# Inaugural Lecture- Professor Anne Nortcliffe: Dean of Faculty of Arts, Computing and Engineering

## Engineering Inclusivity in STEAM, How?

*November 2024*

**Professor Joe Yates:** Hi, everybody. My name's Professor Joe Yates. I'm the Vice Chancellor of Wrexham University and I just wanted to say a warm welcome to staff, students and the public to the to the university.

This is the first inaugural lecture of the year, and it's actually the first inaugural lecture that I've been to at the university.

It's a really big milestone in any academic career and we sort of mark new professors joining the university or academics be made into professors and getting chairs conferred on them with an inaugural lecture. I'm absolutely delighted to be here today to present Anne’s inaugural lecture and to introduce Anne to you.

Anne is a newly appointed Dean; I can still say newly appointed. Anne you've been here since June, and given I've only been here since August, and Paul our deputy vice chancellor, has been here since September, you are still new, definitely. Dean for the Faculty of Arts, Computing and Engineering, Anne’s got 30 years’ experience in engineering and computing education and research, including a range of senior roles in higher education. Anne through her research in teaching and other academic roles and practice has been inspiring and educating the next generation of engineering, computing and arts graduates through delivering a diverse and inclusive curriculum and learning environments.

Really looking forward to the lecture. So, I'll pass over to the main event.

**Prof. Anne Nortcliffe**: Croeso, welcome to Wrexham University.

I'm going to introduce you how I spent the last seven, eight years or ten years, actually, more recently, engineering inclusivity in steam and how and the lessons learned embedded in that.

It'll come more apparent that I do apologise for placing this lecture on the 5th of November.

We didn't quite remember, remember remember the 5th of November, and this was Gen AI effort and mine and that give you a little bit of an insight of what we're planning, I'm planning to give you today.

So I'm going to introduce you to some of the journey and the thank yous of people who've actually contributed to my career so far and who are really important to me, and how that plays a professor of my journey and what's, you know, how people have influenced what I've been doing and that journey into STEAM.

I am very much embracing the faculty of arts, computing and engineering and how that is based on how I've created that inclusive environment is actually based on that scholarship and research and my background within that and that particularly lead to some work which I did my previous institution was creating of a brand new engineering facility, engineering technology design, with very much EDI, equality, diversity, inclusion at that heart.

And they match those lessons learned going forward and how they will be addressing working in the Faculty of Arts computing engineering here.

So, part of my journey is family and friends.

As part of that, two of these young ladies on the left-hand side. One of them I was at nursery with, the other one joined us in infant two. And Margaret's is actually Gillians mom, that's her daughter who I’m godmother to, Charlie, who are very much part of this, and Charlie went into science because of me, so she grew up with me knowing what I did. I would like to say I've actually failed with that in my own family, one is a medic, and one is a historian and legal. So, I'm a third-generation engineer, and it stopped with me. At the moment my nephew, apparently is going into engineering, but my niece is gone into neuroscience.

And these are friends who have constantly nagged me about getting my professorship, and they have been nagging me for about 14 years, particularly one person who wouldn’t stop talking to me in the pub if I didn't get on with writing the applications, so they have all been very much a part of that journey. Colleagues from work and from home and we have Helen here today, who has very much been part of that journey.

My family.

So, as I highlighted, engineering is very much part of my DNA. And part of the research of me understanding a bit more about me and my background and what I grew up with, both my grandfathers studied at the University of Salford, which was the Royal Institute of Technology, which is only just down the road from here. One was sent from literally, he lived round Tower of London and used to travel up on a motorbike in the 1920s, can you imagine that commute? Quite frightening. But he his family ran a biomedical engineering sesame firm down in Suffolk. And my other grandfather was actually born in Liverpool, and he used to work for Lewis’, and he was building services engineer and ended up at the head office in Leicestershire and then moved back to Liverpool and eventually ended up at Unilever as an instruments engineer. Now, the ironic thing about this history behind me I've designed both degrees in building services engineering and biomedical engineering. But both my grandfather’s long since passed away and certainly didn't get the opportunity to see what I was involved in.

My father will tell you that my life's scientific, and those of you who listen to radio four will definitely understand this theme, started off when I was a young child. My father was an academic, metallurgist, material science engineer, would pretty much be writing papers at home and left to look after me at the tender age of 18 months, and mum came home to find me in the kitchen breaking eggs out of the fridge, dad was occupied doing something else.

Mum went a little bit ape, and dad went, no, watch her, she's conducting an experiment. I was taking the eggs out of the fridge and breaking them and put my finger in them and watching them mix. Now, early experiment, one could argue with non-linear liquids because the yolk is a linear but when you mix them together, you get non-Newtonian.

I grew up with microscopes from experiments and my father's metallurgy, so I spent an early part of my career actually in the lab with dad, health and safety wouldn't allow this, but that he was doing materials research on a Saturday, and I'd be doing hardness testing. It's ironic, his samples from his research are now use on the undergraduate degree done in Canterbury, Christchurch University. They're really good crystalline structures, which are really helpful for teaching the students about those structures and hardness. He'd be horrified. Trust me, he'd be horrified that they're being used for undergraduates.

So, my life drawing, again a theme radio 4, I do have an artistic bent. I am only an amateur showing my yellow ceramics as a light relief from doing scientific A-levels. And whilst my daughters were first at school and I only worked part time, but on a Friday I used to go to a working, education, I forgot what the A stood for, but they used to be part time courses that were for people and I used to do life drawing on the Friday, which was great because I used to be on the faculty or arts and computing and engineering, and I actually had a faculty role across the university. So actually, keeping up my art skills was useful for working with artists at the time. But I am only an amateur and that's why I'm passionate about this faculty.

So why does engineering matter? Why does it for me matter? It touches everything in your life. Part of this I need someone to demonstrates, so I've got a lovely little helper who's going to come and help.

So, if you'd be so kind, put the plasticine in there and turn the handle and get a sample coming out the bottom. Brilliant. Now, do you want to describe what it looks like on a surface?

Can you see? Its bobbly, yes, that's a zipper effect. Now plasticine has the same plasticity as molten steel. So actually, Cambridge University use plasticine to investigate what's the problem with rolling mills. Now when you get those bubbles you don't want that on the crust of steel because it's hot, melts, and the steel in there will start to crack and It's going to leak out all over your production line which is last thing you want.

However. So that's wrong over here for the steel industry.

Can you just describe what that looks like? That piece of pasta? It's curve. But in comparison to that one. Can you see what the surface is different on that, so that's bubbly and straight and smooth, and that one's quite rough isn't it. So, do you want to take a seat, thank you very much.

The actual raw ingredient for pasta is pretty much identical, they’re both durum wheat, the difference is ones been manufactured using steel rolling mills, the other one's been using bronze. Bronze is some self-lubricating, so it wears and causes a rough surface. You don't want that on the steel mill rolling, but you certainly do want it on pasta. Your better-quality pasta is due to engineering because the rougher the surface, the more sauce it absorbs and that's why it tastes better.

So fundamentally, engineering is at the heart of things. And what I love about it is that what can be wrong over here can be so right over here, there isn’t a wrong or right answer, It's about context.

So, my journey. This is why I like engineering conversion courses. I didn't do engineering to start with. I did chemistry, I love science, and I actually carried on experiments that carried on at home. I ended up an internship at Nuclear Electric on Simpson Road in Manchester, when we were actually before Digital Twins, we actually did full simulations of the nuclear reactor boiler systems and we worked with control and instrumentation engineers, and I actually really enjoyed working with control engineers and that led me to doing a master's in control. Which led me to Spain in the food production process of a sugar evaporation plant.

And you'll start seeing some themes about my life and repeats.

And then I ended up working in industry, actually walked on site at Hickson and Welch, those of you were old enough that name should resonate because in 1992, the 60 still blew up, killed three people and injured two administrators in the building. I walked on site six months after that to develop a system to sit on top of that still of an artificial intelligence to help them operate that still. Which is shows how AI has been working in that area, so we're talking about early 90s. I was also working, it was a KTP, so I was working in the University of Huddersfield, and Huddersfield actually had a member of staff go off sick long term and they needed someone to So I got so much holiday left over, I ended up being so robotic.

I came home high as a kite from teaching. My husband went, hmm, I don't think you should be having an engineering career in industry, I think you actually should be an academic, which I've been trying to avoid because my father was an academic. So I went back to university, did a PhD in pH control, and then ended up working on a project, again, artificial intelligence, notice the theme was artificial intelligence in my PhD. But I ended up as an engineering academic and was actually placed for 14 years in electrical engineering department, it was not a good fit for me. Actually, I was better off in mechanical and aerospace, which I eventually got, I managed that, and that led me down to Canterbury, Christchurch to setting up a brand-new facility that was more inclusive. And now, of course, I'm here.

So, my journey as an academic, I'm very much more interested in that research side as an engineering education. Believe it or not, an awful lot of engineering education is still based on 1908 and that certainly doesn't fit with generation Z and certainly didn't fit with generation Y or X. So, the traditional academic is that of the broadcaster, which, you know, which is a very broken communications scheme. Well, actually I prefer that academic dialogue between student and learning together. So, some of that contextualisation interacting with the students, looking at surfaces helps them learn and see that actually context. There is an argument for both sides with engineering, but it's actually more like layers. So, I'm more into that, increasing that dialogue and conversation and I've been heavily influenced my career by Cole Holden. I worked together on assessment learning at Sheffield Hallam and more latterly I've worked with Crawley on conceived design, implement and operate, which came out of MIT.

But the primary reason why I ended up more in engineering education. Who am I? I'm beyond dyslexic. I am dyslexic. I spend most of my life trying to find ways and things to get round the hurdle of me struggling with the English language. The written language. I didn't learn to read until I was 7 or 8. I probably was eight and I actually taught myself to read, I actually gave up, I suddenly realised I was missing something, so I taught myself.

But it is a struggle, and I dip in and out. I'm struggling with it. So, communication and writing written feedback was a challenge, so hence I ended up working with audio feedback and developing that and actually internationally renowned for developing the methodologies that we tend to use now for audio feedback. I'm working through that, but we discovered there was lots of happy accidents coming out of it, supporting particularly neurodiverse students, international students were playing back my audio to support their English language learning. Not only were they grasping it for the feedback in the feedforward I was given them for engineering, but it was also helping them cognitively understand English.

So that's what led me into the tech. And then I was a very early adopter of smartphones back in 2007. My research through that area led through about audio lecture notes, the ripple effect from audio lecture notes, because everybody first starts off with audio thinking. That's going to be audio lecture notes.

Actually, very early on, interaction with some Australians who were realising if you record an entire lecture for an hour, students weren't accessing it for an hour, they just do ten-minute segments to where they fell asleep. So, I realised it needs to be note form and short sets and documenting it with simple files that they understood. That led to audio feedback, but actually more of a dialogue and working within the lab and recording those conversations. The conversation feedback, more of a student walking me through their work, particularly when we do research projects. This is an area in every academic subject, it doesn't matter what your subject area is, when you're doing your dissertation research recorded it. They will be so engrossed in your conversation with you and thinking things through, they're not making notes because they're interested in that conversation. They'll walk out that door and forget it. Whereas if you've audio recorded it, they're able to re-listen to it, but it also reconnects some with their thought patterns at that time. So, there's multiple layers of understanding and that led to the autonomous projects. So now, I don't record the conversation I say to them, get your phone out, you audio recorded this, you need this conversation, so I encourage them to make those audio notes. Support them doing it. Of course, that led smartphone technology and interesting how much that so the paper that students and I researched it was probably the biggest read paper during Covid, because everybody was trying to understand because a lot of students were using smart text, they didn't have laptops, so people were accessing that paper when the sound, what technology they could be using support those students. As I say, then, it led me to really understanding inclusivity because the challenge with smart devices is it’s not accessible to everyone, one from an economic point of view, but also different technology, but also different disabilities.

But in engineering this only last ten years, that engineers have come to realise how important EDI is. Now I apologise to the men, but some of you women in the room will know when you were growing up. Some of the mums and daughters will often say only a bloke would design something like this. It’s usually something in the kitchen, we're having a frustrating time with.

Place it in context. Your gas pedal on a car, you have to have a shoe size greater than a six, otherwise, your foot is suspended in the air when you're pressing the gas pedal. Reason why I know this. My mother has a shoe size four which is why she does not do long distance drives, she never has because you try and long-distance drive with your foot suspended in the air.

So, inclusivity matters. It does create more profit; BA systems realised this when the RAF came to them and said do you realise, we have female air pilots, and your helmets do not fit for our pilots. So, they went way and did a piece of research and realised, well, this not three heads, they worked out that was actually 5 to 7 heads, and they could break into the international market they've never been able to break into. So, it really suddenly started pay for them, most companies will see a 26% profit.

It's improved health and safety. As I say, start thinking about that gas pedal and the fact that so many foot suspended in the air and you're going to cause accidents.

Improve sustainable solutions because you're thinking from a wider perspective. In reality around the world, 51% of the population is female and in London, so this is really conceptually important, global majority BAME is 40%. So, you know, mirror image and apart from that is the moral right thing to do.

So how do you go about creating a new school in engineering with EDI principles?

So it needs to be meaningful STEM research, the work the team that I was working with down at Canterbury, Christchurch, so the outreach team, the engineers, the academics and the STEM hub, the research that came out, was it has to be meaningful STEAM/ STEM outreach activities at every stage of the national curriculum and I'm talking about from nursery all the way up to Key Stage five. And if you do that, they will follow a STEM career.

Student marketing. I did an audit of all different engineering websites. The most interesting one was how many- I was ever spotting a female on the page. Mainly white males, white males teaching white males actually doing activities on the page. We know from recruitment of staff- mirror image matters. So, if we know that from recruiting staff and that research came out of delph, why are we not applying it to our web pages for recruitment of our students, reflecting the image of what we want to achieve? So, we did so the very first year of operation of chemical engineering, we had ten female students and two males. Equally we know from student marketing, for recruitment of staff, language matters. So, this is again, this is some really interesting gender language papers out there about HR recruitment. And we know if we reword our applications, you know, job adverts, job descriptions, to feminised, men will still apply regardless. The numbers will still apply but if you feminise it, you'll get more female applications. I applied the same to marketing material for engineering. It does matter because the following year a male academic changed the material made it all male and we had no female applications. Lessons learnt.

Mirror image. So, it was important the staff we created was a mirror image of what we wanted to build. More recent research has shown actually they not only want to see young academics and female academics, but they also want to see people who are at the end of their career. They want to know you've got staying power, because in actual fact women leave the talent pipeline all along, particularly in STEM and STEAM. So, it's absolute imperative you've got role models of every age group.

Inclusive estates, thinking about that estate. So one of the lessons we were learning about creating the computing room and computers, some of the computers need chairs need to be on wheels, some actually need to be fixed because you've got somebody with a physical disability, they need to have the chair stable with the arms stable so they can get out of the chair. Relic tables create better group work or round tables, not square and oblongs because you can create power hierarchies. So actually, facilities matter and make you think about the equipment and PPE and it's, John Paul if he's here reminding me, no size male six shoes are not good on size six females, they actually can cause long term spinal damage because the foot is wider. So, PPE, male PPE is not safe, it's not a good idea and its importance in an education setting that we provide PPE that is all inclusive. Science labs PPE you can buy to fit women and men, when I ordered the female PPE, it was very much designed for Chinese woman its not going to fit a Western woman. We had a bit of challenges getting engineering PPE.

This is to highlight some of the work we did with Ros Barley down at Canterbury, Christchurch. This was the make-up of STEM A-levels, and this is how hard and particularly Kent was, so if you wanted to do physics A-level, you need to live in Maidstone. If you want to do chemistry A-level, be better off living in Canterbury. Maths is all over and it is the most popular A-level, but computer studies you want to be Maidstone or Margate because there's a good computing and gaming industry there. Geography of Kent is 60 miles across and has a grammar school system, so you can see how disparate it is for students to be able to progress in science than you can in engineering, because you can't do your three sciences.

I had students who came to us and genuinely wanted to come to us because we were inclusive, saying, I want to do engineering, I want to do science, I’ve gone to my teacher and said, I want to do science and they’ve said, there's not five of you to run the module or the course, you can do psychology. If you want to be engineering, then join the foundation year.

So that was in 2017, these are the A-level results changes. So meaningful outreach was going on in all those schools and we changed the narrative. Because when I first went down in 2017, Ros pulled up some work on the UCAS and we know 80 people of science students that applied to do engineering nationally, but only ten of got places because they got the wrong education experience. And as you can see, the narrative is up, maths was up, females have gone up literally in computer science and physics, but meaningful outreach makes a difference. Now, believe it or not, I also analyse nationally the numbers, I mean, so the government will say STEM is up because it's in percentages but when you look at the real numbers, the uptake of STEM A-levels nationally in the UK is down. The only counties going up was Kent, there's a lot of work due to the team.

And we've got those equal challenges now here in Wales. And you can see how bipolar it is between what subjects’ females’ study and what male student study here in Wales. Biology is very female orientated and popular, maths is very popular here in Wales, which is really unusual because maths is actually in England is getting pretty equal between male and female now, it's most popular A-level, so there's opportunities to change the narrative.

Okay. So not only did I and the team and I were developing this EDI school, but I also mean, it was originally me and then I built the team. By the way, we got 38% female staff in computing and engineering and 54% of the staff were global majority, and within that as academics were 48%. We bite off everything, so talent pipeline outreach, dealing with it in and the inclusively, recruiting the staff, recruiting the students, the curriculum we designed to be very much inclusive and adopting the CDIO methodology, which is a sensible conceived design, implement and operate. So, it's about doing and helping the students to build upon that, but also challenged with that and enables to bring in that STEAM element and question and contextualise and place things in context, particularly for Gen-Z, who want to question that world and place into context.

We also work very closely with industry as well, to make more inclusive engagement and picking up on some of the other work that's out there by Beddoes was about also group work. So, the classic example in group work, you place a single girl, you separate the two girls together, she gets assigned the project management to do instead of doing the engineering. So it's educating colleagues and the facilitators and academics to make sure in the group work, you actually have more than one girl in the group, and they're not the project manager and you get them rotating, otherwise they'll slip on their engineering skills and not have that confidence then to graduate, they’ll graduate well, usually with a 2:1 or a first, but they won't progress into the industry because they don't feel confident in their engineering skills.

So, we are very much about making that inclusive curriculum. So, we decolonised the curriculum. Some people argue, well what is the relevance to that in computing? But I think the tap shows you that is an embedded system recognition in there and doesn't recognise dark skin. The oximeter, biggest problem in Covid was missing diagnosis of oxygen levels in Covid in Black and Asian people because the oximeter is calibrated to white skin. And as for photography recognition systems, it's notorious, it doesn't recognise black and Asian faces. In actual fact, Cardiff Metropolitan Police were the first ones to spectacularly take hold of some software for crowd management which only recognised white males, it didn't even recognise females.

So, it's important and that we embed that in the teaching and in supporting that and recognising that about digital resources. I talk about my EDI in digital tech, one of the last projects I've been doing is with virtual reality. So, the first project, we know that females IPD inter plural distance between your nose and the centre of your eye, and this distance here is smaller in women. So virtual reality headsets actually don't necessarily work for women. In actual fact, there's one group of people virtual headsets really don't work, and that's Chinese women with glasses and they suffer from chronic virtual reality sickness. So we were looking at that, but also in a more recent project with a deaf student, so they are working with accessibility software, the will pick up somebody speaking and they'll move the head and see the text but it won't pick up music, It won't tell them or describe the music. Or if somebody is moving around the crunching on the ground of somebody moving about. So, they're not getting a full experience. So, it's a long way to go about accessibility of any digital tech. Oh, by the way, the conclusion for the virtual reality headset. No, there is not a single headset out there that will work for everybody. You are better off purchasing in education every headset and having a cluster of everyone.

My journeys have lessons learnt and the scholarship research.

* Mirror image matters. But at every stage.
* Language matters and how we use that language, and probably more feminising of it. Engineering language itself is very masculine and the why we describe things.
* And some of the more recent research I've been doing with employers and with students for helping progressing EDI students into employment. Students really highlighted, yes, if a company has an EDI policy, but they want to see it being honestly done in practice, because more often than not they see in companies, there in the policy, but it certainly isn't happening on the ground.
* Think about good design. Think about that Neurodiversity. Think about, you know, how they will interact with that technology.
* Think about global majority.
* Gender, physiology and physicality is different. There are only three decent research papers about talking about the physiology of women's upper body strength. It's 40% less than a man's. So, you know, think about your Ferrari with its very nice heavy gearbox, a certain vantage point at home, which I don't drive because I get a splitting headache because the gearbox is too heavy. So, think about that physical disability. I've never forgotten at Hallam, walking into a corridor, and we had two ways of going, either you went up steps or you went a flat route. I went into this corridor and there was a student in a chair, and she couldn't go anywhere because somebody had put the access button to open the door at light height. I released her and said, I will go and talk to estates, and this will change, and it was changed within a few days. Because nobody in the estates had gone round wheelchair height to fully understand and appreciate what it was like to be disabled accessing around buildings. And this was after the law changed as well, so I was well and truly cheesed off.
* Cultural awareness- we in education, we like to do gamification, you know, Kahoot and things. However, that is not always probably right, my observation and I need to some more work in this, but I found with Asian students particularly, it alienates them. They come from a culture of working collaboratively together, so actually this gamification and competing one against another, it doesn't work for them. They want a more collaborative process. And that's why you can end up with students migrating and girls particularly as well if you create that communication in engineering, the girls will start leaving the group and the Asian students will start leaving the group.
* So, think more holistically the bigger picture. Invest in your staff and student time.
* My staff at Canterbury, Christchurch we were constantly doing staff development all the time, learning from each other. The advantage we had being very diverse is to learn together, but also, we shared that then with employers. I've already shared some of the lessons learnt that I've done for when working with employers and with students. I've already been showing the employees here, and they’ve gone. oh yes, this is helpful, this will help me with recruitment.
* So, understanding as well region cultural contribution. Students are highlighting they're still victimised against if they've got regional accents, but also international accents can hinder them from moving into employment.
* Reciprocal mentoring. There are lots to learn from somebody senior working with somebody junior and mutual learning you can have from each other, typically with Gen-Z and senior managers. But, you know, reciprocal mentoring also can work for your new generation coming in in that you can be acting as their advocate when you walk into meetings.
* And the other thing that I'd like to leave you with on some of the arguments I've been having with Gen Z, ChatGPT. I have made Siri dyslexic. I have used Siri since 2007, so my account now when it does predictive text is even worse than my dyslexia and I did have a discussion with ChatGPT that if I had the learning switched on, would I make it dyslexic? And, yes, because it holds my memory of my account. So, believe it or not, it's the reason why, Watson became a bit of a problem because it was mainly dyslexic through using speech to text and they did make Watson dyslexic.

So, I will leave you with that thought.

Do feel free to ask any questions.

*[Video End]*

Lecture proceedings chaired by Professor Paul Davis, Deputy Vice Chancellor.

Professor Anne Nortcliffe presented with an Inaugural Plaque by Professor Joe Yates and Professor Paul Davies.