Sue Nelson
Hello, I'm Sue Nelson and this is Create the Future, a series of podcast brought to you by the Queen Elizabeth Prize for Engineering. Now, engineering is often described as problem solving. And in doing so they have to make things. My two guests today know all about what it takes to not only create and engineer something potentially useful as a product, but also how to take that product through to manufacturing. They are Anna Ploszajski, a material scientist and research fellow at the Institute of Making it University College London. And Tim Minshall, Professor of Innovation, and Head of the Institute for Manufacturing at the University of Cambridge. First of all, Tim, your full title is The Dr John C Taylor Professor of Innovation. And there's a connection here with the Royal Academy of Engineering where we're actually recording the podcast at the moment isn't there?

Tim Minshall
That's right. So, for those who don't know, Dr John C Taylor, he is this wonderful guy who's had a huge impact in a way that not many people have seen. And that is, he's the guy who invented the electric kettle switch, the thing that switches it off when it boils. Sounds like a very simple thing to do. But he developed a little bimetallic blade in a certain way and bent in a certain way. And it's absolutely fantastic. Because it makes sure that every kettle switches off at the right temperature, there's a second one to do a failsafe issue if you didn't fill it with water. Absolutely brilliant. Every day. I love this figure; 1 billion people use his technology. Absolutely fantastic. Not only did he design the actual component that switches off, he rather fantastically also built the machine with his team that makes these devices. So, he's done the two things of inventing, protecting and then also protecting the process of making it as well.

Sue Nelson
That is the motherlode isn't it, for an engineer? Also, doesn't he have a connection to your, he's endowed your position effectively. And I know you've got something in your room related to it?

Tim Minshall
Indeed. So, through a series of accidents I ended up actually getting this role, which is fantastic. And it was the first endowed professor of innovation at the University of Cambridge. So there will always be now for evermore a professor of innovation at Cambridge, which is great. And we're very grateful for Dr John C Taylor for that. And it's not contractual. But I do carry with me at every time I'm out, one of his kettles switches, which is pointless to do on a podcast like this, but I can just show it to Anna. And you can see that's what it is. And that's a little bimetallic bit there. So again, I can just describe it, it's very, in some ways, very simple, but the execution of it is beautiful. And it has to be flawless. It has to work every single time.

Sue Nelson
And that looks just looks like a bit of a black plug with the back open, a little circular, two pieces of metal round look like bits of jewellery, or earrings in design, because they're actually quite beautiful.

Tim Minshall
They really are. And it's both the functionality of it and the material itself and the way it's been produced. So precisely. It has to work every single time.

Sue Nelson
Anna, I suspect you must look at things very differently to how I might look at things. For instance, as a materials scientist, were you someone who made things? Or are you someone who tore things apart?

Anna Ploszajski

Absolutely, yeah, I could always be found tearing apart my toys and my fancy dress costumes and all the rest of it trying to work out what things were made out of.

Sue Nelson
And what would you describe in a material science? Sometimes you think of chemistry, not always about engineering, or the very title material science makes you think, well, it's science, but not engineering. So how would you describe material science,

Anna Ploszajski
I usually describe it as the middle of the Venn diagram between chemistry, engineering, and physics. And actually, sometimes material scientists have a bit of a sort of personal sort of conundrum about whether they identify as a scientist or an engineer, because we really do sit between both camps. Because the science of materials is really trying to understand how atoms behave at the very tiniest of levels. And the study of materials is all about looking at what those atoms are up to, and seeing how they interact. And then understanding how those atoms interacting in certain ways will result in different materials properties like hardness, or stiffness, or softness or flexibility, all these things that we delight in the world around us and in the materials around us. And so the material scientist looks at those atoms, understands what they're doing, and can then engineer new materials to do new and exciting things. And what sort of materials do you work with? At the moment, I'm working with smart materials, which are materials that have a property, so it could be their shape, or maybe their colour, and that changes in response to external stimuli like heat or light or moisture, or pressure or pH levels. And so actually this little device that you've brought here is an example of a smart material because those metallic components change shape in response to the stimulus of heat. In one way, how do they change, they just get bigger? Yeah, so the bimetallic strip, it's really an engineered smart material as opposed to being like a pure smart material. But the bimetallic strip works, because the two metals on either side of the strip have a slightly different coefficient of expansion when they get hot. And so as the material gets hotter, one expands more than the other. But because they're bonded together, it causes the material to fold and bend.

Sue Nelson
Cool, cool. Now, you also work with plastics and fabrics, I mean, give me an example of a fabric smart material that you're working with.

Anna Ploszajski
So I've been really interested in fabrics with the application of sort of smart clothing and wearable, smart materials. I've been working on a 3D printable fabric. And so I'm combining smart materials with 3D printing in this new technology, which has become known as 4D printing, the fourth dimension being time sort of materials that move. And so I've been 3D printing with a really standard polymer called PLA, which is one of the most common materials with 3D printing. And I've been combining that with fabrics in order to try and make them fold up and bend in different ways in response to this heat.

Sue Nelson
Well, before we go on, I want to just play you this extra, this is what Lord Browne, who is the chairman of the Queen Elizabeth Prize for Engineering Foundation, said when he was asked about the importance of 3D printing.

Lord Browne [Audio Clip]
“It's a very important advancement. So you can make things, customize things for individuals based on scans, for example, parts of limbs can be eventually manufactured by 3D printing, you can manufacture things that

you couldn't otherwise do by hand. So very complicated pieces, for airplanes, and so forth. And 3D printing does allow you to make things on site that you would otherwise have to make somewhere else. So it brings home some parts of manufacturing".

Sue Nelson
Tim, how important the role does 3D printing play at the Institute of Manufacturing?

Tim Minshall
It's very important, important, it is one of the interesting emerging manufacturing processes. But I think what we've learned is there was a huge amount of hype over it. About five years ago, there was this wonderful Gartner hype cycle, which tries to map technologies as they emerge, and it has this wonderful five stages. If I get remedies correctly, there's the trigger where something is invented or discovered, and people go, "Oh, that's interesting". Then it shoots up into the peak of inflated expectations, and it plunges down into the trough of disillusionment, and then you end up heading up to the, what's called the 'plateau of productivity'. And it's a bit contrived. But the basic point is, people get very excited by new technologies, and the potential of them, and there is huge potential around 3D printing, but it's not going to be in the way that it was portrayed back in those days where it was, the whole Star Trek replicator thing that we wouldn't need factories anymore, because everything would be made in our house.

Sue Nelson
The eternal disappointment quite frankly.

Tim Minshall
For all of us. I think, however, what is interesting that it is delivering value in interesting ways. And it's maturing, and there are multiple technologies. It's not just a single technology, it has multiple application areas, just three quick examples would be it's, I guess, in its original form, it's for prototyping, it was a prototyping and speeding up technology, make a model of the thing you're going to make. There's also applications in tooling to improve an existing process you have, and then finally, to actually produce the object that's going to be used, I guess that's where your organic if you're producing thing that someone's going to use, right. And that's very interesting. But it's, it's not, it's quite specific what you can and can't do with it. And so I know a lot of people working in 3D printing in the the companies that provide them as services, they get quite set up with people ringing up going, I'd like to make this thing in 3D. And they go, "No, what do you want to do, and we can help you choose the right material in the right process". So it's got a bit overhyped. That said, it's a really important technology. And we see it particularly in those two areas of it's, it's a way of producing units of one customized so you have the progress towards mass personalization and mass customization. The word mass is a bit optimistic for this at the moment. And then secondly, this issue of you can change where you manufacture, you can you can shorten the distance between production and consumption, which has lots and lots of benefits.

Sue Nelson
Lord Browne mentioned, you know, the printing of limbs and prosthetics is a really useful part of it. But there's also part within biology of 3D printing meshes so that you could grow human cells on it. So I assume there's a an example of the technology that does have enormous potential where you're actually using a biological material rather than something that we would consider. I don't know what the word would be for it's something that's not a biological, non biological material, I suppose.

Tim Minshall

Absolutely. And Anna, you're much better position to comment on this. But my quick take on it would be there's a whole range of materials and the whole range of processes and the whole range of applications. And it's matching those together, isn't it? And that's what we're really about.

Anna Ploszajski
Yeah, definitely, I would add the personalization of 3D printing is really what is key, because the power of 3D printing comes from our ability to mockup the 3D image in a computer model first, and then send that to the 3D printer. And so, this, the computer power of this is phenomenal. In fact, this afternoon, I was talking to a professor of pharmacology, who was talking to me about the future of drug delivery, really. And his vision for the future was that you would be able to have your doctor send the instructions to the pharmacy, the pharmacy would then 3D print new your personalized medicine, that medicine would have a tailored drug delivery profile, which means the drug would be released in your system in your own personal way that was most beneficial to you. It could contain multiple different drugs, if you're someone that takes multiple different drugs in a day. And it's all completely personalized.

Tim Minshall
Maybe if I can just pick up on that point about pharmacology, in pharmacies and where it's going, if I made this really interesting thing around that, which is absolutely this fantastic idea that with personalized medicine, you can start to say that the physical manifestation of the drug is made for you. And as you say, delivering in different ways in different times and different compounds are present some absolutely terrifying sidelines as well, which is we've then got all this data floating around related to individuals and particular chemicals. And again, talking to some colleagues about this, they said, but you get that compound wrong. It sometimes it just doesn't work. But in other cases, you get it slightly wrong, it kills a patient. So some really exciting opportunities which have been taken forward. But also there's the sound quite in the background of many, many lawyers screaming at the moment going, Oh, my goodness, can we make sure that this could be delivered safely. So the dream of having as we have longer living aging population, going to hospital is never usually a good thing, unless there's a very particular reason to go there. Delivering support at home, the thought you could have, I don't know a little Nespresso, like machine and you walk downstairs and there is today's pill, you don't need to do anything else, it's there. But the thought that that might go wrong in some way is kind of terrifying. But the benefit you could get you overcame those problems are huge.

Sue Nelson
I must say, of course, other coffee machines are available. So Tim, how do you work at the Institute with material scientists like Anna?

Tim Minshall
So I think it picks up on something that Anna said earlier about the fact that what's the material scientist, what's an engineer, it's very much blurred, right. And so we absolutely operate in that space. So Institute, we've got around 350 people working across technology and management and policy. So we're looking at new manufacturing processes, we're looking at the way in which you develop the right business model for that. And we're looking at the policy context within which all this stuff happens. And what's really interesting is that the type of problems I think we're all trying to address, do lend themselves to interdisciplinarity, that no one discipline can own the solution to these problems. We still need experts in certain areas. But the real value comes from from material scientists and engineers working together. And actually having those interesting conversations, right, we we're not quite sure what the solution will be. And you'll know way more about materials than I ever will. And it's about how we have a conversation that sort of leads to a solution to particular problems. Would you think that's fair?

Anna Ploszajski
Yeah, absolutely. I think the collaborative aspect is really important. And material scientists and engineers speak similar languages, but not completely the same languages. And those problems can be exacerbated by me wanting to collaborate with pharmacologists or with designers, or with architects, all these different fields that could benefit from collaboration, we need to be able to talk the same language, which can be a real challenge.

Sue Nelson
I want to say here at this point that you know, your background is physics. And Tim, your background is engineering. So already, we've got a nice little cross disciplinary approach here. Before we even get to the material scientists. Tim gave us a sort of, you know, the sort of things that they do in terms of manufacturing and cover policy as well. Do you cover that at the Institute of Making or Is that considered something that's way down the line? You know, but that's before you get on to making products?

Anna Ploszajski
Yeah, no, definitely. So we have recently opened a new plastics hub called the plastics waste Innovation Hub, which is actually the, with them associated with the Institute of Making. And the whole purpose of that is to influence policy around plastics in response to the so called war on plastics, this this real spotlight on a certain material that we've seen in the last couple of years, so we're absolutely aiming to influence policy as well.

Tim Minshall
Critical, isn't it that without that sensible dialogue with those involved in policy, we avoid we, if we do have a sensible dialogue, we avoid some of these crazy decisions that can be made, right where someone says “Well, let that's a popular topic, we should do something about that”. Forgetting that the bigger issue is perhaps a bit duller in the background, it's going to take a lot longer to fix, but we should still do it. Right.

Anna Ploszajski
Yeah, definitely.

Sue Nelson
So Tim, what from your point of view, what makes a successful product

Tim Minshall
That is a really good and involved question, there’s multiple ways of answering that. I guess the key thing is it got to be addressing a need. And that sounds really trite. But if it's just someone saying, here's a thing, here's my mousetrap, it's better than anyone elses mousetrap, people will come to me Well, in some cases, it does happen. But it's pretty rare. It's got to be understanding that sense of here's a need that needs addressing. And then having this sort of technology market fit thing, there's a world out there of big problems that need solving their world of possible solutions, it's finding that match, when you get that match, then you get a chance for a good product or a good process or a good service. But it's pretty rare. And if you agree to get it right first time, there's lots of iterations around it and experimentation to get to the right thing. But I do want your question, perhaps one way is to say, when it's done badly, it's very much here's a clever thing. It's what you want. Versus I'm understanding really what is needed, we can develop different solutions to that.

Anna Ploszajski
I think that difference between need and want is really interesting. So with the example of plastics, a lot of consumers want alternatives, because they have an idea of how they feel about plastics, which is influenced by

popular culture, David Attenborough, etc. And actually, the need, according to experts, might be very, very different.

Sue Nelson
Well, I'm going to put some, some examples of just purely down on Twitter in terms of what the need might be, or if I said, if you could talk to a material scientist and engineer, what are the sort of things do you think we should do? And I like your opinions? It can be one word, it can be a discussion, it's up to you on each one, because we've got a few here. Some are a little bit more realistic than others. Okay, a teleporter. A little bit further into the future there. But Stephanie Hill said room temperature superconductors. I know people are working on it, but we're not there yet. I've got some nods there. She also said I could do with a Hermione Granger time turner. Claire Ainsworth, a permanent anti-microbial coating that could be sprayed on surfaces like lift buttons or underground train handrails to limit the spread of diseases. Now, that's something I would have thought for a material scientist is quite a good idea.

Anna Ploszajski
Well, anti microbial surfaces already exist in very ancient materials. Copper is a fantastic anti-microbial surface. And it's why you see door handles made of brass, which is got copper in it. And so you could easily imagine a sort of nano sized copper particles that can be applied in a spray that would be able to do that.

Sue Nelson
Okay, here's another one that goes in the realm of teleporter. But I do like it Roger Bamforth, materials strong enough to make a space elevator, controllable fusion reactors. And, a device to convert seawater to breathable oxygen in a suit, basically gills for scuba divers, so the scuba part becomes no more. Well, that already exists as well. Also, electrolyzers are electrochemical devices, which is the opposite of a hydrogen fuel cell. So a hydrogen fuel cell takes hydrogen gas and oxygen and combines it together to make water and electricity. And electrolyzer is the opposite of that. So you take water, and it splits it into hydrogen and oxygen, with the input of electricity.

Sue Nelson
staying with swimming at that at this point. Now I know last year that you swam the English Channel, correct, which is pretty impressive. Is this one, you're working on fabrics for a swimsuit?

Anna Ploszajski
Maybe I could have done with a bit of a boost.

Sue Nelson
And what is it you're doing with that that fabric for a swimsuit? What is it that you want your swimsuit to do?

Anna Ploszajski
Well, I was interested in being able to tailor the mechanical properties of the fabrics so that we can wear given different stimuli. So lots and lots of sportswear companies are actually really interested in this as well. This idea that we can wear fabrics that are adaptive to our bodies. So for example, Nike and others are producing fabrics that will react to your sweat levels or your temperature levels to become more or less insulating, depending on your body's sort of exercise levels.

Sue Nelson
Crossing the channel that would be a huge boon.

Anna Ploszajski
Yeah, definitely. However, the channel swimming rules have extremely strict so you can only have one very standard shaped and materials swimming costume you can only have one pair of goggles in one swimming house.

Sue Nelson
David Bradley, clockwork solar and lithium batteries, really don't cut it despite awards and Nobel's so basically a material that would make a better power source.

Anna Ploszajski
Well that's the jackpot.

Sue Nelson
A device that accurately predicts if a baby's birth will be straightforward so that women aren't enjoying days of labour only to end up with an emergency caesarean, followed by Weetabix repelling baby clothes. Now, that might sound trite, but actually, we do have water repellent clothing. That's the man in the white suit. Basically, the older Alex Guinness film isn't a suit. Michael J. Sanders. He wanted to know in terms of new material, transparent aluminium. A Star Trek 4 reference. It was nice to see that people engaged with material science. Tim, is there no such thing as a stupid idea, or maybe I should put it the other way. What are the most common mistakes that are made between coming up with a material, and then you being able to help people take it right through to a manufacturing process.

Tim Minshall
So I think though, those ideas there, this is the fantastic thing about innovation, you need to have the outlying ideas. So if we just said, we're going to make a little bit better, a little bit faster, that's great. And that does add value and improve things. We absolutely need ideas, such as the ones you were saying, because they do show well, why not. And it's a really useful thought process to go. Perhaps many of those we can't do now. But many of the elements that could be, would be necessary to that each one of those could in itself be valuable. Would you agree?

Anna Ploszajski
Definitely. And just the act of pursuing Some of those could throw up some other really interesting innovations. Absolutely.

Tim Minshall
So we certainly find that with the encouragement of the really creative ideas. There's a lot from science fiction, and people always saying, "Ah, yes, science fiction is fantastic. It predicted everything" and it also basically just said, everything. And then you know, a few of those ideas are going to be right. But in some cases, there's a really interesting school of thought, which does look systematically at science fiction literature to say, well, could that happen? What are the things that are just going to stop that happening? How could we overcome them? So I think this sort of pushing the boundaries is a really important part of innovation and engineering and material science.

Sue Nelson
And do engineers react well, to change, and to the fact that technology is changing so quickly, and we are, you know, immersed now in a sort of digital world, or at least that sort of transference towards it?

Tim Minshall
I would say yes, again, generalizing massively, but engineers like the new things, they like the novelty, the thing that's going to change things, I guess, where it gets particularly interesting is engineering in a commercial context, we are in an organization with shareholders that want returns on their investment, and the company's got assets, which it wants to use wisely. And if you come along with a totally new thing, there's a risk associated with that. So, we're very interested in this balance between how does an organization deal with basically paying the bills, keeping things going, while also doing a new thing? And that's our whole series of issues that go right back to the what's going on in the r&d Lab, what they pick up from exciting startup companies outside? How do they understand what's going on. So they can do something to create value for their shareholders. So economic value, but also social value addressing a particular need, such as reducing plastic or helping us to reduce co2 emissions?

Sue Nelson
Can you tell when an idea right from the beginning is going to make it to the end? Or do you see some ideas that you see them evolve, and then become sort of front runners? And as a bit like Bake Off? Something like that?

Tim Minshall
Very similar to Bake Off, so no. No, I think it's really hard. I mean, if there was an easy way to do it, you know I'd be extremely rich and doing it now. Instead of which I think there's a series of questions you can ask, which is kind of you unfold the answer, do you say well, that that leap over that massive leap you're suggesting is huge. That's going to take a long time to get there, we don't know where you can get there. But do this first and see how that goes? And go okay, well, what about that? There's a phrase used from the tech startup world at the moment, called minimal viable product. You don't go, here's my idea, I'm going to need millions of pounds to build it and then get it made. And then we'll send it in front of the customer and see if they like it. That's really, really risky. What you do is, in fact, linking it back to 3D printing is that you build you talk to customers, and you see what they might want, or might need, and then you make something and then you get just 10 of those or 50 of those from a 3D printer in the hands of customers. And they go oh, well actually, I don't know. You want it like that, it's just too difficult here, it doesn't quite fit there doesn't do that bit, then you iterate. And then you can start to say, right now we know what the customer wants. We can now scale up, get investment for that scale up and produce the product at volume. Is that something you see from the perspective of kind of the material side and the early development of the product?

Anna Ploszajski
Yeah, that sounds really familiar to me. Actually, funnily enough, going back to the swimming thing. I'm currently one of the user testers for my friend's new swimwear company. And she's asked me to test different materials of swimming costumes, which is Incidentally, my dream job.

Sue Nelson
Yeah. Do you feel far removed from what Tim does? Do you feel at the sort of one end of the not quite factory process? Or are you at the stage now where you want to work with start-up companies yourself? Because I know you, you did do that when you were doing your degree?

Anna Ploszajski

Yeah, I've had feet in both camps. So when I did my first master's degree, I was stationed in industry in a start-up company, there was about six to eight research scientists and me as a little master's student. And I really enjoyed the fast-paced aspects of the research, it felt really exciting that we were meeting deadlines on a weekly basis, and really pushing this technology forward. In contrast to academia, which is less obviously profit driven. And so you are able to be afforded a bit more of a kind of blue sky thinking, time and, and money and approach and stuff. And I think both of those are really valuable. Because often the ideas come out of academia, and will grow into in this example, a little start-up company that was spin off company, I felt that that the fast pace of industry was really exciting. And I really enjoyed that. So yeah, in the future, I'd be really interested in going down more of that route. I just need an idea first.

Sue Nelson
I was funny enough, I was just about to ask you, you know, we've heard from people what they would love to have, but what about you what, what sort of material? Would you, you must have thought, “Oh, I love a material that could do?”

Anna Ploszajski
Well, one of the things that we really struggle with, with materials for 3D printing is flexible materials and sort of stretchy things and things that you want to wear really, we're very good at hard objects, hard plastics, we can do metals. Now as well, we can do ceramics, but flexible materials are difficult, because when you 3D print, it's also called additive manufacturing. So you're building upon material that you've already placed down to build up a 3D object. Now, if that 3D object is wobbling around as you're trying to print with it, then that's a problem. So what I'd really like to develop would be a soft material that could be 3D printed, either the material or the process, we might need to change the process in order to do that. But my idea is to 3D print swimming goggles, because swimmers just find it really hard to find goggles that fit properly. And obviously, it has to be watertight, and comfortable and soft materials. So that's why I really like to do.

Sue Nelson
I swim about two or three times a week? So I can totally, totally get that. Back to the smart materials again, I remember, probably nearly 20 years ago now doing a report for News Night, which was about these new smart materials. And you know, and again, it's bit like Tomorrow's World, once you do it it’s the death knell really, for every sort of appearing, you say here's this new crazy thing. And the implication was within a few years, we'd all be wearing smart clothes. And they had got to quite a, I would say quite a you know, a position that we're starting to weave the metal that you would need or the connectivity within the fabric of the clothes. Where’s it gone?

Anna Ploszajski
I suppose with fashion, it's difficult because we live in a world that is driven, really by fast fashion. I think that economics or fashion is probably driven from price as the main sort of impetus really.

Sue Nelson
That would make sense because you would think with everybody now wanting to charge up their phones on the go, to be connected, to have Bluetooth, to have this, to have that, that smart clothing would be here. And yet it doesn't seem to be.

Anna Ploszajski
That's true. But I wonder if that's a want rather than a need.

Tim Minshall

Yeah, absolutely. I think there's something really interesting about the smart material side of things. It has enormous potential. But the compelling business case for it as it were, to say we can do this we can do this at volume there are enough people who will buy this and they'll last long enough and that they have applications that there's clear benefits, not just the features. Look this thing can do this thing. It's it can do it, and this makes your life better. So I think we're way off. I personally think we're way off that within a few agree?

Anna Ploszajski
Yeah, I think there's a really interesting question to be asked about whether we should be creating some these things. So with the example of your kettle technology there, I can see at least three or four different materials on that component of a kettle. Now, we spoke about plastics earlier, and it's in the public consciousness now that we are being very wasteful about all of the materials that we use. And so actually there's a bit of a philosophical question then, should we be making our products more and more complicated, more involving more and more materials involving more and more resources more and more money, when that means that there are recyclable and can't be reused, and that is not a particularly responsible use of materials, especially going forward into the future, when all of our resources are becoming more and more scarce.

Tim Minshall
I think there's something really interesting linked to this with the right to repair coming on becoming much in the public consciousness that we know, people want the right, they want the ability to repair something and the way many products are designed, it's just impossible to it's not. It's either impossible, literally impossible without smashing it, right. Or there's just there's no value in repairing it, because you open it up and go, well, there's nothing I can rebuild here.

Anna Ploszajski
And I can buy another one for six quid, right.

Tim Minshall
The ethical dimension of engineering material science, I think is really quite rightly coming much more to the fore now. So as an Institute for Manufacturing, we think very hard about, you know, hang on, are we just encouraging the production of more stuff, which has certain benefits, but actually doing it with a sense of on what are the what are the needs we're really addressing here? And are we doing it in the right way?

Sue Nelson
And for the future Tim, would you say there is something that you predict engineers are going to need more in the future than they need now?

Tim Minshall
That's a great point. So, we've been pondering a lot about what the engineers of the future are going to need. And interesting to hear what their material scientists of the future are going to need as well. We've kind of grouped it into three areas, because there seems to be, there's some fundamental stuff about engineering, the basic maths, the physics that isn't going to go away anytime soon, that's always going to be needed. Then there's knowledge about stuff now, what's leading edge? What's, you know, a bit overhyped. What are we using now, that perhaps I didn't use when I was studying, but is used now. But then the third and most important bit is, how do we help people learn about this uncertain future? How do you do that that thing where you're helping people learn how to learn for the rest of their life. And that's what's really exciting because you go, well, I'm still adjusting to the world of, you know, the internet and social media. And I see what my kids are doing now, very, very different, how quickly they've adopted everything. And so there's a whole new set of values, new set of technologies, new set of behaviours going on there, that we're gonna have a huge effect on the

world of engineering, the way we think about things, the way we buy things, the way we use things. And that's the world in which engineers are going to be operating. So, we need them to be able to think, how can we absorb this new knowledge very quickly, and make good decisions? How can we have a sense of critical thinking on all of this? Absolutely, to your point Anna about yet we can do this thing. Now, going back to Jurassic Park. Now? What was the phrase they spent so much time thinking about whether they could they stopped thinking about whether they should? Yeah, and that's so true, isn't it? And that's what we want to get into engineers is, yes, there's amazing things you can do. And the idea is you were pointing out earlier, absolutely fantastic. And there are many things we could do and perhaps should do. But we need engineers and material scientists, if I may, who can? Who can do this in a very in a way we can't predict it.

Anna Ploszajski
Yeah, I totally agree. I think the missing piece in that puzzle is going to be ways of communicating, and also channels of communication. Because we can create all of the innovation that we like in our labs, and then take it out into the world and people won't understand the need for it or what it does. Or we can create something that we think everybody's going to want. And actually, we've totally missed the mark. And so, what we need to be better at I think is communicating collaborating with users and with other experts outside of our fields.

Sue Nelson
Is this why you do stand up?

Anna Ploszajski
Well, it's part of it, actually. Yeah, I became interested in science communication, and which is associated with engineering, communication and material science. A few years ago, through stand-up comedy, I took part in Bright Club and Science Show Off which are to stand-up comedy nights, designed to help researchers distil what they do into a nine-minute stand-up comedy set to a public audience, a great discipline.

Sue Nelson
Quite a tough one.

Anna Ploszajski
Really tough at the time I was doing my PhD on hydrogen storage materials. It's a hard sell but it teaches you communication it teaches you how to understand your audiences. And it teaches you just to get to the crux of it to not get bogged down in the details. And that's a crucial skill that I've taken through into my professional career writing my PhD research, for example, I wrote it like I would write a stand-up comedy set, in terms of I put one joke in it, but also just making a story of it, bringing in the characters from the literature, seeing what papers were, you know, done in the same lab. Why did they do who were their rivals like bringing some drama into it. And yeah, they seemed to enjoy reading it, amazingly.

Sue Nelson
Well, I've really enjoyed talking to you both. Anna Ploszajski from the Institute of Making and Tim Minshall from the Institute of Manufacturing. You know what, I think it's pretty easy to see why you won an Excellence in Teaching Award Tim, from the Royal Academy of Engineering. Thank you both very much for joining me on Create the Future.