Module 11
Advanced Game and Character Texturing

Eve Ryan

Introduction

For this brief, we have been tasked to revisit the Meet Mat challenge we were set in the first year of our course. We have been asked to aim our focus back into the different techniques of texturing in substance painter to emphasise our creativity and experimentation. By the end of the half term, I will have designed a Meet Mat demonstrating these skills.

The 'Meet Mat' challenge was introduced in 2017 by Substance 3D which is a texturing contest that has blown up in the realm of texture design (Meet MAT 2 - Substance3D Contest, 2021). Many people use Mat to demonstrate their texturing skills even in 2021 and are a very popular contest among all designers. Each year there are different categories set that designers will adhere to with the competition and the quality of the designs are incredible.

(Meet MAT 2: the 3D Texturing Contest winners!, 2021)

Here is an incredibly textured piece by William Ruhlig, who designed a 'Polar Climate Scientist' which won the general category for Meet Mat this year. A great piece of work, showing his skills of creating realistic textures, and using many different techniques when using the different texture maps to add reflection, roughness and more. I really enjoy the fluffy hood and the costume which looks

extremely realistic. I want to take inspiration from this design, especially the base he has added to which I wouldn't think to edit. I love the creativity and style and enjoy how he has completely changed the face of Mat to a penguin. I think it's really creative as he hasn't stuck with the base shape of the face, he has instead created a hood.



(Meet MAT 2: the 3D Texturing Contest winners, 2021)

This Mat was created by Nikolay Marinov, who won the student category this year. I'm in love with this design and I think it looks incredible. I can see where he has extruded the horns on the head and used really interesting alphas and brushes to create the texture on the clothes. I really enjoy the colour scheme Marinov had used and think the attention to detail is amazing, especially the scratch marks and teeth which he has textured on the face. In my Meet Mat, I want to use many alphas to create a great design and look into the different techniques I can use.

Software

Quixel

Quixel offers three software: Megascans, Bridge and Mixer, an exclusive resource collection, and two 3D development frameworks (Quixel Megascans, 2021). Quixel is used in films, architecture, computer games, and personal projects (VG247, 2021). Teddy Bergsman and Waqan Azim founded Quixel in 2011. Quixel was designed to reduce the time required by developers to design visual worlds by giving them access to a massive repository of textures, models, components, and software to make the process easier, it also builds its assets within Epic Games (Quixel joins forces with Epic Games, 2021).

Quixel's offices are in Sweden and Pakistan, and the bulk of the company's employees have extensive experience in the games industry (Quixel joins forces with Epic Games, 2021). Quixel is just £18 monthly for individual use, and the megascans catalogue is accessible if you already have an Unreal Engine licence, which is now free for all. This will be able to do "so much better for the art community," according to Quixel (Quixel joins forces with Epic Games, 2021). As a result, it will guarantee "an incredible amount of thrilling content to share while you're in the weeks and months ahead." (Quixel joins forces with Epic Games, 2021). Quixel is now partnering with Epic & Unreal Engine.
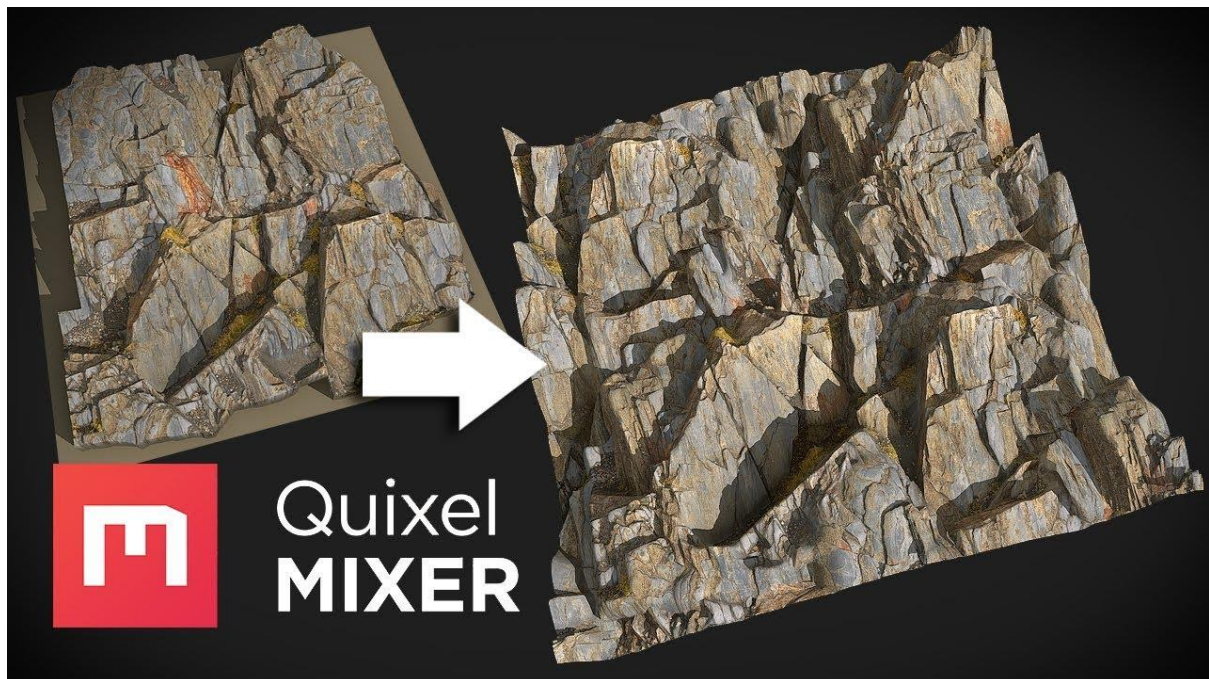
Substance Painter

In film and video games, Substance painters and designers can be used to produce industry-standard customized textures that are entirely under the artists' influence. Substance was launched in January of last year (About us | Substance 3D, 2021) and has quickly become a common tool in the industry, originally owned by Allegorithmic but is now acquired by Adobe (Adobe systems: Une acquisition Dans le Secteur des Jeux vidéo, 2021). The designer will be able to produce several textures, shapes, and material sets, as well as fully modify them. The artist has the option of using ready-made materials or creating their own. "If you've already used Photoshop, Substance Painter would feel right at home." (About us | Substance 3D, 2021). To exhibit true decay and corrosion, Substance Painter uses smart materials that instantly apply to the mesh you're painting on. Substance Painter also includes mask templates that can be customised to fit any form as well as any paintbrush.

I conducted some further research into Substance Painter by reading an article by James Ritossa, a 3D artist at Avalanche in New York City. In the article, he discusses multiple tricks and professional tips to help aspiring 3D artists when using substance painters. The first tip he elaborates on in the article was how everything either has some sort of dirt or a layer of dust on it. (Ritossa, 2021) He makes a good point as sometimes when objects and assets are too clean they can come across as a little bit fake and too perfect. I agree with this and will keep it in mind when creating my model.

The next tip he discusses is how even though the material may be named what it is, it doesn't necessarily have to be used as that material all the time. The example he gives us is that rust can also appear as a stylised dirt texture. I will bear this in mind as sometimes I use textures too literally.

Another trick he gives us is that small details are completely significant and should not be overlooked, even a very translucent layer of scratches splotches or even smudges that appear unnoticeable all come together to make the object look extremely realistic and closer to the object we are trying to create (Ritossa, 2021). He elaborates more on this by suggesting to add imperfections on our models, such as chips in the paint, scratches on metal and more. He suggests looking at our objects as though he is layering them in real life. What is the base material? What comes after the base material, and what lies on top?

The next step he uses is instead of creating a texture from memory and trying to style it that way just like when creating art or drawing somebody or something we should always use a reference image (Ritossa, 2021). It's very easy to miss small significant details when remembering what certain textures look like. we may assume a gold plated ring is completely smooth however it will have small scratches, dents may be flakes of white that we don't see unless we look closely.

Finally, Ritossa suggests creating the perfect presentation in relevance to the object. Lighting on composition can completely change the way a render looks (Ritossa, 2021). He suggests checking all options under the lighting to true, and playing around with the different settings to create either a softer or harsher scene as well as playing around with the angle of light And the angle of the model itself.

I found these tips and tricks extremely helpful and I will definitely bear that in mind when creating my own model for this project. I have used substance before however, it is a software I would really like to master and become a lot more comfortable with after this project as there were a few things I struggled with in my last piece. I intend to focus more on the actual texture building and layering more so than just painting onto the model as I am used to doing. Textures are an extremely important aspect of games and assets so I really want to push myself this brief to create a beautiful model.

Autodesk Maya is a 3D computer graphics system developed by Alias Systems Corporation and now operated and developed via Autodesk. It runs on Windows, macOS, and Linux. It's used to make objects for immersive 3D games, animated movies, television shows, and special effects. Maya's extensive use in the entertainment industry is generally linked to its appearance in the Disney film Dinosaur, which was released in 2000. (Warren and Jones, 2017) It was noticed in works such as The Lord of the Rings: The Two Towers, Spider-Man (2002), Ice Age, and Star Wars: Episode II – Attack of the Clones, when the organization won an Academy Award for technological marvel in 2003. (Sellers, 2003) VentureBeat Magazine reported that Autodesk Maya was being used in every film nominated for the Academy Award for Best Visual Effects, and it had been "used on every winning film since 1997." (Terdiman, 2021)

Texture in ps, price of substance, history of textures, another idea, metal robot, mistakes, concepts, looked back at lees look how far I've come to show development

Texture Maps

Digital textures are made up of many different multiple layers of maps, these include the normal map, ambient occlusion map, diffuse maps and a displacement map. I conducted some research on the different kinds of texture maps to see exactly what each map is used for in general, as well as what it was used for in digital texturing.

The diffuse map holds all the colour information of the entire texture. It will display what colour the texture will be at different angles. There is no detail in this map, just colour (What are the different texture maps for? 2020).

(What are the different texture maps for?, 2020)

The ambient occlusion map allows the texture to have prominent highlights and shadows. It simulates global illumination and is usually a grayscale texture (What are the different texture maps for?, 2020).


(What are the different texture maps for?, 2020)

There is also the roughness map which defines the smoothness or roughness of an object. This is used in PBR shaders. The glossiness is defined on a numeric scale, 0.0 being rough and non-reflective, and 1.0 being a mirror (What are the different texture maps for?, 2020).
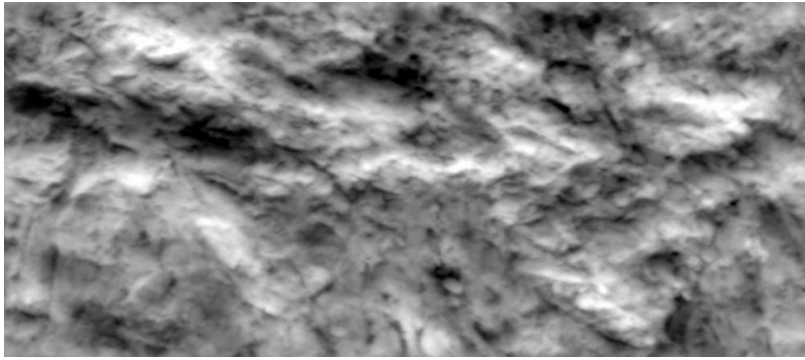

(What are the different texture maps for?, 2020)

The normal map is used to create small to medium bumps within the texture, it has a purple base with faint green and pink hues over the top. These represent the different axis of direction so that the software can recognise the shape of the texture (What are the different texture maps for?, 2020).
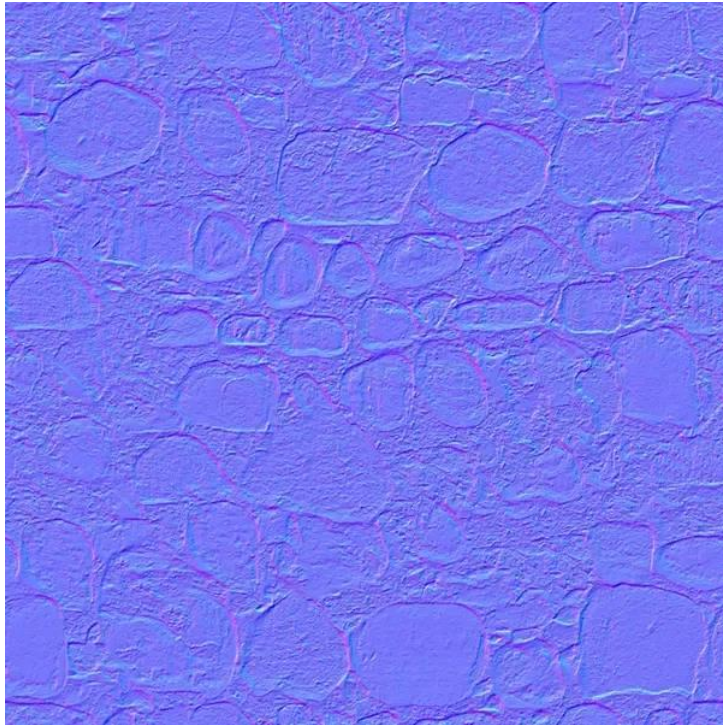
(How are normal maps made?, 2020)

The displacement maps are often used to give a surface structure, similar to normal maps. The normal map produces only the illusion of a 3D structure, however displacement mapping, by incorporating geometry, generates true depth. This is accomplished, for example through micro-triangle displacement or other techniques, depending on the strengths of the rendering technology used. This is typically used for surfaces such as dirt, rocks or peaks, where the material's shape is important as it needs considerably more mesh detail (What are the different texture maps for?, 2020).

(What are the different texture maps for?, 2020)

Atlas Maps

Multiple materials, such as 3D meshes, textures, particle systems, and user interface elements, go into making a game. Texture maps are used in both of these, and they must be named on each frame (Practical Texture Atlases, 2021). When a game runs at 30 frames per second, it is referred to as 30fps. It's known as a draw call. Atlas maps, also known as texture atlases, can store various textures for different parts of a game. It's mostly used for Foliage and UI elements. If this goal is not reached, the game will not be optimised. Atlas maps are used because using more draw calls allows for faster rendering of objects. It is more efficient to keep those things to a minimum. They're ideal for smaller or bigger props, which are often used in user interfaces (Batching using Texture Atlases, 2021).
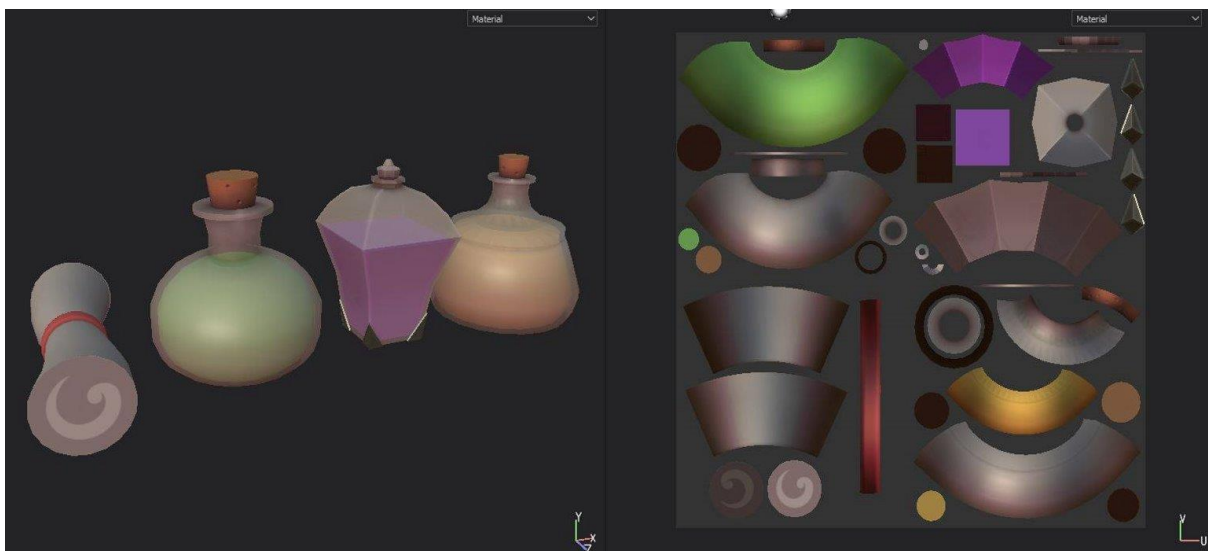
Here is an example of what I was shown last year, which helped me understand atlas maps more.
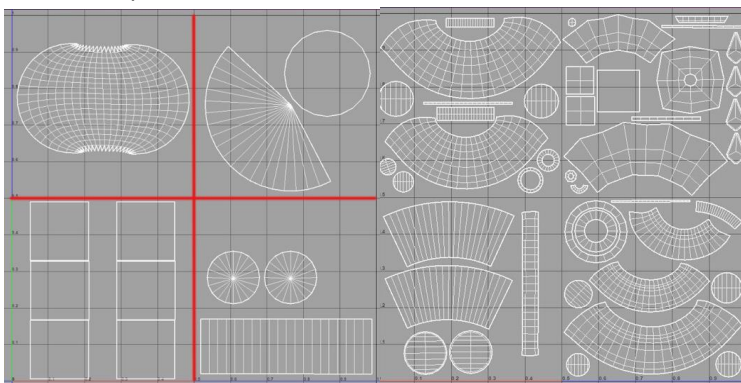
More complex models are arranged by dividing the UV 0-1space into quarters. It's just enough to call textures once.
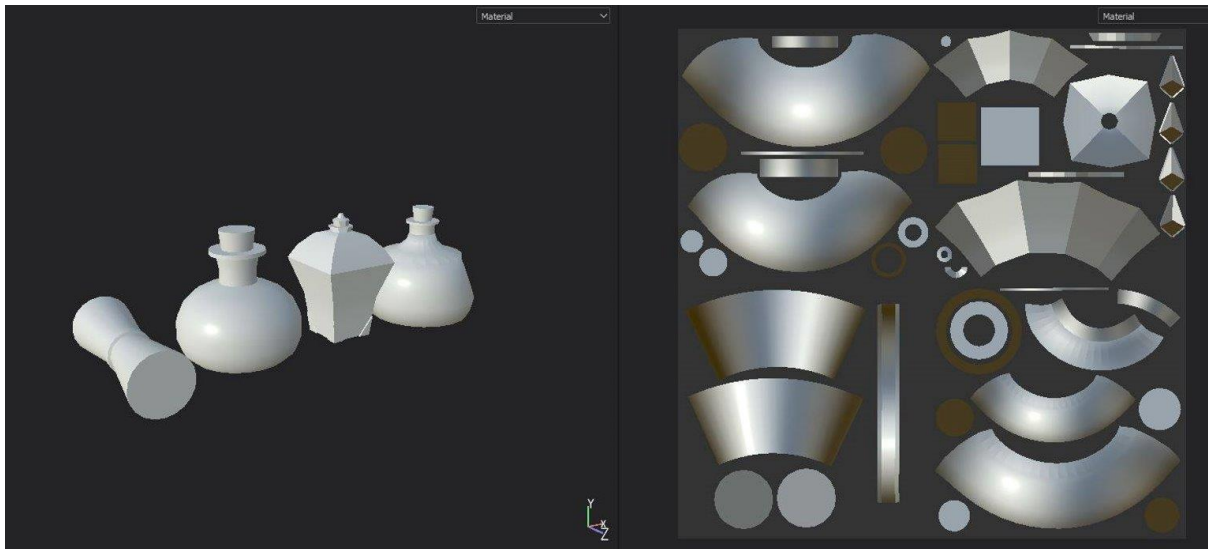
Here is what the map looks like after being placed into substance painter.

Here is what the map looks like after it has been painted.

High to Low Poly Baking

The baking method projects rays from a high poly model into another model from a certain distance away from the model (Most of the time, a very low-resolution sculpt for gaming needs) . When a projection intersects the second model, it tracks the texture layer description and transfers it to a texture map by using Texture Coordinates of the high poly sculpt.

There are particular steps to follow when creating the low poly:
Firstly, naming the object, so that later on there is no confusion as to what we will be texturing. In Maya, we then apply a material (I use a lambert for most objects) and name the material 'M_ItemName' so I know what material it is for. I then soften and harden the edges, based on the borders of the UVs. I set up the pivot to make sure it is aligned correctly, and ensure I delete the history as well as freeze all the transformations. Then the low poly is ready to be exported.

After the low poly is completed I then move into the high poly, over in Zbrush, however, there are different softwares which can be used. Firstly I subdivide the low poly without smooth on to around five sub divisions, after this I then turn the smooth off and divide it to nine. I then sculpt the object in whichever way I please, and then export the high poly as an fbx, making sure to use the correct naming conventions.

I then open up the substance painter and add my low poly mesh to the software. I select the desired resolution and set the map format to DirectX if I am going to be using the object in Unreal Engine. I then select done and my object has been imported along with all the UVs. Once this is done I go to the bake options, I bake in a particular order, starting with the normal and world space maps. I do this so that I can see if there are any problems right out of the gate, so I am not waiting for all of the other maps to load. I make sure to set anti-aliasing to 4x4 and play with the max frontal distance and max rear distance before baking the rest.

I can then use the position and thickness maps, the position helps the computer locate the mesh geometry and save it to the texture, and the thickness maps work similarly to the ambient occlusion map, casting rays from the top of the mesh to the inside of the mesh. Lastly, I bake the ambient occlusion map as this is the map that always takes the longest to process. This map contains all of the lighting data and adds soft shadows around my model.

Once everything is baked I then export the model. I export the textures as a Targa so that they are packed neatly together, alongside the object. The textures will automatically be renamed to what the maps are. We have been taught to rename these to industry-standard conventions such as T_ for texture, _BC for the base colour, _NRM for a normal map, and _ORM for occlusion, roughness and metallic map.


UE4 Master Materials

Master materials are used for many different aspects within Unreal Engine, they give me a lot of power and flexibility to design over multiple aspects of my game, while still lowering the performance effects. Just one master material will be needed for the engine to compile everything.

To create the master materials, I initially create a new folder and create a new material, naming it correctly with an M_ before it. This is what is known as the base master material. Once this is created, I then enter the material's editor by double-clicking. I then can use any textures I want and wire them correctly to the material node.
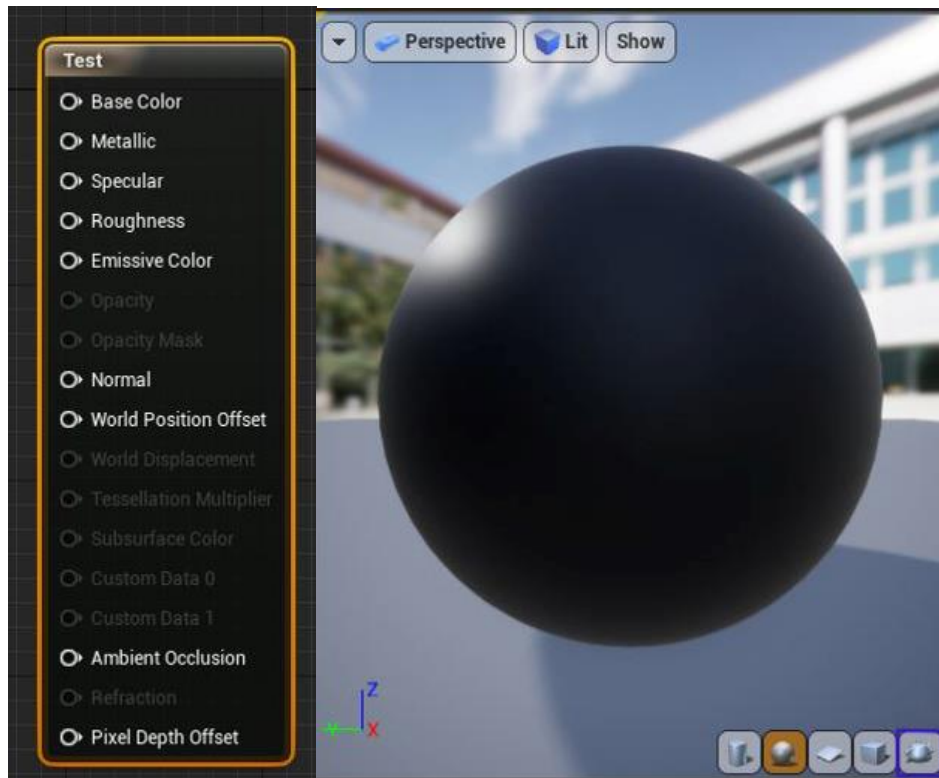

I will see changes in the materials viewport as I connect these inputs, which helps me to know if I have made any mistakes. The material would be showing at this point, however, we have no other control than which maps have been imported into the material.
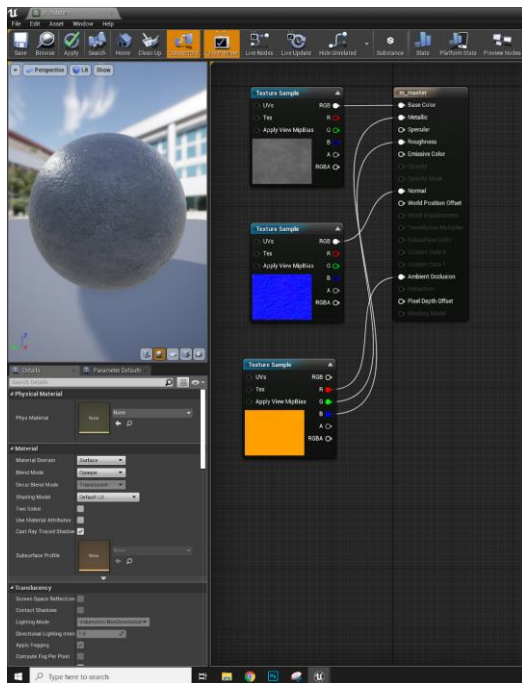
We can change this by adding nodes to control our material. For example, we can alter the base colour by adding a scalar and a multiply node, connecting these to the texture sample. I can also then set up UV tiling by adding a Texcoord, scalar parameter and multiply node, plugging them correctly into textures. These material functions are extremely handy when wanting to quickly edit a material. If a texture doesn't seem like the right scale, instead of redoing the texture we can simply add these nodes to create the functions.
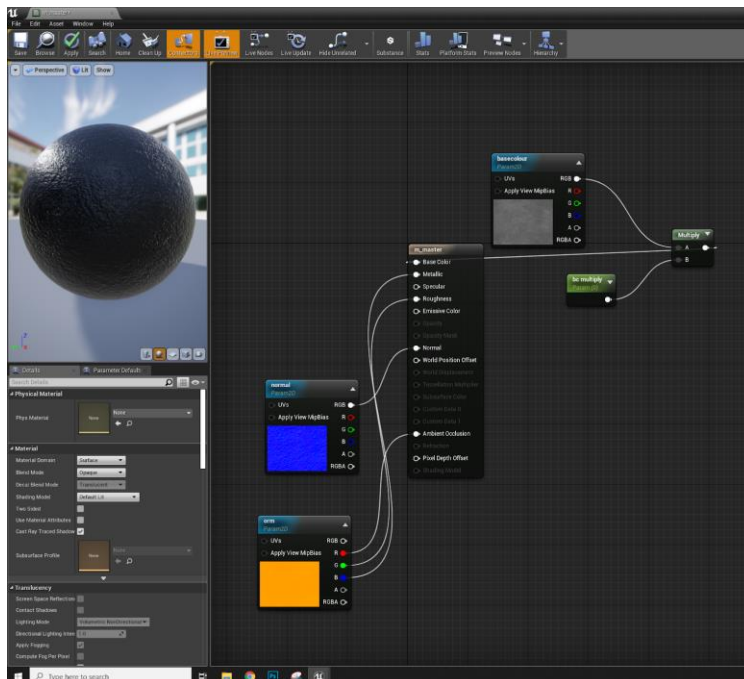
From here, I can then create a material instance, which creates a child of my base master material. This is where I can edit parameters, apply textures and edit the settings to overall increase the performance of my level.
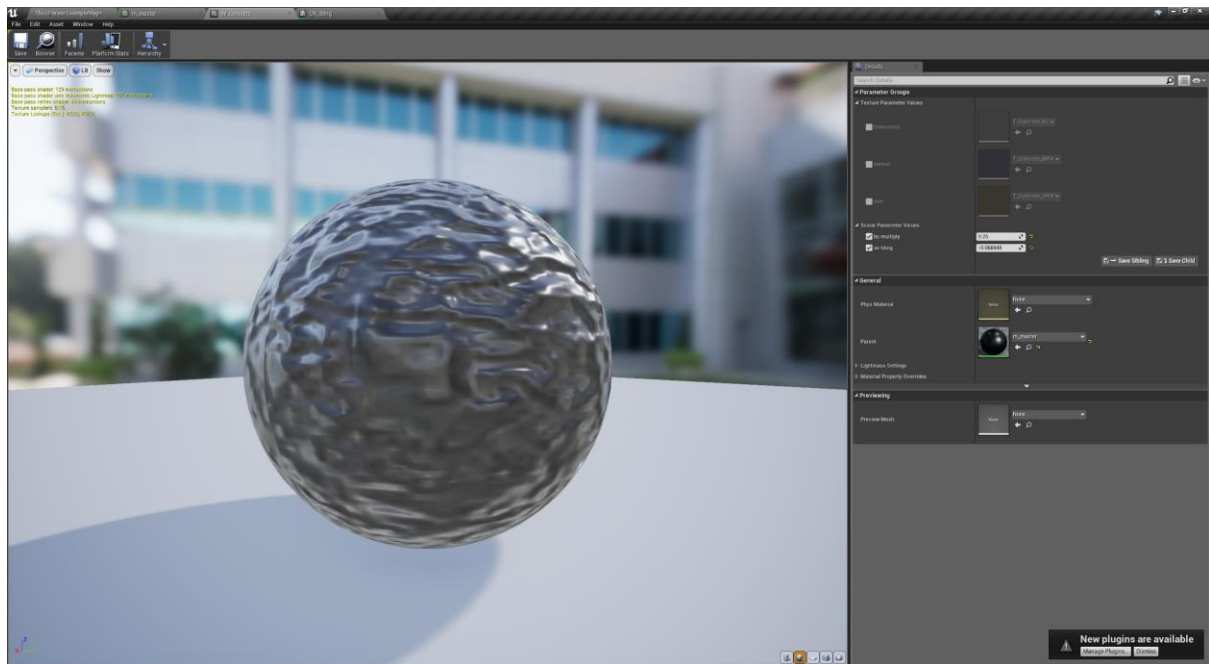
As an example of how these parameters can work, I recreated a texture to practise my skills and knowledge in the material editor.

Firstly I opened a new folder, making sure to use correct naming conventions so I didn't lose the folder. I then created an empty material and named it M_MyLava. In the starter content folder which comes with UE4 basics, I searched for an existing map to add to my texture that I wanted to create. I copied these over and began editing my new material.

The first thing I decided to integrate was colour, not shortly after I then added a texcoord node, as well as a multiply node and multiple scale parameters. I used a scalar parameter to edit alone the scale of my new material, the multiple nodes and other parameters affecting the speed that the maps rotate on the axis. I then created a new material instance from this texture, ensuring to name it correctly as MI_MyLava. By doing this, I can easily edit and alter the colour a lot easier than individually editing the textures, on top of being able to directly alter the rough map and the reflection map.
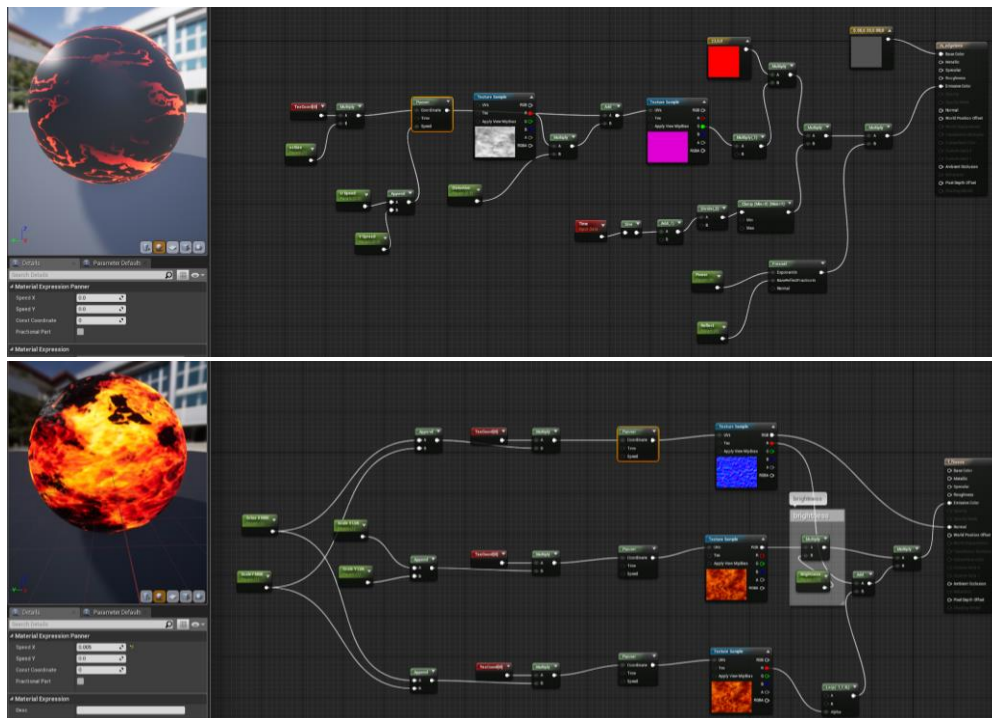
UV Mapping

UV mapping is a 3D modelling technique for texture mapping that involves translating a 2D image onto a 3D model's surface. Since "X", "Y", and "Z" are already being used to represent the axes of a 3d model in state space, and "W" is also already being used in computing quaternion rotations, a popular process in computer graphics (Rosenfeld, 1988), instead, the characters "U" and "V" were chosen represent the axes of the 2D texture.

Texturing using the UV space allows ordinary images to be drawn with colour onto a polygonal surface that creates a digital 3D structure. This would be named a UV texture map (Mullen, 2013).
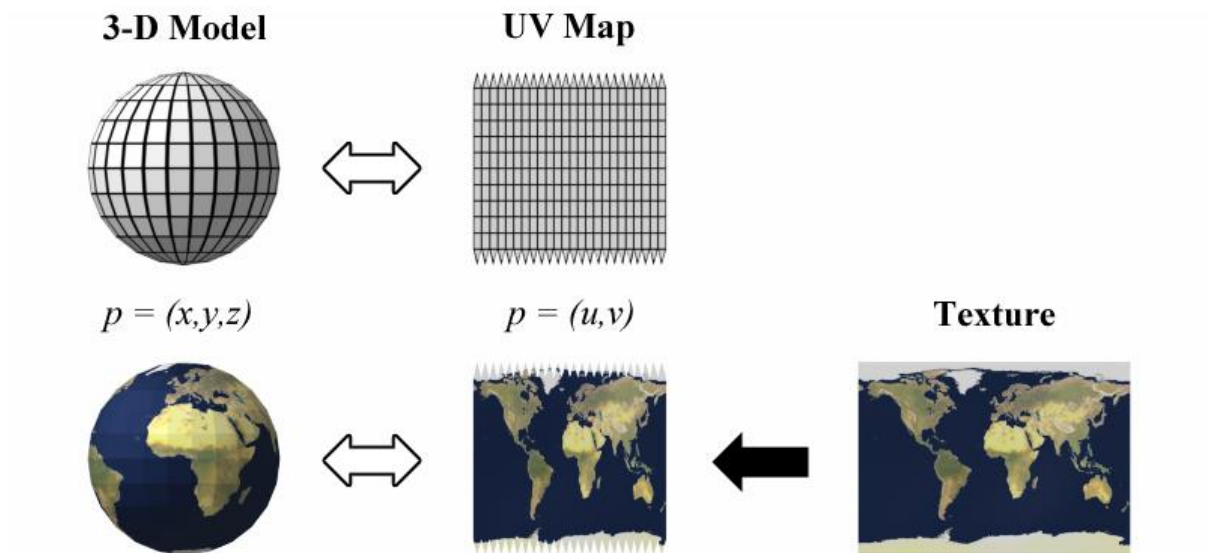
(Tschmits, 2021)

Research

What I aim to achieve in the Meet Mat model I am going to design is to heavily focus on creating my own textures and learning more in-depth skills and techniques to further my preparation for working in the industry. I have used substance painter twice previously. I first created a book, and textured the pages and some mushrooms which grew out of the book. I then painted an elf which I also sculpted in Substance Painter which I don't think I textured very well. I didn't know what I was doing with a lot of the settings and materials, so for this brief, I want to challenge myself to create something simple looking to the eye. However, I use many new techniques and challenge myself to create something professional rather than rushed and unappealing when zoomed in like my previous models. From my report on texturing I have realised how important textures are in games and due to it being a field I want to work in professionally, I need to learn how to texture professionally.

The idea I have generated for my model is inspired by Westwood/China pottery. I love the theme of blue and white and would love to create a porcelain style Mat. I also really enjoy Kintsugi, the art of fixing smashed pottery by soldering with gold or silver. (Definition of Kintsugi, 2021)

Kintsugi

Throughout the ages, Zen masters among China, Vietnam and Korea claimed that broken pots, bowls and other pottery should not be neglected, and that they were in fact more beautiful for being broken (Definition of Kintsugi, 2021). This is when Kintisugi was created, 'Kin' meaning 'golden' and 'Tsugi' meaning 'Joinery'. Pots would be fixed back together carefully using a lacquer mixed with golden dust (The Japanese Art of Mending Ceramics, 2021).

A theory as to how Kintsugi became a common practise today, is the theory that the 8th Shōgun (military dictator of Japan) of the Ashikaga shogunate (the military government of Japan, during the Muromachi period, 1338-1573), named Ashikaga Yoshimasa (Ashikaga Yoshimasa | Japanese shogun, 2021), returned a broken tea bowl to China for fixing, when returned, it was fixed with unappealing staples, which inspired many different Japanese craftsmen to try and discover more attractive means of repair (Gopnik, 2021).

(Ashikaga Yoshimasa | Public Domain, 2021), (Hoffman, 2021)

Kintsugi is comparable in theory to the Japanese philosophy of wabi-sabi, which embraces the imperfect or flawed.   Use of an item's wear is looked highly upon in Japanese style. This can be interpreted as a reason for holding an artifact around long though it has fractured, emphasising the fractures and damages as merely

an occurrence in the life of an item instead of causing its duty to stop at the time of its degradation or breakage, and as a variation of the old saying "Waste not, want not." (Pui Ying Kwan, 2021).

(Kintsugi, 2021)

I want to blend the Kintisugi practise visually alongside Chinese pottery, as I love the colour theme of blue white and gold. In this type of pottery, they used clay or porcelain decorated with glaze mixed with cobalt oxide, a naturally occuring blue pigment (History Of Science And Technology In Islam, 2021). The depictions of the pottery ranged from scenes from ancient literature, landscapes, public figures and existing illustrations (Weidong Li, 2021).

(Hunt, 2021)

(170 Kintsugi Ideas in 2021, 2021)

I Developed a mood board of the kintsugi to look into the exact patterns and formations of the melted down gold, to see the kind of shapes they form and a kind of shape ID to create in my Meet Mat model.   I have noticed how usually the gold has a Stark contrast against the dark Blues, however, I'm much more attracted to the gold against the white with a hint of blue. I feel as though it looks

a lot more classy and striking and a little less Greek as opposed to the Blue pottery pieces.   From this, I will look into an artist who I found extremely inspiring. I would love to take great inspiration from her during the process of my model.

Yee Sookyung
Seoul, Korea
Artwork

Analysis

Korean artist Yeesookyung created sculptures from recycled shards of porcelain, arranging them to create new shapes, and fusing them with gold leaf in her groundbreaking collection Translated Vases.The projects that result are often natural in design, depicting soap bubbles or other biomorphic shapes.

Yee emphasises the vulnerability and flaws of human life, as well as the eventual collapse of any effort to establish historic unity, by 'translating' these porcelain components. To suggest hints of opulence, Yee attaches touches of 24-carat gold over the fractured and re-sutured joints in these re-articulations of other people's work. She clarified that the Korean word geum can be interpreted as "crack" or "gold."

I adore the colour palette Yee works with in her creations, as well as the minimalistic blues she uses to contrast the heavy porcelain white. Within my sculpt, I will use this artist as great inspiratin as I adore the style and appeal of her creations, they look extremely aesthetically pleasing and I'm excited to try her methods within texturing digitally.

(Sookyung, 2021)

Here is my artist page for Yee Sookyung, an artist from Korea who I came across whilst creating my mood board.   I really enjoyed the Stark contrast within her work and the crazy shapes and forms she produces using the method of Kintsugi. I find the colour palette of her work to be visually stunning, I believe this is the exact colour palette I would like to use in the creation of my meet Matt model.   I have yet to find another kintsugi artist who is as unique as this one, so I will have to draw as much inspiration as possible from Sookyung.

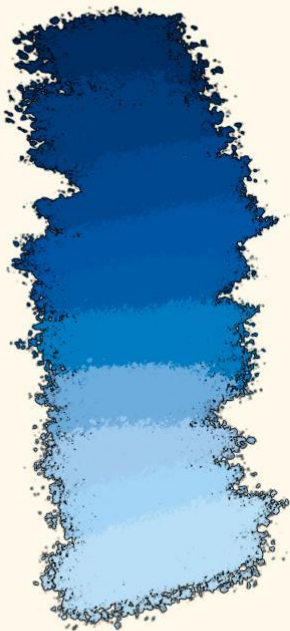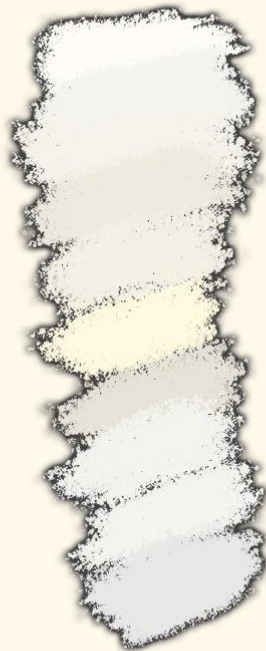# Colour & Texture Palette
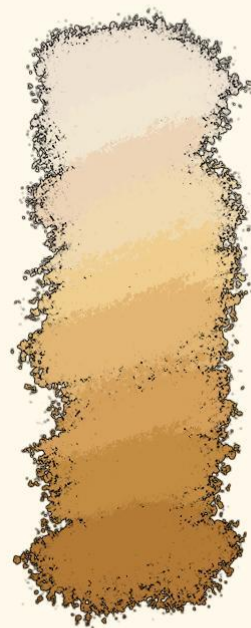
Base Skin

Details

Face

Base Stand

Blues

Whites

Golds

From my artist research I decided to break down my colour palette into textures and colours separately from here I could really plan the exact textures and shades of colours I wanted on my meat Matt model.   I decided to stick with the classic Fine China blues, slightly cooler and I see as opposed to warmer toned blues.   For the whites I decided to stick with a pearl/ porcelain white colour scheme, with a mix of yellow tones of white and slightly purplish tones of white, to really bring to life the colours of the porcelain on my meet Matt model, as it looks in real life shown by the texture above.   For the actual gold of the kintsugi, I decided to go for more of a warm-toned, almost skin colour, bronze gold.   This is so that it contrasts well against the cold blues however matches well with the different tones of whites, complementing the warm tones of the porcelain.

Development of my Meet Mat

The first thing I am going to do for my Meet Mat project is baking the textures. To do this I have to go to the bake mesh maps option within substance painter and edit the settings shown. I decided to turn off colour ID as I don't use it, I also have changed the resolution to 4K, and enabled the 'use low poly as a high poly' option as I do not have a high poly Mat to work from. I also turned off 'enabled seams' in curvature and applied this setting to everything. I baked all these texture sets and waited for them to be complete, which took a while.

As I am planning to use displacement maps I am going to change the settings to activate subsurface scattering and change the scattering-type to the skin. Due to this, it gave my Mat a slight pink tint, so I just changed this to a pearl blue in the settings under where I chose skin. In the shader settings, I turned up the subdivision count to nine. I have chosen to add subsurface scattering as I want to do a porcelain material, and if there isn't any bleeding of colour it will look too sharp to create the effect of porcelain, however, if I add too much it could look clay-like and I definitely do not want that to happen to my Mat.

This is how Mat looked after baking him down with my chosen settings. I then created an instance in my layers so that it would affect the whole model even though Mat is broken up into three sections; his head, body and stand. This was a great tool within substance which I'm glad I learned how to use, as it saved me lots of time when creating the base material of my model, as I only had to apply the settings to one folder. Next, I found a texture from the Substance Share website (Cracked Ceramic, 2021) which resembled fired porcelain the most. I downloaded the texture and placed it on the Mat model however I found it didn't look very nice, it looked more like deep, ugly concrete cracks than natural porcelain cracks on the actual model, so instead, I found a royalty-free porcelain crack image on google and edited it in photoshop so that it was black and white, to look like an alpha.
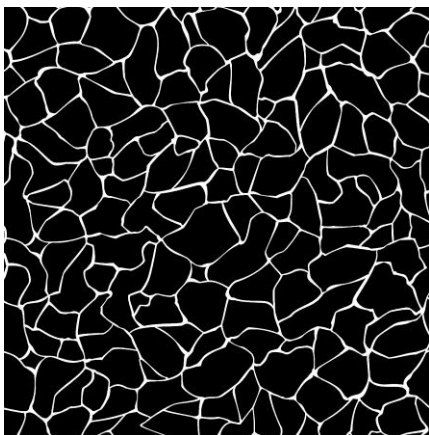

This is what the final edit looked like after playing with the invert tool in photoshop. I then dragged this into a substance painter and added it to my shelf. I then created a new folder within my instance and named it 'Porcelain Material'. Within this folder I added the base colour and cracks onto fill layers with masks, dragging the image I imported onto the crack folder.

This is how Mat looked when I initially dragged the image onto the crack fill layer. From here I scaled the cracks until they looked to be the right size on the model, and then added an invert filter onto the crack layer which inverted the colour of my cracks. I also changed the layer mode to multiply so the cracks would be darker and the white would disappear, as well as changing the projection mode to Triangular instead of projecting directly on the UVs. This made the cracks look a lot more naturally placed and stopped any breakups of the cracks.
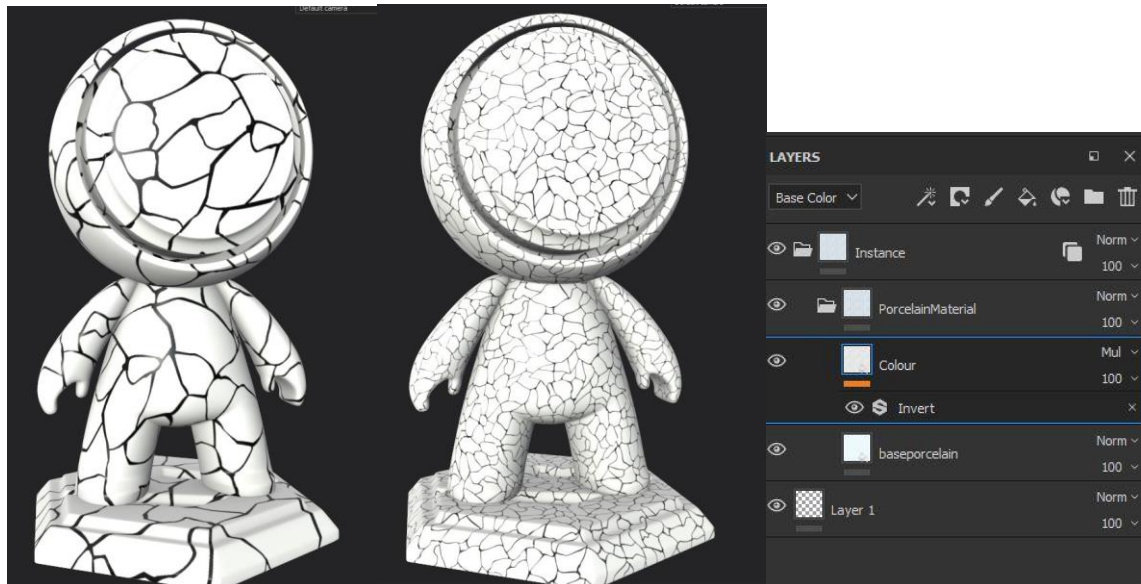
After this, I duplicated the cracked layer as when examining images of porcelain up close, the colour of the cracks tend to bleed. To create the bleed effect, using the duplicated layer of cracks I added a blur filter and played around with the balance and contrast of both crack layers until it resembled porcelain the most. This is the reference image I used when trying to recreate the glazed porcelain.
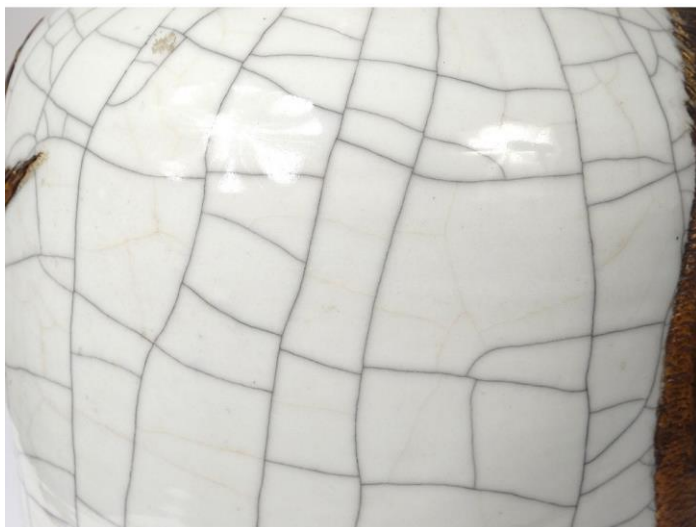

(Antiques de Laval, 2021)

After I achieved this as best as I could using the I added a new fill layer above the cracks and added a mask. Instead of painting manually on a mask, I added a cloud alpha onto the mask layer to the mask so that it would partially cloud over some of the cracks below so they weren't dark consistently around the whole model. I really liked how this looked and played around with the scale and values until it looked the most realistic. This was a minor detail however it really added to the effect of worn porcelain.
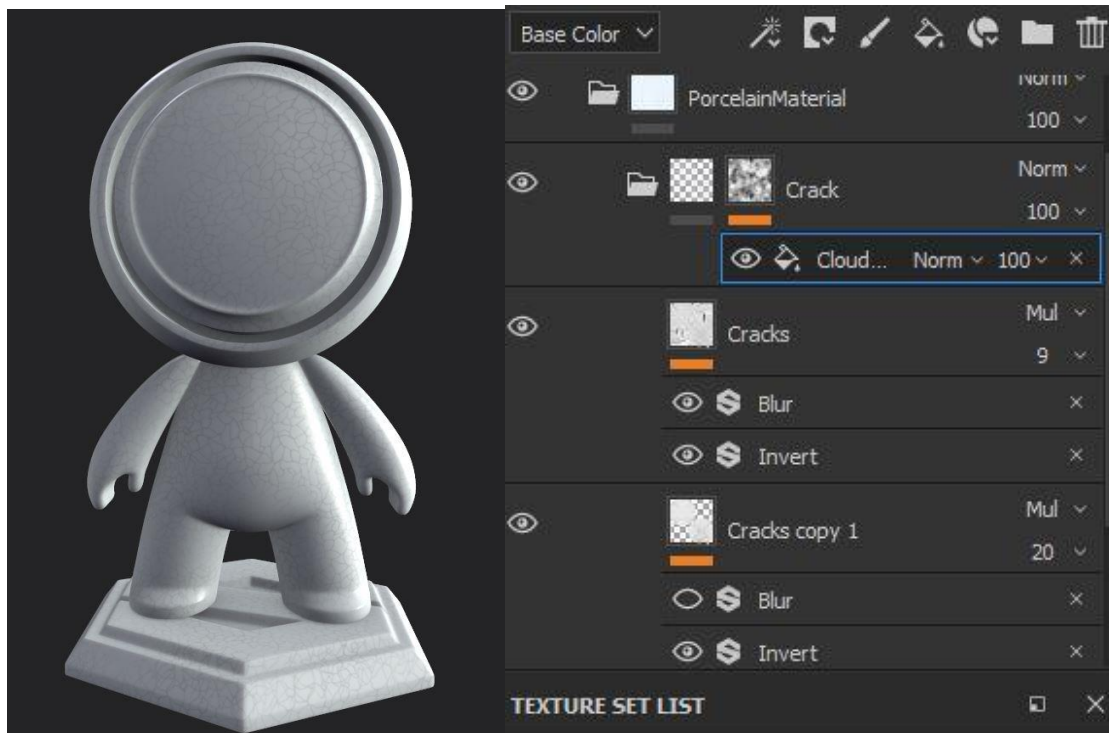
After this, I then wanted to add some speckles and chips very minorly just to add a little more subtle detail to the base of the model. I did this by adding a displacement map and a mask using a dirt speckle alpha. The details were very subtle however it did help with the realism of the old worn porcelain.
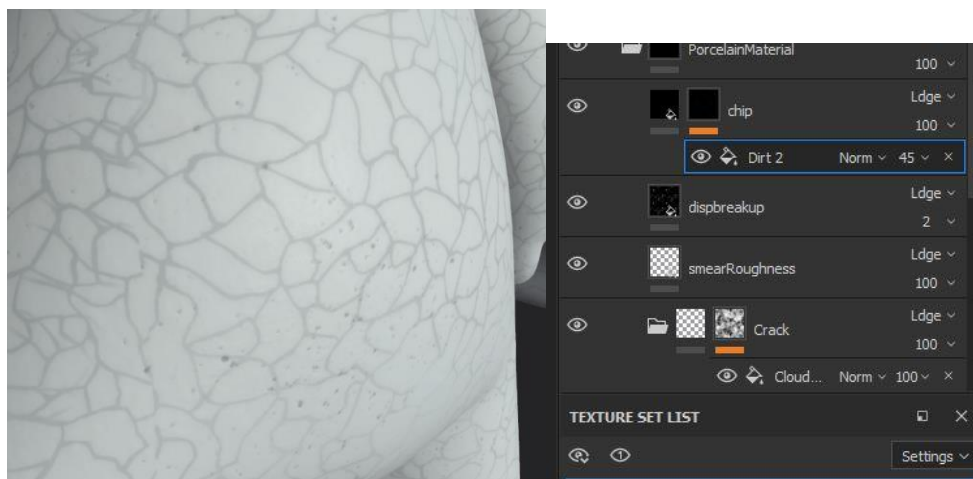
From here it was time to add some of the paint. I studied some designs from China and decided I wanted there to be illustrations of bluebirds around the model. I found a plate I liked on an antique website (Blue Willow China, 2021) and edited away everything apart from the birds, I then put the birds into Photoshop and created a pattern. I did this using the levels tool to remove everything apart from deep tones, as well as hue and saturation to make the image black and grey instead of dark blue. I copied and pasted the birds and manually placed them on

different layers until the square was full. I then finally used the invert tool so the image was black with a white foreground.
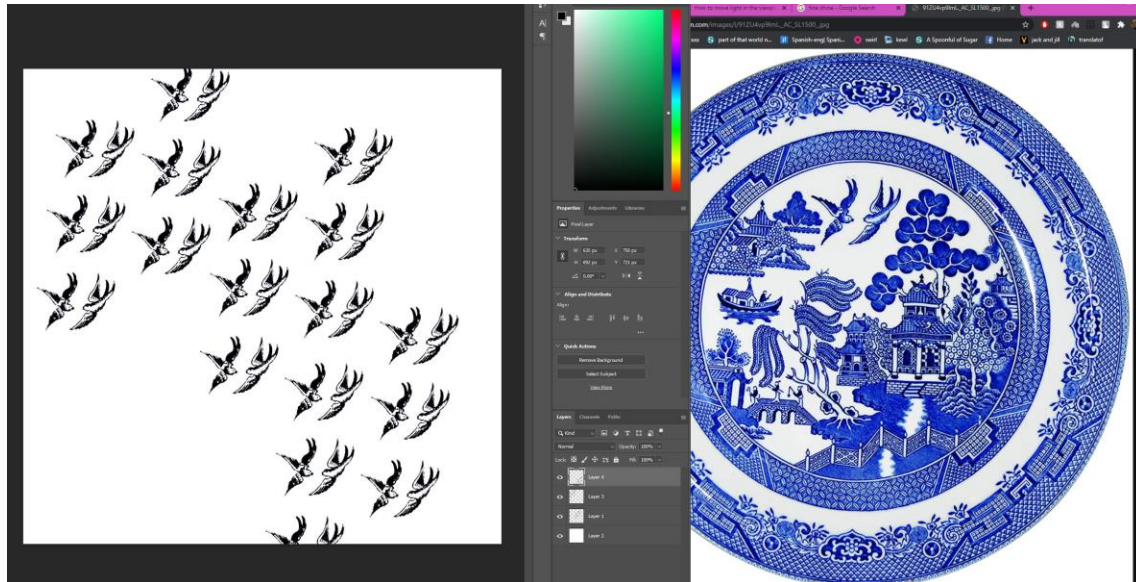
The pattern I made looked like it would work well to create the design I want, so I uploaded it into Substance Painter. I created a fill layer with the base colour of the fill being the royal blue colour; I then added a black mask to the layer. I then placed my bird pattern onto the mask to create the pattern of just bluebirds directly onto the porcelain.

Overall I was extremely happy with the design of the birds and the colour of blue I chose seemed to look like the perfect blue China colour, however, there was some overlap of some of the birds. I also wanted the images of the birds to all be facing different directions and have different rotations, so I reopened my bird pattern photoshop file and edited the birds to be more randomized by removing the ones cut off on the edges and rotating the different birds.
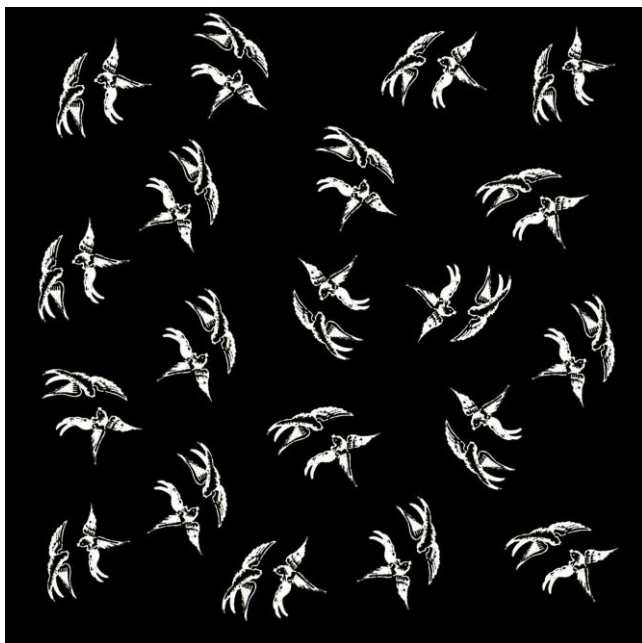
I then replaced the old mask with the new one and placed it on the Mat model. I again changed the project state to triangular and it looked a lot better than before, so I decided I was done with the base colour and designing the base China pattern.

I now wanted to add a filter to my birds, as I needed the colour to bleed just like the cracks to look more realistic and hand-painted. I again duplicated the layers and added a blur slope instead of a blur to my birds. This would make them appear more hand-painted and blurry around the edges almost like watered down ink.

After I was happy with the blur and the overall design I now had to add the Kintsugi gold lacquer onto China. I started by adding a new fill layer, and instead of using my own material, I used the damaged gold smart material from the smart materials shelf which already existed in Substance Painter. I looked through the layers which came with the material, and removed a couple of the damaged layers as I wanted a softer, more clean gold.

I then added a black mask onto the model so that I could hand paint onto the black mask with white coloured paint so that the gold would be visible wherever I painted. This is better than painting with just the colour, as I can easily erase any errors by switching to black colour. I also activated the heightmap on the layer and turned up a small amount so the gold would have dimension and look like actual glue.
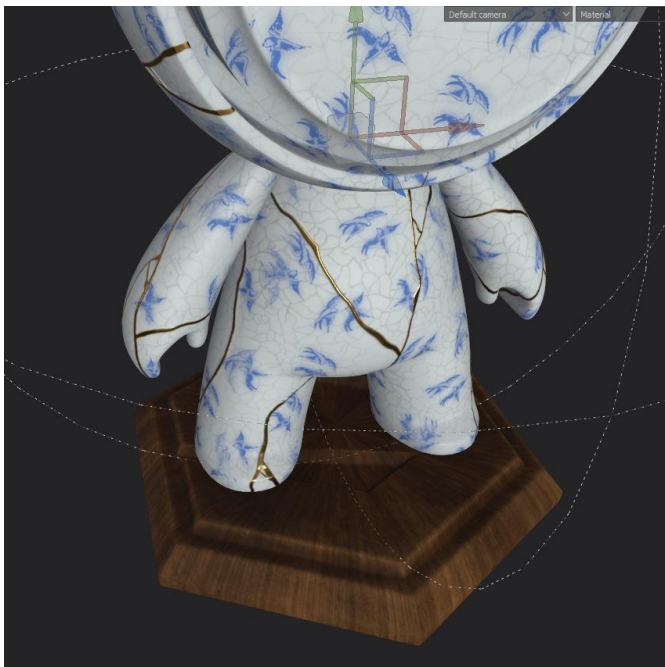

I really enjoyed painting the lines however due to covid and leaving the university accommodation I accidentally left my tablet pen at my accommodation, so I had to use a mouse to paint the lacquer. This made the design of the lacquer take a lot longer and I had to be very careful when painting. I held shift and drew out straight lines, and then went back over them creating variations of thickness with the lines. This did help with making the lines look hand-drawn and realistic, so it may not have been a bad thing after all.

I now wanted to design the base as I wasn't sure what to do with it. I again looked in the smart materials shelf and added a pre-existing wood smart material, and made the projection spherical so that it formed in the middle of the

wood. I then wanted the 'S' to be a different colour, and instead of hand painting it which would have been difficult using my mouse, I used a new technique.

I used the view topology tool to be able to paint the squares of the topology individually. This also allowed me to view all the topology of the model, and I could drag and paint each individual square with my mouse on top of just clicking each individual square. I added a gold fill layer and a mask and again began painting on the black mask with a white paint tool.
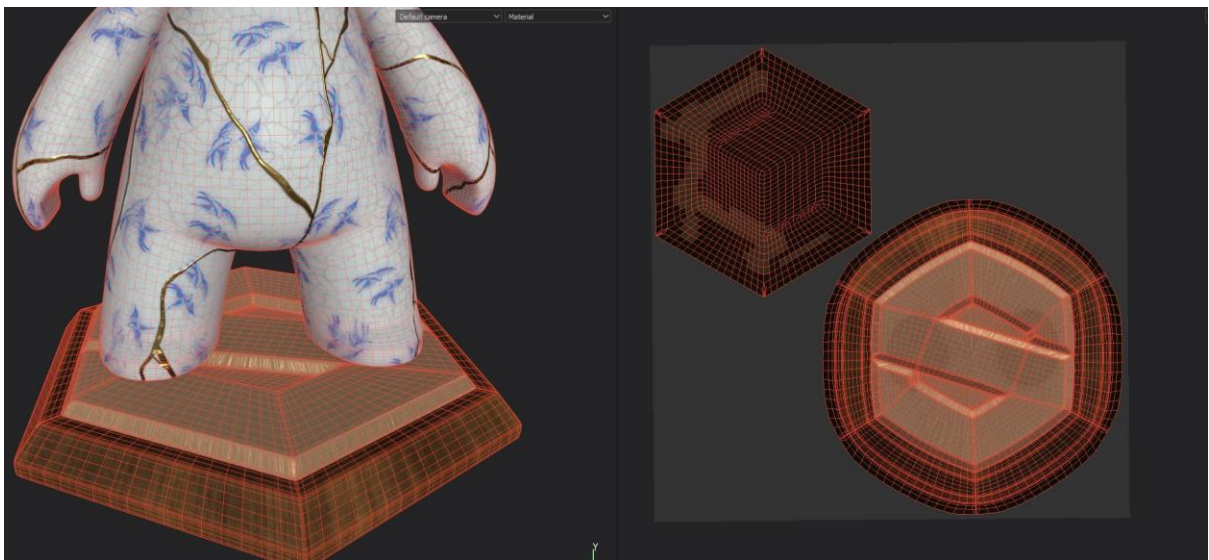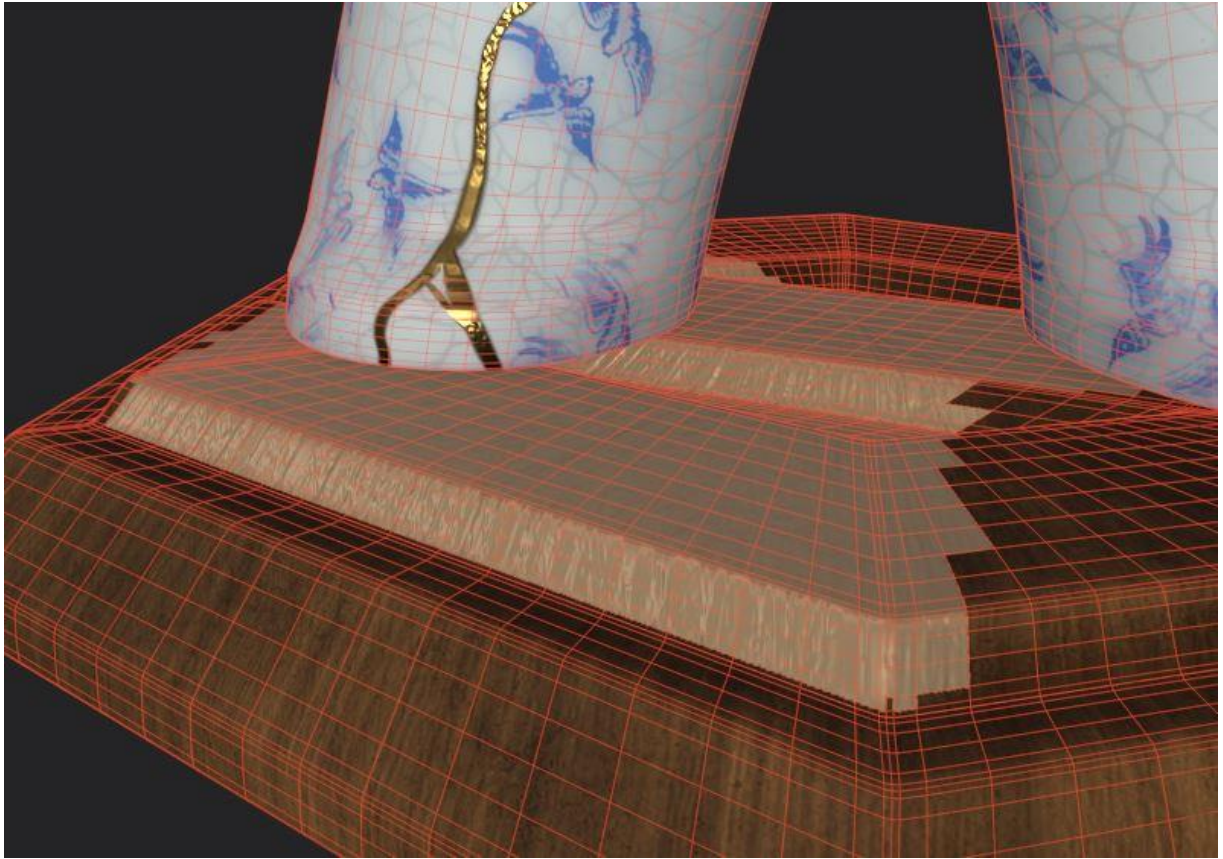
After the 'S' was completely filled in, I corrected the accidentally painted squares on the bottom of the base by just changing a normal soft paintbrush to black and painting on the golden mask layer. I also turned off the preview tool so I could see the base in real colour.
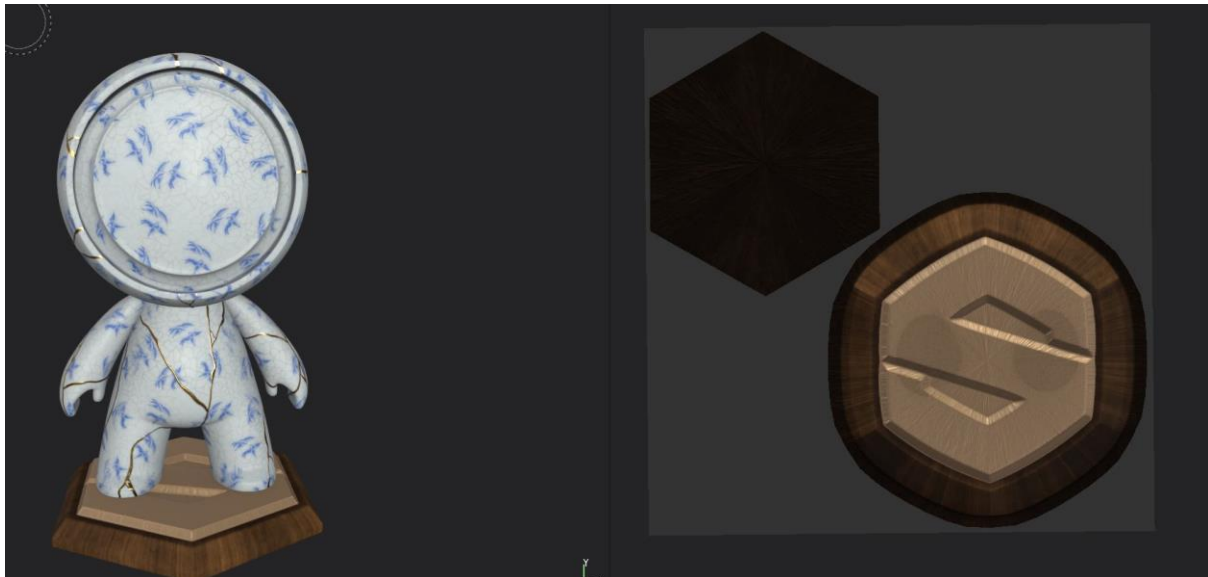
I decided I wanted to add a plaque onto the wood, however, I ended up not liking the design after I tried to do it. I used the polyview tool to draw a rectangle of gold onto the wood and used a plus sign alpha to paint on the screws, increasing the heightmap on both the screws and plaque to create depth. The screws ended up looking strange so I decided to remove them. I'm not sure what the issue was however they appeared very low quality and spikey. I did add a blur filter to the plaque to fix the spikiness of the border, however, this did not work for the screws.
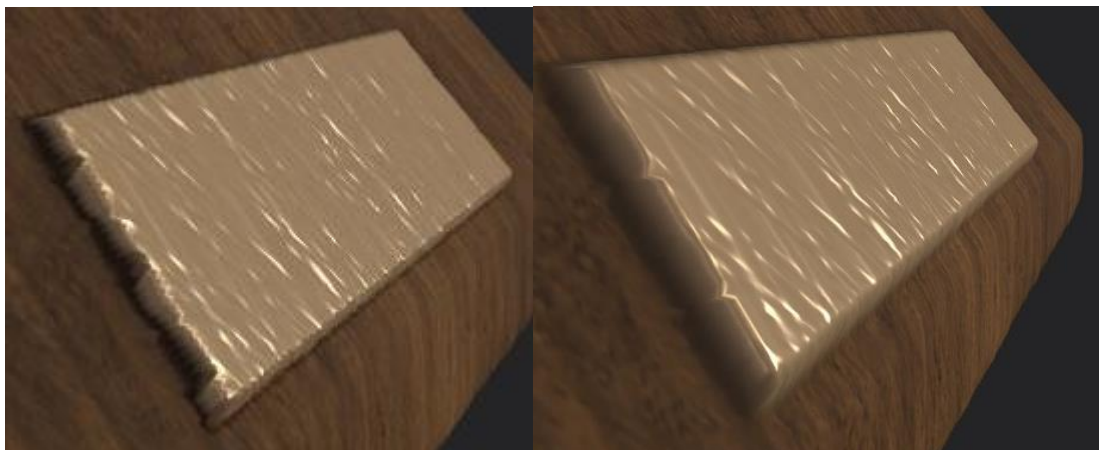
After this, I now wanted to paint the details on the face. I wanted to be very careful about how I designed this as it is the focus of the whole model. I needed to find a way to speed up the painting of my Mat model, and I also wanted the textures to be symmetrical. I had to find a way to activate symmetry in my painting. I found there was a tool I could use to do this. I first quickly created a

white mask and painted away the birds on Mat's face so they were no longer
visible.
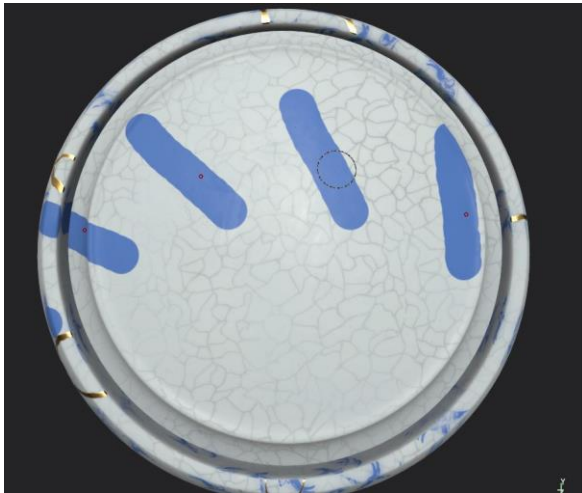
I activated the symmetry, however, as shown in the photograph the midpoint of the symmetry was incorrect. There is no way to choose the midpoint without using sliders or guessing values so it took me a while of trial and error with the symmetry settings to find the correct midpoint of Mat's face. After I was successful in pinpointing the midpoint I then increased the divisions of the symmetry up to the max (16) so that the circle was split into as many sections as possible.

I practised by painting a line when I think I had the correct midpoint and it seemed to be as close to the middle as possible. From achieving this, I then painted the details on the outer rim. I used a blue fill layer and added a black mask so I again could paint it over with white. I painted the outer rim with blue, lowering the flow so the paint looked a lot more natural and softer. I then changed the paint to black and created some circles, and then filled them in with blue. I chose this pattern as it is a common design on the rims of plates in china.
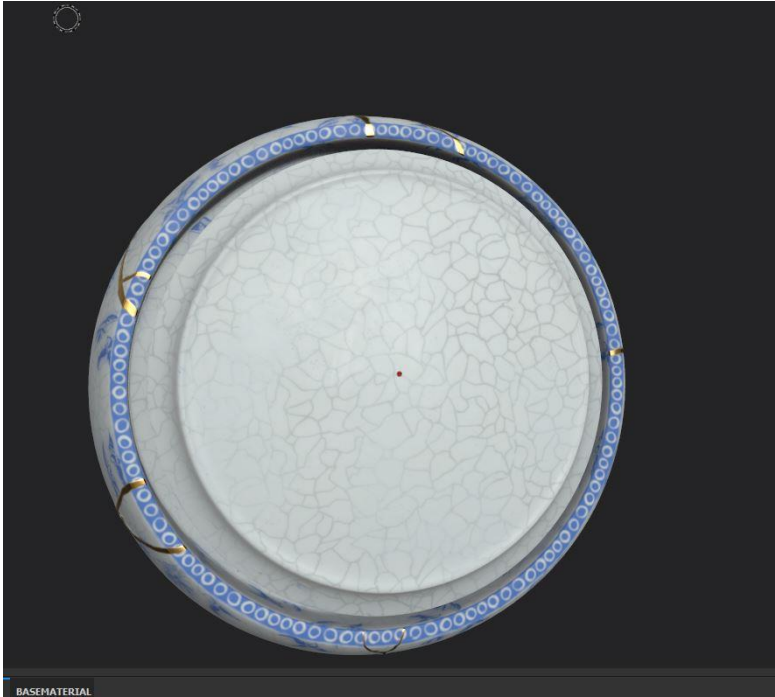
I had to use my computer mouse to do this. However, as I lowered the flow and was very steady, it genuinely does look hand-painted which is the effect I really wanted to achieve. IT also didn't take as long as painting the gold lines as the symmetry helped a lot.

To paint the inner rim, I wanted a different pattern. I thought a diamond pattern would fit best so I had a browse through the existing patterns in Substance painter. I found a few different patterns and tried multiple out, however, I found a really nice one that resembled the China diamonds quite well.
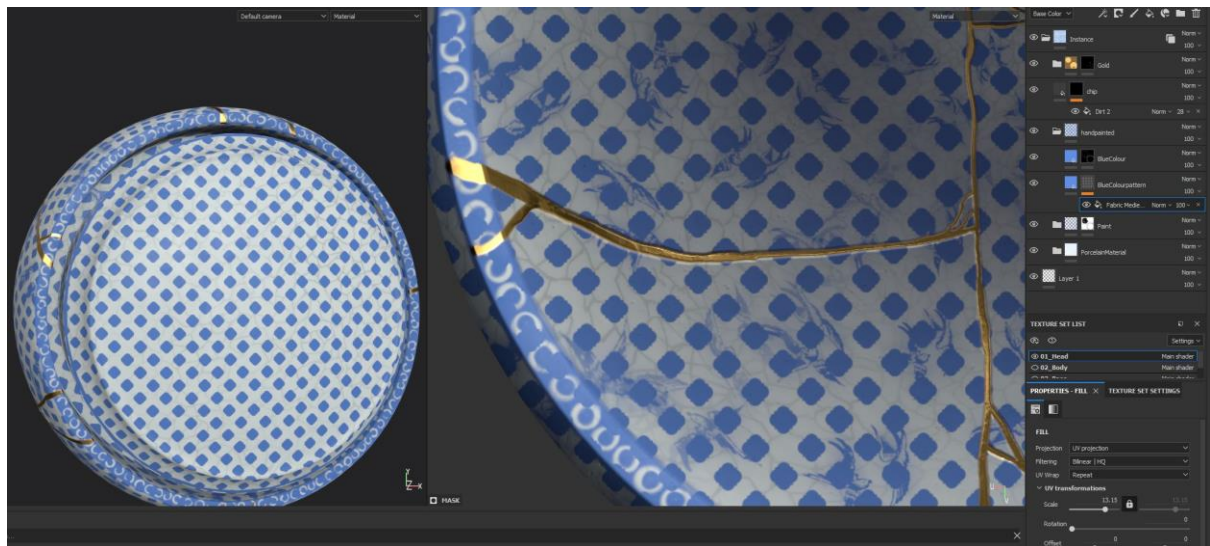
I tried playing around with the projector settings, as I wanted the diamonds to run around the edge in a circle. I played with the offset, rotation and projection shape of the pattern however I couldn't get it to do what I wanted. This was frustrating as it really comes down to trial and error. I instead changed patterns and moved on. In the future, I hope to fix this issue and learn more about projecting techniques.

The pattern I used for the final looked like China so I was satisfied. I again added a black fill layer and carefully painted it over in white where I wanted the pattern. I also then added two rings around the back and front of the deep-set ring to tidy up the outside.

When this was completed I now needed to create the art on the face. I would have loved to have hand-painted the design however due to the lack of my drawing tablet pen I instead made an alpha from an existing design of an ancient China plate. I used a very old design that looked the most visually appealing and placed it into photoshop, playing with the levels and shapes to make it into alpha. I did this the same way I created my bird pattern from an existing China vase.

When I finished creating the alpha I then duplicated the blue fill layer in Substance and added a black mask. Instead of selecting a brush I instead imported my alpha and used this as the brush shape. I had to play around with the size of the brush and rotation however I got it to be as central as I could.

When the stamp looked well placed enough, I then selected a brush that looked scratched and dirty and painted over this fill layer mask in black, to make the edges of the paint look worn and like it was fading around the edges. I really liked this effect and it helped blend the paint into the outer rim.

I am extremely happy with the final design, so it was time to render Mat and save the professional renders to see what it looks like under professional lighting.

Final Renders

Conclusion

To conclude, I am completely in love with the finished product of my Meet Mat model. I really got to learn way more about substance painter and learn so many more new techniques designing this than I knew before. I also loved that from having a realistic texture to recreate, I had to study with a lot more detail what the real texture looked like, and come up with ways in which to recreate this digitally. I really enjoyed playing with layer masks, adding filters, symmetry and creating my own textures and alphas which is something I haven't done before. I also feel a lot more confident when using smart materials, editing bake settings and changing details in the shaders and environment. I am really happy with the lack of visible seams which have always been a problem for me when using the substance, however, this is due to me texturing my own 3D models which are not to a professional standard, so it was good practice for me to test my texturing skills on a perfect topologised and UV created model. I am really happy with the final look of the porcelain skin itself, as the blurred birds and cracks genuinely make it look extremely realistic. I couldn't be happier with the skin however in the future I'd like to work on thinking of ways I could be more creative with the base.

I did face a few problems when rendering, as my computer is not industry-standard it took an extremely long time to render my final renders. I couldn't let them render to an extremely high quality as it would take hours so I had to edit the render settings to a max amount of time to ten minutes. The renders look a little grainy however if I were to render it on a better computer they'd look even better.

Another problem I ran into that I couldn't fix was the spherical projection on Matt's face. I couldn't find a way to project the texture the exact way I wanted, however in the future I will do more research into a spherical projection or look at possible alternative methods in which I could learn to create the effect I want.

Peer Review

I asked a few of my friends/family members to review my model to see what they liked or disliked, to see anyways I could improve in the future. I also briefly explained how I produced each section of the model to see if they had any input on other ways I could try things in the future.
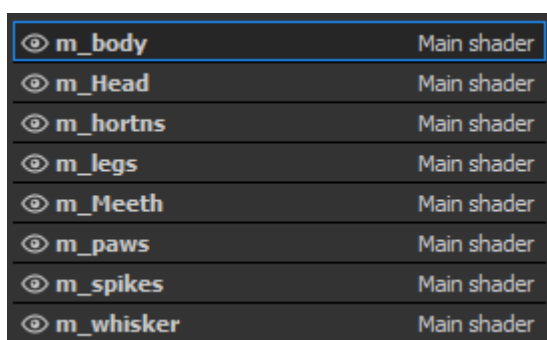
A well-received positive from my peers was the design itself. The appearance of China is 'visually stunning' and 'elegant'. Another positive was that 'The porcelain

looks really realistic, I'm impressed you compiled all the different layers yourself to make it look this way. I was happy with this feedback as I also really enjoy the cracked porcelain with the cloud alpha and blurs to make it look realistic.

One area for improvement was the face itself. 'I would've liked to have seen more of a hand-painted look on the face to blend in with the birds, however, it still looks really pretty'. I will definitely do this in the future as I want to hand paint the image, next time I will use a drawing tablet when available to create the authentic look I wanted. Another area for improvement would be the stand 'I'm not too sure what else could be done however maybe you could do something a lot more creative with the stand, without taking away from the model itself'. I completely agree with this statement, and would definitely like to return to this model in the future and edit the stand.

Texturing my own Model

After texturing meet mat I realised that I really enjoyed the texturing process and want to further my skills in texturing a character asset.   Instead of doing one completely separate model I think it would work well if I textured the model I was creating for module 10.   For module 10 I decided to challenge myself and sculpt the depiction of an ancient Chinese dragon. I think this will be really interesting to texture and I can play with colour, light, scales (as opposed to skin) as well as a lot of different materials and texture maps.   I scratched the surface of the things you can create with substance painter, therefore I want to really try my hardest to texture well and develop my skills.

After my model sculpt was complete I applied separate materials to each main part of my model in Maya.   I labeled them accordingly and opened the model in substance painter.   I began by baking all the maps down using my high poly to bake any details, ensuring to bake down the normal map first to check for any errors quickly.   I didn't edit my low poly too much, as I wanted a lot of the main details and depth to be textured rather than baked down from a high poly.   The only thing I did sculpt in the high poly was the eye shape to create the shadow under the brow bone and the eyelid.   I also added some strokes where the horns

were.   The first thing I did was create a fill layer on the M_Body. In this fill layer I added a base colour, a height map and a roughness map and imported my scale texture which I downloaded from substance share.   The scales were originally blue which I didn't want so I applied the hsl_perspective filter which allows me to edit the hue, saturation, and lightness of the texture. This filter is great, as when creating my own textures and materials I don't have to get the colour perfect the first time around, as well as if I decide to change the colour of the texture after modelling it to a colour that feels more appropriate I can quickly just add a filter to modify it.

After I achieved an emerald green colour on the scales I then added two more fill layers.   I added a scale fill layer below the green scales, coloured gold with the hsl_perspective filter and then went back to my original green fill layer and added a white mask.   I painted on the white mask with black to reveal where I wanted gold to shine through.   This made a lovely gradient on the leg leading down to the paws as well as a bit of gold on the tip of the tail.   The other fill layer above the green base layer is used to add very soft mint green highlights to where I wanted my dragon to be brighter such as on the lower stomach.   I again used a black mask and painted on with white where I wanted the lighter parts to show through.   I have always used masks during my time in using Adobe Photoshop, this comes naturally to me to use the masks and I'm very happy that they are implemented in substance.

I then moved on to the dragon head. I began by adding a base using a smart material called 'creature skin'. I loved using smart materials because it has an incredible level of detail instead of just a smooth base colour, all in one folder. This saved a lot of time, instead of creating my own skin from scratch.   Within this creature skin folder I manually clicked the different layers and directly edited the colours and masks already present.   I changed the colour of the darker blotches, lighter edges and undertones to match the colour of my dragon's body using the eyedropper tool.   I then created multiple paint layers above the creature skin not needing to use fill layers as I wanted to paint on particular details in small sections of the face. I began by selecting a metallic gold brush and changing the colour slightly to a more tuscan gold as opposed to a classic butter gold which tends to have more orange tones. I then decided to increase the height map from 0 to 0.2 and began painting on the details for the lips and some curls around the face leading up to the eye, using a soft calligraphy brush. I really enjoyed painting curles however it was rather tricky to master them in one flick of the wrist.   Next time I will add a black layer mask and sharpen up the edges when painting on the face directly with black instead of trying to get the curls and edges right the first time.   After that, I was happy with the gold details on the face, completing it with some golden curls on the chin.. I kept the same colour ID and made the whiskers the same exact colour.   I noted down the hexadecimal code just in case I could not achieve the exact same colour. The eyedropper tool works well however if the colour is affected by the light and

shadow rendered on the model, as well as the layer masks making it metallic, it could make the colour appear darker.

I did another layer, naming it 'eye_balls' and began directly painting on the eyes with a soft watercolour brush.   I didn't know how to activate symmetry on the other side of the model, however my model isn't perfectly symmetrical anyway so I had to just paint the eyeballs twice the same way. In the future I'll make sure my low poly and high poly model is symmetrical to save me time whilst texturing. I added a hot orange background to the eye and then added bright yellow veins, as well as darker orange veins to contrast, almost like the blood vessels, had a shadow. I made sure to focus a bright yellow soft background on where the pupil would be to make it look like the eye was glowing.   I would love to have a tool that actually made the eyes glow, however I'm not sure if this is something that you would have to add in an engine as opposed to substance painter.   In the future I will look into this because I would really like to add particle effects or some kind of glow material to my models. I then painted on the pupil and added a white dot to make it change the direction of where my dragon was looking and repeated this process on the other eye.   I also painted the inside of the mouth with a pink brush, adding darker pink in the middle and blending it out with the watercolour alpha selected. I did the same thing to the veins on the eyes later.

I also clicked on the base of the face and added the scales. I tried my best to rotate and change the scales to make It blend well with the neck, the seams are slightly obvious, so next time I will keep the head and body all in the same material.   I added a black mask and rubbed out the scales on the inside of the mouth and used a grey brush to soften the scales at the top of the head and on the tips of the horns.   For the Horns themselves I added another smart material called polished marble and went into the smart material folder and directly changed the colours within there to make the horns look a bit more yellow than they were porcelain white. I picked out a hard brush, turning up the height map and turning off the metallic map, I painted directly onto the UVs with a quick swipe to create some bands around the horns for extra detail. I then went back to the head and painted the tips of the horns red, adding lots of details like curls and blending gradients to make the green fade into the red seamlessly. I also added shadows and hints of red around the eyes to make my dragon look more angry and more life-like as she would not be perfectly symmetrical all over. I also added a fill layer to the teeth to make them more yellow; they didn't need much texture, so I just turned up the roughness. I added some fill layers to the spikes keeping them the same colour as the red tipped horns with the eyedropper tool and played around with a grunge alpha on the roughness map to make the spikes look a bit more coase. After adding some more finishing touches I was ready to render the model. I pressed the camera button and saw what it looked like in the light. I could tell that the scales weren't as reflective as I would want so I went back into the substance editor and made the metallic map on the scales way higher of a value than it was previously.   I re-rendered my model and the scales

were perfectly shiny and ready to be placed in Unreal Engine.   I used Unreal Engine as I'm very confident building quick environments to showcase models and other assets much like I did in module 10:1 character rigging with my final rigged character.   I placed my dragon in and imported a few meshes of Chinese temples into the engine as well as some point lights. I went into the post process volume, adding lens flares and got some great snapshots of my final textured model.   I will include the images below as well as some screenshot of the process of me texturing my model.   In the future I think I will be a lot more comfortable texturing as I have learnt so much this term about substance painter and how to use it as well as tips and tricks to create certain effects within a model.   I now understand why texturers say it is close to Adobe Photoshop as it definitely is. Overall with the three briefs I am genuinely happy with how much my skills have improved and I cannot wait to utilise them in the future and improve even more.
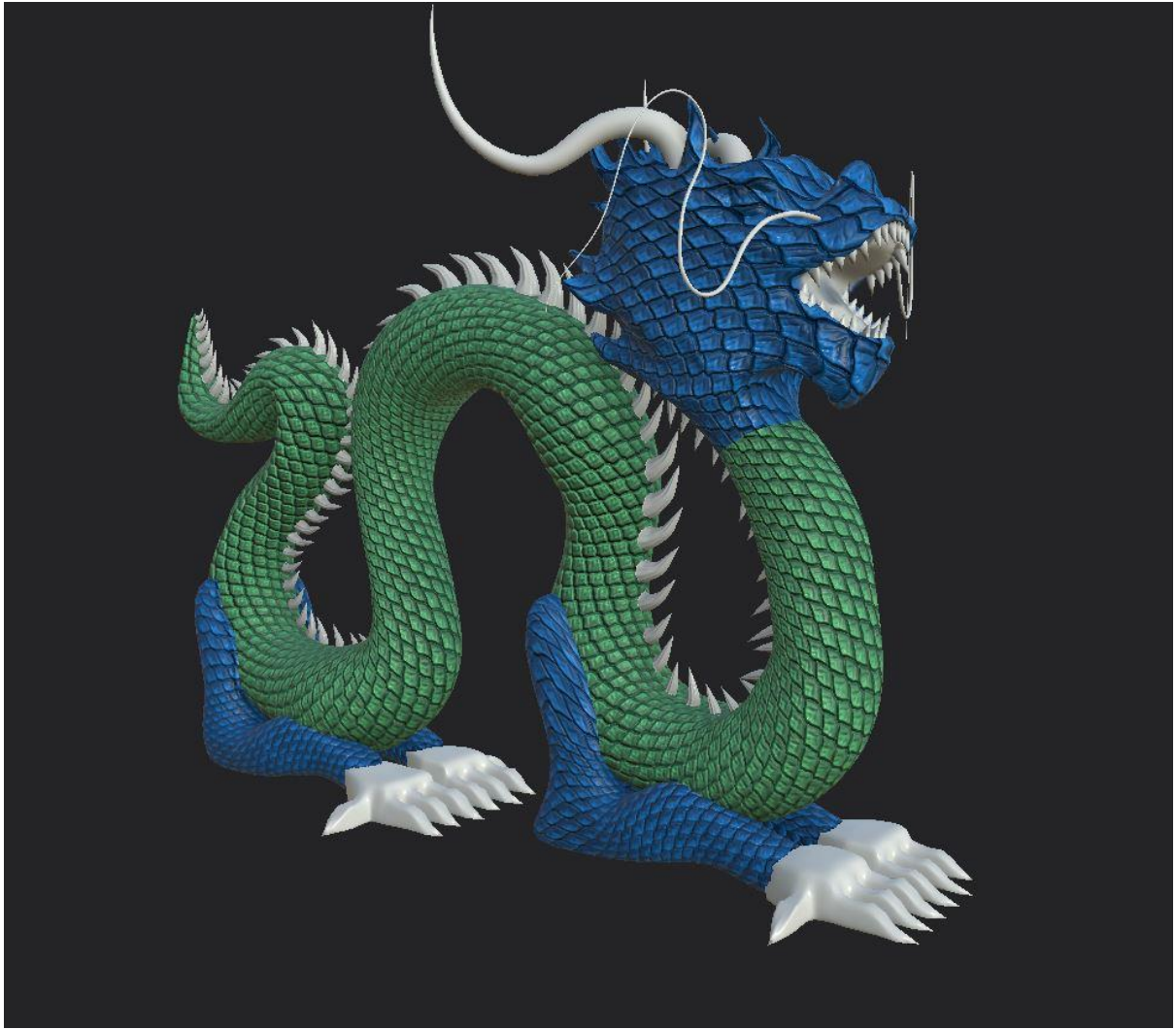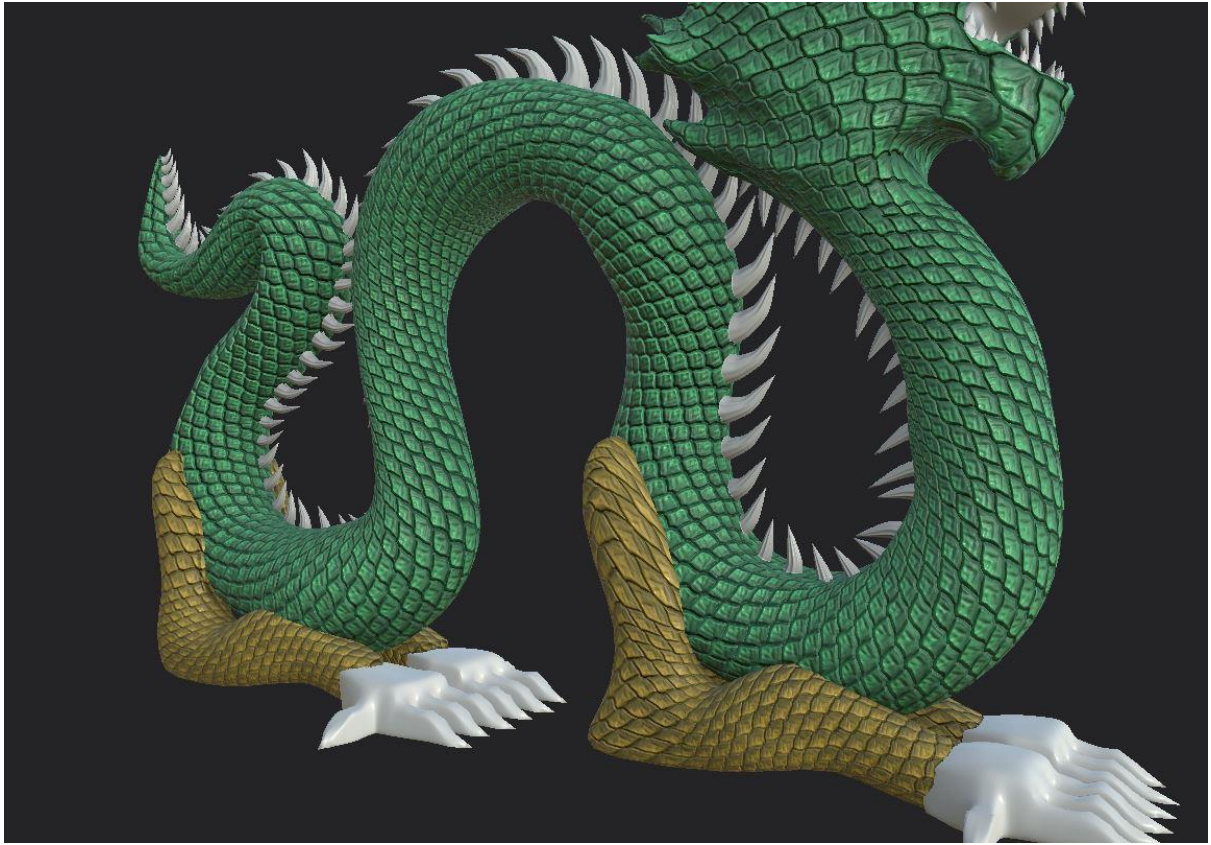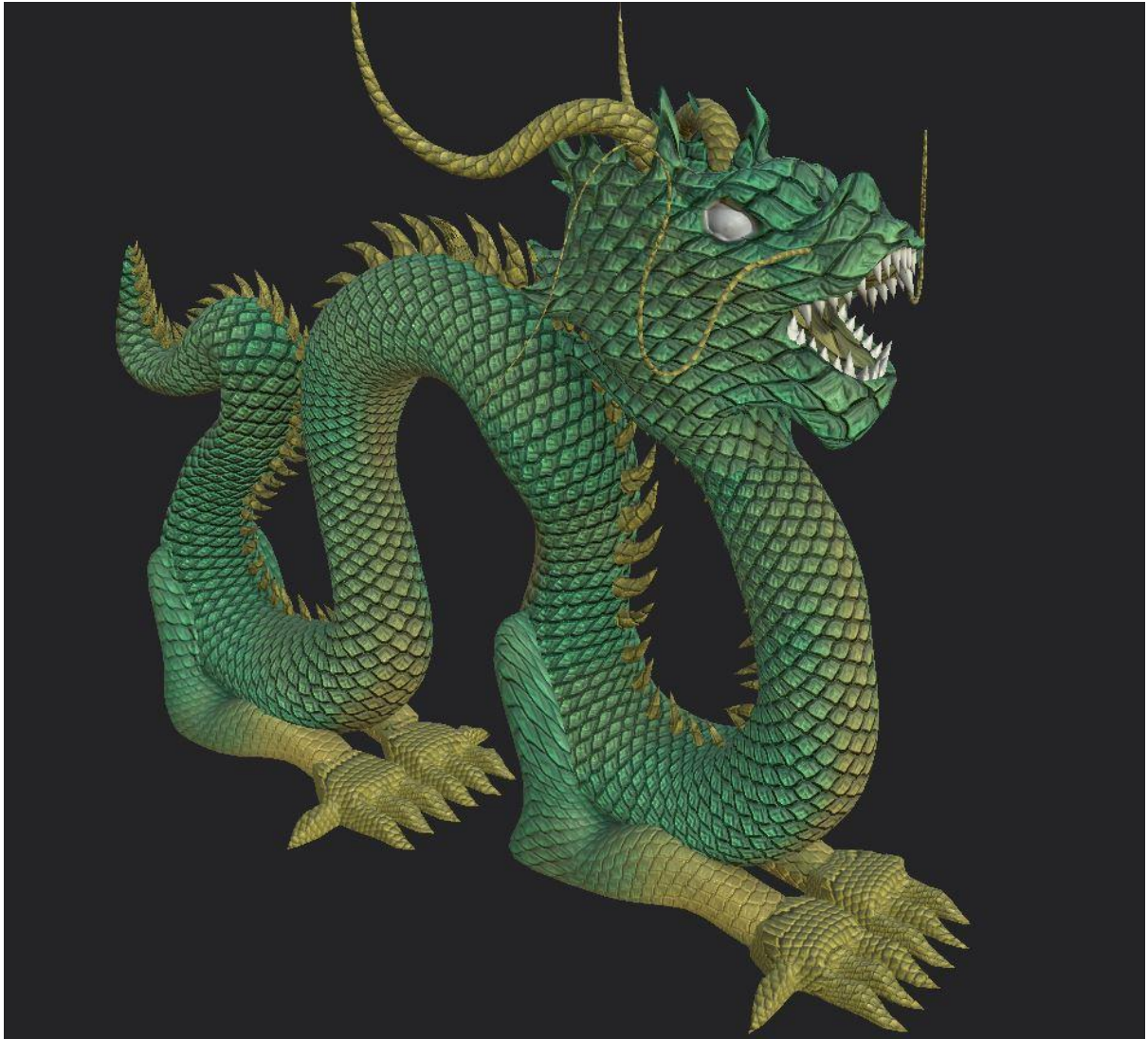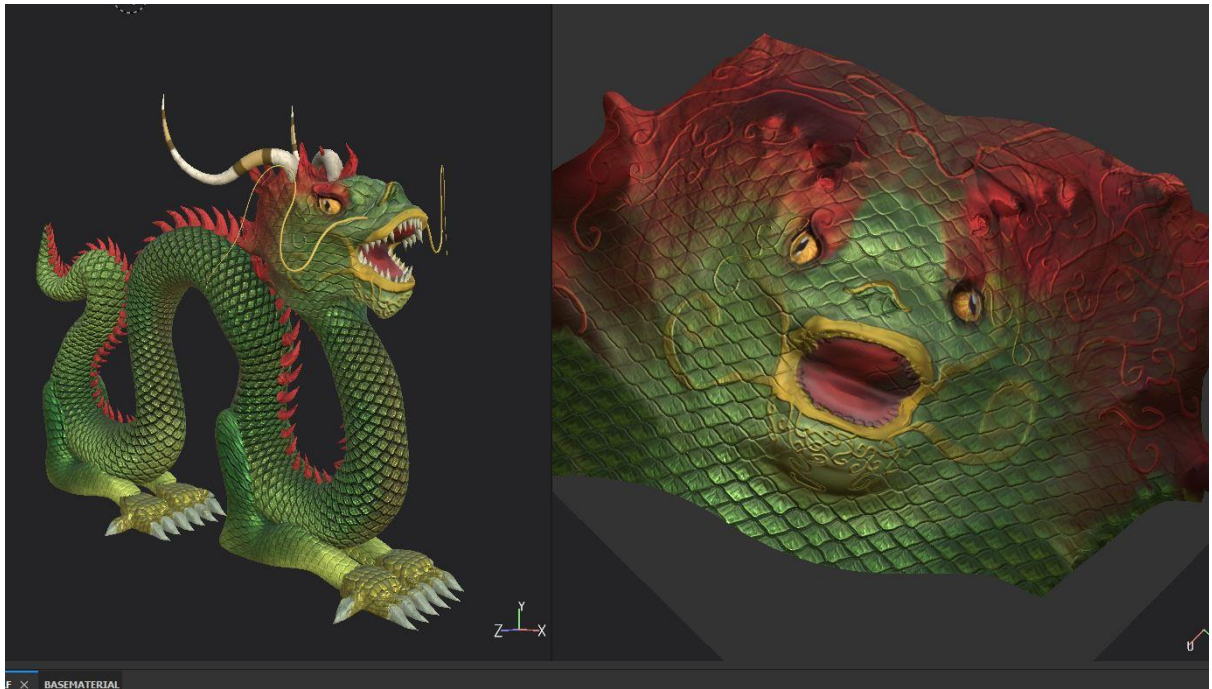
Evaluation

What happened on the project?

For this brief, I was tasked to revisit the Meet Mat challenge we were set in the first year of our course. I then aimed my focus back into the different techniques of texturing in substance painter to emphasise my creativity and experimentation. I completed my meet mat model by the end of half term, having him fully textured and rendered. On completion of this I could then choose a path I wanted to go down with my texturing journey, either creating an environment, texturing a model or making my own textures. I decided to integrate module 10 and 11, and spend a lot of effort texturing my own sculpture to produce a great outcome.

What was produced?

I produced a meet mat model this term, as well as a fully textured and rendered asset which I made from scratch. For the meet mat model, I drew inspiration from many places. Yee Sookyung is a sculpture artist who I based my meet mat model on this term. Her sculpture exhibit used porcelain, with blue features and gold kintsugi paint. I recreated the features from this sculpt on my meet mat model, and referenced original kintsugi art from the Muromachi period. After texturing this model I moved on to texturing my Chinese Dragon in Adobe substance painter.

What did I enjoy the most?

My favourite part of this brief was the learning curve using Substance Painter. Before this brief was set I was not confident with Adobe Substance Painter at all, however since pushing my texturing abilities with this project I was able to discover a lot of new methods, tips and interesting features that I did not know about previously, such as instances and different methods of projection such as Uv standard and Triplanar to have different effects of projection. I also am much more confident with baking down texture maps, knowing why there are errors and how to fix them.

What was the most challenging?

The most challenging part of this brief I found was the research. There is a lot of different information to unpack and learn about, such as the softwares itself, texture maps, atlas maps, high to low poly baking, UE4 materials, UVs, and my research into my texturing. It was quite taxing to do so much research, however I left myself plenty of time to really absorb the information I was reading, and I

found that conducting so much research and reading through a lot of the articles helped me learn. I even found that I learned well through Harvard Referencing, as it was a very tedious task to reference all of my research though I think I did well and got a lot quicker at doing each reference, even though it was challenging with time given.

Feedback from peers?

"I absolutely love the idea of using the china plates and creating a meet mat out of it. I especially love the plate design used on the face of Mat as it really draws the focus to that and the simplistic body work really compliments the intricate design on the face. I really love the gold streaks running through the design as it breaks up the white and blue colours that are used throughout too. Moving forward, I would definitely do something with the stand that Meet Matt is standing on to make the design appear more finalised, maybe incorporating the gold used in the cracks? I would also love to see you changing the height in certain areas of the meet mat just to show different dimensions to him too. I think that would work really well!"

"I really love how you have pulled key areas of your inspiration to create a delicate yet beautiful looking sculpture which suits your general aesthetic of Chinese pottery. The use of the golden cracks also bring this aspect forwards. Moving forwards, perhaps try to integrate the base of the model into the overall design and see if you can work on different inspirations for the base to bring forwards the Chinese culture with carvings, or even just bringing more of the delicate plate. Other than this It looks incredible and I love how you have managed to present it as something so fragile! Keep up the amazing work!"

"The textures for the model look amazing, you could change the base of the meet mat to be something other than wood"

"Awesome work this is Eve! Very beautifully arranged and put together. You could maybe add a little chipped piece of meet mat's body onto the base. Like a work in progress idea. Would be a nice way to explore displacement and tessellation too."

What did I learn from this feedback?

I learnt from this feedback that the intricate design and details were very aesthetically pleasing and I clearly got across the type of feeling I wanted for my audience. I really enjoy how it looks 'fragile' as that is the exact look I wanted to go for, as I noticed a lot of other porcelain models don't look too porcelain, they appear more marble like. I agree with the feedback that I could change the base of the model, as it is my least favourite part and it is where I began to lose artistic inspiration during the texturing process. I wasn't too sure what would match and the wood base ended up looking quite cheap and similar to ply would. In the

future I will take this feedback onboard, maybe adding some more personality to the base and make it match the quality of the top of the mesh.

What have I learnt about planning?

Through the duration of this brief I have learnt that my planning can be a little bit one sided, focusing on one brief more than others. I tend to work in chunks all at once and then take long breaks. I do enjoy the way I work and I am always left with a few days to polish my projects, however I may try and work more on my research towards the start of the model to get it out of the way so I can focus on actually improving my texturing/modelling skills, as I spend more of my time writing thoroughly and perfecting my written work that I do learning new skills. In the future, I don't think this will be the case as I am aware that next year we will be moving over to video blogs instead, which will push me to work weekly as well as spend more time developing new skills and methods.

What would I do differently next time?

Regarding the Meet Mat challenge, next time I would add an offensive amount of detail, pushing myself to add very intricate chips, carvings and detail, especially in the base. I believe I could add chips of the model to the base, and leave a hole in the model where it would've fallen off due to my new skills. I'd love to revisit the Meet Mat challenge in the future and produce something similar.

In regards to my texturing journey, I'd love to create more textures like I did with the Meet Mat bird texture, porcelain lines and face china plate. I really enjoyed doing this as those textures are specific to me and no one else has them. I love the idea of my model being this unique and it didn't take me long at all when creating these textures and coming up with the idea, so in the future I will definitely take advantage of this and create a lot more textures; even more detailed than that. Moving forward I also want to try and master the UE4 materials, as I am still not confident creating textures and coding them, which is something I am very interested in, however it wasn't the main focus of this brief. I will practise over summer and work towards achieving this goal of UE4 master materials.

Bibliography

Antiques-delaval.com. 2021. *Large Chinese porcelain vase cracked gilt dragons in the nineteenth century*. [online] Available at: <https://www.antiques-delaval.com/en/porcelain-ceramic/9018-chinese-vase-cracked-porcelain-gilt-dragons-xixth-century.html> [Accessed 22 February 2021].

BFM Bourse. 2021. *Adobe systems : Une acquisition dans le secteur des jeux vidéo*. [online] Available at: <https://www.tradingsat.com/adobe-systems-US00724F1012/actualites/adobe-systems-adobe-une-acquisition-dans-le-secteur-des-jeux-video-845571.html> [Accessed 11 April 2021].

Definition-of.com. 2021. *Definition of Kintsugi*. [online] Available at: <http://www.definition-of.com/kintsugi> [Accessed 11 April 2021].

Encyclopedia Britannica. 2021. *Ashikaga Yoshimasa | Japanese shogun*. [online] Available at: <https://www.britannica.com/biography/Ashikaga-Yoshimasa> [Accessed 11 April 2021].

Gamasutra.com. 2021. *Practical Texture Atlases*. [online] Available at: <https://www.gamasutra.com/view/feature/130940/practical_texture_atlases.php> [Accessed 14 May 2021].

Gopnik, B., 2021. *Golden Seams: The Japanese Art of Mending Ceramics*. [online] Washingtonpost.com. Available at: <https://www.washingtonpost.com/wp-dyn/content/article/2009/03/02/AR2009030202723.html> [Accessed 11 April 2021].

History-science-technology.com. 2021. *History Of Science And Technology In Islam*. [online] Available at: <http://www.history-science-technology.com/notes/notes9.html> [Accessed 11 April 2021].

Hoffman, M., 2021. *Fifteenth-century shogun Ashikaga Yoshimasa: Impotent or indifferent?*. [online] The Japan Times. Available at: <https://www.japantimes.co.jp/news/2016/10/15/national/history/fifteenth-century-shogun-ashikaga-yoshimasa-impotent-indifferent/> [Accessed 11 April 2021].

Hunt, C., 2021. *18th century blue and white Chinese porcelain charger*. [online] Cathy-hunt.co.uk. Available at: <https://cathy-hunt.co.uk/18th-century-blue-and-white-chinese-porcelain-charger> [Accessed 22 February 2021].

Mullen, T., 2013. *Mastering Blender*. 1st ed. Indianapolis, Ind.: John Wiley & Sons, Inc.

Nvidia. 2021. *Batching using Texture Atlases*. [online] Available at: <http://download.nvidia.com/developer/NVTextureSuite/Atlas_Tools/Texture_Atlas_Whitepaper.pdf> [Accessed 14 May 2021].

Pinterest. 2021. *170 Kintsugi ideas in 2021 | kintsugi, kintsugi art, ceramics*. [online] Available at: <https://www.pinterest.co.uk/michal2701/kintsugi/> [Accessed 11 April 2021].

Pinterest. 2021. *Blue Willow China | Burleigh Willow Plate c1920s and 1930s | Willow pattern, Blue willow china, Vintage china patterns*. [online] Available at: <https://www.pinterest.co.uk/pin/177751516529628680/> [Accessed 22 February 2021].

Pui Ying Kwan, 2021. *EXPLORING JAPANESE ART AND AESTHETIC AS INSPIRATION FOR EMOTIONALLY DURABLE DESIGN*. [online] Designedasia.com. Available at: <http://www.designedasia.com/2012/Full_Papers/Exploring%20Japanese%20Art%20and%20Aesthetic.pdf> [Accessed 11 April 2021].

Quixel. 2021. *Quixel joins forces with Epic Games*. [online] Available at: <https://quixel.com/blog/2019/11/12/quixel-joins-forces-with-epic-games> [Accessed 11 April 2021].

Quixel. 2021. *Quixel Megascans*. [online] Available at: <https://quixel.com/about> [Accessed 11 April 2021].

Ritossa, J., 2021. *Learning Substance: Professional Tips and Tricks*. [online] 80.lv. Available at: <https://80.lv/articles/learning-substance-professional-tips-and-tricks/> [Accessed 11 April 2021].

Rosenfeld, B., 1988. *A History of Non-Euclidean Geometry: Evolution of the Concept of a Geometric Space*. Springer New York.

Sellers, Dennis. 2021. *Maya gets an Oscar for Technical Achievement*. [online] Available at: <https://www.macworld.com/article/1008800/oscar.html> [Accessed 9 April 2021].

Share.substance3d.com. 2021. *Cracked Ceramic*. [online] Available at: <https://share.substance3d.com/libraries/3300> [Accessed 22 February 2021].

Smithsonian. 2021. *The Japanese Art of MendingCeramics*. [online] Available at: <https://www.si.edu/Exhibitions/Golden-Seams-The-Japanese-Art-of-Mending-Ceramics-4567> [Accessed 11 April 2021].

Sookyung, Y., 2021. [online] Yeesookyung.com. Available at: <https://www.yeesookyung.com/i-am-not-the-only-one-but-many> [Accessed 11 April 2021].

Substance 3D. 2021. *About us | Substance 3D*. [online] Available at: <https://www.substance3d.com/about-us> [Accessed 11 April 2021].

Substance 3D - Magazine. 2021. *Meet MAT 2 - Substance3D Contest*. [online] Available at: <https://magazine.substance3d.com/contest/meet-mat-2/> [Accessed 11 April 2021].

Substance 3D - Magazine. 2021. *Meet MAT 2: the 3D Texturing Contest winners!*. [online] Available at: <https://magazine.substance3d.com/meet-mat-2-3d-texturing-contest-discover-the-winners/> [Accessed 22 February 2021].

Techcrunch.com. 2021. *TechCrunch is now a part of Verizon Media*. [online] Available at: <https://techcrunch.com/2019/01/23/adobe-acquires-allegorithmic-makers-of-the-substance-texture-tools/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig= AQAAADmpdb4VSLs39Tl0cxc-TOvJUMeYB-yoIvHz1NGLxMlSplE8_2KvKU_pdrN8xN3IVdVTLjB0OmpnSV5gi5gHbDe-NhHzjdhzX4xzH8haBQypcmX6rRf2gr0MlyLPue87a5OkcwNhAT5FMc-eEfDRAI8d3N4BR56ekHQn2ZOuBwsX> [Accessed 9 April 2021].

Terdiman, D., 2021. *And the Oscar for best visual effects goes to...Autodesk's Maya*. [online] VentureBeat. Available at: <https://venturebeat.com/2015/01/15/hollywood-fx-pros-i-want-to-be-an-oscars-maya-win> [Accessed 9 April 2021].

The School of Life Articles. 2021. *Kintsugi* -. [online] Available at: <https://www.theschooloflife.com/thebookoflife/kintsugi-2/> [Accessed 22 February 2021].

Tschmits, 2021. [online] Docshare02.docshare.tips. Available at: <http://docshare02.docshare.tips/files/25546/255469300.pdf> [Accessed 11 April 2021].

VG247. 2021. *Epic Games acquires Quixel for the world's largest bank of photogrammetry data - VG247*. [online] Available at: <https://www.vg247.com/2019/11/12/epic-games-acquires-quixel-worlds-largest-bank-photogrammetry-data/> [Accessed 11 April 2021].

Warren, S. and Jones, G., n.d. *Learning Games*. Available at: <https://www.springer.com/gp/book/9783319468273> [Accessed 9 April 2021].

Weidong Li, 2021. *A Landmark in the History of Chinese Ceramics: The Invention of Blue-and-white Porcelain in the Tang Dynasty (618–907 A.D.)*. [online] Taylor & Francis. Available at: <https://www.tandfonline.com/doi/full/10.1080/20548923.2016.1272310> [Accessed 11 April 2021].