

# WORK EXPERIENCE REPORT

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## Additive Manufacturing Center for Mass Customisation Production

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May 16, 2021

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## 1 Introduction

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This report details the work undertaken in order to fulfil the requirements of the degree regulations set out by Engineering NZ. It is a recount and critical reflection of the time spent attaining over 400 hours of practical work experience with the Additive Manufacturing Center at the National Taipei University of Technology. The objective of work experience is to expose students to a professional engineering environment which includes processes, management structures and practical engineering applications in professional work. This report will focus on the completion of 4 key learning outcomes during the work experience

- **Undertake work that allows for critical reflection on the professional responsibilities or roles from an engineering perspective, related to the degree major**
- **Undertake work that provides an opportunity to assess procedures in the workplace and their relative strengths and weaknesses**
- **Undertake work that provides an opportunity to assess aspects of health and safety in the workplace and their relative strengths and weaknesses**
- **Undertake work that allows for critical reflection on engineering management practices**

This report will be structured to reflect my experiences to completing the above 4 learning outcomes through out my time with the Additive Manufacturing Center at the National Taipei University of Technology. Each learning outcome will be written in separate chapters defining the work I did and the experiences I encountered which led me to be confident that I had achieved the learning outcomes.

## 2 Internship Organisation

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The Additive Manufacturing Center for Mass Customization Production at NTUT develops industrial level techniques for 3D Printing and provides solutions to achieve innovative types of mass custom production models. The center focuses on research, development and integrates the techniques of manufacturing and production whilst also welcomes industrial collaboration.

The center assists not only with industry (such as Franz, Delta, TBIMOTION, Shihlin Electric and Pegatron just to name a few) but also medical and household in additive manufacturing by using integration of measurement techniques, analysis and modelling, material design, additive manufacturing techniques and validation assessments. The goal of the center is "Cultivating talent and linking industry, the center will assist domestic manufacturers in technological innovation to become the cornerstone of the global manufacturing supply chain." Another thing the center does is it also collaborates with other companies and industries. An example of this is Zabway - a masters student had thought of supporting the soles of the foot so it is more comfortable, the machine measures the foot by the person standing on the machine - this machine measures the feet very accurately if socks are taken off. It measures multiple things such as pressure of each foot, widest point of each foot, length of each foot and then it produces a QR code for the person to scan. This QR code opens up a web page containing all the details of the measurement.

### 2.1 Company Profile

**Title:** Additive Manufacturing Center for Mass Customisation Production

**Established:** 1958

**Current Managing Team:**

- Professor Yang, Che-Hua
- Professor Wang, Jia-Chang
- Professor Su, Cherrng-Yuh
- Professor Chen, Weng-Pin
- Professor Jiang, Cho Pei
- Professor Timotius Pasang

The Additive Manufacturing Center for Mass Customization Production is located in the National Taipei University of Technology in Taipei, Taiwan. The institute of Manufacturing Technology was established in 1999 at the university.

**Address:** No. 1, Section 3, Zhongxiao E Rd, Da'an District, Taipei City, Taiwan 10608

## 2.2 Facilities

The technology lab and the Additive Manufacturing Center are located next to each other on the second floor of the Mechanical Engineering Building at NTUT. There is also another technology lab in another building across the road on the 8th floor where they not only house a multitude of computers to teach CAD software on but also resin printers and two very expensive SLA printers. In addition to this, they also have 18 FDM printers, another 4 resin printers, 2 SLS printers and a 3D scanner in the main Additive Manufacturing Center.



Figure 1: Campus of National Taipei University of Technology



Figure 2: On Campus, in front of College of Mechanical and Electrical Engineering



Figure 3: College of Mechanical and Electrical Engineering

### 3 Capabilities and Services

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<https://formlabs.com/blog/fdm-vs-sla-vs-sls-how-to-choose-the-right-3d-printing-technology/> The Additive Manufacturing Center is located within the National Taipei University of Technology. It mainly develops industrial productivity additive manufacturing techniques and provides complete production solutions to achieve a new type of mass customised mass production model. The center aims at research, development, integration of manufacturing and production techniques and cooperates with industry.

The center focuses on assisting industry for the application of additive manufacturing and keeps up with the trend of mass customisation by integrating measurement techniques, analysis, modelling skills, material design, additive manufacturing techniques and validation assessment techniques for not only industries but also the livelihood of people in the medical industry.

The center provides industry assistance for upgrades, advancements and a combination of automation intelligence and emerging mass customisation manufacturing techniques in support of Taiwan's industrial development. With a goal of procuring talent and linking them to industry, the center assists domestic manufacturers in technological innovation in the hopes of becoming the cornerstone of the global manufacturing supply chain.

### 3.1 Non-Destructive Testing

Non-Destructive testing is used to evaluate material properties, components or systems without causing damaging it. This technique of analysing is very valuable that can save time, money in product evaluation, troubleshooting and research as it does not permanently damage the material. There are a few different methods that can be used in non destructive testing which are eddy currents, magnetic particles, liquid penetrant, radiographic, ultrasonic and visual testing. It is commonly used in forensic, mechanical, petroleum, electrical, civil, systems and aeronautical engineering.

Non destructive testing relies on electromagnetic radiation, sound and other signal conversions to examine a wide variety of articles whether it be metallic or non metallic for integrity, composition or condition with no alteration of the article undergoing examination. The most common applied non destructive testing method is via visual inspection - this is often enhanced with the use of magnification, borescopes, cameras and other optical arrangements for direct or remote viewing. The internal structure of a sample can be examined for volumetric inspection with penetrating radiation such as X-ray, neutrons or gamma radiation.

Another NDT method is via ultrasonic testing through the use of sound waves. The mechanical signal (sound) is reflected by conditions in the the material and evaluated for amplitude and distance from the search unit (transducer). This is the method that NTUT uses mostly.

Another common method uses fine iron particles, either suspended in liquid or dry powder - this only works on ferrous materials. The fine iron particles are applied to a part while it is magnetised, either continually or residually. The particles will be attracted to leakage fields of magnetism on, or in the test material and will indicate via particle collection on the objects surface which can then be visually evaluated.

Visual examination of defective material is often enhanced with the use of liquids to penetrate the test article surface through contrasting colours which allows for visualisation of flaws or other surface conditions. This method, liquid penetrant testing involves the use of dyes which are often fluorescent or red coloured, suspended in fluids and is used for non magnetic materials usually metals.

Some applications that uses Non Destructive Testing includes weld verification, structural mechanics and medical procedures.

**Weld Verification:** Welds can be tested using radiography or CT scanning using X-rays, gamma rays, ultrasonic testing, liquid penetration test, magnetic particle inspection or eddy currents. In a good weld, there would be no cracks from the radiograph, show a clear passage of sound through the weld and back and will indicate a clear surface without penetrant captured in cracks.

**Structural Mechanics:** Structures undergo many varying loads throughout their lifetime such as a lead carbon battery. In Non Destructive Testing, the structure undergoes a dynamic input such as a controlled impulse. Key properties such as displacement or acceleration at different points of the structure are measured as the corresponding output. The output is recorded and compared to the corresponding output given by the transfer function and the known input. Differences may indicate an inappropriate model, failed components or an inadequate control system.

### 3.2 FDM 3D Printing

FDM 3D Printing uses PLA or TPU filaments to print. During the time of the internship, three printers were assembled, calibrated and used to print. They were called the Rainbow 3D Core XY printers. These printers although big, were budget and because of this, a lot of the 3D printed parts provided ended up breaking. There were also a lot of issues such as the Steady State Relay not heating the bed to the preset temperature, the extruder becoming blocked from melted filament, no wiring diagrams for the power supply and we had to tap and drill a heatsink for the extruder in case it got really hot as the manufacturer only provided a tiny fan

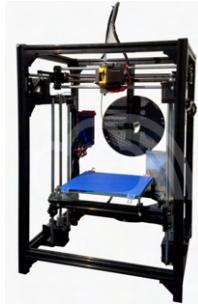


Figure 4: Rainbow 3D Core XY Printer

The machine was calibrated by placing a piece of paper under the nozzle of the extruder and moving the nozzle to feel if the nozzle is uniform with the bed. If not, the appropriate corner of the bed should be adjusted with the allen key. Moving this piece of paper around the four corners of the bed and also moving the nozzle around to calibrate the bed in order for it to print properly.

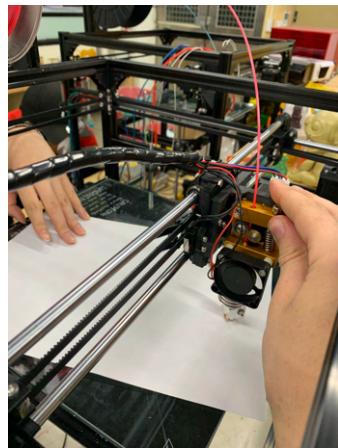


Figure 5: Calibrating the printer

Once calibrated, the machine is then ready to print. The PLA needs to be preheated first for the filament to go through the nozzle. Then, STL models are downloaded from Thingiverse or can be made through Solidworks and imported into Simplify3D. Simplify3D includes everything needed to work with any type of 3D printer. Model setup and plating, slicing and print file creation, pre-print simulations, customisable support structures, mesh analysis and repair, machine control and monitoring just to name a few.

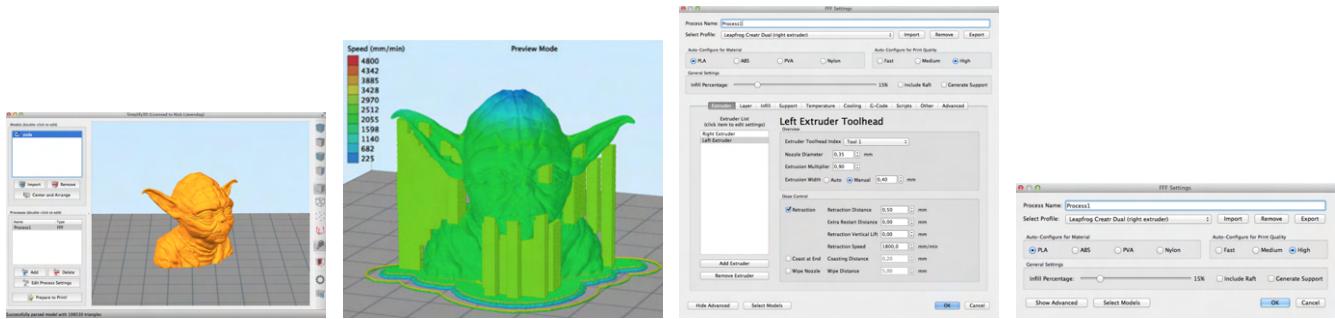


Figure 6: Printing Yoda in Simplify3D

Simplify3D needs to have the printer settings before it can print anything. Input all the necessary settings such as nozzle diameter and temperature in and then import the STL file. Transform the object so it has the least amount of supports hence reducing the print time. Clicking 'Ready to Print' in Simplify will produce toolpaths in G-Code which the printers can read and print from. As seen in Figure 3, an STL model file of Yoda from Star Wars was imported to Simplify3D for adjustment before printing. The printed model is shown below in Figure 4



Figure 7: Calibrating the printer

Following the success of Yoda, another STL model file was put into Simplify3D for printing - a little boat.

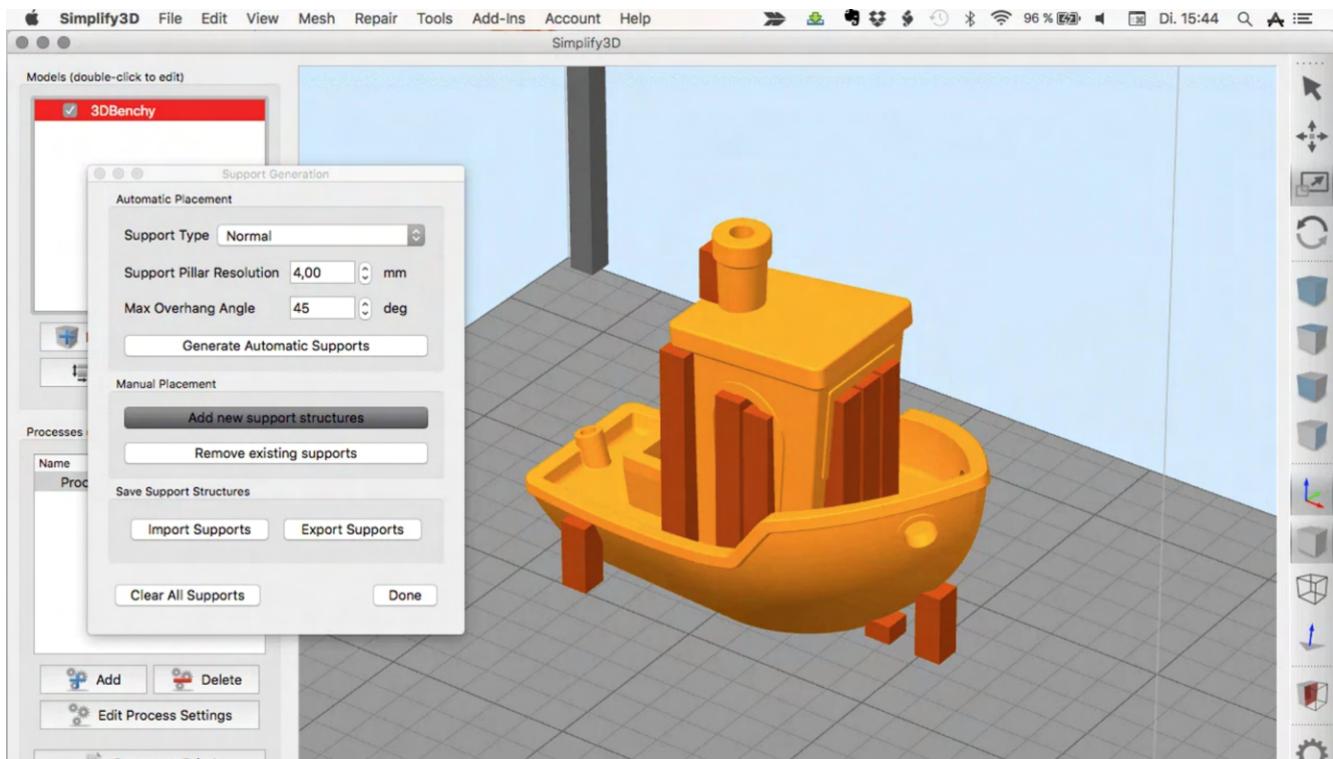


Figure 8: STL file of boat in Simplify3D

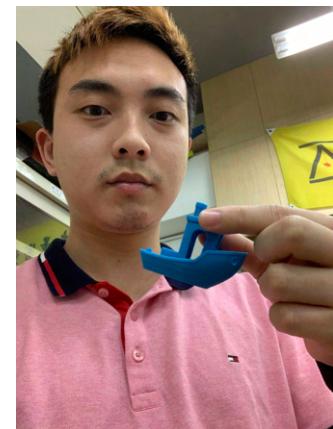


Figure 9: Printed Boat

### 3.3 Ceramic Printing

Applied Solvent based Slurry Stereolithography, also known as 'Ceramic Printing' was used to produce 6 ceramic roses and 6 stars. These were printed because they were premade custom files for testing. For a successful print, the rose petals should be intact and the base should be round. The stars need to have 'Taipei Tech' on one side of the centre and 'AMC 2019' on the other side of the centre.

Firstly, a bottle was prepared with the following ingredients:

Material	Amount
Dispersant	6g
Alumina Powder	700g
Resin	180g
Alcohol	180g
Zirconia Ball	20
Colour	0.36g

Table 1: Ingredients required for Ceramic Printing

After putting all the ingredients into the bottle, it is put onto a rack where a machine spins it constantly. The bottle is left there for 24 hours - this allows the mixture inside to smoothen out. See machine below.



Figure 10: Machine that spins the bottle with mixture

First the plate and scraper is attached and using custom software by 3DT, called Morning 1.0, the scraper is turned on. As the scraper moves around the plate, if it makes any noise, the plate should be adjusted accordingly - tightened screw or loosened screw.

Now the bottle of liquid is poured into a container within the machine. This container has a rotating propeller to spin the liquid inside. The lid is also attached to a tube which feeds through a pneumatic motor that draws the liquid from the container and feeds it through to the slurry deposition system where it will be deposited onto a clean plate. Using the custom software, STL files are loaded into the printer and settings such as speed of deposition, position of deposition, extrusion material, projector start, projector UV lighting time, scraper speed and height, thickness of material, amount of extruding material and extrusion delay ensuring it is 12 seconds

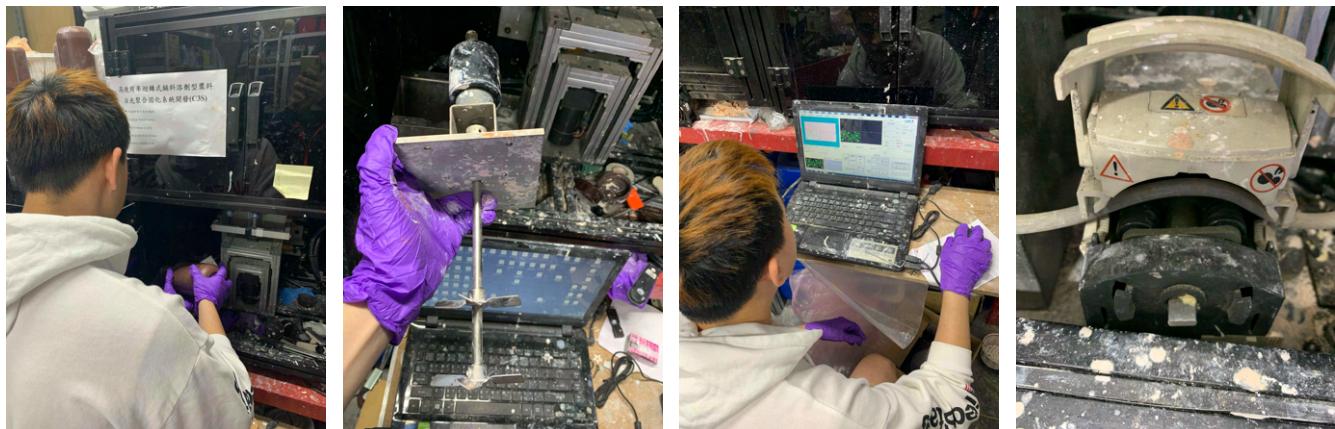


Figure 11: Ceramic Printing Process

To start, the scraper should be positioned just before the deposition tube. Once positioned, turn the pneumatic motor on using the custom software and some slurry should be deposited onto the plate. As soon as this happens, turn the scraper to full speed. Check the deposition on the plate every 20 - 30 minutes and adjust the amount of extruding material accordingly. If there is a big clump of liquid ceramic in front of the scraper, decrease the amount of extruding material and also get something to mix the clump, making sure only to mix it when it is away from the projecting UV light.

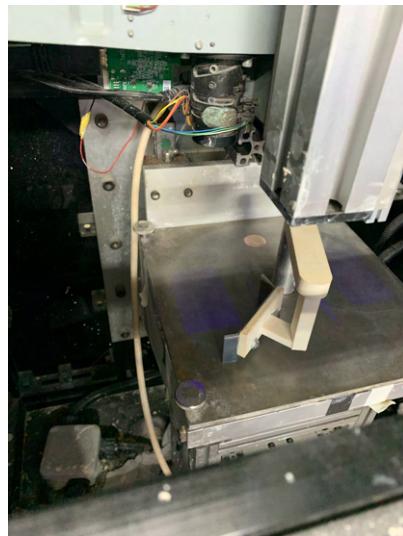


Figure 12: Scraper position

There are 2 sections on the plate which that the STL files will be printed on, the left and the right - it is where the UV light is projected. The plate is taken out of the machine and the circle is cut according to where the UV light was projected. The sections where the UV light wasn't projected is thrown away as it doesn't contain the printed parts. The remaining sections are then left on the plate and brought under a tap to wash. Washing the parts usually take a few hours under light flow as the semi hard ceramic is washed off from the heat treated parts, exposing the printed parts. See Figure 4

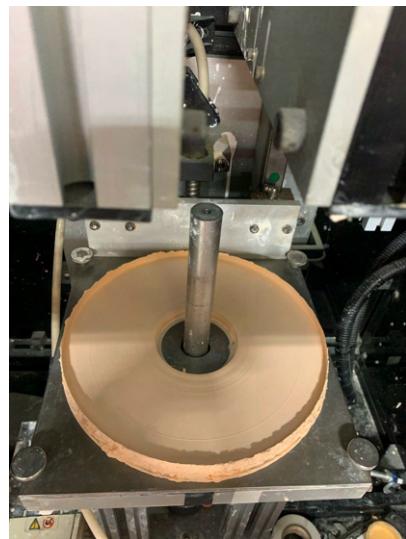
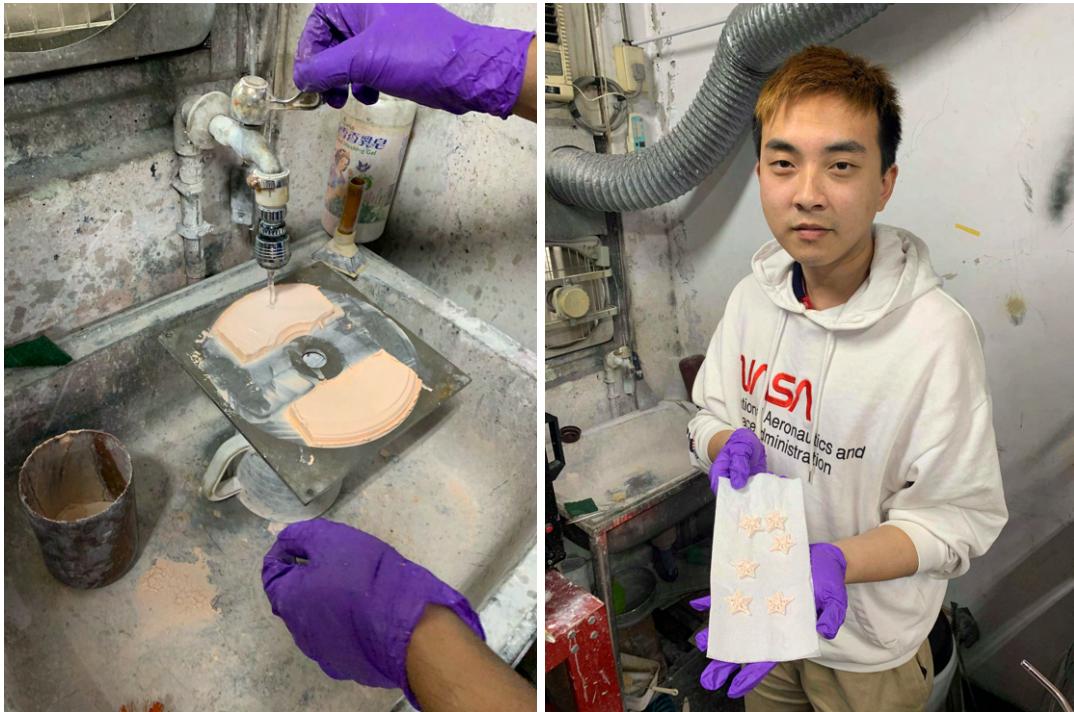


Figure 13: Finished ceramic on plate

Once the majority of the parts are washed under the tap, use a needle filled with water to wash off the tiny details on the parts.



### 3.4 SLS Printing

SLS, as known as Selective Laser Sintering, is a technique of Additive Manufacturing that uses a Carbon Dioxide laser as the source to 'sinter' the material - in this case it is plaster. The laser will aim at points in space defined by the model, binding the plaster together to creating a solid structure. SLS is usually used fror rapid prototyping and production of component parts. One advantage SLS has is that it can print colour onto the 3D model - it is done by importing the STL model file into Autodesk Netfabb and colouring in model. Once coloured, it is saved as a Virtual Reality Modeling Language File (.wrl)



Figure 14: Cometreue SLS Printer

The Cometreue SLS Printer uses its own software called Cometreue to print .wrl files. This SLS printer, just like the Ceramic printer is controlled via a laptop or computer through the software at a click of the mouse. First, the .wrl file is loaded into the software and transformed into a position that doesn't break any compromised parts of the model as the disadvantage of printing SLS is that the models are quite fragile. Once the model is transformed, the software shows a depth and this is the depth of plaster required in order to print the model.

The existing powder on the right hand side in figure 11 is dusted onto the left hand side which feeds powder into the extruder. The printer is then calibrated, which looks like a nozzle print calibration of a normal printer as seen in Figure 11. Once calibrated, the printer then fills the right hand side with plaster powder and flattens it. After this, the printing process begins. It starts printing the model from the bottom to the top, so the base of the right hand side starts going down and the extruder will put on another layer of plaster powder and so on until the print reaches the set depth of the model.

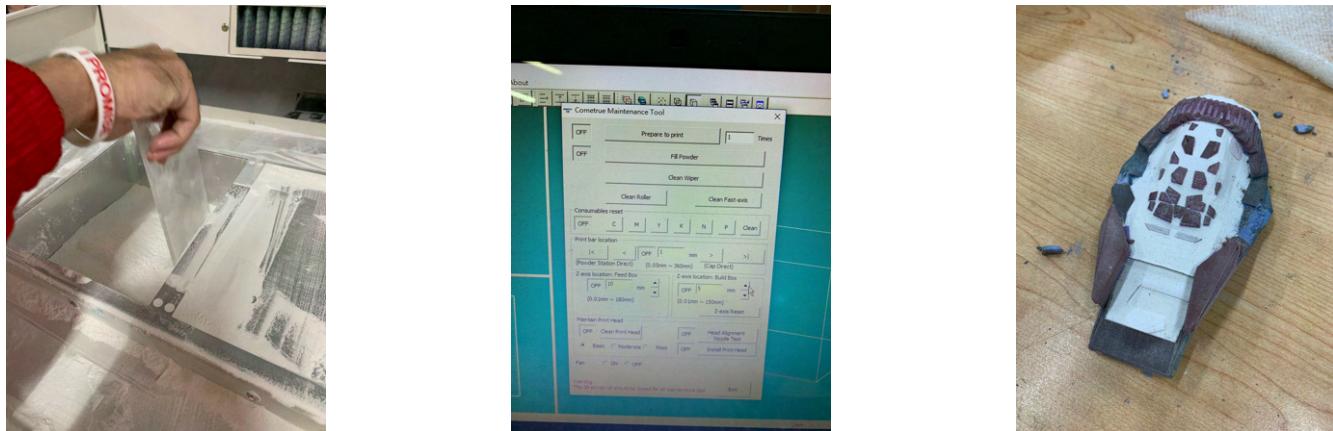


Figure 15: Printed Interstellar Ranger with colour

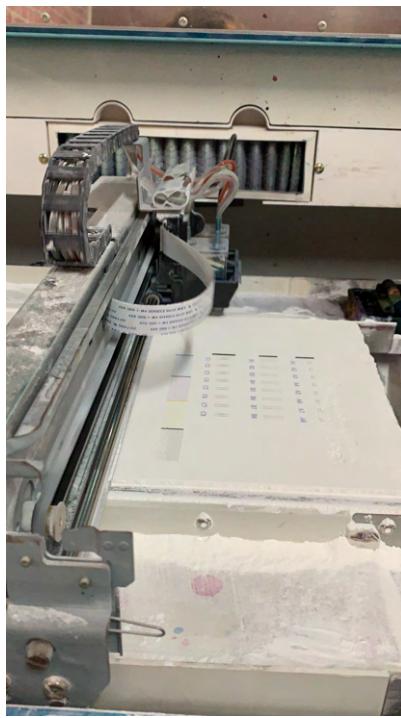


Figure 16: SLS Printer Calibration

### 3.5 SLA Stereolithography

SLA, also known as Stereolithography Apparatus is another additive manufacturing technique that used for creating models, prototypes, patterns and production parts. It is done in a layer by layer process using photochemical process such as Ultra Violet light from a projector. At AMC, I learnt SLA using resin and UV light projection to cure.

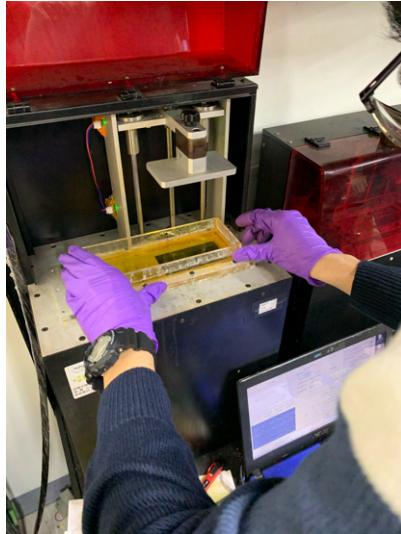


Figure 17: Resin Printer

First, the STL file is loaded into a computer connected to the SLA printer. Since the SLA printer beds are small compared to FDM and SLS printers, the STL file must be scaled down in the software which is Autodesk MeshMixer. This software does not automatically generate supports like Simplify3D does, so supports will have to be added manually. Different types of supports can be chosen such as supports with round edges or sharp and angled edges. A lot of supports can be added as they are easy to remove after printing - better to be safe than sorry as some prints can get heavy and collapse whilst curing. This is because SLA prints work by the bed pulling the printed and cured resin up as it sticks to the bed. After supports are added, the model is then opened in Materialize Magics where the file is repaired.



Figure 18: Bed with projected UV light

Once the model has been repaired in Materialize Magics, it is then opened in a custom software called 'LAB VP CONTROLLER FOR BVP3RD.' This software is similar to the ceramic printer software. It can adjust position, control, exposure, slicing and layer thickness. Once desired settings have been selected, wait for the printer to connect and start printing. Though the bed/plate will need to be clean before printing. It will need to be taken out of the printer and cleaned with Methanol ensuring the bed/plate is completely clean and flat before putting it back into the printer.

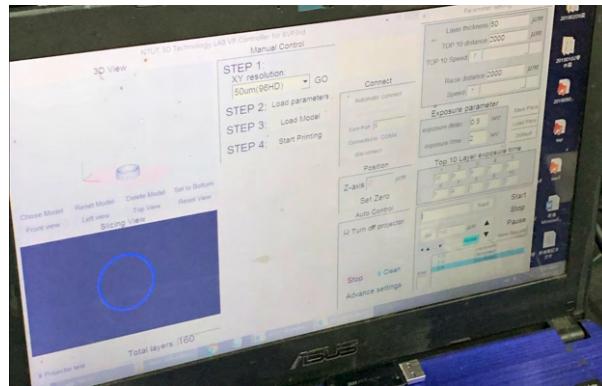


Figure 19: Custom SLA software that controls printer

SLA prints are usually quick and detailed. The post print process isn't long either. To take a finished print off, the bed/plate is taken off first and is sprayed with methanol until the supports loosen and the print can be pulled off. Usually the supports become weak and fall off by themselves after sprayed with methanol, however they can be pulled off carefully. There will still be some imperfections so it will be put into an ultrasonic cleaner. It is put in an ultrasonic cleaner for around 2 minutes and the result is a smooth print. To harden the resin print, it is put into an ultra violet microwave for around another 2 minutes. The timing really depends on how big or thick the print is. If it is overdone, the print will become white, fragile and crackly. So it is advised to put it in the ultraviolet microwave in small intervals such as 1 minute and check, then another minute.

## 4 Description of Work

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I started at the Additive Manufacturing Center, National Taipei University of Technology during the summer holiday (November) 2019 of my third year of university. Whilst still dealing with a high court battle, I embarked on a work experience trip of a lifetime and came back proficient in 3D printing. Me and two others were chosen for this work experience at the National Taipei University of Technology. I had no prior professional engineering work experience so was excited and had no expectations of what I would or could be doing in my new role. I'd arrived two days after the other guys and so jet lagged me went in to the center and started to build the FDM Printer whilst sleep deprived which wasn't ideal in hindsight. When I arrived, formal introductions began and I met Professor Jia-Chang as well as the supervisor who could help us if we had any questions. Professors assigned us to assemble these two flat packed FDM printers that didn't come with any instructions but only came with a Chinese installation video that only I could understand out of our group. The supervisor was also a Masters student so he was quite busy and doing his own thing and we didn't want to bother him with what he would consider a simple question. But in the end we finished assembling it with only a few minor issues which I talk about in learning outcome 2.

At first I was so confused because I thought what happens after we assemble these FDM printers? Will we move onto one of these bigger, cooler machines or will we just be building and printing from these FDM printers. However, towards the end of the week I realised the principle of this activity was for us to get familiar with how a 3D printer works, from the basics. Because the next week professor got us individually to use the SLA ceramic printer inside another room. From assembling the FDM printer the previous week, I could easily notice the differences between this SLA printer and FDM printer. Although they both utilise a bed and extruder, their operating principles were different. Instead of extruding PLA and it cooling down to harden, the SLA printer extrudes a slurry ceramic mixture and flattened with a blade and then it is 'cured' with a UV light which hardens file it is printing.

After printing some ceramic stars, the next week Professor Jia-Chang got us back into FDM printing, this time getting use to perfect the settings for the file we were going to print. Different files need to have different settings such as infill percentage, supports, outer shells and layer heights. But the most important skill was learning how to level the bed properly and knowing when the bed is level because if the bed isn't level, the whole print would need to be destroyed, resulting in not only loss of plastic but also time because these FDM printers would take at least 10 minutes to heat up the bed and nozzle.

In the next few weeks, we were assigned a few projects from Professor Jia-Chang which included 3D scanning our faces and reverse engineering a 3D model downloaded from the internet (Thingiverse) and putting our scanned faces on those models. Although this was difficult, we managed to get through it and now have the skills to reverse engineer any 3D model. We also went and learnt the software(these included using Autodesk Netfabb, Magics, Meshmixer as well as custom software) for resin SLA printing as well as SLS printing which used plaster and sandstone, something I have never even seen.

## 5 Learning Outcomes

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### 5.1 Learning Outcome 1

**”Undertake work that allows for critical reflection on the professional responsibilities or roles from an engineering perspective, related to the degree major.”**

Within my Engineering Qualification, I had chosen to major in Mechanical Engineering. Mechanical Engineering involves designing power producing machines such as electric generators, internal combustion engines, steam and gas turbines as well as power using machines, such as refrigeration and air conditioning systems. Mechanical engineers also design machines inside buildings, such as elevators and escalators. Through my time at the Additive Manufacturing Center, I was exposed to all sorts of 3D Printing I had never seen before. There were a multitude of Master and PhD students working on projects whether it be for themselves or for industry customers, from these people, I learnt about their roles and responsibilities and how important their skills and professionalism are to society.

There were students designing 3D Printers, medical apparatus' as well as developing industrial productivity additive manufacturing techniques as well as providing complete production solutions to industry. One design flaw through their software (Solidworks, Meshmixer as well as custom developed software) could not only cost the Additive Manufacturing Center a lot of money but also the customer. This is why Professor Jia-Chang has weekly meetings and gets everyone to make a slide about their project and compiles into one big slide and everyone at the Additive Manufacturing Center can voice their opinion and offer advice how it could be better. This way, any errors could be found easily and improvements can be made so the end product can be flawless. On the other hand, there were students designing the next generation of 3D Printer, which was like a carousel because one downside to FDM prints is you can only print so much on one bed. But a carousel of beds you can print a lot more. This student had come in every day to test the printer multiple times and on the very last day, he managed to get it working and printed the purple dog as seen in Figure 20.

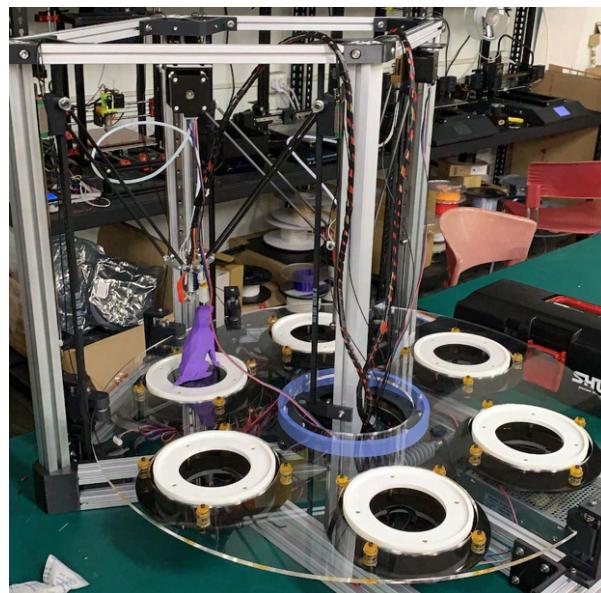


Figure 20: Custom carousel 3D FDM Printer

Seeing how many times this student came in to tinker with this custom printer as well as seeing the hard working students on software 11 hours a day designing components really inspired me to work hard because they know society depends on the components they are creating so they need it to be top notch. I was motivated by my surroundings and took my responsibility into my own hands to learn as much software from them and pick their brains as much as I could because at the end of the day, I had gotten this amazing opportunity to go overseas for the internship that not everyone has the chance to get.

## 5.2 Learning Outcome 2

**"Undertake work that provides an opportunity to assess procedures in the workplace and their relative strengths and weaknesses"**

Procedures in the workplace is an important aspect in the company to ensure it operates smoothly and without error. My time spent in the Additive Manufacturing Center at the National Taipei University of Technology exposed me to many procedures intended to be followed by students and customers. The ones I would like to discuss are a few I encountered during my first two weeks where we had to build a FDM printer from scratch.

Because we were the only students new to 3D Printing, the Additive Manufacturing Center gave us two new machines that were flat packed and asked us to assemble it from scratch. Although they had no procedures for this, it meant we had to create a procedure for future students. The FDM machines had no English installation manual. This required me to watch the Chinese installation video and translate each step. Throughout the installation, we encountered several problems which included using screws that look the same but were different lengths as well as over tightening of screws which resulted in the printer frame looking all distorted and not sitting flat on a table.

Through the construction of the first printer, we wrote down all the steps and learnt from the mistakes made from the installation of the first printer to install the second printer. The second printer was a breeze except for a manufacturing defect of the aluminium frame where one was bent and could not be used. These two printers were plugged in and a file was downloaded from Thingiverse to be printed. Two issues were found from this, the first issue was the z drive motors were not properly aligned with either side of the z axis rods, the second issue was the z axis rods did not come with lubricant so running the printer with these two issues we didn't know about nearly damaged the threads of the z axis rods. The installer from the video we watched did not encounter these issues so did not warn us of this. However, this taught us to be vigilant and not to rush any installation. These issues were all written with the step by step procedure and given to the fourth student to install a third printer one month later. She successfully installed the printer perfectly by herself and much faster than us and had no issues which meant the procedure created worked as intended.

Although they had no procedures in place for the construction of a FDM printer, they had procedures for construction and operating other printers which are much more expensive, but it gave us an opportunity to create one and learn through the process and mistakes so future students don't make the same mistakes.

### 5.3 Learning Outcome 3

**"Undertake work that provides an opportunity to assess aspects of health and safety in the workplace and their relative strengths and weaknesses"**

Although I only worked in one environment during my time at the Additive Manufacturing Center, there were many health and safety practices in place to ensure students and customers safety. The health and safety requirements were unique for various parts of the room which housed different printers.

Before starting the applied solvent based slurry stereolithography, a quick safety induction was done before I could enter the room which housed the SLA printer. For the applied solvent based slurry stereolithography, it required a few materials to be mixed together in a bottle. These materials were alumina powder, resin, alcohol, zirconia balls, colour and a dispersant. Because of this, an N95 mask, closed toed shoes and nitrile gloves were required to be worn when utilising the machine and mixing the materials in the bottle. The applied solvent based slurry stereolithography works by hardening the slurry ceramic mixture via UV ray through a projector mounted top down, it was advised during the operation of the machine not to open the door and look directly at the UV ray as it would not only ruin the print but also harmful for the eyes. Things that could be improved would be to close the door so people do not accidentally walk in and breathe in any of the substances, wearing a face shield and hair net so particles do not fly into the eyes or scalp.

The resin printer also required closed toed shoes as well as nitrile gloves as it deals with liquid resin which is harmful to the skin. Although no mask is required, this printer also uses UV light projected from the bottom up to 'cure' (harden) parts of the liquid resin while the build platform raises up slowly 'pulling' the 3D print out from the liquid resin.

For SLS printing and FDM printing, just closed toed shoes were the requirement as SLS printer uses plaster/sandstone which isn't harmful and FDM just used PLA which is also food safe.

Overall, the supervisors at the Additive Manufacturing Center made sure each and everyone of us were safely using the printers and following procedures to ensure a smooth operation.

## 5.4 Learning Outcome 4

**"Undertake work that allows for critical reflection on engineering management practices"**

Within the Additive Manufacturing Center we reported to Professor Jia-Chang Wang, whom established the 3DT lab and Additive Manufacturing Center. He gave us tasks to complete and set deadlines such as for FDM printing, he wanted us to find a model from Thingiverse and then use the lab 3D scanner to scan our faces to put on the model that we had downloaded from Thingiverse. He also assigned people to help us if we had problems using the software. He would come in and check on us once in the morning and once in the afternoon and ask how we're progressing. Although it wasn't corporate management but it was still engineering management in the research and development side, as long as you figure it out and get it done then that project is considered complete because at the end of the day it is about understanding how it works and its processes. So the center functioned more on informal management structures than formal ones. An example of a project I was given was to put my face on any famous person so I had to figure out how to work the software myself, although I could've asked one of the supervisors but I had a sense of achievement when I accomplished it myself



Figure 21: Original 3D model from Thingiverse



Figure 22: My face on Bruce Lee model

Although there were no formal meetings for me, I still attended the formal meetings Professor Jia-Chang Wang had with his master and phd students for their projects within the Additive Manufacturing Center. In the meetings everyone could voice their opinions and what needs changing or improving and how they could go about doing it. And then Professor would then voice his thoughts, it was informal that it was more like a discussion. In the meetings, it felt like everyone was level-headed and that no one was 'higher ranked' than anyone else. Though when it came to the presentations, Professor Jia-Chang and other professors would be quite strict because it became a formal environment. The weakness of these meetings was that they weren't recorded and couldn't be used when things go wrong. Because of this, some students opt to sleep in the lab, sometimes on the floor in order to not miss a meeting that was happening the next day.

## 5.5 Conclusion

In conclusion the 3 months I was at the Additive Manufacturing Center, National Taipei University of Technology, I was exposed to everything 3D, whether it be 3D scanning, 3D printing or Non Destructive Testing. I'd learnt so much about Industry 4.0 and how additive manufacturing can help society and the future as well as completing over 400 hours of practical work experience. During this time, I have not only met a diverse amount of people from different backgrounds but also different disciplines from which I picked their brains. This gave me insight into the professional roles and responsibilities of people working within the research and development sector. I got to see the various procedures and process of various additive manufacturing techniques as well as experiencing them, this also included a lot of health and safety protocols which were in hazardous environments in which I not only saw but also experienced the successes and failures of these procedures. I also learnt quite a lot about the management aspect and how it can contribute to success or failure. I think communication is the key to keeping the operation running smoothly. My time at the Additive Manufacturing Center has given me confidence, developed problem solving techniques as well as developed professional relationships.