. Even indoor tortoises will enjoy some natural sunlight every now and again, so it's a great idea to create an outdoor pen for them to explore throughout the warmer months, too, which can also be used in the summer months in the UK providing temperature remains sufficient.

Although Herman's tortoises are not considered to be climbers, the walls still need to be tall enough that they cannot climb out; 6" is the minimum but it is a good idea to have the walls as tall as the length of your tortoise to ensure that they can't climb out.

**Health**  
Hermann's tortoises can suffer from the same illnesses and diseases as any other captive tortoises, if not given the correct environment. Care needs to be given to ensure the correct lighting and diet is given to prevent metabolic bone disease and monitor the humidity to avoid respiratory infections. Which ultimately would lead to death and therefore no need for a product.

**Hibernation**  
Hermann's tortoise's do hibernate when the temperature drops too low, captive specimens however may remain active all year round if the temperatures constant and high enough. If the tortoise is kept outside, then you should move it inside to maintain the temperature and avoid hibernation.

**Research Conclusions relating to design features:**  
From researching the different breeds of tortoise that are owned by my clients I have seen that there are different needs and wants that are required for the different breeds of tortoise. With the Herman's tortoise there are different needs to the leopard tortoise which means that different design decisions and considerations need to be made to ensure that the design remains inclusive!

- Lifespan/weight - due to both tortoises living a surplus of 60 years the enclosure will have to be extremely weather resistant and therefore will need to be built from strong long lasting materials that do not wear as easily to ensure that over the years it requires minimal upkeep - equally will have to have a large enough entrance so that the tortoise will fit as it gets bigger!
- Water - will need a supply of clean water so possibly design some rainwater filtration collection system!
- Heat - will need insulating and will also need to retain heat so will need to be sealed - the heat matt in my earlier research will sustain the right amount of heat needed - that combined with the insulation will sustain the needs of a Herman's tortoise.
- Enclosure size - with the Herman's Tortoise love to climb the external walls will need to be sufficiently high potentially 25cm due to their average height of the full-grown Herman's.
- Hibernation - keeping in mind the fact that Herman's tortoise hibernate there is no need to affect the design as the tortoise will need to be moved to its designated hibernation area when its sleeping through the winter anyway.
- Furnishings - Herman's like rocks so this bodes well with my naturalistic wishes from my clients, I will just have to ensure that any rock features are not too steep as if it is too high then the tortoise could potentially flip itself.

## - Fiberglass resin kits -

After conducting some research online, the way to use fiberglass in the most efficient way is to use a fiberglass kit - so the kits will include;

- Chopped strand mat - of various lengths.
- Resin - will be a large amount.
- Hardener - this will be contributory to the amount of resin and the length of the chopped strand mat.
- Maybe some official brushes and gloves for more safety precautions?

I have earlier expressed interest to my clients in using fiberglass to build my structure which they were very keen on me doing. I will now do some in depth research into the actual properties of fiberglass compared to its price and overall workability to make an informed decision whether or not it would be beneficial to use for my product.

### What is fiberglass?

Glass-reinforced plastic (GRP) is a composite material that consists of a polymer matrix and glass fibers. The polymer matrix is usually an epoxy resin, it also requires a hardener which is contributory to the type of resin required/ being used. Fiberglass is strong across its vertical axis (when the chopped strand mat is laid flat) but weak along its horizontal axis as it is very thin and doesn't have a particularly large surface area which can allow breakages such as snaps, cracks, chips or just generally falling apart as a whole.; if you can orient the strand mat and layer it like plywood so the "grains" primarily in each layer go a different way then the weak points won't be distributed along various axes instead of a single axis, and then when the resin and hardener has been applied and is all set you will have a much stronger fiberglass that is less susceptible to breakages and faultiness.

### fibreglass

[ˈfɪzbɛɡlɑːs]

NOUN

fiberglass (noun)

1. a reinforced plastic material composed of glass fibres embedded in a resin matrix.
2. a textile fabric made from woven glass filaments.



This video explains the basic process of using fiberglass, earlier in my portfolio I attached videos of how to use fiberglass for particular processes, but this is a basic overview of how I would use the material.

### Is fiberglass sustainable:

Well, it all depends on how you use it. As a base material, Fiberglass is a highly sustainable and environmentally friendly material. The material that it is mainly made up of is abundant and easy to extract relative to other materials such as metals and polymers, both the production and application of fiberglass are tremendously more energy efficient and as such, translates to lower emissions as to make fiberglass you don't have to go through the extraction process like you do with metal ore as such. HOWEVER, due to the serious health risks coming with it, fiberglass must not be heated up above the recommended temperature as it can lead to it "evaporating" and ending up air borne which is harmful to the environment and the respiratory systems of those around. So, it absolutely must not be warmed at all!

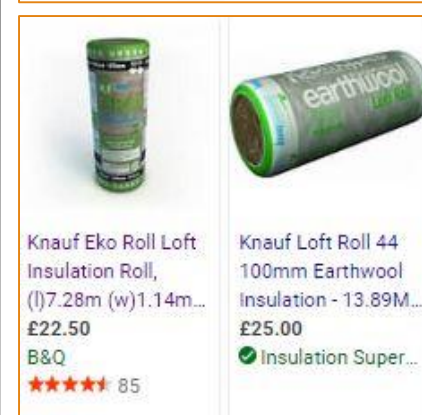
### The Advantages of using fiberglass are as follows:

- **Long-Lasting and Strong** - generally speaking fiberglass is much stronger than most sheet metals, it has good tensile strength and impact resistance.
- **Cost Effective.** Although fiberglass is reasonably expensive to use, it is worth it, your pretty much guaranteed premium designed products that are strong and lightweight which you just have to look at when purchasing the material. A product that is strong and lightweight will also result into lower shipping and storage costs, which is greatly beneficial for a commercial market.
- **Design Freedom.** One benefit of using fiberglass is that it has minimal molding restrictions which give the designer unlimited possibilities.
- **Special Characteristics** - Fiberglass is radio frequency transparent and non-conductive. This property makes it a perfect fit for covering electronics without interfering with their performance. The material absorbs sound waves and does not bounce off meaning it can be used for sound prevention. Fiberglass material has the least contraction with stress, heat and cold, unlike wood, plastic and metallic materials.

### The Disadvantages of using fiberglass are as follows:

- **Expensive** - even though it being cost effective is a bonus, the fact that it is a very expensive raw material is a bad thing.
- **Wastage** - due to the cost and temperament it would be the worst thing to have any of the material wasted.
- **Health implications** - the chopped strand mat is made of tiny microfibers of glass all "woven" together, if the fiberglass mat breaks apart or is inhaled the segments will irritate the alveoli and can cause lung disease. Equally as the fiberglass is so small there is some data which suggest that fiberglass in the lungs can cause cancer as it slices the DNA and causes cell mutations - fortunately this can be overcome by using PPE when manipulating or cutting the mat.

Fortunately, the pro's far out way the cons so as long as the protective measures are in place the fiberglass should be perfect for my product.



These exercise balls would be perfect for the "pizza oven" technique that I investigated earlier on in my portfolio, the two sizes used will be the 75cm & 85cm ball, I will then proceed to inflate the larger ball and fiberglass the shell to make the hard shell that is required, then I will deflate the ball to retain the dome shape, it is important, to lubricate or protect the ball firsthand to ensure that it doesn't stick to the dome, then I will inflate the smaller dome and create the hardened shell with their respective flanges, the 10 cm gap between the two domes should be sufficient to hold the correct amount of expandable foam insulation need for the tortoises desired heat retention. The only problem that could occur is if the ball sticks to the fiberglass shell or if the balls puncture whilst the resin and hardener are curing, or of the temperature changes during curing causing cracking.

### Insulation materials & methods

Spray foam insulation is a cost-effective and energy-efficient way to insulate products, equally as shown by this product it is very cheap to purchase. It works by spraying into a space which it then reacts with the air and expands and hardens to retain heat and strength, it remains lightweight

Blown-in or loose-fill, this type of insulation involves using specialized pneumatic equipment to blow fluffy strands of fiberglass, cellulose, or mineral wool into the desired gaps in the products that require insulating, unfortunately this is not a viable product due to the fact that there will be so much in excess, and it requires more of an industrial equipment. Which is not desired by my clients and users.

Batts and roll insulation. Also known as blanket insulation, batts and roll is the most-common type of insulation. And would therefore be suitable for my product if it was a standard shape, as my clients want a unique naturalistic shape to it such as cave or shell look then it would be foolish to waste money on chopping up segments of the mat to slot into place where another gap filling insulator would be more suitable. And therefore, would also be cheaper.

## - Finalizing the exploration of my product concept-

## - Non-technical Specification -

### - Technical specification points -

Here I will outline the specific needs and wants of the clients and stakeholders and how my research relates and will assist the making products, the designs will need to include and associate with as many specification points as possible in order to be brandished as successful designs.

1. "Design must be Naturalistic in looking." - This will be accomplished by using a variety of materials, the pizza oven concrete dome that I explored earlier on will be mimicked but instead I will create some fiberglass domes of different sizes and lay them on top of each other, after the domes have set and are affixed to a base the naturalistic effect will be made up out of air drying clay to look realistic and stone like, not only does this fit with the stakeholder needs and wants it also is beneficial to the tortoises as from my research into their anatomical basic needs and wants they are statistically happier when living in a fairly primitive environment that mimics their ancestral homes of deserts and rainforests etc.
2. "Design must have a sufficient heat source." - This will be accomplished by the use of a heated mat that will lay flat onto the base of the inside of the product it will then have a sufficient power source powering it, likely the use of an external 3 pin plug socket, that will be water sealed and will completely leak free through the use of sealant that was researched earlier on. Equally the use of the plastic "dog" domes will ensure that the tortoise gets more heat and also UV light that it would in a natural habitat.
3. "Design must have a sufficient access to clean water." - This will be accomplished through the use of a pet water filter that will be placed/slotted into the water cavity which will prevent bacteria growth which will prevent the tortoise contracting water based diseases.
4. "Design must be heat retentive and warm." - This will be accomplished through the use of insulating foam that was researched earlier, the two fiberglass domes that will each have a flange around the base of them will be layered over one another will be filled with expandable insulating foam which is pet friendly, the domes will be sealed to the base of the product to avoid water damage.
5. "Design must be easily moveable, well balanced and not too obscure in shape." - This will be accomplished by having the product in a fairly symmetrical shape and having the product very well balanced and sized, this will ensure that it does not topple over and that the product
6. "Design must be lightweight." - This will be accomplished by the product being a hollow shell structure and through the use of light weighted materials, it is likely that the clay structure on the top will be heavier but overall the product will remain lightweight.
7. "Design must be waterproof." - This will be accomplished by the use of marine ply for the base and the outside coating of clay and paint will have a waterproof sealant/varnish, equally the fiberglass and resin domes, when cured and set will be self sealed and waterproofed.
8. "Design must be Long-lasting." - This will be accomplished by using all the correct sealing methods and materials which will prolong the life of the product to the full life expectancy of the animal which is a very extended period of time so needs to require little upkeep.
9. "Design must be cost effective." - This will be accomplished by using cheaper materials and practices and using methods that reduce the loss of materials and money to ensure that there is no profit loss.

To summarise my current findings I believe that there is definitely a gap in the market for a bespoke designed unique sustained tortoise or reptile habitat for outdoor use, ultimately with my findings whatever is designed for outdoor use can be used inside as well however I am purposefully designing it for my client who will use it outdoors.

There are a few technical problems that could potentially crop up when designing that could be a problem these are generally material based such as:

- The wood that is used splinters and fragments so it cannot be used so another must be manufactured
- The resin kit combined with the fibreglass proves ineffective and doesn't shape the way I want it too.
- OR it doesn't bond together as expected so therefore will not come off the mould hen set.
- Equally the electronics that have been installed may also not work outside which would be extremely disappointing.
- The absolute biggest problem for me would be that the product does not retain heat therefore leading for it to become nonaffective and wrong.

Equally I have considered the wider marketability of my product and how it would work manufacturing my product in an industry and how the different methods of manufacture would compare to a large scale market, Obviously you wouldn't get the uniqueness like this however I concluded that using VACUUM FORMING, to make the inner and outer shell as well as using EXPANDABLE FOAM INSULATION, I could produce my product on an industrial scale - this way things like bioplastics which are inaccessible to me could be used and the amount of profit made would not affect the cost in material.



Design brief overview:  
My earlier design brief started with me exploring the problems with reptile housing in today's society and more specifically the outdoor housing. Research online and in stores has concluded that there is a gap in the market for a sustained outdoor house. Research into tortoises specific anatomical needs has established that a tortoise living in Britain can only live outside during the spring summer and beginning of autumn months which means that the product made needs to be long lasting, sealed and weather proof. After meeting with stakeholders and clients I have established a list of specification points that my designs will need to meet in order to function correctly and to suit the general and extended needs of all those involved with the process of making.

### POTENTIAL MATERIALS LIST:

From my collective stakeholder and client needs the materials I will be using in my designs are:  
**Wood** - marine ply due to its waterproof ability, Red Cedar due to its oily nature and self finishing ability. Also, potentially oak or beech as the hardwoods are durable.  
**Metal** - mild steel tubing with brazed joints will hold the structure.  
**Fiberglass** - the resin mixed with the fiberglass will help to create the structures of naturalism desired.  
**Clay** - air drying clay is lighter weight and provides realistic texture and look.  
**Acrylic** - I will be incorporating clear acrylic domes and panels to provide windows for tortoise happiness.

Next steps:  
Using the technical specs and all the needs of my stakeholders and clients I will design different variations of my product that is centred around the 9 design specs of the users. I will then produce CAD designs of these ideas and discuss with my stakeholders and clients to produce a developed and final design for manufacture.

Comments:  
All specifications are important to me, to meet the design criteria ensuring my product functions as I wish it to.  
*[Signature]*

# STRAND 2 – DESIGN

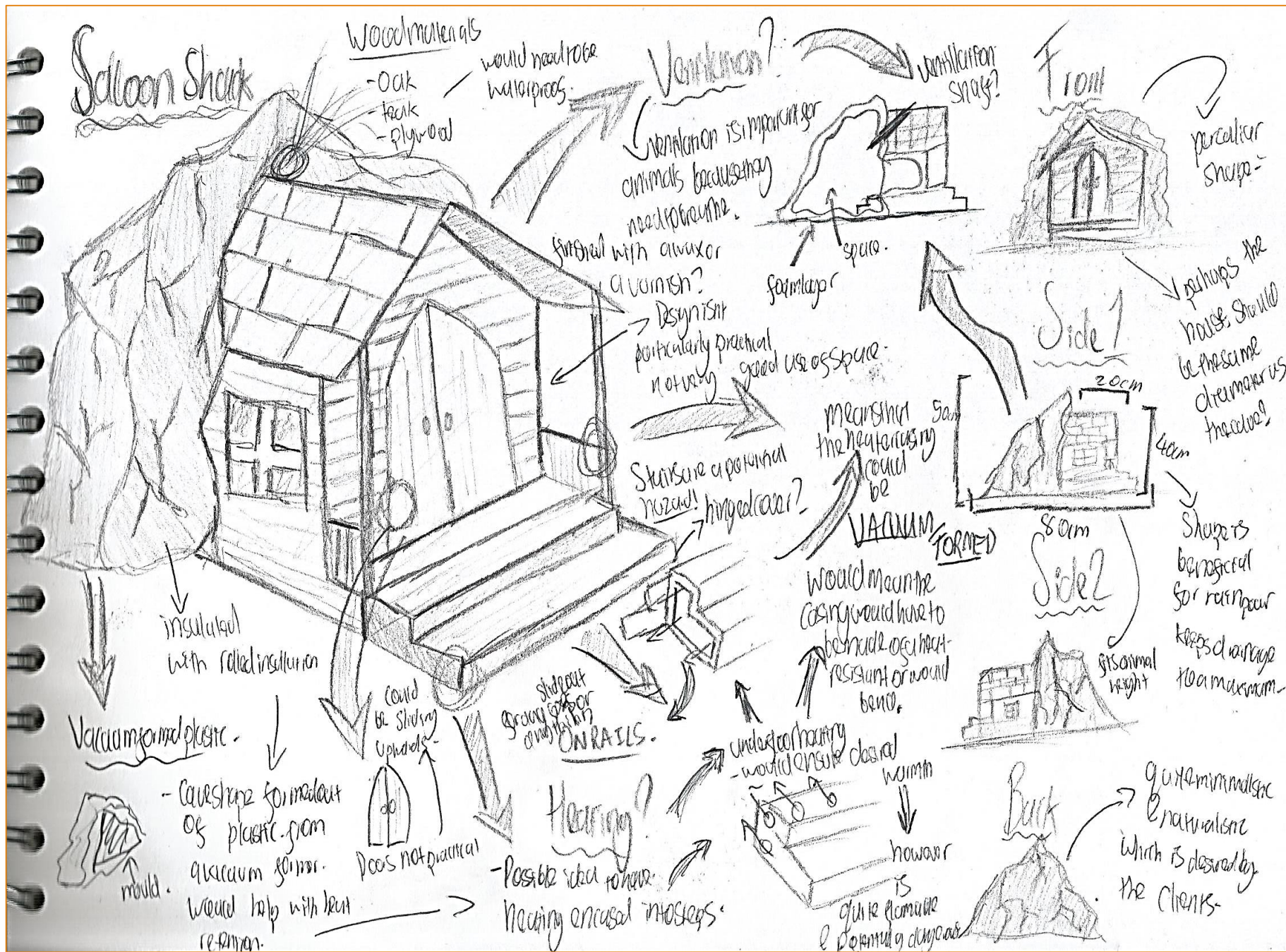
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# - Initial Design 3 -



**Pro's:**

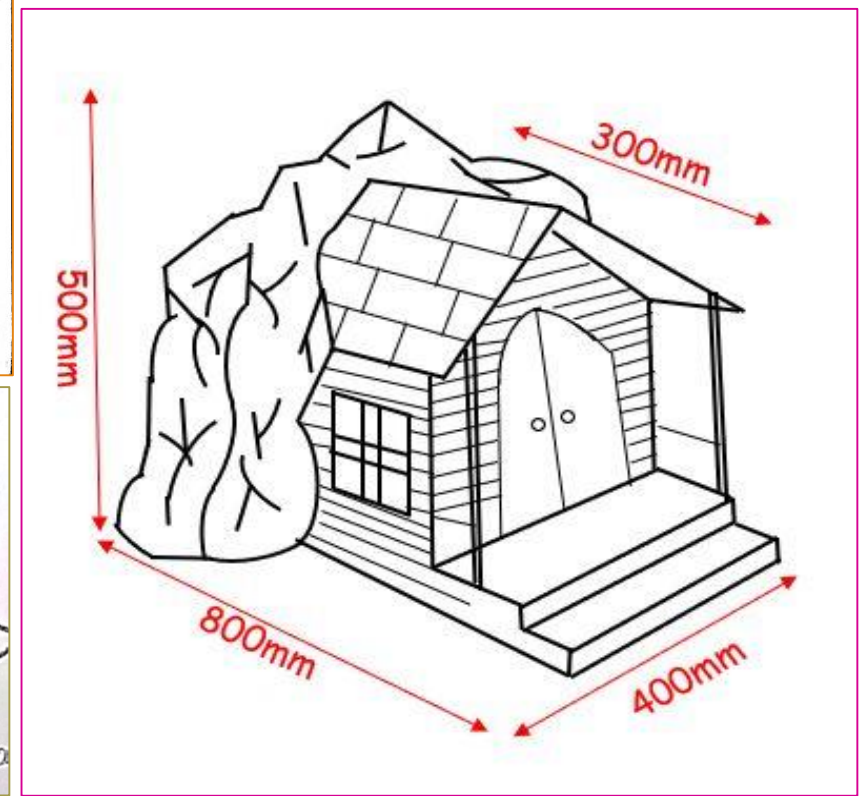
- This design is perfect for the **naturalistic aspect**, the choice of materials is perfect for the **rock-like texture** through vacuum forming. (Criteria 1)
- The wood design is **quirky and unique** which is **desired** by my clients. (Criteria 1)
- The added **ventilation hole** could potentially also double as a **rain collector** which could **supply water** to the animal. (Criteria 3)
- **Insulation foam** between the plastic layers will help to **retain the heat**. (Criteria 4 & 2 both are along side this)
- Appropriate **enclosure size** is also beneficial. As it will allow the tortoise to **move about freely**. (Not a specific design point but still useful)

**Cons:**

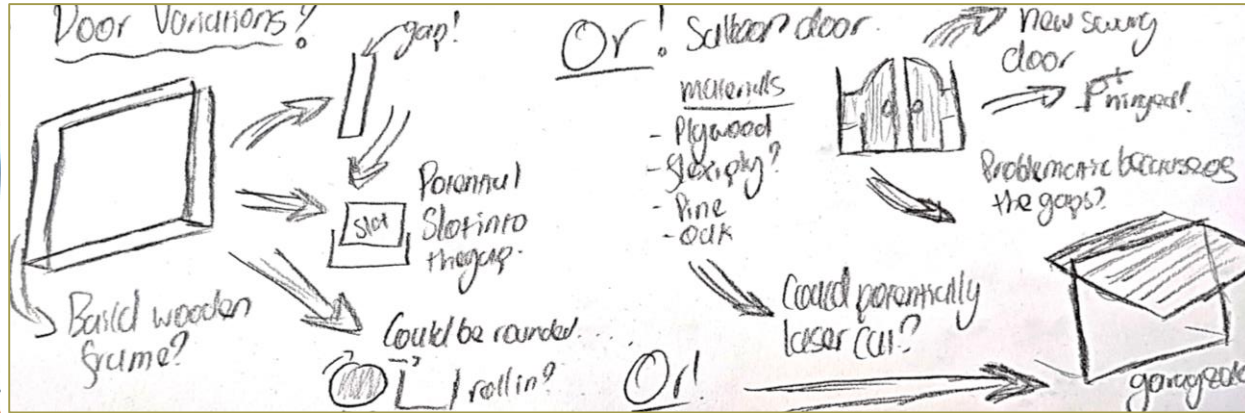
- The general shape of this design is quite **peculiar** and generally would be very **difficult to attach the plastic to the wood** whilst retaining the heat seal. (criteria 4 and 2)
- The entrance to the "saloon" is also not **workable** due to the size of the animal, equally the size of the stairs means that the **likelihood of the tortoise flipping over increases**. (not a criteria point but is a animal safety point)
- As I'm working on a **bespoke product** in a **school workshop** the access to more **industrial machinery** is again **limited so vacuum forming** is possibly **not possible**. (again not a criteria point but I do need to actually make it)

**MY CONCLUSION:**

Overall I think that due to the **volume of cons** over the **pros** this design needs a couple of different changes in order for this **design to be completely functional** to ensure that the product meets all of my **clients needs**.



**Comments:**  
I like the rock effect however I am concerned about the stair design and how the two sections will be joined together.



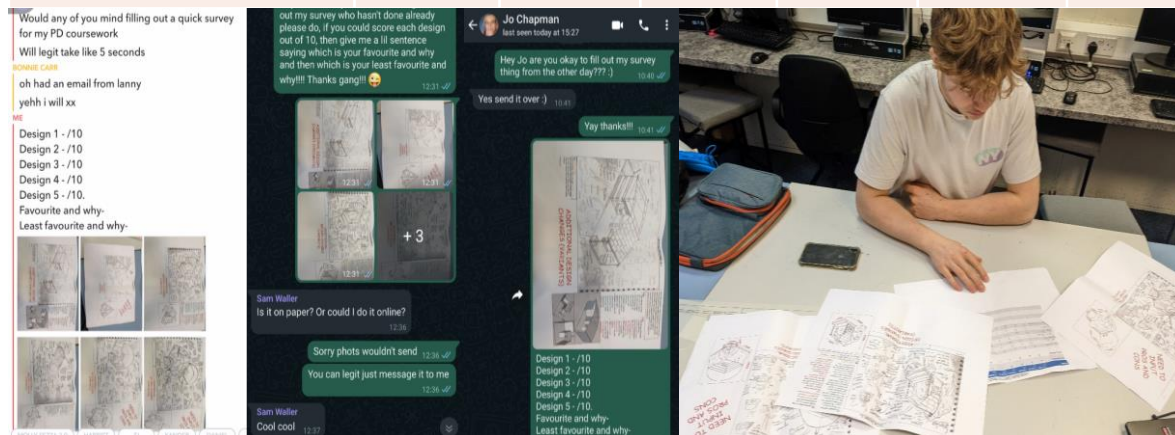






# - Large Scale Client Feedback & Response -

Name:	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6	Which is your favourite design & why?	Which is your least favourite design & why?
Joe Guilford	6	6	8	5	7	9	"6 because it is interesting."	"4 because it doesn't seem as practical."
Alice Walker	5	6	7	7	6	8	"6 because it is a very innovative shape."	"1 because the shape is fairly boring and not very creative."
Alex Cooper	7	6	7	6	7	9	"6 is pretty interesting"	"2 because I despise triangle"
Ava Vaccari	7	5	8	4	7	10	"5 is extremely nice and wonderful yay"	"4 because its boring #yawn"
Rosalind Mannering	6	2	7	1	5	8	"6 Is the most fun"	"4 I hate logs they are musty"
Grace Hancock	5	2	7	5	6	9	"6 is the most creative"	"2 because I don't think the tortoise would like it."
Mia Anneson-Wood	9	2	1	7	2	10	"from an art perspective 6 is my favourite"	"3 is gross to look at and I don't like it"
Poppy Bridgeman-Hughes	6	3	5	2	4	10	"6 is pretty cool"	"4 wouldn't suit needs of other users"
Edward Chapman	6	2	6	5	8	9	"6 is the most innovative however I'd work about the feasibility of it."	"2 why a pyramid? The focus seems to much on the shape for this design and doesn't suit the animal."
Jo Chapman	7	7	8	8	8	9	"6 is the quirkiest and most fun to look at, very whimsical."	"I do not like 1 because it is really boring."
Toby McDermott	7	6	8	9.5	7	7/.5	"4 because I like the logs and its not an eyesore."	"1 is very much an eyesore and is not pleasing to me."
Bonnie Carr	8	8.5	9	8	8	8.5	"3 is super cool design"	"1,4 & 5, are all good but not as interesting as the others."
Harriet Inwood	7	6	7	9	6.5	7.5	"4 is well good;, I think that it is a very suitable design."	"2 is not as interesting and would look weird in my garden"
Molly Ferris	8	6	9	8	7	8	"3 is my absolute favourite and is epic"	"2 is just plain boring and weird so it's a no from me"
Sam Waller	5	7	8	4	6	9	"6 is the most aesthetically pleasing and thought through"	"4 as I am not a fan of the log vibe."
Max Whitaker	8	10	7	9	8	8	"2 is my favourite because think the windows are cool"	I don't like 3 because I don't really think it would work well"



**Survey:**  
I decided that to get a wider response to my designs I would create a survey and ask the general public some questions about my designs where they would rank the feasibility and aesthetic look to my product on a scale of 1-10 (10 being the best) and then I got the surveyed to decide which was their favourite design and why and which is their least favourite design and why.

**Results:**  
I was surprised by the results of my survey, Design 2 proved the least popular which didn't surprise me as it didn't coincide with many of the design criteria set forth by the clients. Equally the design aesthetic is not loved by many people so its unlikely that the pyramid shape will be used.. Designs 5 & 6 proved both to be favourites so I think that possible combing the two into a developed design would ensure that all the design criteria would be met, equally the aesthetic for these designs was loved.

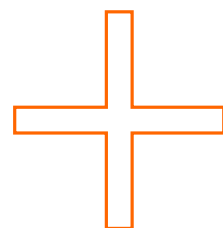
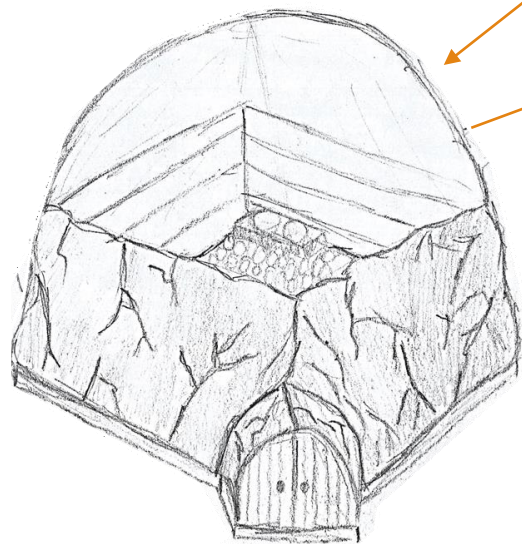
### Design process for final design:

Due to the feedback from my stakeholders and clients as well as my conducted survey it is clear that of my 6 original designs not one of them would fit all the design **criteria** so combining some of the original designs would be more beneficial to create a developed "super" design.

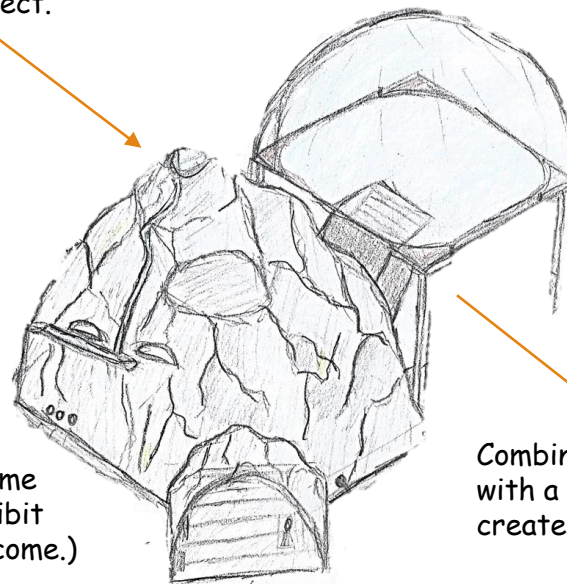
## - Development Of Chosen Design 0.1 -

Neither of these designs completed all the criteria and both received an equal amount of praise from the survey, so hand picking the key features and **design points** that are beneficial will ensure a potentially perfect design which will suit the end users and assist with the stakeholders goals with the project.

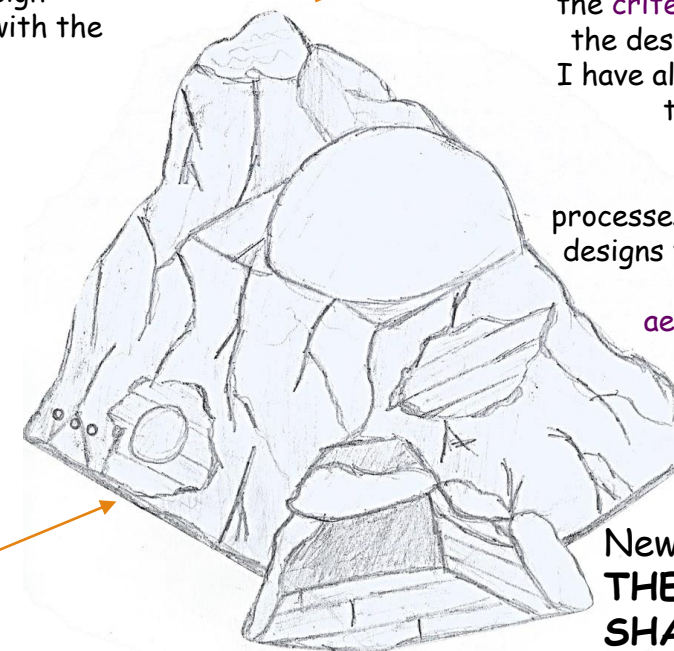
This design includes all the **criteria points** that both of the earlier designs missed out on and it will also include the **criteria points** that the designs do as well, I have also hand picked the **best design features** and manufacturing processes from the two designs to enhance the final design **aesthetically and literally**.



(Both designs do miss some **criteria points** which inhibit the potential design outcome.)



Combining the two together with a few **criteria tweaks** creates this design!.



New design name: **THE SHELL SHACK**

### Pros:

This design is beneficial for many of the 9 design criteria it works for the design points:

- **Criteria 1:** The design is naturalistic in appearance.
- **Criteria 2:** The domed window in the summer will provide a sufficient heat transfer from the summer sun.
- **Criteria 3:** The water bowls inside the cave assist with this point.
- **Criteria 4:** The insulation and acrylic dome provide heat retention.
- **Criteria 7:** The sealant will provide an adequate water seal as does the waterproof finish on the paint.

### Cons:

This design is also not beneficial for many of the 9 design criteria so doesn't work for the design points:

- **Criteria 1:** The design could be considerably more naturalistic and is quite boxy and square so isn't the ideal shape.
- **Criteria 5:** The design is massive in size and is likely to be extremely difficult to move around making it unfeasible.
- **Criteria 6:** Due to the size of the product and the amount of materials and the choice of materials the product will be extremely heavy and difficult to move.
- **Criteria 8:** Door way is too small so will eventually be outgrown by the tortoise.
- **Criteria 9:** Design is not very cost effective as will require upkeep

### Pros:

This design is beneficial for many of the 9 design criteria it works for the design points:

- **Criteria 1:** The product is naturalistic and innovative in appearance and looks like a modern day feature.
- **Criteria 2:** There is a sufficient heat source with the heat mat and the acrylic dome to provide sun heat.
- **Criteria 4:** The hollow shape is heat retentive and insulated so will be warm.
- **Criteria 5:** Double square shape allows for moveability.
- **Criteria 6:** The hollow shape will ensure that the product is moveable and lightweight.

### Cons:

This design is also not beneficial for many of the 9 design criteria so doesn't work for the design points:

- **Criteria 3:** There is no access to clean water, there is no allowance for water flow or clean water which is a problem.
- **Criteria 7:** The doorway and the plastic dome will be difficult to waterproof as would the clay exterior.
- **Criteria 8:** The plastic dome and its stand would be ridiculously difficult to keep long lasting, the metal frame would eventually degrade from the inside meaning that it would eventually fail.
- **Criteria 9:** Design is not particularly cost effective due to the likelihood of parts and components needing to be replaced and fixed on a regular basis.

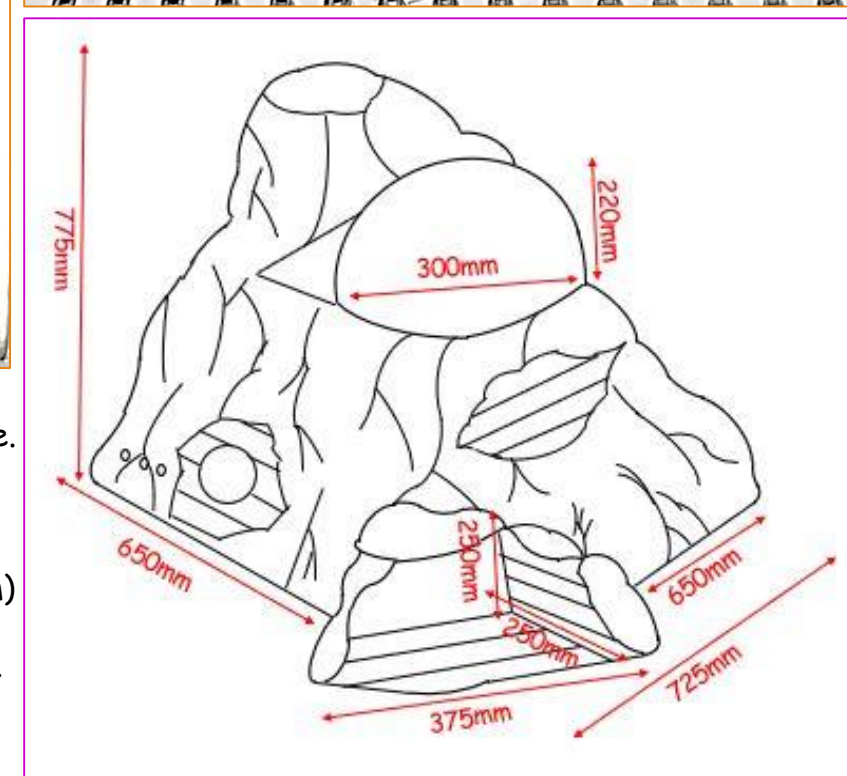
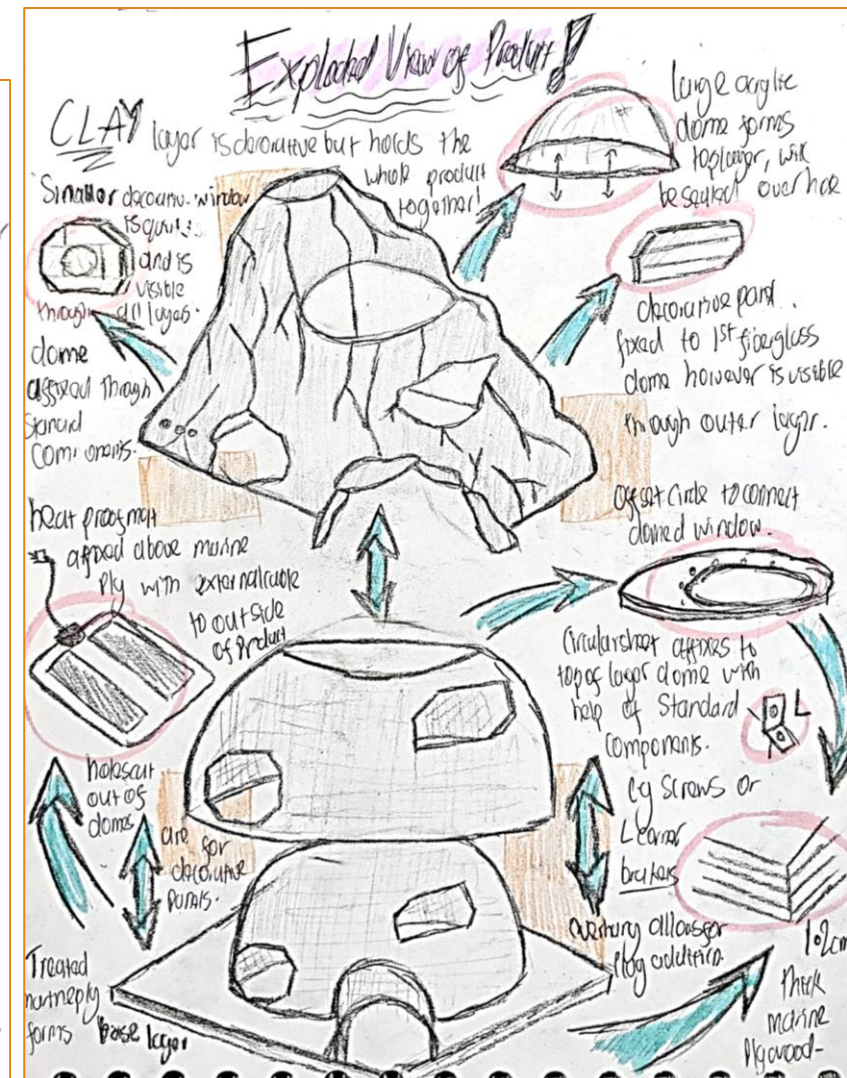
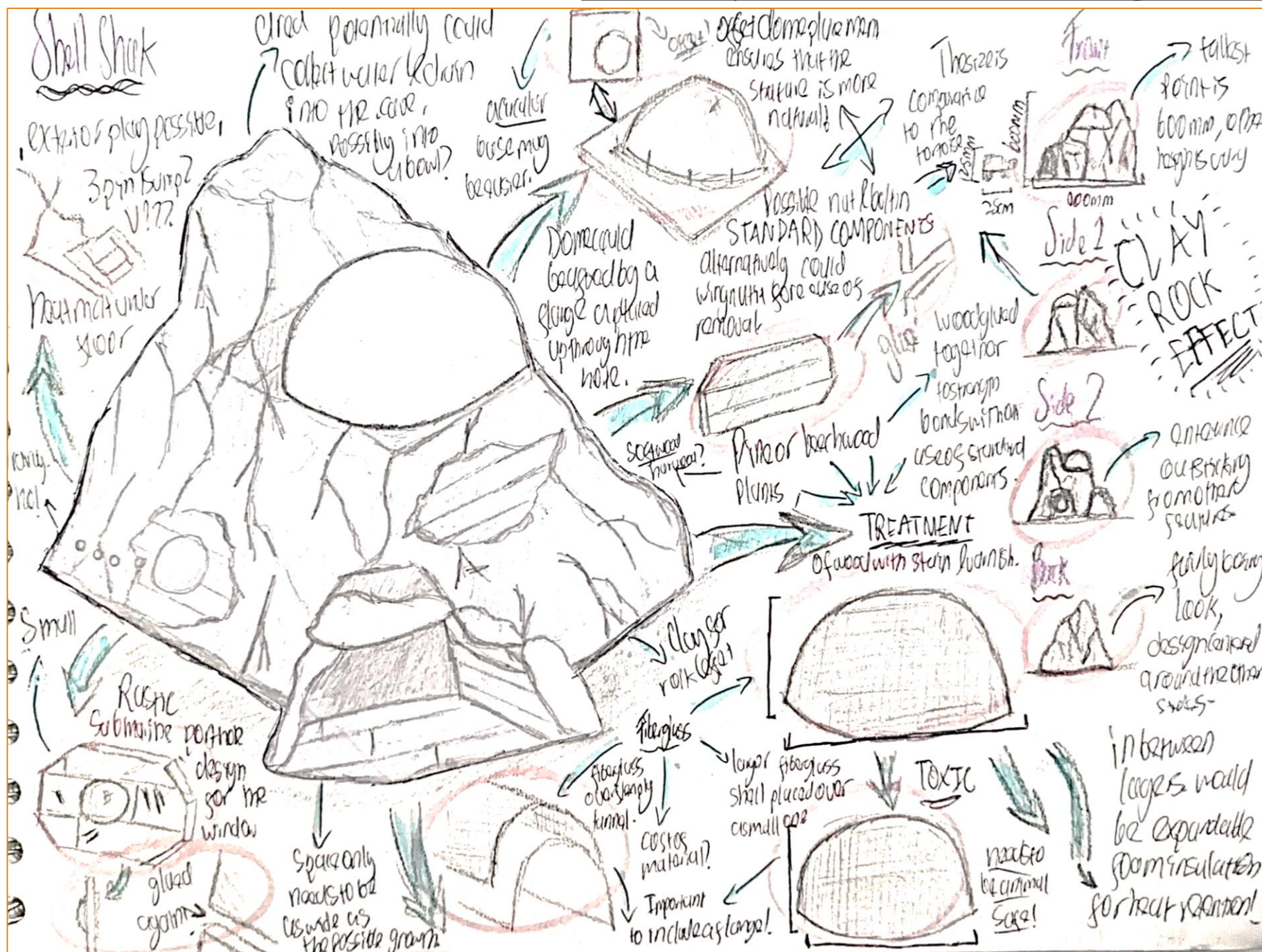
### Updated Design Criteria:

- **Criteria 1:** The design is naturalistic in appearance.
- **Criteria 2:** There is a sufficient heat source with the heat mat and the acrylic dome to provide sun heat.
- **Criteria 3:** The water bowls inside the cave assist with this point.
- **Criteria 4:** The insulation and acrylic dome provide heat retention and the hollow shape is heat retentive and insulated so will be warm.
- **Criteria 5:** Simple Square shape allows for moveability.
- **Criteria 6:** The hollow shape will ensure that the product is moveable and lightweight.
- **Criteria 7:** The sealant will provide an adequate water seal as does the waterproof finish on the paint.
- **Criteria 8:** The hardened and protected materials will be long lasting with their finishes.
- **Criteria 9:** The Reduced materials and techniques ensures for a cheaper product.

### Conclusion:

If the product can abide by all the combined 9 criteria points from the stakeholders and clients then the outcome of the product will be positive and reassuring and will work to its best ability.

# - Development Of Chosen Design 0.2 -



Comments:  
 Perfect! Makes great use of my design criteria & is fitting for my design brief I like the choice of materials!!!  
 Yes

- Materials List:**
- **Marine Plywood** - this will be for the base of the product and will support the acrylic dome.
  - **Fiberglass & Resin** - this will be used to construct the two domes that will sit atop one another and hold the generic shape!
  - **Pine Planks** - will be used to add decorative panels to the outside structure.
  - **Acrylic domes** - will be used for decoration and heat absorption (1x80mm & 1x300-450mm)
  - **Clay** - this will be used to give the naturalistic appearance to the cave.
  - **STANDARD COMPONENTS** - potentially screws, nuts, bolts, wingnuts, L corner brackets.
  - **Glues & Varnishes** - will be used to hold sections together, includes stains and paints.
- THIS DESIGN FOLLOWS ALL 9 OF THE STAKEHOLDER CRITERIA POINTS!!!!**

## - Building A Working Model 0.1 -

### Vacuum forming:

To begin making my working model of my developed design I decided to use the vacuum forming process to mimic the fibreglass dome that I will be producing, I selected an appropriate plastic (HIP - High Impact Polystyrene) this was chosen as its strength to weight ratio mimics that of a hardened fibreglass dome and it also shares many of the same properties but with a 1:4 ratio, with fibreglass being 4x stronger than the Polystyrene.

#### Step 1:

The sheet of HIP's was chosen and was checked for any cracks or damages or sharp edges as this could lead to a faulty model meaning that the model wouldn't replicate the properties of the actual materials chosen.

#### Step 2:

Two Pyrex bowls of different sizes were chosen to mimic the "shell in shell" effect that would be needed for the dome - having two of different sizes allows room for the expandable foam insulation which provides heat retention.

#### Step 3:

The Pyrex bowls were placed into the vacuum former and then were descended into the chamber, they are descended to allow room for the vacuum to form the plastic around the mould, this ensures that all of the mould is covered with plastic.

#### Step 4:

The plastic sheet was firmly fixed into place and then the vacuum forming process began, the strip heater was pulled out and suspended above the plastic which began to bend and weaken the bonds of the plastic meaning it was more elasticated for forming.

#### Step 4:

ERROR - I discovered an error when vacuum forming my initial prototypes, THE mould cannot sit too close to the chamber walls or the vacuum creates a ridge that doesn't form to the shape so this means that more space needed to be inputted.

#### Step 5:

Normally when vacuum forming, the mould would have air holes to ensure that the product can be easily removed, my pyrex bowl did not have this so the plastic stuck to the bowl, so a small incision to introduce air was made.

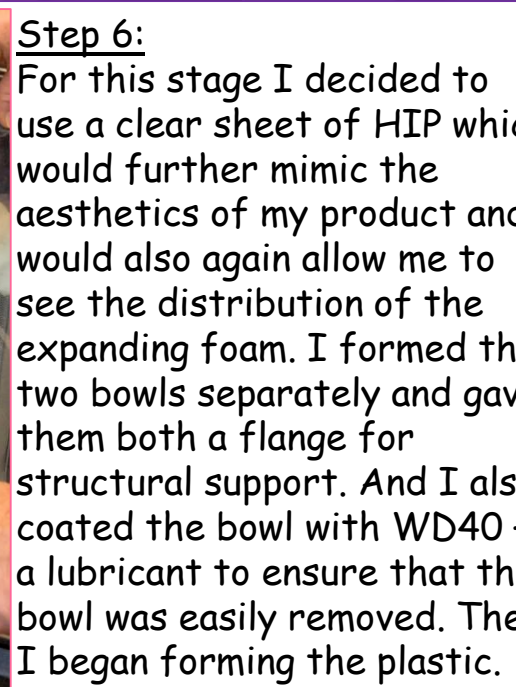
#### Step 6:

For this stage I decided to use a clear sheet of HIP which would further mimic the aesthetics of my product and would also again allow me to see the distribution of the expanding foam. I formed the two bowls separately and gave them both a flange for structural support. And I also coated the bowl with WD40 - a lubricant to ensure that the bowl was easily removed. Then I began forming the plastic.

### Furthering the "Mock Up":

To ensure that the working model is also close to the end product as possible without wasting expensive materials, substitutions with reduced properties that do however present similarly to the official materials have been used they are as follows:

- Plastic Dome - mimics the fibreglass shell.
- Plywood Bass - Bass is made of 3mm plywood as opposed to 25mm marine ply (not as water resistant)
- Hot glue - mimic the waterproof sealant that will affix all the holes on the product to ensure heat retention.
- Expandable foam - easily accessible so the foam used for the model is the one that will be used for the end product.
- Cardboard tunnel - this mimics the fibreglass tunnel that will be produced - not as strong as the domes of vacuum formed plastic.
- The wooden décor - lolly sticks mimic the treated pine wood tat will be applied.
- The decorative plastic window domes - these will be mimicked from smaller plastic domes that can easily be fabricated, equally this is beneficial using a smaller scaled dome as the properties are exactly the same as they are made of exactly the same materials.
- Paper Mache - the strips of paper Mache and pva glue, are a mimic of the fibreglass strips and the resin and hardeners which will be applied over the top of the fabricated domes to apply a stronger structural integrity.
- Air Drying Clay - again is easily accessible so the clay used in the mock up is the same that will be used finally.

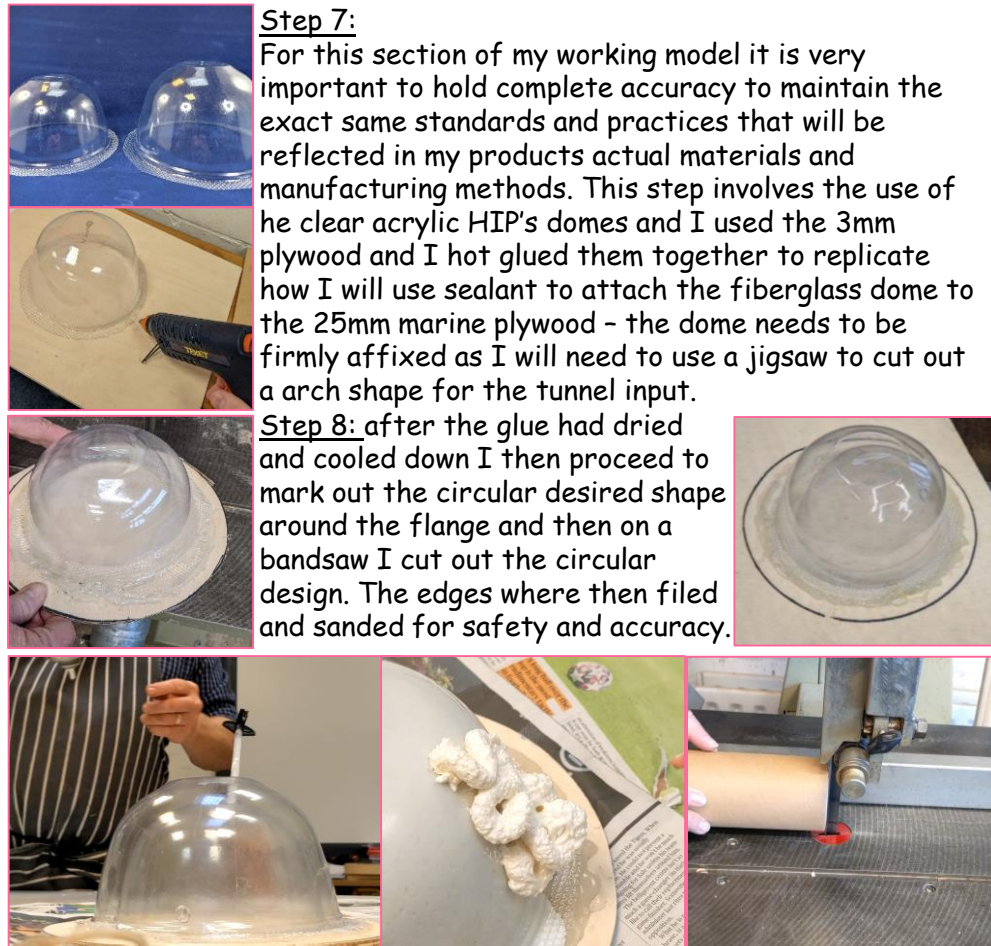


# - Building A Working Model 0.2 -

## Step 7:

For this section of my working model it is very important to hold complete accuracy to maintain the exact same standards and practices that will be reflected in my products actual materials and manufacturing methods. This step involves the use of the clear acrylic HIP's domes and I used the 3mm plywood and I hot glued them together to replicate how I will use sealant to attach the fiberglass dome to the 25mm marine plywood - the dome needs to be firmly affixed as I will need to use a jigsaw to cut out a arch shape for the tunnel input.

**Step 8:** after the glue had dried and cooled down I then proceed to mark out the circular desired shape around the flange and then on a bandsaw I cut out the circular design. The edges were then filed and sanded for safety and accuracy.



**Step 9:** The next step involved me affixing the larger flanged dome on top of the smaller one to mimic the fiberglass structure. Then the larger one was glued on as well. Then the expandable foam was retrieved and the tube hole diameter was measured and a hole that measured the same diameter was melted into the domes, one at the top of the large dome and one at the bottom of the large dome on the alternate side. The holes are necessary to ensure that there is a sufficient amount of air in the space to react with the foam and harden into a honeycomb shell like structure.



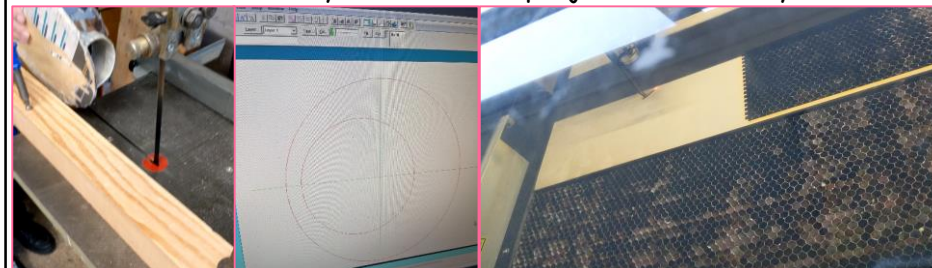
## Step 10:

For this stage of my model building I cut a hole out of the plastic domes and measured the diameter of the arch cut out, then I acquired a sheet of cardboard where I worked out the circumference of the dome cut out and then using a bandsaw cut the correct amount of cardboard and bent into the right shape. Then using a g clamp I affixed the model to the table and used the correct waterproof sealant to seal the archway tunnel to the plastic dome structure around all of the edges to prevent water damage.



## Step 11:

This step was fairly simple and involved using paper mâché to mimic the additional fiberglass sheets over the top of the domes there where many layers added with pva glue (to mimic resin) and then quickly dried with the use of a hairdryer, in the real project time will dry the resin.



## Step 12:

I sliced the top of the model off to get a flat edge to which I can add my additional details and features too, the top was measured in diameter to ensure the correct to scale measurement was taken for the off centre hole that will house the window which was the laser cut.



## Step 13:

Oddly after the top was cut off and the foam insulation was revealed I noticed that the foam had not spread to all the space in-between the domes, this I concluded was down to the fact that the WD40 had made a chemical reaction that stretched the foam meaning a different lubricant will need to be used in order to separate the dome from the mould.



## Step 14:

The wooden panel and side decorative window were laser cut and affixed with hot glue to the main structure which is going very well, then I sealed the window in with the earlier waterproof sealant.



## Step 15:

At this stage the remaining rock like structure was introduced to the top of the model and was made out of the paper mâché mimicking the fiberglass.



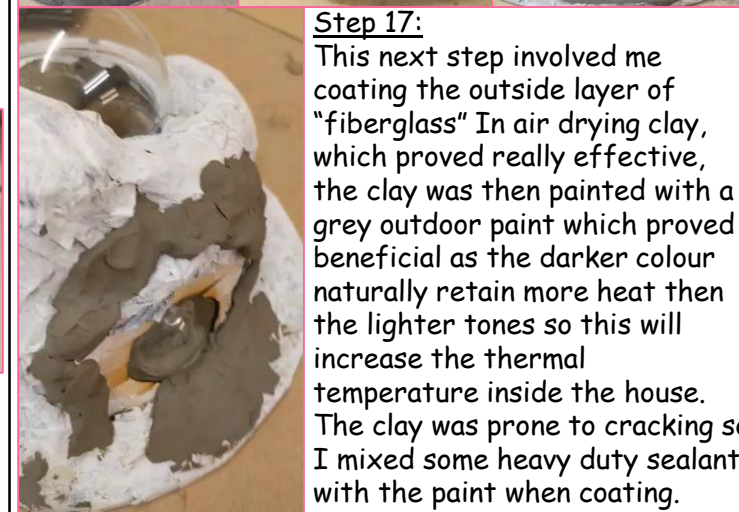
## Step 16:

This was a very simple stage where I mixed white paint with PVA glue to make a hardener that would retain the shape of the "cave" when the clay is later applied.



## Step 17:

This next step involved me coating the outside layer of "fiberglass" in air drying clay, which proved really effective, the clay was then painted with a grey outdoor paint which proved beneficial as the darker colour naturally retain more heat than the lighter tones so this will increase the thermal temperature inside the house. The clay was prone to cracking so I mixed some heavy duty sealant with the paint when coating.



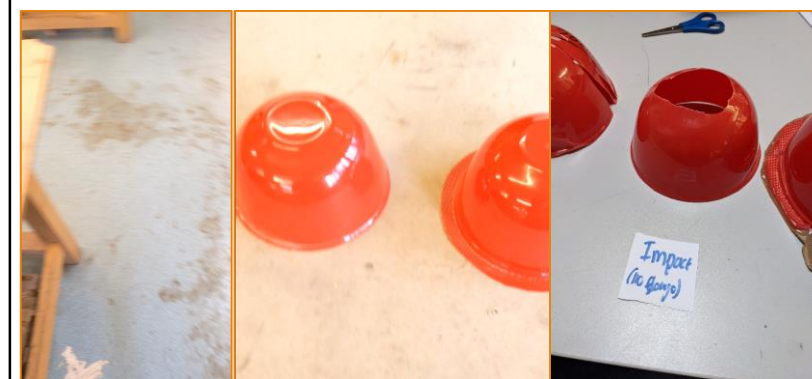


**Step 18:**  
This final step involved me coating the clay in a protective grey paint coating, the paint is waterproof and stops the molecules of water from maneuvering into the cracks and expanding when it freezes and then further cracking and failing.

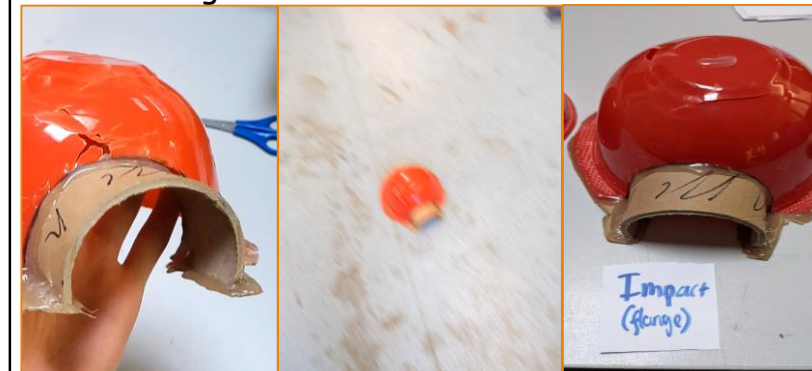
It became apparent that stress testing the working model would be greatly beneficial as it would show me how the real product and materials as the results to the stresses would be similar in results. The materials used in the stress testing do mimic the actual ones being used. The models use a vacuum formed plastic which has a lower tensile strength (about a 1:4 ratio) than the fiberglass shell that is going to be used for the official product. The results are as follows:



The test conducted where, heat resistance, shock resistance, weight resistance, impact resistance (with a flange and without a flange) and water resistance.



**Impact Resistance (No Flange):**  
The results of the flangeless prototype conclude that a lack of the flange does indeed cause the dome to crack and perish and will therefore affect the design so I think that it would be beneficial to consider the use of a flange around the base of the dome.



**Impact Resistance (Flange):**  
The results of the flangeless prototype conclude that the use of a flange does indeed have a better protection against the impact however it does also crack when impact is applied, BUT it does also protect better than the lack of flange as the dome still retains its shape. And won't affect the tunnel.



**Water**  
From this test it concludes that the dome structure is waterproof, when the resin dries as will the fiberglass.

**WORKING MODEL EVALUATION**

From conducting numerous material tests when assembling my working model, I conclude the following:

- The materials that I have chosen will be effective and will allow the product to perform in an optimum condition. The use of fiberglass, marine ply, clay, expandable foam insulation, sealant etc.
- The general fiberglass shell will survive all its stresses presented in its environment e.g., impact, water, weight, shock, heat. Obviously, everything has its limits, but It is highly unlikely that the environment the product will be in will be exposed to the high levels of stress required to break the structure of the product and its materials it made of.
- Equally the use of a flange for the domed bass will be a beneficial design element to my products shape as the flange, from my stress testing, has proven to be very strong and good at retaining shape and heat etc.



**Heat:**  
The results of the heat test, which consisted of me applying constant heat for a long period of time showed that the product structure will not be compromised using heat with the chosen fiberglass shell.

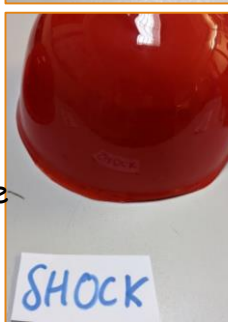


**Shock:**  
The results of the shock test, which consisted of me applying constant flow of charge to the plastic dome proved that no damage will be to the product. Equally fiberglass is not conductive so won't carry a charge.



**Weight:**  
The results of the weight test, which consisted of me applying an increasing sized weight to the plastic dome proved that damage would occur if enough pressure is applied at a flow, the shell will simply crack and fail which means

That overall, yes, the dome will be strong when it is made with the fiberglass however there will be a certain point that will result in the dome to crack and perish like the model, however with the added layers of resin and chopped strand mat the strength will increase tenfold, but precautions should still be taken.





# STRAND 4 – Making

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# - 10 Step Plan of Making-

Step No.	Detailed Step By Step description:	Materials Needed:	Machinery and Techniques needed:	Risk Assessment:
Step 1:	<ul style="list-style-type: none"> <li>Balls to be pumped up to their correct sizes.</li> <li>Scrap wood to be routered to fit the smallest ball.</li> <li>So, panel pin need to be inserted to center and the correct hole on the guide tool.</li> <li>Sharp edges from scrap wood to be sanded if needed</li> </ul>	<ul style="list-style-type: none"> <li>Large scrap of wood</li> <li>750mm Diameter Exercise ball</li> <li>850mm Diameter Exercise ball</li> <li>Panel Pin for router</li> </ul>	<ul style="list-style-type: none"> <li>Router</li> <li>Guide tool for the router.</li> <li>Hammer</li> <li>Hand pump</li> <li>Extension cable</li> </ul>	<ul style="list-style-type: none"> <li>PPE needs to be supplied e.g., safety goggle to be worn whist routing to prevent eye damage.</li> <li>Windows and fans need to be used to ventilate the area.</li> <li>Power chord of router needs to be held at distance to prevent damage to machinery.</li> </ul>
Step 2:	<ul style="list-style-type: none"> <li>Small exercise ball needs to be plastic wrapped and moistened, then creases need to be wrinkled out.</li> <li>The fiberglass sheets need to cut into long thin strips</li> <li>Resin and hardener needs to be mixed and then the strips need to be coated over the ball using the paper Mache skill.</li> </ul>	<ul style="list-style-type: none"> <li>1000ml of polyester resin</li> <li>20ml of Resin hardener</li> <li>5000mm of Fiberglass sheet</li> <li>Plastic wrap (2000mm)</li> <li>Spray Bottle of water</li> </ul>	<ul style="list-style-type: none"> <li>Measuring Jug and Syringe</li> <li>Fiberglass resistant brush</li> <li>Stanley Knife and cutting mat.</li> </ul>	<ul style="list-style-type: none"> <li>PPE will be very important, Thick heat proof gloves to prevent spikeage and skin corrosion from the resin.</li> <li>Lots of ventilation, all the door and windows open.</li> </ul>
Step 3:	<ul style="list-style-type: none"> <li>Wooden panels need to be cut on table saw, glued and held, then sanded, stained, varnished and finished.</li> <li>Hole for window needs to be drilled and fret sawed, window then needs to be affixed and sealed from the inside.</li> <li>Larger panel needs to be cut, glued, stained, varnished etc.</li> </ul>	<ul style="list-style-type: none"> <li>Pine planks</li> <li>Exterior wood stain and wood matt varnish</li> <li>Water sealant</li> <li>Acrylic dome window.</li> </ul>	<ul style="list-style-type: none"> <li>Table saw</li> <li>Wood Glue and tape "cross to hold together.</li> <li>Cloths for varnish and stain</li> <li>Standard component screw</li> </ul>	<ul style="list-style-type: none"> <li>Saw blade is sharp and requires care.</li> <li>PPE Gloves should be worn with glue varnish and stain to prevent skin damage.</li> <li>Care needs to be taken when using screwdriver as it is sharp and temperamental under stress.</li> </ul>
Step 4:	<ul style="list-style-type: none"> <li>Polyfiller and seal any holes that remain in the fiberglass mesh to ensure no leakage.</li> <li>Mark and cut off the top of the dome with jigsaw.</li> </ul>	<ul style="list-style-type: none"> <li>Polyfiller and hardener</li> </ul>	<ul style="list-style-type: none"> <li>Jigsaw</li> <li>Pallet knife/spreader</li> </ul>	<ul style="list-style-type: none"> <li>Jigsaw is sharp and requires accurate cutting.</li> <li>Polyfiller fumes are toxic, need ventilation and potentially a mask to avoid fumes and inhalation</li> </ul>
Step 5:	<ul style="list-style-type: none"> <li><del>Construct larger dome out of fiberglass place over other.</del></li> <li><del>Using expandable foam insulation, insulate the gap.</del></li> <li><del>(SEE STEP 5 FOR CHANGES)</del></li> </ul>	<ul style="list-style-type: none"> <li><del>SAME AS STEP 2</del></li> <li><del>Expandable foam canister</del></li> <li><del>(SEE STEP 5 FOR CHANGES)</del></li> </ul>	<ul style="list-style-type: none"> <li><del>SAME AS STEP 2</del></li> <li><del>(SEE STEP 5 FOR CHANGES)</del></li> </ul>	<ul style="list-style-type: none"> <li><del>SAME AS STEP 2</del></li> <li><del>(SEE STEP 5 FOR CHANGES)</del></li> </ul>
Step 6:	<ul style="list-style-type: none"> <li>Gather marine plywood sheet and mark for cutting.</li> <li>Cut marine plywood on table saw into a 900mm square and a smaller 750mm square</li> <li>Using the router, router both square sheets into a 900mm circle and a 730mm circle.</li> <li>Sand off the rough edges.</li> </ul>	<ul style="list-style-type: none"> <li>Marine ply (2440mm x 1220mm)</li> <li>Panel Pin</li> </ul>	<ul style="list-style-type: none"> <li>Router</li> <li>Guide tool for the router</li> <li>Table saw</li> <li>Sandpaper of various grades.</li> </ul>	<ul style="list-style-type: none"> <li>PPE needs to be worn for the table saw: protective eyewear.</li> <li>PPE needs to be worn for the router: thick gloves to prevent splinters and hand damage.</li> <li>Power chord of router needs to be held at distance to prevent damage to machinery.</li> </ul>
Step 7:	<ul style="list-style-type: none"> <li>Lay components ready for assembly.</li> <li>Treat marine plywood base.</li> <li>Measure and draw accurate lines on fiberglass structure ready for cutting. For entrance and window panel.</li> <li>Using a pilot hole and jigsaw cut out desired shapes.</li> <li>Using polyfiller, firmly affix the window panel into place.</li> </ul>	<ul style="list-style-type: none"> <li>Marine Ply base</li> <li>Fiberglass/insulation structure</li> <li>Window panel</li> </ul>	<ul style="list-style-type: none"> <li>Wood varnish</li> <li>Ruler &amp; Compass</li> <li>Hand Drill &amp; Jigsaw</li> <li>Polyfiller and g-clamp.</li> </ul>	<ul style="list-style-type: none"> <li>PPE to be worn to prevent skin contact with varnish.</li> <li>PPE gloves and eyewear to be worn when drilling and sawing &amp; masks as fiberglass is harmful.</li> <li>Assistance from person to stabilize the structure when drilling so it doesn't move.</li> </ul>
Step 8:	<ul style="list-style-type: none"> <li>Paint inside of the dome with grey slate paint.</li> <li>Apply layer of glue and then spread tortoise terrain on wall</li> <li>Pillar drill then fretsaw a hole to perfectly fit temperature adjustment for the heat mat. Rewire plug to 3 pin standard</li> <li>Polyfiller panel into the structure, then glue and affix the finished dome to the marine ply base.</li> </ul>	<ul style="list-style-type: none"> <li>Structural components</li> <li>Tortoise terrain</li> <li>PVA Glue &amp; Slate Paint</li> <li>HEAT MAT</li> <li>3 Pin exterior plug and fuse for rewiring.</li> </ul>	<ul style="list-style-type: none"> <li>Paint brushes</li> <li>Pillar drill</li> <li>Fretsaw</li> <li>Sandpaper</li> <li>Wire strippers and pliers</li> <li>Polyfiller</li> </ul>	<ul style="list-style-type: none"> <li>PPE Gloves for paint, glue and polyfiller applications.</li> <li>Rubber gloves to prevent electric shock incase of electronic malfunction.</li> </ul>
Step 9:	<ul style="list-style-type: none"> <li>Using router, route the 450mm hole for the larger window in the top panel. Apply window and hand drill 4 equidistant holes and apply nuts and standard components.</li> <li>Table saw a piece off FlexiPLY with same circumference as arch entrance. Then slot into place and seal down.</li> <li>Paper Mache the outer layer of whole dome structure.</li> </ul>	<ul style="list-style-type: none"> <li>750mm marine ply circle</li> <li>450mm acrylic dome window.</li> <li>485x220mm FlexiPLY sheet.</li> <li>News Paper &amp; PVA Glue</li> </ul>	<ul style="list-style-type: none"> <li>Router &amp; Guide tool</li> <li>Circular saw</li> <li>Hand Drill</li> </ul>	<ul style="list-style-type: none"> <li>PPE Ventilation needs to be good for the routing as the small fragments of wood are damaging if inhaled.</li> <li>PPE goggles when using the hand drill and the table saw to protect eyes.</li> </ul>
Step 10:	<ul style="list-style-type: none"> <li>Spread clay around outer layer and form rock like structures out of clay, then paint with waterproof mix.</li> <li>Table saw a semicircle of marine ply, laser engrave, apply paint, wood stain and varnish for decorative effect.</li> <li>Measure the area around the temperature dial, cut a block on a table saw to that size, with angled sides, then vacuum form a clear HIPS casing with flange, then screw down.</li> <li>Finally, to conclude, apply an additional layer of paint.</li> </ul>	<ul style="list-style-type: none"> <li>Nylon Reinforced Clay Composite</li> <li>Marine Ply arch (285mmx220mm)</li> <li>Paint, Wood Stain &amp; Varnish</li> <li>Clear HIPS sheet, &amp; wood block</li> <li>Grey waterproof paint mix</li> </ul>	<ul style="list-style-type: none"> <li>Circular saw</li> <li>CNC Laser cutter/engraver</li> <li>Paint Brushes</li> <li>Vacuum Former</li> <li>Guillotine (For HIPS Sheet)</li> <li>Standard components (screws)</li> <li>Sandpaper</li> </ul>	<ul style="list-style-type: none"> <li>PPE gloves to prevent long term exposure damage from clay, paint, varnish, wood stain etc.</li> <li>PPE Eyewear must be worn when using circular saw &amp; most importantly laser engraver.</li> <li>Must ensure that the vacuum former is safely sealed to prevent suction and heat damage to skin.</li> <li>PPE use the protective guard when guillotining.</li> <li>Don't inhale fumes, keep area well ventilated.</li> </ul>

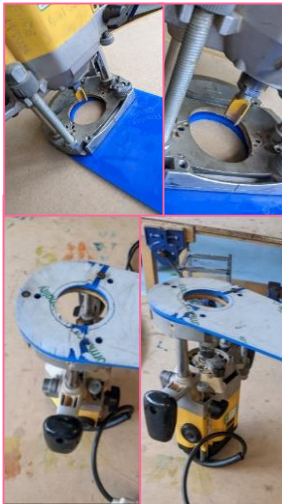
To start off my project I purchased these exercise balls from amazon, I chose to use these balls and mimic the earlier investigated "pizza oven ball trick" that allowed the use of an exercise ball and then concreting over it to create the perfect domed shape, I would however do this with polyester resin and fiberglass sheets instead to ensure that the weight is not too large. I purchased two balls; one with a diameter of 75cm and the other with a diameter of 85cm, this insured that when the domes are completed there will be a 10cm gap in between the two domes for me to insulate. The domes were then both hand pumped to inflation and measured to ensure that they are the correct size.



## - Step 1 -

Before routing began there were some certain and particular safety features that I had to put into place to ensure that all surrounding people are not in any danger, these safety features included;

- Opening any windows and turning on any extractor fans in the nearby area to make sure that any dust or shards of wood were evacuated safely.
- Securely fastening the guide tool to the router base to make sure that it remains accurate and constantly safe.
- PPE, this was the most essential, all nearby workers including myself wore protective goggles to protect our eyes, I didn't feel that gloves were essential as the wood being cut was mdf so a very softwood.
- Ensuring that all cables are kept out of the cutting line to avoid, electrocution, death and machine damage or injury.



I then located a scrap bit of wood that would be large enough to have an 85cm hole cut in the middle of it, the mdf happened to be circular which is beneficial as I planned to cut a circle out of it. I then located the router and the specialist tool, the specialist tool is a piece of acrylic that has been inscribed with various measurements on it to act as a guide when cutting the holes, as my first hole was 75cm wide I located the 37.5cm "guide hole" and set that at the center of the piece of wood. To locate the center of the wood I drew lines across the wood from edge to edge to see where they all joined up, as it is a circle this concluded the location of the center.

After the hole was cut the ball with the diameter of 75cm was then placed inside of it to show a dome which proved that the hole cut was exactly half the width (and the largest segment) of the ball, this allowed me to quickly move on to step 2 which involved me starting to coat the ball in the fiberglass layers. To create the hardened shell required.

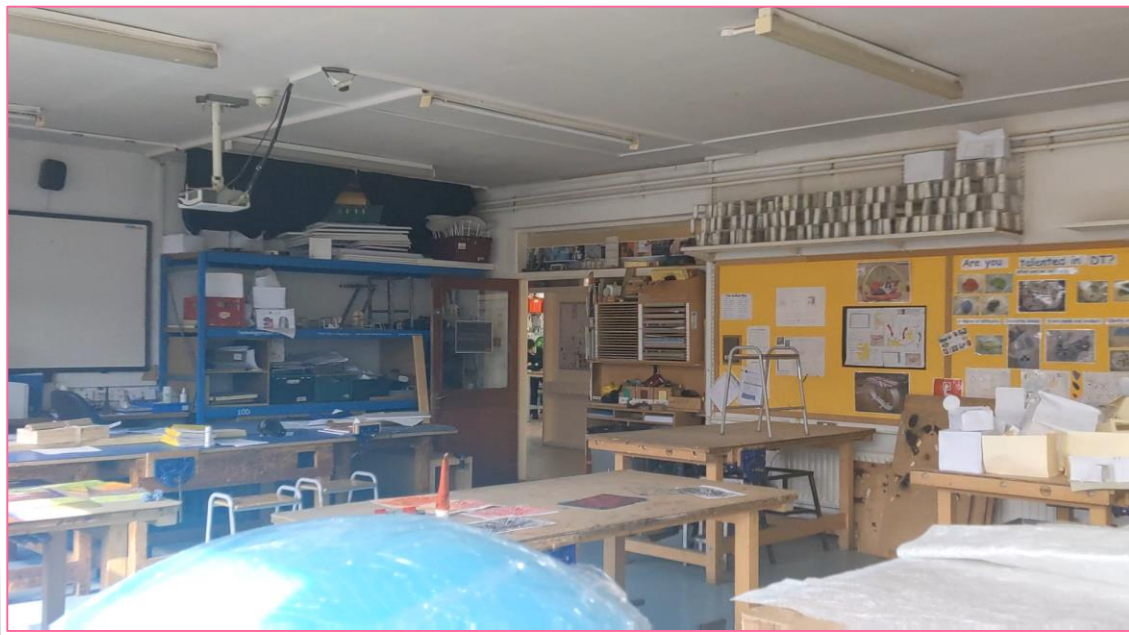


## - Step 2 -

Now that the hole in the wood was cut/routed I could begin to create the shell of the dome, to protect the exercise ball I coated the outside of it in cling film which coincidentally also ensured that there would be a smooth surface on the inside of the dome when complete, I then proceeded to moisten the outer layer of cling film, the water acts as a reactant and subsequently assists in the removal of fiberglass from the mold when complete. I had to ensure the whole area was wet.



Because of all the serious health implications of the fiberglass and resin to the human body, explored in my research, more PPE was introduced: All windows and doors and vents were opened to promote airflow, and then thick heat proof gloves were worn by me to allow more protection against corrosion and cuts from the glass and resin. The opened doors helped with the smell. Then to ensure accuracy with quantities of resin and hardener I used a measuring jug and syringes that were provided in the pack. I followed all the instructions with mixing the two and used a new unopened fiberglass resistant brush to spread the resin across the dome.



I now began to coat the protected ball with the resin and fiberglass, I used the paper Mache technique explored earlier in my model and research making to laminate strips of fiberglass over the dome with the resin, the resin set pretty fast, so I had to ensure that the strips were applied effectively and that none of the resin was wasted as it was expensive.



### - Step 3 -

This step was rather crucial to make my stakeholders and clients happy, combined their biggest criteria point was that the overall design of the tortoise house be kept naturalistic, however they did also like the rustic setting as well, so part of my design was to incorporate a rustic cabin feel into the clay and stone structure.

- So, to begin I selected some pine planks and then marked and cut them to the desired "overlapping" wood brick effect, then I used wood glue to glue and fasten the sides together (the use of glue is more sustainable than standard components and allows for a more rustic setting, then the glued planks were taped together into a grid to retain their shape).
- I did have to sand down the surfaces on both sides where the pressure from the tape grid had forced some of the glue to the surface, however sanding it provided a consistent texture.
- I then sliced, at an angle, the sides of the square off to form a hexagon and using the pillar drill drilled a small 5mm hole in the center where the decorative window will go.
- The 5mm hole greatly allowed me to use the fretsaw to accurately cut the hole the size of the acrylic window out meaning I could fit it into the panel.
- Next, I used some exterior wood stain to stain the wood panels to a rustic look desired by my clientele, I made sure to stain the whole panel on both sides which will help it retain its rustic look for an extended period.
- With this wood stain it is important to add additional layers every few hours to darken the wood further and keep a consistent colour and texture.
- Then I added a "matt coat" varnish to the outer layers of the window panel which protects it from water damage, beneficial as mine is an outdoor product so will need protection from the elements.



Next, I added some decorative indentations and scratches to the outer surface of the panel. As pine was used the soft grained material allowed for ease of scrape from the back of a screwdriver. Having the scratches highlights the imperfections and also accentuates the rustic look. To conclude this step, I popped the window through the hole and screwed its flange to the underside of the panel, then using the waterproof sealant as seen earlier in my research I sealed the window to the panel thus providing an extra layer of water protection to the product. Then I repeated this step for a bigger window-less panel.

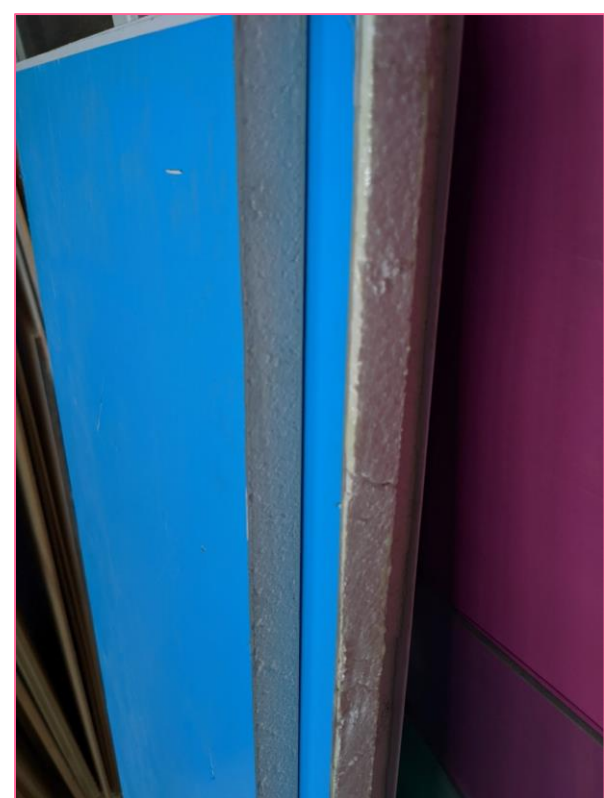


### - Step 4 -



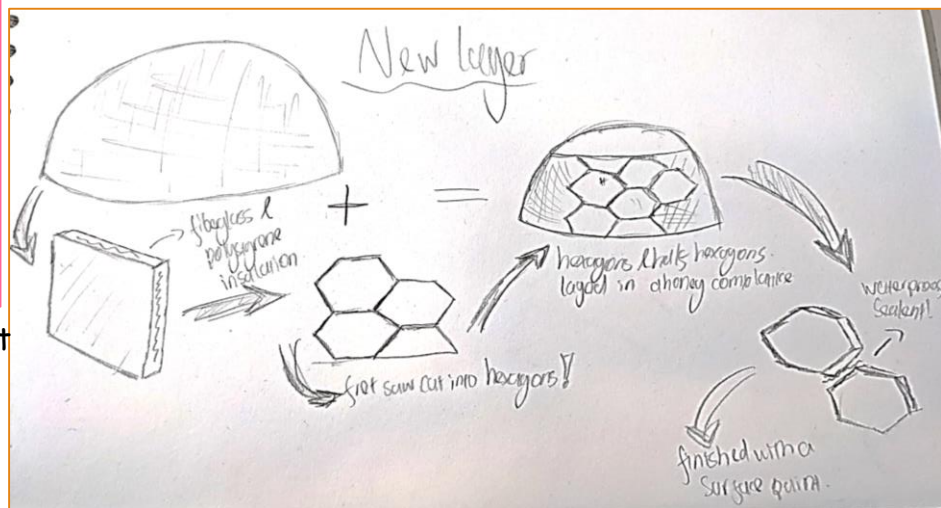
This step was by far the simplest so far, after the fiberglass and resin mix had set and the shell was completely hardened, it was time to deflate the ball inside the dome, so I did that. Then I filled the holes of the mesh with a polyfiller and hardener mix, due to the fiberglass being a mesh there were some weaker parts of the shell that required a further upkeep and filling. Then I drew a line round the whole top of the dome and using a jigsaw cut the top of the dome off to further along the development of my design.



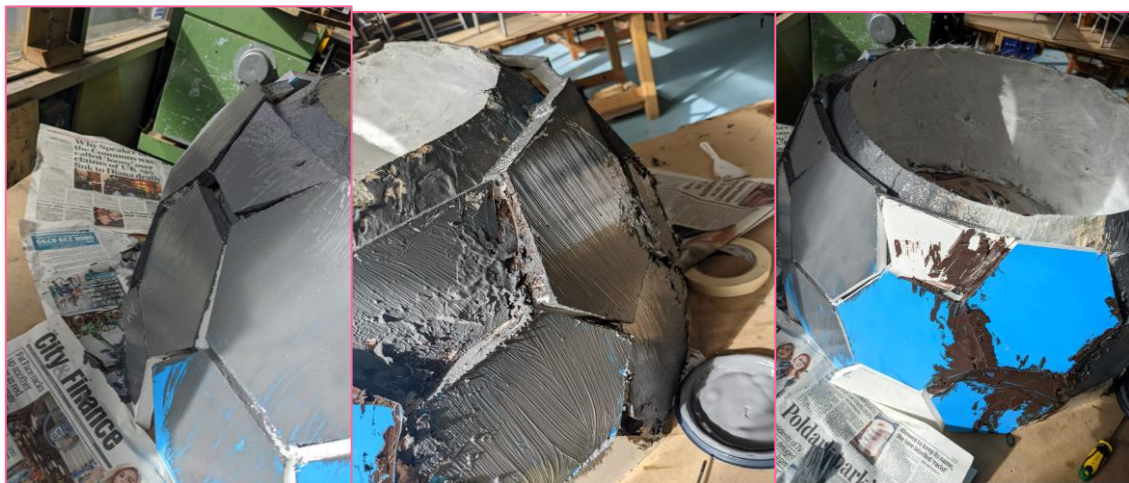


## EVERYTHING CHANGED!!!!!!! - Step 5 -

So, after designing making and finishing the first dome for the cave project I ran into a few problems which meant that I had to change my design ever so slightly. After consulting with my stakeholders who are financing the project, we concluded that the second and larger fiberglass shell could be substituted for a cheaper and more viable material, I sourced these insulated plastic and wood panels that had previously been used to line and insulate a dog kennel. Now I repurposed these and changed the design of the outer layer of my house project the new design would negate the need for a layer of insulation as well as the need for a second dome. This is it:



So with this new design I was able to cut out the hexagons and the half hex's on the fret saw, they made clean cuts so were not in need of a sand after wards, then I laid them out ready for affixing.



I used the same polyfiller and hardener that I used to fill the holes in the mesh to fix the hex's onto the dome at a slight curvature in the angle to allow them to follow the curve of the dome, the filler used is anhydrous meaning it repels water which means that It wont degrade if wet which coincidentally means that the panels won't subside and fall off. I then used the sealant that I researched earlier to seal the gaps between panels.

I did however encounter a problem, the dome was higher than the paneled walls, this was overcome by rotating the whole structure across a circular saw blade, getting a clean and perfect cut across the surface.



Step 6 was probably the most crucial and important stage in the making process so far, this step involved me preparing measuring and then cutting the layers of marine plywood to the correct shape to firmly affix the dome to. To begin I gathered the sheet of marine ply (2440mm x 1220mm) and cut it into a 900mm square on the circular table saw. Then I drew several faint lines from edge to edge so that I could find the centre of the shape, then using the router and the guide tool from earlier I made a small indentation round the circle with about a 2mm depth. Then I took the sheet to the bandsaw where I proceeded to then cut around the outside of the circle indentation, the 900mm was gathered from the total width of the base of the dome with all of its layers.



## - Step 6 -



After the large base circle was cut out with the bandsaw I turned my attention to the smaller dome, I measured the total width of the top of the dome including the layers of insulation it came to 730mm wide so I used the pillar drill and ruler to add another hole to the guide tool at 365mm to ensure that the circle would fit, then slowly layer by layer I stripped down the marine plywood with the router slowly descending the cutting tool a few mm every time until it had cut completely through the whole board thus creating an even circle that perfectly fits the top of the domed structure. Again PPE was used:

- Protective eyewear was used to prevent splinters of wood and dust from getting In the eyes.
- As the plywood was more of a mix between layers of softwood and hardwood the splinters that came off when cutting where much harder ad larger than the mdf routed earlier, so protective gloves where worn to prevent splinters,
- There was also plenty of ventilation to prevent inhalation of wood!

After the routing was complete I then proceeded to sand down the sides of the plywood ready for wood treatment.





To begin this step, I started by assembling the current stage of the product, I placed the base marine plywood on a flat surface and then proceeded to add the dome to the top being careful to place it as centrally as possible, then I placed the top layer of plywood on it as a "lid". I am happy with the current stage of the product as it is starting to take shape somewhat, fortuitously the decorative panels made earlier will fit amongst the honeycomb hexagon lattice, which is beneficial as they were made before the choice to switch from second dome to honeycomb hexes. The clay also arrived from my supplier, I chose to use air drying clay and I found a composite that is nylon enforced which will help in its bonding and heat retention, after the panels are installed, I can apply the clay, however it is now time to firmly affix the dome to the marine plywood circles.

## - Step 7 -



Next, I decided to treat the base of the marine ply to give it an ore antique and professional appearance to it, as the stain is in the inside of the product it helps keep the look naturalistic and ornate which is something that my clients will like!

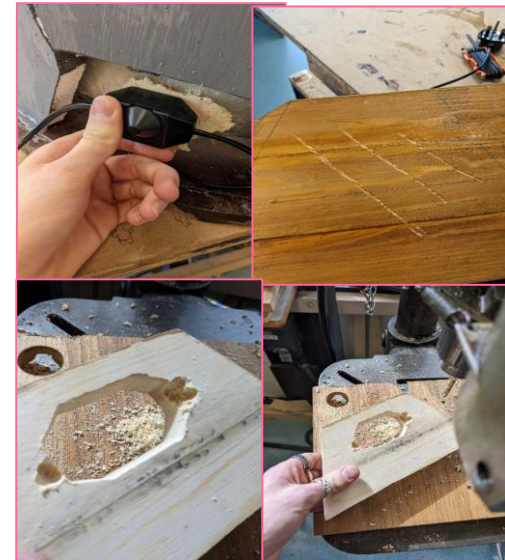
Next I used some of the techniques from earlier and I marked out using a precise compass measure to create a perfect semi circle shape for me to cut out using a jigsaw, to begin I used a hand drill to drill a hole the width of the same blade on several points of the structure. I then precisely cut out the dome from the base of the product to the height of the desired tortoise height, then I sanded down the sharper fiberglass edges and the insulation panels to avoid damage



Now it was time to add in the earlier made panel with the window in it, I first prized off the hexagonal insulation panel and scraped off the excess polyfiller to ensure a smooth surface, I then held the panel up to the gap and drew around the outside of it and then I used the same power drill followed by jigsaw to cut out the desired shape with a 5mm tolerance on either side for the filler. Then using the polyfiller researched earlier I filled the gaps between the space on the inside and the outside of the dome and waited for it to finish and dry.

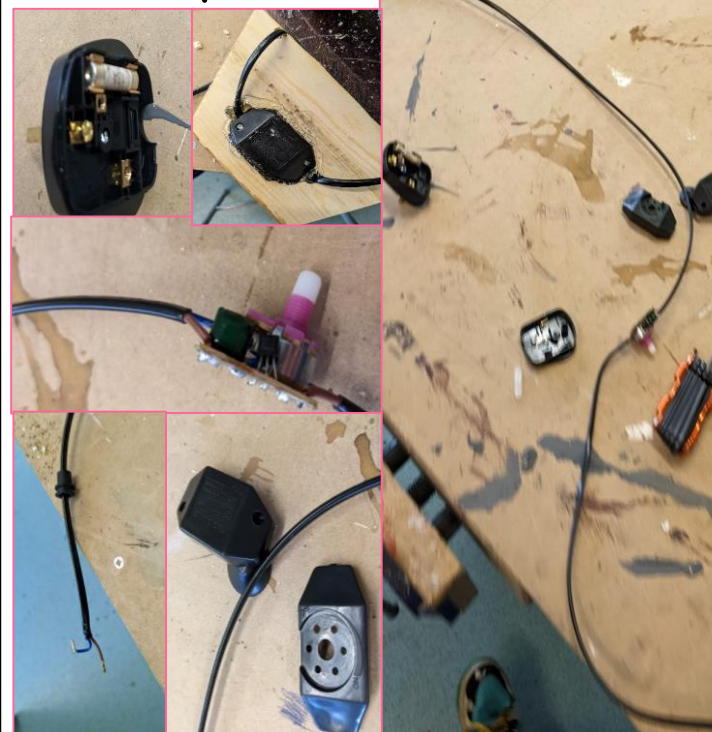


To begin this stage, I decided to take an aesthetic look to the inside of the cave, I coated the inside of the fiberglass with a dark grey slate paint to ensure a darkened naturalistic backing, then I coated the walls with a durable exterior PVA glue and then I spread calcified tortoise terrain around to give the cave a more homely and naturalistic look to it.



This stage was quite important as I decided to incorporate an adjustment setting to the heat mat, so I drilled a hole in the panel made earlier and fret sawed the shape of the component out.

## - Step 8 -



Then I had to ensure the wiring of the plug was compatible with the use of an outdoor product then I had to ensure that the wiring was reconnect safely after the sealant was added by ensuring the earth and the live wire where connected safely to their correct pins in the plug, then I fed the wire and the mat through a hole in the dome structure and fed the extra wire around the inside between the layers of the dome, and finally I connected them all back to gather sealed heir plastic casings polyfilled the panel down.





Accuracy was extremely important in this stage of the making process, every step here was so crucial and had to be precise to ensure a competent product. So, to start I got an additional sheet of marine ply and cut it into a large circle of a 750mm diameter to suit the top of the dome that was cut off, then I pillar drilled an additional hole on the guide tool for the router so that it could cut a hole with a 450mm diameter, then I marked the center of an offset circle on the marine ply and the routered out the 450mm circle to ensure that the large dome decorative acrylic window will fit perfectly with no other gaps for water damage, so after it was cut, the holes were drilled through the dome and wood for affixing it down with bolts.

### - Step 9 -



Then to ensure that I could have an entrance for the animals to get in I bent a sheet of FlexiPLY into the arch entrance way, this was doubly beneficial as the sheet stuck out of the structure and extended inside as well meaning that any water wouldn't be collected just in the entrance and would run off and out of the house. The FlexiPLY was then treated and sealed to prevent future water damage.



This stage was not originally planned in, however after seeing how the plastic outside layers of the insulation panels were very hydrophobic and anhydrous therefore repelling water-based materials such as paint which kept flaking off, I decided that the clay would more than likely come off when the moisture is drained out during the drying process. So, I decided instead to coat the outside layer in a few layers of paper Mache made with a durable exterior pva glue which makes it waterproof. This also allowed me to add some more of the rock like features in with a lighter weighted material so that not as much clay had to be used to create the texture, it also meant that I could flatten off the top the cut off dome meaning that the lid that is removable would be easy to take it off and on when needed as it would be flat, I added several layers of paper Mache to reduce weight.

### - Step 10 -

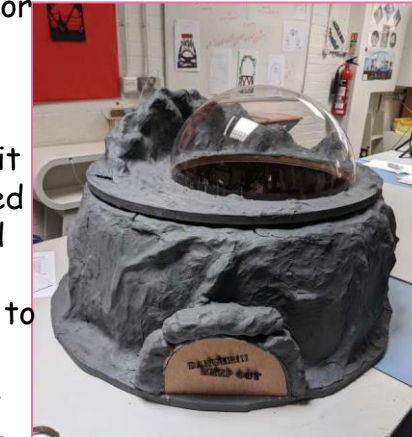


This was potentially the most important and crucial step was to create the naturalistic sealant look to the exterior of the structure, to do this I mixed water-based Sealant with durable exterior pva glue and rock paint to create the perfect water repellent mix then as it was mixing, I began to build up the clay around the outside, this was so very important as I had to incorporate different textures and extremities and lumps too make the structure look very naturalistic and normal to an environment. I spread the clay thinly and evenly to evenly distribute the weight around, then once it dried which was quite fast, I then added more and more layers until I was satisfied with the outcome, by this time my sealant paint mix had finished combining so then I applied it to the cave to give it an even look to it. Then I decided to create a cave and rock like structure around the back of the dome window, the structure is hollow to minimize weight, and then it was coated in my waterproof sealant paint mix.



To finish off the final stages of my project I needed to ensure that all the exits' areas are covered to prevent damage, I started by measuring the size of the heat adjustment dial and cutting a block with angled edges to ensure ease of removal from the vacuum former when I formed it, then I screwed it down.

The final stage was to create a door to cover the tunnel entrance, so I cut using a circular saw the semi circle shape out of marine ply and sanded it down until it perfectly fit the hole, then it was laser engraved with some comical lettering, it had colour, wood stain and varnish applied to weatherproof it, finally to conclude the whole shell shack I used rubber sealant to seal all the gaps and crack to weatherproof it.



# STRAND 5 – Evaluation

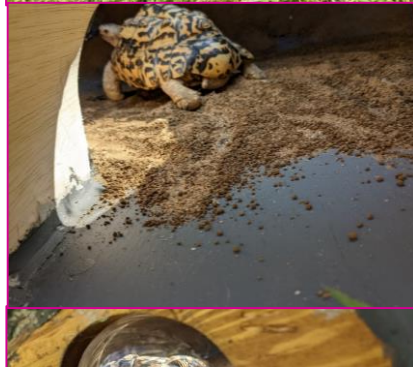
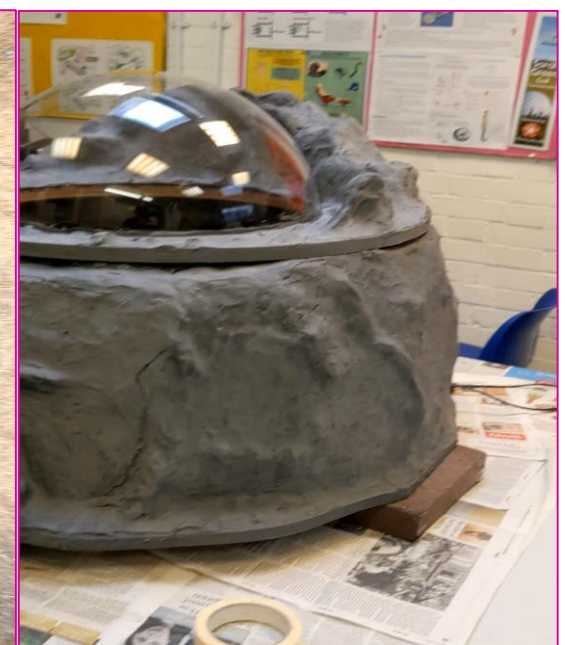
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## - Evaluation and Feasibility the Design Solution 0.1 -

Overall, I was very happy with the outcome of my product, aesthetically it looks really impressive and effective. Most importantly it is a good design solution for the problem that my clients faced "problems with outdoor reptile housing". There are definitely some room for improvements however overall, I do believe the manufacturing of this product was a success and it definitely fills the gaps in the market for a product of this sort and also one thing that is very important is that it first the criteria needed from my clients which ensures that the product was successful as I established earlier that the only way to ensure the product was successful is to follow the 9 criteria points:

1. **Naturalistic in looking:** the product looks natural and is fitting for the area of use (garden)
2. **Sufficient Heat Source:** the heat mat and adjustable dial for temperature control are a suitable heat source combined with the use of the sun as a secondary source.
3. **Sufficient access to clean water:** due to the water seal and waterproof materials, the use of a water bowl inside the product is sufficient for clean water.
4. **Design must be heat retentive:** the walls of the product are insulated and heat retentive, and the acrylic domes help warm the product in hot weather.
5. **Easily moveable and well balanced:** The design is an appropriate weight to prevent against weather moving it around, also can be carried between two people.
6. **Design must lightweight:** the design is not light however it is not heavy, due to it being hollow and made of clay rather than concrete it is not heavy.
7. **Design must be waterproof:** due to the sealant and the coatings and varnishes and materials used, the product is watertight.
8. **Long lasting:** all the materials and processes ensure that the product will last the approximate same length of time as the tortoise, the material degradation and corrosion life is surplus of 15 years.
9. **Design must be cost effective:** the materials and process used where definitely cheaper than other options that could have been used and overall was not an expensive product to make.



### Tortoise opinion:

The biggest and most ethical problem faced with this product is ensuring that the tortoise is happy, Frank spent a significant amount of time in the trial period where I sent my product to the clients, Frank was definitely pleased with his new home as he did not leave for almost an entire day, it was clear the he especially liked the use of the calcium enriched tortoise terrain which was used to coat the walls and floor of the product as it is reminiscent of home, the fact that he enjoys using the product is he biggest goal for me as it was most important in the design process that the product be ethical and want to be used by the tortoise and that they be happy using it.



## - Evaluation and Feasibility the Design Solution 0.2 -

What	Who	Where	Why	How
Andy Lyes	Stakeholder	Clients Home	This allowed me to assess for feedback and improvements/changes from the client who is financing the project.	Client interviews to assess general feedback.
Martin Turner	Potential User	Online Messages	This allowed me to assess for feedback from a different user who shares the same problem as my primary cliental.	Client interviews online through email messaging.
Frank the Tortoise	Primary User	Clients Home	Although the client does not give verbal feedback his feedback is more visible, and this allowed me to see if the animal itself was happy.	Client observations through watching the tortoise in its new environment.
Online Forum	Potential Users	Online Messages	Allowed me to assess feedback from the general public, although they don't have any personal or financial stake in the project their feedback as potential users.	Online survey to assess the general publics opinion of the project.
Weight Test	-----	Testing at Workshop	Allowed me to assess how easy clients found moving the product.	I had two random members of the public attempt to move the project to gather how easily the project is to move.
Impact Test	-----	Testing at Workshop	Allowed me to assess the outer layer of the product for its structural integrity.	I struck the outer layer of the project in likely weak points to understand its structural integrity a little better.
Weather Test	-----	Testing at Clients Home	Allowed me to test how the product acted under the different weather conditions e.g., sun, rain, wind etc.	I left the project in the client's garden outside over the course of 2 weeks to assess how the project reacted to its weather prevention precautions. And to see what effect the weather has on the product.
Heat Test	-----	Testing at Clients Home	Allowed me to test the heat retention of the product with the use of its integrated heat mat.	I activated the integrated heat mat and left it turned on over night and using a thermometer I measured the heat retention by seeing how warm the product remained after 1 night.
Animal Test	Primary User	Testing at Clients Home	Allowed me to test weather the tortoise/animals can use the project and weather it suits all their anatomical needs.	I visually observed the tortoise in its new product/house and assessed weather all the tortoises' anatomical needs have been met with the product.

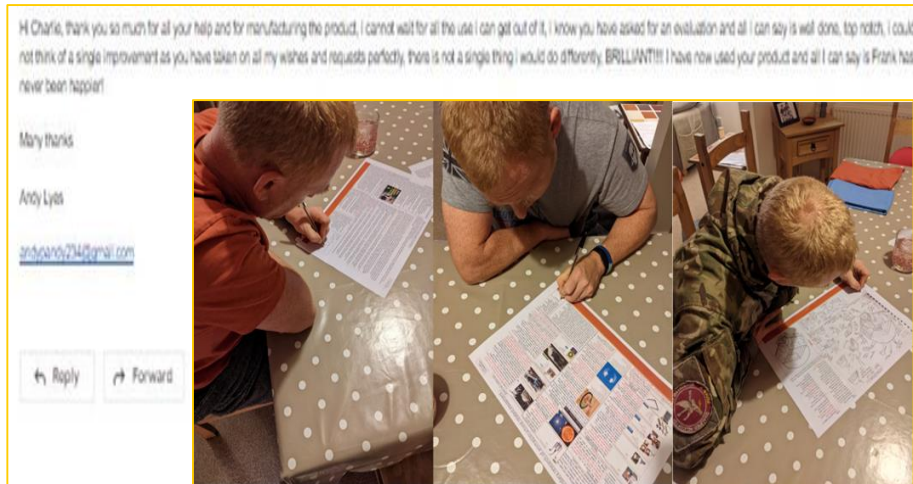
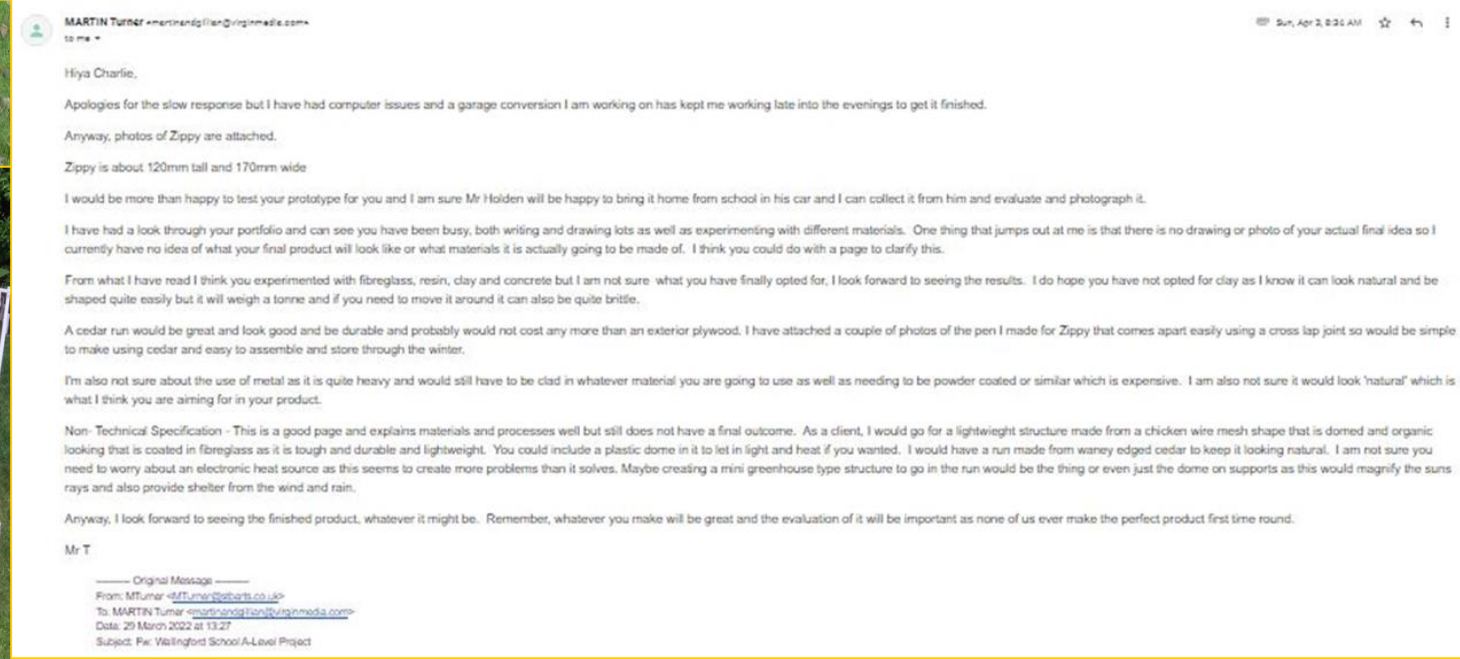
What	Results of The Tests:	Tortoise Needs:	How was it met?
Andy Lyes	The stakeholder and one of the primary clients of the product gave very informative feedback and allowed me to see what further design developments he would have liked to see on the project.	Lifespan -	The materials used have a very slow degradation and corrosion life due to all the finishes and protective measures, they will only start to wear away after 25-30 years depending on serious weather conditions.
Martin Turner	He gave some very broad feedback which was very beneficial as he was an outside client who had some different needs to the other ones however had very similar problems with housing his own tortoise, he too gave me some feedback to assess what he would have like to have seen differently in the future.	Behavior's -	The product has areas of shade allowing the tortoise to escape the sun, it has areas perfect for basking in the sun, such as the windows.
Frank the Tortoise	It was hard to assess the feedback from the tortoise itself being as he doesn't talk, however it is very clear from his interaction with the product that he does enjoy the product and is comfortable living in it.	Substrate -	The walls and floor are coated in a calcium enriched soil substrate which promotes a healthy shell and protects against diseases such as shell rot, so the substrate used is perfect for the tortoise's needs.
Online Forum	My online forum that I sent out yielded very different results with 91.6% of the recipients saying that they would use the product if they too had a tortoise, these 91.6% also where very informative as they described what they liked most about the product which overall appeared to be the naturalistic looks, the other 8.4% said that they would not use the product even if they shared the same problem.	Humidity -	The use of a heat mat and the soil substrate keeps the air in the cave very humid and moist which is good an suitable for the tortoises needs as they need very hot climates to thrive and survive in.
Weight Test	The results of this test where simple, I got two members of the general public of average stance and build roughly 5ft 8" and asked them to simply move the product which they could do with ease as the product is very moveable with a second pair of hands, due to its shape its difficult to move by itself.	Heat -	The heat mat provides an efficient use of heat and keeps the cave at a constant temperature of 32°C which is the prime temperature needed for a tortoise living in the united kingdom outside in summer.
Impact Test	This impact test was very unusual, the even distribution of clay and protective coatings of such and should have had an even distribution of impact resistance however there where some areas of the structure that did crack a minute amount when struck however this was very unusual, it is likely that there was not enough protective coating on these areas so additional layers of the paint sealant mix where added to prevent further damage to the outside structure.	Furnishings -	The rock like structure is reminiscent of the ancestral living qualities of the tortoises, there is also much room inside for furnishings such as basking rocks or logs for comfort and happiness.
Weather Test	The product was unaffected by the weather, it did get rained on however the inside remained dry and sealed, I did have concerns with sun potentially causing the clay to shrink and thus crack, but this was not the case at all.	Lighting -	There is a sufficient amount of lighting and shade for the tortoise through the careful placement of the window roughly half of the interior is shaded from the sun and provide areas for cooling down.
Heat Test	The heat test was a massive success, the temperature (once warmed) stayed at a constant 35°C until the morning, it retained its heat through the cold night where the temperature reached lows of around 2°C, I did not leave the tortoise in the product over night purely because if for any reason the heat mat did not work efficiently the tortoise could potentially become very ill which is the reason, I tested he heat retention without the tortoise.	Enclosure size -	The interior provides adequate room for the tortoise to move around and get in easily, there is no current outside "area" as m clients garden where the product is to be used is fenced off and sealed.
		Care Routine -	The product has a powerful enough heat source to provide heat for the months of April-August however not for the late autumn or winter months due to the much lower temperatures the tortoise will have to revert back to its inside home, this was desired by my clientele anyway so isn't a problem as the cave was a summer house.

## Client Final Evaluative Feedback - Martin Turner:

I was very happy with Martin's feedback as he was not the primary user or stakeholder. His insight allowed me to gather what other in the general public who do not have a financial stake in the project would want to see happen to it instead. Martin liked the idea of having a walled-off area, as my primary client's garden was walled off he did not need or require any form of run, however it may be beneficial to include a walled run in the product to allow it to suit the needs of more people in society.



## - Evaluation and Feasibility the Design Solution 0.3 -



## Client Final Evaluative Feedback - Andy Lyes:

Overall, Andy was very pleased with the design, his comments and feedback were very fair and even throughout the project, he especially liked how I catered the design to meet not just one or two but all of his design criteria that he requested. He enjoyed the use of naturalism to make the product look not only unique but realistic as it is perfectly fitting for his garden. His one final feedback comment was very fair he said *"Hi Charlie, first of all I love the cave its wonderful however my one concern is the temperature dial! I think for a future development I would have loved to see the casing with some form of door or hinge so that I could get into the casing and change the temperature more easily, but overall, that is not a major drama, and I am pleased with the outcome of the project! Good job! Cheers, Andy"*

So as a future development I think having an easily removeable casing would be key for the product's success, alternatively possibly moving the dial may be easier?



## Commercial Viability & Marketability of the design prototype:

After the research and manufacturing and feedback processes of my product there is definitely a need and gap in the market for a product such as mine, the prototype made is extremely viable and marketable and most importantly is also unique and innovative.

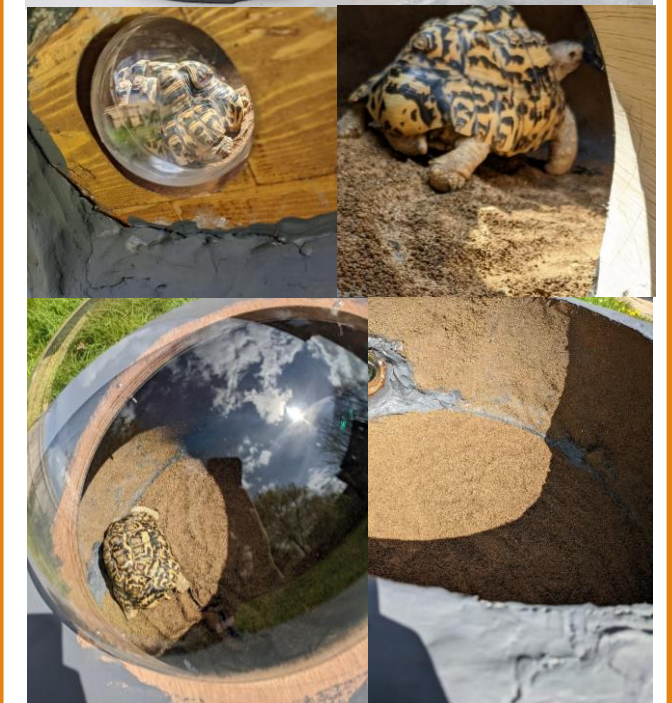
The price point for the product as a bespoke one-off design using the materials that I have would have to start at £58.05 so would potentially have to sell at £100-112 to gain a good profit, alternatively there are other ways that I could sell my product to the general public. To make the largest possible product profit and to decrease the amount of labor needed I would sell the product as more of a flatpack DIY project where you are supplied with the following:

- 2x Vacuum formed HIPS plastic domes, 10cm difference in diameter
- 2x Marine Ply sheets cut to the correct sizes and shapes
- 1x canister of expandable foam insulation
- 1x block of nylon enforced exterior clay
- 1x pack of all the paints and varnishes required.

Selling the product as a DIY kit greatly increases its viability and marketability as customers will be more inclined to choose a product that they can customize themselves.

Equally the manufacturing process could be increased to a large-scale batch production which would again lower manufacturing costs overall and also would allow the product profit to increase, equally if the product is sold as a kit, it removes the need for an assembly line. The product would be shipped in a large box to the supplier and instructions would be printed to ensure that the customer knows how to assemble the product and what precautions to take when handling the chemicals, I expect that on average the leaflets and instruction would cost around 13p per product, and then with postage and shipping I would likely use a large carrier service like DPD to ship as there shipping for items over 5kg is much cheaper than other goods carriers. Finally, I would ensure that work with suppliers to stock my product on the shelves of some of the leading brands in the UK, I would set the DIY Kit sale price at around £79.99 as this is a unique product that can save owners much money. I would also sell some adjusted products to ensure they can be used for other things such as housing geckos and lizards or perhaps selling a run that joins on to the product but keeps the area enclosed.

The End



The Shell Shack