Chapter 1: Human Needs

Navjot Singh Sawhney

The most important piece of advice that I would give is to fall in love with the problem, because the solution will always change. My name is Nav, it means ‘new’ in Punjabi and I am the founder of the Washing Machine Project. So the machine that we have in front of us is the Divya 1.5 manual crank handle washing machine. You put your clothes in detergent and water, and within half an hour your clothes are washed. So preventing the kind of backbreaking work you have to do when you hand wash your clothes. So this machine, it’s really specifically developed for people in humanitarian and development settings. So refugees that have lost everything and are hand washing their clothes in camps and in development settings where people really are on the poverty line. So typically, people – women, who are disproportionately affected – spend up to 20 hours a week doing this activity of hand washing clothes. When you’re using this machine, you’re saving up to 50% of time and 75% of water. So what that means is you spend less time on this activity and more time on more productive activities like school, work, spending time with family, and resting.

Yeah, when I was young, I was just very curious and wanted to know how things worked. So I’d look into the VHS video player and just see the cogs turning and just being fascinated. And I knew, you know, I wanted to fix things or create things from a very young age. I studied engineering, I joined one of the world’s best graduate programmes. But I realised about three years into my experience at this organisation, I was basically making a vacuum cleaner for a rich person and I really wanted to help people and I wanted my engineering to go further. So I decided to quit my job. I found myself in a very rural village in South India, making cookstoves and my next door neighbour, a lady called Divya, changed my life. You know, Divya’s life was an everyday struggle. And as an engineer, I felt this needs to be fixed. And it’s then that I promised her a manual washing machine.

I came back to the UK and I started what is now called the Washing Machine Project. I’m so proud that I know now that every bit of good engineering I’m doing is helping people. I really enjoy traveling around the world, speaking to people, whether it’s in camps or in poverty stricken areas, understanding their problems and then feeding that back into our design. Everyone has the right to feel the dignity of clean clothes. You know, after India I came back home to the UK and did a Master’s in Humanitarian Conflict & Development, and that’s where I really learnt about how to create things for people who really need them in development settings. I want to help society and I know as an engineer that I can do that.

Chapter 1: Human Needs

Dr Natalia Falagán

Currently we are wasting at least 40% of the food that we produce. I’m Natalia Falagán and I’m a lecturer in Food Science and Technology at Cranfield University. I’m an agricultural engineer by training. So my job has different sides that are all focused on the same objective, that is reducing the food waste that we have in our supply chain, in our systems.

This facility is unique in the world, it’s nine metres high. But the important part, apart from being able to mimic any growing condition in the world, is that we have a gantry with lots of cameras inside that allow us to monitor very, very specifically the growth of our plants within the glasshouse. The importance here is the data that we can collect and that will help us make decisions in the future.

Currently, we have a growing population that we need to feed. And even though that’s something we all know; we are wasting at least 40% of the food that we produce. From my perspective it’s not about keeping on producing more and more fruit and vegetables, food, and putting that pressure in our agricultural system, it’s about utilising the food that we already have.

We are in the plant science laboratory at Cranfield University where we do our analysis to know if the fruit or vegetable fresh produce is good enough for the consumers. This is an automatic texturometer. What it does is compress the fruit. So it tells us objectively how hard or soft our specimen is in this case. The value that we get, we will compare with the requirements of supermarkets to know if it's feasible to sell it or not.

I always wanted to do engineering. But the reason why I wanted to go for agricultural engineering is because it puts together two disciplines that are very, very important to me. One is the biology, the natural systems, natural capital, environment. And we need solutions. We need to find solutions, technological solutions, to tackle the challenges that the environment is facing.

I think the beauty and what I love most about my work is that it allows us to develop technology that make us use those resources better. So we waste less water, waste less fruit and vegetables, food in general. So it's a better use of the resources that we have.

Chapter 2: Climate and Environment

Pierre Paslier

Alright, cheers. No waste. Notpla is a sustainable packaging startup. We develop alternatives to single-use plastic, using seaweed and plants that are natural, biodegradable, and in some cases even edible.

I'm a mechanical engineer by background. But today, as the company is growing, I'm really involved in many aspects of the company. I think I've always been really good at math and physics in the kind of primary education. So it was always kind of projected that I was going to go into science, without even thinking too much about it.

We produce about 300 million tonnes of plastic every year. So that's really where we focus our attention on these things that you're going to use in less than five minutes and that are going to leave like traces for a millennia if it's made of plastic. So we need to use natural materials. And luckily for us, seaweed has a lot of those solutions. When you grind and dry the seaweed you end up with fibrous material and then we can turn it into the building blocks that we were talking about for making packaging. Pour some of that solution over here. And then I'll spread it thin, spray it so that it turns solid. And we've created a film that can be used for different types of packaging applications.

So we have hundreds of different combinations all suitable for a particular application. Here we have our first product, we call it Ooho. It's an edible packaging. In this like little bubble can contain different types of liquids. We use it for marathons and races, and we also use it for fun, like festivals and parties. And if you eat this, it will actually be a source of dietary fibre. With the pasta thrown directly into the boiling water in the pot, it dissolves and the packaging is gone. One of our latest developments is this olive oil pipette. When you eat the salad on the go, you can literally eat the packaging if you want. You don't really have to eat it, it's more to prove that if I can eat it, nature can eat it. For example, for ketchup, we can fill the Oohos with the condiments, and then you can just kind of like cut the corner up and squish it and then throw it away just like any food waste. If you have a home compost, you can put it in your home compost.

One thing that is very exciting for people who are considering joining engineering education and eventually making a career in sustainability and engineering is that we are not short of problems that need solving and working with purpose on something that really is trying to make a change. The more people we bring, the more diversity there is. So I'm really excited about an army of new people who want to solve problems.

Chapter 3: Powering Our Future

Katriya Sabin

Our fusion machine is the hottest thing in the solar system. My name is Katriya Sabin. I'm a development engineer and I work at the UK Atomic Energy Authority. Engineering, it's always been something that's been interesting because when I lived in Thailand, the only English speaking TV show was the Discovery Channel. So we just watched so many documentaries on everything. I was just super into particle physics. I just found it like magic. And as a kid, I was always very curious, I just wanted to know more. No answer was ever enough. So I started looking around and thought there are a lot of apprenticeships out there and I saw one for UKAEA and I thought, wow, okay, I never knew you could do an apprenticeship adjacent to fusion.

We are currently in the control room for the Joint European Torus. That is the largest fusion experiment in the world. There are particle accelerators that push hydrogen straight into the plasma so that the energy is transferred, so its motion is transferred to create fusion, and you can see it in the plasma itself. We recently just broke a fusion power record of 59 megajoules.

Fusion is the process where two atoms come together and create one larger atom. That's pretty much it. But when it does that, it releases all of this retained energy and light. JET is a doughnut, a magnetic doughnut is the simplest term I can give it. It has magnets around it. These magnets squish the plasma together so that we can get fusion to happen. So when JET is running, the plasma inside can reach around ten times hotter than the Sun and afterwards, things can be a little bit radioactive, so we don't want people just going in there and changing the tiles inside themselves. That's where we get MASCOT to come in and change it remotely.

What excites me most about JET is the potential that it unlocks. When we get fusion on the grid, it will solve so many problems for humanity, we will no longer need to fight for fuel. We can have a much greener planet, and this is what all of these scientists and engineers are ultimately working toward. We're doing things that are expanding the breadth of experimental physics as well. Not only is it good, it's also really interesting. Engineering's important because it creates those physical changes. It creates those changes that make us comfortable in the future. It also feeds our visions. We want to expand into space, say, or we want energy that is clean and abundant. Engineering is going to be the force that takes that from concept to reality.

Chapter 3: Powering Our Future

Manjot Chana

It's not just engineers who are problem solvers. Being a problem solver makes you an engineer. My name is Manjot Chana. I'm Head of Systems and Integration here at H2GO Power.

If I'm honest, I didn't really know what engineering was when I started my journey as an engineer. My closest encounter with engineering was in design technology, DT, at school, but when I ended up in my apprenticeship at Jaguar Land Rover, I knew that this was the perfect route for me. There was no question whatsoever.

So this is the engineering office. When I'm designing a board that looks something like this. It starts off as a 2D design, what we call a schematic. And if you put the 3D board next to my 2D design, you can see that it's the exact same thing. One's just one I can hold in my hand and the other is something that exists on the screen.

So after working at Jaguar Land Rover for eight years, I wanted something different. I wanted my work to make an impact and that's why I applied at H2GO Power. So these electrolysers take water, H2O, and they split it into hydrogen and oxygen, and we use these electrolysers to generate that hydrogen and store it in our reactors. So at the moment when renewable energy is generated, if it's not used instantaneously, often we literally just waste it. And it's because we have no way to store it effectively. With our technology, when the renewable energy is available, we can use that energy to generate hydrogen and store it. The energy's locked into our technology and it will last for years. So this in front of me is our hydrogen storage reactor. And in this, we can store up to 18,000 litres of hydrogen. Now, a bottle of Coke is two litres. That's 9,000 bottles of Coke in this.

In the future, what I want to see more in engineering is more diversity. And I think we're getting there. So what I often think people don't think enough about is having people from different socioeconomic backgrounds in the business and in positions of leadership. I would love to see that. Meeting different engineers, you can often see the world from a different perspective. Literally the lens that that exists in their mind. You know, someone might think something's really cool because of the way it looks, but someone might think it's really cool because of the way it works. So I love meeting new engineers because you get different views of the world through their eyes, you know?

So I love challenges. I've always loved challenges and I think that's why I'm so passionate about engineering. My dad was a disabled person and he couldn't climb the stairs and I used to dream about making this lift for him. And now I have the skills to be able to make that lift. We're all problem solvers, you know. That makes you an engineer.

Chapter 4: Infrastructure and Construction

Professor Anastasios Sextos

With the technology that we develop, we can find some low cost, simple solutions that can protect lives and reduce loss and pain that an earthquake causes. I'm Tasos Sextos and I'm a professor of earthquake engineering at the University of Bristol. I experienced a large earthquake in 1978. I was five years old, and then we lived in a tent for about two months or so with my family. About 50 people were killed in the city. It was quite a strong experience and I think this makes you think that probably there are ways that you can help the society reduce this toll. And somebody told me, well, if you want to have many ways to be dealing with the community, you can become an engineer.

We are at the National Facility for Soil-Foundation-Structure-Interaction, and this is the six-by-four, 50 tonnes, 2G shaking table. There are many cool things that we can test in this shaking table. Conventional structures and infrastructures, building bridges, schools and hospitals, offshore wind turbines or components of that. But we can also test things that we don't know that exist at large, right now. New materials, nanomaterials, buildings with some smart fuses and some smart mechanism to absorb energy. Now we can move to the control room and turn the whole thing on and do some proper shaking.

This platform has a weight of 30 tonnes, and it can move buildings and bridges, or specimens up to another 50 tonnes, with forces and accelerations up to 2G. So twice as high our weight. There is a hydraulic system below this table so that through the pressure of the oil, the actuators get the power to move the table and through the movement of the table, we are moving the buildings and the bridges and whatever we're testing on the table.

This laboratory has three different elements; two shaking tables and a soil pit. Part of the structure you test it on the pit, the other one on the table, and everything in between you model with computers. So this is called hybrid experimentation, it's very demanding, very novel and can help test at very large scales, very complicated structures. This particular equipment that we've got helps us test things at large scale. The larger you test, the lower the uncertainty, the lower the uncertainty, the safer and cheaper all the design of infrastructure worldwide.

The most rewarding thing in earthquake engineering is that you can use your mathematics, computer models, every tech you know, and then at the end of the day, affect the life of a single person by keeping this person safe.

Chapter 4: Infrastructure and Construction

Georgia Lilley

The more I've learned about buildings by doing the job, the more I've started to see the beauty in things that I never understood before. It really has changed my outlook. Hi, my name is Georgia Lilley. I'm a design engineer apprentice at Waterman Group. I stumbled across engineering more than strove to become an engineer. So I left school at 18, after having done three A-levels, biology, chemistry and physics. I knew I really enjoyed physics, but I didn't know what I wanted to do exactly. So I decided to do an apprenticeship in civil engineering. When I saw the opportunity here at Waterman, I thought, what a great chance to try a career. And since they sponsor me through my course, I don't pay my university fees. They do. And I'm also getting paid a wage.

I think what's surprising about a role in engineering is you don't have to be brainbox of Britain to excel at it. You know, I think I'm probably fairly intelligent, but I've never thought of myself as, you know, one of them high-fliers at school, who are really academic and I think that's a stigma that's usually around engineering and maths based subjects. Go through school and go through life following the path which you're enjoying. Then, you know, whatever career you end up in, it will be one that suits you, one that you enjoy. So I wouldn't tell myself to do anything any differently.

What I love most about my work is that every day it's different. You know, I can go on site, which I really enjoy, but I do, probably, prefer working predominantly in the office. What's also fantastic about structural engineering in particular is you get to see the projects you design in the flesh and you get to, you know, it's kind of like an immortal aspect of it that will live on way past you do. So, you know, you walk down the street and you can say to people, you know, I designed that and it's really gratifying.

Engineering is extremely important, especially considering the kind of climate crisis that we find ourselves in currently. What excites me the most is the opportunities to, you know, really produce sustainable buildings that are energy efficient but also impressive. We've got a real responsibility and a real position of power here where we could turn things around.

Chapter 5: Healthcare

Dr Uğur Tanrıverdi

As an engineer, my goal is to leave a legacy behind, to look back and say: I did this. My name is Uğur, which means good luck in Turkish. I am a bioengineering scientist and co-founder and CEO of unhindr. Ever since I was a kid, I was interested in engineering and machines. When I went to the high school, I realised that I'm interested in the human body. Then I discovered biomedical engineering, which is machining the human body. It was a bridge.

Our bodies change shape throughout the day, most of us don't notice these changes because we have flexible clothes. But when you lose a limb, they give you something to wear that is made of hard plastic. And hard plastics don't change shape. Three out of four amputees are unhappy with their prosthetic fitting. So we thought, what if we have a technology that changes its shape when the leg changes shape.

So we are now in our research office at Imperial College, where I do my PhD. This is also where we work for unhindr. So this is a standard prosthetic liner. So now I put the liner on the 3D printed leg. The biggest problem is here, the human changes shape throughout the day, so when there is that change, this liner doesn't function as it's supposed to be functioning and it starts feeling uncomfortable to walk and that's why amputees lose mobility when they have fitting problems. And because of all these problems, we developed Roliner.

So it looks like a normal liner, it's black, but its difference is it comes with this control box where they can actually control the comfort settings of the liner. It has these channels inside and these channels are filled with pressurised gas and this gas is controlled by this control box, and the control box is controlled by the app. So as I press these buttons, the control box is changing the direction of the gas and the pressure of the gas as I want. Then this inflation–deflation results in the liner changing its shape, and that's what makes Roliner adaptive. But the best bit is that Roliner's AI understands these changes and learns them, so the AI will know how exactly how they want it and where they want it and start adapting to those changes to do them automatically. These changes normally require clinical appointments, hospital visits. So AI will replace those clinical visits and will reduce the clinical dependency, and amputees will be more unhindered.

The rewarding aspect is the moment you see that it actually works and it makes a difference. So three weeks ago we had a trial with a patient in Charing Cross Hospital and it was such an emotional moment for me and for the team and for the amputee as well. Seeing that, we all looked at each other and even now thinking about it, I'm getting emotional. We all looked at each other and we said 'we did this'. That's the reward.

Chapter 6: Advanced Materials

Dr Clara Barker

We're playing snooker with atoms. I mean, that's what we're doing. And behind me, we have a big, massive laser. I am Dr Clara Barker and I am a thin film material scientist and engineer. I work at Oxford University and I manage the Centre for Applied Superconductivity. So this is a superconducting demonstrator and superconductors when they go below a certain temperature, they trap magnetic fields and have zero electrical resistance. So when I cool this down, and put it on top, it'll just levitate on top of the magnetic track and move around. There are magnetic levitation trains, Maglev trains, where they actually use similar sort of technology to this. The trains float or lock above the train track and so travel above the train track. This is being done on a scale that you can move people, which is pretty cool. Knowing that we're always on the edge of a breakthrough, we're always on the edge of fixing something or coming up with something new and just the idea that we might make that breakthrough is just super, super exciting.

So I always had sort of the idea of going into engineering or science, but it took me a while to put the dots together. I was always trying to fit a particular mould, trying to fit the stereotype that we saw, and that meant hiding a lot of who I was. You have this preconception of who a scientist is and it turns out that, you know, I've been in science a long time and there is a broad range of people that are scientists. I'd say that science isn't made up of the sort of people that you think it's made up of.

So my career was a very odd one. I'll be honest, I grew up on a council estate in North Manchester, so no one went to university where I went to school. I was good at school and my mum saw that. But I did have a lot of issues growing up in the eighties and nineties, we didn't know about being LGBT and things like that. We didn't talk about it so I had a lot of trouble with my mental health, so I actually dropped out of school before I completed my A-levels and spent a few years doing different jobs. In my spare time I was doing things like building computers or fixing equipment. And so someone said, 'well, why don't you do an engineering degree?' And it's like, 'oh, yeah, that makes sense'. And so since then, I've continued to be in science. Engineering and science are improving. We've still got a long way to go when it comes to people with disabilities or BAME people or LGBTQ people. And the big thing with engineering is ingenuity. We want new ideas. If we're just doing the same thing over and over again, things aren't going to be changing that much. So we want fresh ideas. But we are improving. At least they are seeing different people these days and so more people can aspire to be an engineer.

Chapter 7: Communication

Jahangir Shah

Without engineers, there would be no TV, there would be no radio. You wouldn't be watching Netflix sitting at home. My name is Jahangir Shah and I'm a projects engineer at Sky. So if you're sitting at home and watching a TV show, the first thing you see on your screens is this studio probably where the talent sits. Then behind the scenes, you've got your camera operators and your sound operators. And from here, the signal flows all the way back into the control room, where you've got your technical staff. That's kind of where everything's combined into one place, and then it's transmitted all the way across to your homes. Right now, we're in a production control room at Sky. Essentially, it's the brains and the command centre for whatever TV show you may be watching.

This is one which is used for football specifically, and behind me you'll see a screen full of loads of videos. Usually there'll be a load of cameras coming in from the football pitch and sitting over there would be a vision mixer, director, there'll be various people in here and then back there there'll be engineering, kind of in charge of all the incoming feeds and outgoing feeds.

As a project engineer, everything that you see here would have been built by us. So we would be the brains, like in terms of technically designing all of this, how it all links together. And essentially we draw it on paper and we do it in reality and this is kind of what it looks like. During a live show, the atmosphere in here is pretty thrilling. It gets adrenaline running through everyone's veins at that point and it's going to millions of people's homes around the world, so you make one mistake everyone's going to notice.

As a kid, I think I was, well, I've been described as someone who used to like to break up equipment, take it all apart, be really fascinated in terms of like how things work. I did some work experience in the broadcast industry, where I found the real great thrill and vibe of working in live production. And from that point onwards, I started looking into engineering and I came across broadcast engineering.

I have to say that doing an apprenticeship was one of the best decisions I made in my life. You would learn stuff, but then being able to apply it straight away in the real world and being treated like an engineer was something which I thought was probably the best way of learning. I think anyone can become an engineer. I don't think you have to be a specific type of person, everyone has their own traits, everyone's good at something. But you just have to find kind of how you can apply that to an engineering role. I myself used to be a very shy person, and the fact that I'm standing here right now in front of a camera and speaking, it just goes to show that this is just a learning experience and you've just got to give yourself that little bit of a push and kind of get out of your seat and say, 'You know what, I want to do this today.' And just go for it because you're not going to lose out on anything. And if anything, you don't know where you'll be in the next ten years. So my advice is don't hold back and do whatever you want to do.

Chapter 8: Smart Manufacturing

Neil Glover

Well, you might not think it, but having a coffee shop and running a roastery, I use engineering every single day. I'm Neil Glover and I'm the owner and coffee roaster at Figment Coffee. I had my own business in the oil and gas sector. Instead of having an office, I would work out of coffee shops. And I went to this one coffee shop in Houston and I had this drink that tasted like no other coffee I'd ever tasted. I said, it's a latte that changed my life. And I just started to fall in love with the specialty coffee industry. As a child, I would always play with LEGO, built treehouses, was a huge fan of American comic books, and the part I loved the most was their gadgets.

So I used to like design my own suits and try to come up with my own gadgets. I didn't know that was engineering at the time, that was just cool stuff that I liked. And then as I had to sort of go work through school and choose a career, I started to realise that those things were all tied in. I was training for six or seven years as a coffee roaster and I was visiting coffee shops all over the world. I was starting to learn what I loved about them, what I didn't like about them and this space is like my ultimate coffee shop. It's like when I was designing those suits of Iron Man armour as a kid, I took all the best bits and put them into one sort of design and that's really what I've tried to do here. Every coffee is different, so we have to spend a lot of time trying to dial in the roast profile. I love that part of it.

So we are here in the Figment Coffee Roastery. These are the green beans that we bring in from all over the world and this is the starting point for our roasted coffee. What you might not know is that these are actually the seeds of a cherry and it's really important to us then to roast it in a way that we bring out those fruit flavours in the coffees.

This is our coffee roaster. As you can see, a beautiful piece of mechanical engineering. We take the green coffee, we put it in here, it drops into here through this lever, into this barrel and then it slowly roasts there controlled by the laptop we've got connected up to it, which is connected into temperature probes. And then at the end of that profile, we drop it out into this cooling bin and then we turn a fan on that instantly cools it so that it stops cooking. And that turns it from the green coffee to the roasted coffee over a period of about 30 minutes.

The thing that surprised me most about career in engineering is just the sheer variety of things that I've been exposed to. I hope that I'm an example of where engineering can lead, that it just provides a great background for many, many different careers. Engineering is in everything; everything we do from the design of clothes to the creation of coffee to building bridges and buildings and it's the fundamentals of our society. I would definitely encourage kids to go into it as a career.

Chapter 9: Transport

Krystina Pearson-Rampeearee

Engineers make ideas a reality and solve problems. And there are a lot of problems in the world that need solving. My name is Krystina Pearson-Rampeearee and I'm a Senior Flight Systems Engineer at BAE Systems.

So this behind me is a mock-up of Tempest, which is our next generation fast jet programme. This is going to be a replacement for our Typhoon aircraft. I work on parts that will help this fly safely through its missions and enable it to do what it needs to do. I think it's going to be pretty amazing when we actually get to see it go into service. Having worked on it so well for so long, like years ago, from almost the beginning of it, to seeing it as a real flying jet. It's going to be, I can't even describe what that feeling is probably going to be like.

So the coolest part for me at the moment is probably the cockpit and the helmet. It's really cool to see different ways of showing the pilot, different things on their visors and looking at all the new technologies that they use to make the cockpit more advanced. It's something out of a game or something, really, and something that I didn't think I'd see on an aircraft. Yeah, that's probably the coolest thing for me.

In terms of timescales, if you think about it, I'm working on this now alongside my team, but it actually won't enter service until around 2035. So it's still got its whole life ahead of it, which is where the next generation come in. We have a skills shortage and we need more engineers so my hope is that we can inspire kind of the next generation to get on board and yeah, find a passion for engineering like I have. Being in a team, collaboration is really important. It's not just the team that I work with, its engineers and other departments, aerodynamic engineers, structural engineers, all sorts of different people that I have to work with. And it's really great to be able to work with different people as well. so collaboration is really important, especially in engineering.

I always enjoyed the mechanical side of physics and the logical side of maths and I think it was the solving problems that attracted me to engineering. And then also kind of the fast jet side of it was really cool. There are so many different types of people doing engineering and we need different minds and different ways of thinking to come up with better solutions to problems. So something I would have told myself when I was younger is, don't be afraid to put myself out there. I found that actually putting myself out there isn't too bad once you've done it and once you do it a little bit, you start doing it more and more and more. I tell myself, what's the worst thing that can happen is that, you know, I get told no or I find out that there's something that I don't enjoy doing, but until I try something I don't know. So I tell myself to not be afraid to put myself out there.

And at the moment, the future looks really exciting. For an example, the Tempest programme, we're looking at lots of different technologies for the future. There are new developments happening, we're looking at more kinds of sustainability and new technologies that can be used. There's a lot of things going on and it's really exciting to be part of the industry.

Chapter 10: Entertainment

Pavlina Akritas

Lighting is really important because it shapes the way we experience spaces. My name is Pavlina Akritas and I'm an associate lighting designer at Arup. The thing that fascinated me about lighting is how visual it is. You really can create very different lighting effects, or you can completely change the space by just by manipulating the lighting. So today we're in the light lab in the ARUP lighting lab. Here we come to test different lighting. We test them in terms of colour, changing their beam, what effect they have against different surfaces. So it's something that we use quite commonly in our everyday work. So I graduated from the University of Illinois with a Bachelor's in Electrical Engineering. And the moment came to what to do next.

So I decided to do something that could combine both science and art. And I did my Master's at UCL in Light and Lighting, and I ended up finding a job at ARUP as a graduate lighting designer.

Colour lights are quite interesting to be used in exterior applications. Because you know, you can have a normal setup, which is the white light, but then you can have some fun.

I worked on many amazing projects such as the London Aquatic Centre. I worked on quite a lot of museums, for example, the Science Museum, the British Museum Islamic Galleries, the V&A photography galleries. I actually worked on fashion shows as well. So I've done a few fashion shows for Celine, for Paris Fashion Week. So it really ranges. Airports, offices, many different kinds.

I went into engineering not really expecting something. I was sort of guided by my family. What surprised me is how much I love what I do, and it's always a different effect depending on how you light it. So if you lighted it from the front, okay, it could be nice, but you know, it looks a bit more interesting lighting it from the back. One of the nice things about lighting is that creativity and the technical aspects come hand in hand. So you need to be creative to create a scheme, but at the same time, it needs to work technically. It's the quality of the light that sort of improves your health and the way you feel. For me, it's very important to use light in a positive way because that's our job ultimately, it's to make, it's creating buildings that people feel good in and happy to come to.

Chapter 11: Robotics and Artificial Intelligence

Joshua Schofield

So this is no NoProbLemo, a heavyweight combat robot. I'm Joshua Schofield. I'm a student and a research engineer. It's been a bit of a journey to get myself where I am today. I did a four year engineering apprenticeship and then I carried on working for a little bit, and then I decided to go to university and study towards a Master's in Aeronautics and Space Engineering.

The four year apprenticeship was far beyond my expectations. I enjoyed myself so much. I learned so many transferable skills. During the COVID-19 pandemic, during 2020, myself and a group of other engineers here at NPL, we got together and we developed a working prototype for an emergency low-cost ventilator. So this is the ventilator itself, and this is a test lung. So I'll be starting my Master's later this year. So I'm really looking forward to hopefully be able to collaborate with NPL, apply what I'm learning during my course into some real life projects. I really enjoy the creative side and the engineering side. The lines can blur very often as well.

Myself and another group of engineers, apprentices, were tasked with trying to design, build and test a robot capable of winning BBC's *Robot Wars*. What we have is this 30 kilogram hardened steel spinner which spins away from the robot and that's driven by a belt, which is connected to a motor in here. And then we have these two wheels to give us differential control like a tank, so it can turn on its own circle, some batteries and some electronics, which connects to a remote control to allow control of the robot for about 20 metres. So once we designed and built the combat robot, we eventually had to get around to testing it. And for our first test, we found some unlucky pieces of fruit from the local supermarket. And those were just juiced. They were basically vaporised immediately. It was ridiculously fun.

The majority of the combat robot was manufactured here in-house. We worked really closely with some of the experienced engineers and technicians down here to figure out what materials, what machines were best to use to manufacture a lot of the parts. For a number of the simple parts, we manufactured ourselves. I really, really enjoy working in the engineering workshop. It really tests your practical skills and your application of theory. It's a brilliant way to apply engineering. I am quite a practical person, very hands-on, and that definitely feeds into the reason why I did an apprenticeship. So being involved in a project like this, having the support that we did, was phenomenal because I really got the opportunity to express myself, use my practical skills, apply what we were learning, and some of those skills will stay with me for a very long time.

Chapter 12: Exploring Beyond Our Planet

Professor Michele Dougherty

My first view of Jupiter and Saturn was through my Dad's telescope. And now here I am, out there myself in a sense, so it's cool, it's really cool. My name is Michele Dougherty. I'm head of the physics department at Imperial College, and I'm a planetary scientist. So planetary scientists sounds really cool and I think it is actually. My team build instruments that fly on spacecraft and those instruments measure the magnetic field. So we've gone to Saturn and we're going to Jupiter and we use the magnetic field measurements to understand what's going on around the planet, but also what's going on inside the planet as well. The critical aspect is how we're going to build the instrument to take that data? And that's where the engineers come in.

They can't wait to do it, that's what they trained to do. They want to be able to do things that people have told them they can't do. We have just delivered the flight instrument for the Jupiter spacecraft. Our main focus is Ganymede, the largest moon in the solar system. We're going to go into orbit around Ganymede and what we're planning to do is, we're planning to measure electrical currents that are flowing in the ocean and that will tell us how deep the ocean is and what its salt content is. And that's what I lose sleep over.

So what we have here are two models, one of the Cassini spacecraft, and then this is a LEGO model of the JUICE spacecraft. So on Cassini, we had an 11 metre boom with one of the instruments halfway down the boom and one at the end. And then JUICE, our instrument is son this long boom here, and that's 10.6 metres in length. If we don't have a long boom, we just can't do the science that we want to do. So all of the stuff that you can see in front of me is the flight spare of our instrument that is on the spacecraft to go to Jupiter. So we always build a flight spare. And so this here is the electronics box and that's what essentially tells the instrument what to do. Two of our instruments are in these canisters here, and these will be put on the boom of the spacecraft. And so we're just making sure that everything works together and we will then keep it ready just in case it's needed.

If I was talking to someone who was thinking about doing spacecraft engineering, for example, I would say make sure at school you keep on doing maths and physics, so that you have the basic grounding that you need in case you decide you want to go on into engineering. When I get asked how I feel about building something that then goes on to Jupiter, or went on to Saturn, I'm in awe that I can be involved in something like this. The best way to describe it is there is a fantastic image of Saturn, which was taken by the camera onboard Cassini. And you can see the moon that we made a discovery on orbiting in one of the rings and you can see the Earth. And I'm thinking, and even talking about it now, the hair on my arm stands up on end you know, you build an instrument, orbit around a planet for 13 years, and while it's orbiting, it's taking pictures of that planet, but it also sees the Earth as well. So it's great, I wouldn't want to do anything else.

I also look at the young kids in the audience when I give outreach talks and I say to them, it's going to take us eight years to get to Jupiter. You're going to be the people who are going to be working the data, not me, I'll be watching you work it.