

Education Committee

Oral evidence: [Fourth industrial revolution](#), HC 1007

Tuesday 16 October 2018

Ordered by the House of Commons to be published on 16 October 2018.

[Watch the meeting](#)

Members present: Robert Halfon (Chair); Lucy Allan; James Frith; Emma Hardy; Trudy Harrison; Lucy Powell; Thelma Walker; Mr William Wragg.

Questions 1-58

Witnesses

[I](#): Professor Rose Luckin, Professor of Learner Centred Design, UCL Knowledge Lab, UCL Institute of Education, University College London, Brian Holliday, Managing Director, Siemens Digital Factory, and Joysy John, Director of Education, Nesta.

[II](#): Pepper the robot, Professor Martin Loomes, Pro Vice-Chancellor and Executive Dean of the Faculty of Science and Technology, Middlesex University, Joana Da Cunha Miranda, final-year BEng robotics undergraduate, Middlesex University, Nicholas Fitton, final-year BSc computer science undergraduate, Middlesex University, and Babak Jahanbani, General Manager, Festo Didactic.

Written evidence from witnesses:

[Written evidence submitted by Nesta, FIR0014](#)

[Written evidence submitted by University College London: Institute of Education \(IoE\), Computer science and the Institute of Health Informatics, FIR0020](#)

Examination of witnesses

Witnesses: Professor Rose Luckin, Brian Holliday and Joysy John.

Q1 **Chair:** Good morning, everybody. Thank you very much for coming. We are looking forward to this session. For the benefit of the tape and those watching, please introduce yourselves with your titles.

Professor Luckin: I am Professor Rose Luckin from University College London.

Joysy John: I am Joysy John, director of education at Nesta.

Brian Holliday: I am Brian Holliday, managing director for Siemens Digital Factory.

Q2 **Chair:** Thank you for coming today. How prepared is Britain for the fourth industrial revolution?

Brian Holliday: Perhaps I could take that one first. We are waking up to the opportunity. You could argue that we lost out largely on the third, if you think about that being the augmentation of human physical effort in the factory. The fourth, of course, is the augmentation of human intellectual effort. I think we are waking up to the possibilities that that will bring to us in terms of competitiveness and productivity. We have made a start. Reviews such as “Made Smarter”, through quite a lot of input from, in this case, more than 200 organisations, are bringing to life the potential behind the fourth industrial revolution, which of course is a global race.

Joysy John: There are some really interesting things happening. For example, there is greater emphasis on how technology can be used both within the classroom and outside, within the workplace, to build some of the skills that are important for the fourth industrial revolution. Where more needs to be done is in building a much broader curriculum because what is needed is skills such as creativity, confidence, resilience and ability to learn, which are currently being pushed out of the curriculum owing to an over-emphasis on exams and league tables. That is the first thing.

The second thing is: are we building a society that is inclusive and diverse? If AI is going to change the world—it is not just about robots; it is everywhere, in our phones, in our computers—who is changing AI and are we getting enough women and people from disadvantaged backgrounds shaping AI, writing the algorithms and designing systems?

Finally, are we building the skills—not just the digital skills, but also the social and emotional skills—that are needed to thrive in the fourth industrial revolution? There is some progress, but a lot more needs to be done.

Q3 **Chair:** What are those things that need to be done?

Joysy John: There are three things. First, the curriculum needs to be



much broader so that you focus on multidisciplinary learning and you are not just learning maths and science or English, but also learning things such as collaboration, communication and problem solving. The second thing that needs to happen is much more investment into R&D and research, so that kids and teachers are aware of things like machine learning and AI, and are not afraid but are well prepared to be able to use it. The third thing is changing the narrative from fear to hope and optimism, because we invented the machines. They are not here to replace us. Robots are not taking our jobs. We need to make sure that we change the narrative from robo versus humans to machines working with humans with a better process.

Professor Luckin: I agree with my colleagues, but I think perhaps the waking up has been focused far too much on the technology and not enough on the humans. We need the technology to be what we want it to be. It should not be the technology driving us. It has to be what we see we want from the human race moving forward. What kinds of people and what kinds of societies do we want? The technology is there to serve us. We are waking up to that, but the waking up has been very much about the amazing potential and amazing advances in artificial intelligence.

There is no question that we have built awesome machines that can learn. That is a fundamental change to anything that has been possible with AI before. We really need to recognise the significance of that and understand much more about the relationship between human and artificial intelligence, because that is the part of the puzzle that has not had the focus it needs. That is the bit we need to focus on. We need to behave intelligently.

The parts of AI that we have focused on sing to the old adage, "You treasure what you measure." We can now build artificially intelligent systems that could ace GCSEs, A-Levels, most undergraduate degrees and other qualifications. We can do that, because the ways in which we have valued intelligence to date are precisely the ways in which we have built the systems. We have built the systems in our own image, but the parts of our own intelligence that we have not valued so much are the very parts that AI cannot do, and that is where we must move. We need to look at a much more intelligence-based approach to education and skills.

Q4 **Chair:** What does that mean in practice? What would you do tomorrow in the schools?

Professor Luckin: I would focus on how we develop what I would say is meta-intelligence. We know that people who do well have highly sophisticated perceived self-efficacy. What do I mean by that? I mean that they have very good meta-cognitive awareness—they can regulate their own behaviour, they know what they know, they understand how to formulate goals, and they know how likely they are to be able to achieve those goals. This is highly sophisticated intelligence of a sort that we cannot artificially automate, because it requires a lot of self-understanding and self-knowledge.



Most of the literature that looks at meta-cognition and self-regulated learning shows that it is linked to an understanding of a subject knowledge, so you cannot get away from the importance of knowledge and I certainly would not want to. But rather than seeing knowledge as something we learn, we need to see it as something we need to understand. What is knowledge? Where does it come from? What is evidence? Why should we believe something? We only have to look at the problems that we have at the moment with fake news to realise that a lot of people do not really understand what evidence is, as distinct from information, and it is very hard for them to tell what is true and what should justify what they believe to be true, so our approach to knowledge needs to be slightly different, and needs to have much more sophisticated epistemology—a horrible word. We need people to have a more sophisticated personal epistemology, so that they see knowledge as something that is constructed, relative and not offered to them just as it is, but as something to be challenged. If we do not get that bit right, we run the risk that we will just believe our AI systems, and maybe we should not always believe our AI systems.

For evidence of that, you only have to look at medical advances in AI to realise that some of the systems are not necessarily giving you the optimal answer, so we need people who have a really good ability to question. That relates to what Joysy was saying about collaborative problem solving—debating. There are lots of ways in which we can hone these skills. In order to give ourselves time in the curriculum, I would suggest that we use AI to do some of the tutoring of the hard-core knowledge that we want people to have, because we can do that.

Q5 Chair: Brian, with regard to practical changes to the curriculum, do you think we are unprepared at the moment, in terms of our existing curriculum, and if so, what would you do to change it to meet the needs of the fourth industrial revolution?

Brian Holliday: I see a curriculum at present that, although increasingly standardised, seems to be focused very much on key performance indicators for students and teachers. I see that leading to high levels of reported anxiety as well—stress for our teachers and our children in the pursuit of predominately knowledge-based learning. Forgive me for the oversimplification, but I see an absence of applied learning opportunities for teachers and students in schools. We do not have teachers visiting industrial facilities and learning about the world of work, or the application of some of the learning that is derived from school. I have seen some tremendous examples of that, for example the Greenpower initiative, where students get together and apply what they have learnt into racing electric cars. I have seen it with undergraduates through hackathons, where they have come together for 48 hours, for exercises that involve pizza and lots of sweat and tears, getting together to try to solve big problems. What they tell me on the back of that is that they have failed to achieve the type of learning experience in which they got to apply learning through their schooling to date.



HOUSE OF COMMONS

There has to be more collaboration with business to bring real-world examples into school environments, so that pupils understand why they are learning something in schools. My concern is that if we continue to pursue a knowledge-based approach to academia we are setting our kids up increasingly to compete with computers, with devices that we all use that are now 1,000 times more capable—more powerful—than they were just 15 years ago. The debate we have to have is, “What about the primary school children today who will have devices 1,000 times more capable than these again at their fingertips to help solve things, including access to knowledge through natural language and so on?” So I agree entirely that we have to be much more focused on developing the creativity, imagination, intuition, and emotional and ethical skills that we look for when we start to assess people for world-of-work jobs.

- Q6 **Chair:** Some studies done by serious consultancies have suggested that by 2030 some 28% of jobs could be lost by young people under the age of 24 to automation or AI. Brooks, as you will know, has suggested that something like 47% of United States jobs are at risk to automation, and there are many other statistics that we could spend all day quoting at you. What is your literal assessment of the risks to jobs in the UK with the arrival of the fourth industrial revolution, and also of the number of jobs you think will be created?

Professor Luckin: This is a classic academic answer from an academic: it depends. It depends on how we react. If we don’t get it right, we will allow too much of what we should be doing to be offloaded on to our automative machines, and then they will take our jobs. A very particular example, building on what Brian said, is that if you look at the knowledge-based curriculum and you systematise it in a way that makes it very automatable, you are actually reducing the sophistication of the job of the teacher and putting them at risk. I do not believe that teachers are at risk; I do not believe that they should be at risk.

What I am trying to say is that the extent to which jobs are taken depends on how we use the AI to match with our human intelligence, because that is the bit that matters—it is how we use them together. If we get it right, we see our AI systems as things that can make us smarter and we have augmented approaches to jobs. So it is about working with an AI. I am in a group, maybe there are three people and two AIs and we are working together, synthesising and solving problems—

- Q7 **Chair:** Have you done any analysis of the figures?

Professor Luckin: I have looked at the literature. I haven’t analysed the figures you refer to. They were done using machine-learning algorithms to predict, based initially on previous skills, and then the report that you were involved with, Joysy, looked at using a combination of AI and predictions from humans about the kinds of skills. The problem with looking at the numbers is that the evidence is not necessarily comparable, in that different people are looking at different things in different contexts. You are not comparing apples with apples, so it is quite hard to do an analysis. The sort of literature synthesis we have done has looked at the



HOUSE OF COMMONS

work done by Frey and Osborne, the work done by Fidel, the work currently being done by the OECD, and the World Economic Forum, and they all come up with a similar version of the fact that it is going to change and that we need to give people better skills to help them to work effectively, and there is a sort of consensus around a set of knowledge, skills, characteristics and attitudes.

Joysy John: The first thing to note is that a lot of these really scary statistics are based on just one thing: that automation is going to take away the jobs. But what we need to remember is that it is not just automation; there are many other mega trends, such as an ageing population, rising inequality and the increase in the green economy. Those things have an effect on each other. Nesta has worked with Pearson and Oxford academics to look not only at insights from humans but at trend analysis, and to combine that with machine learning to predict which jobs will be in high demand and which will be in decreasing demand. The findings of that report were that only 10% of jobs will see an increase in demand by 2030, while 20% will see a decrease in demand. We can guess which jobs will decrease in demand: things like administrative services and routine tasks that can be easily automated. The future of the middle 70% is highly uncertain; as Professor Luckin said, it depends on how we respond. If we have an education and training system that can respond to those changes, we can change the likelihood of those jobs being in demand.

Brian Holliday: I was privileged to work with the leadership team of the “Made Smarter” review last year. We estimated that 175,000 net new jobs would be created over the next 10 years if we deploy the sort of industrial digital technologies that we have referred to under the banner of the fourth industrial revolution. If you look at the OECD and Oxford University estimates and so on, they all lean towards our needing policy instruments to ensure that that happens. However, as a responsible employer we automate for productivity, so that we can improve tasks and then deploy people into other, more value-adding roles. I think policy instruments need to lean towards addressing what to do when people are displaced and disrupted—as they will be—in administrative roles and in roles in which robots and cobots will augment human effort in the factory.

Q8 **Thelma Walker:** Good morning. One of the most challenging times in my life was in my previous career as a teacher; I was a deputy head, a year 6 teacher and a special needs co-ordinator. If somebody had said to me then that artificial intelligence could take away all the bureaucracy, the assessment, the individual learning plans and all the other paperwork, that would have been my dream. I could have focused completely on the children in my classroom. How do you see AI supporting teachers with all the teaching, learning and wonderful work that goes on in the classroom? Could it take away the bureaucracy, so that they can focus on their core purpose of supporting and educating children? What might the barriers to that be?

Professor Luckin: Absolutely. The vision that you have just painted is what I would love to see, and it is absolutely possible if we get it right.



Yes, we can take away some of the routine work, particularly record-keeping, data and marking. We can help with differentiation; we can have very good AI systems that can tutor—not teach, but tutor—in specific subject areas and give teachers a chance to spend quality time with less able or more able students.

We can really help if we get it right, but in order to do that we have to demand from our technology companies that they engage with educators. At the moment most of them simply do not, which is a real problem. I work with ed tech start-ups and SMEs, many of which use AI—in the last year we have worked with over 140. The first thing we say to them is, “What is the educational need, and how do you know that it is a real need? How are you working with educators in the development of your product?”

That is what we have to demand from the people who develop the AI to be used in our education and training systems: that they work with teachers. That will also help teachers to develop the skills, knowledge and understanding not to be frightened of the technology. If they know what they can get from it, it will get us into a much better scenario, because they will become part of the design of our AI systems—they will have skin in the game, so to speak.

Q9 Thelma Walker: Fear of the technology is one of the barriers that I was referring to. Leeds Beckett University says that the woeful shortage of scientifically literate teachers in primary schools is a disaster.

Professor Luckin: AI can help us with that, because it can help teachers to develop the scientific skill and knowledge that they need. But one of the core skills that educators will need in order to be part of the decision-making process over what AI systems end up in our classroom is an understanding of data, evidence and outputs, because those are what machine-learning AI feeds on. We need people—everyone, particularly educators—to know how to use that data, that analysis, that evidence, to provide those wonderful human interactions that make sure that children and adults get the best education.

Joysy John: Your question is: what are the opportunities and what are the challenges for AI to be used in the classroom? In terms of opportunities, there is huge potential to reduce teacher workload: things like lesson planning, admin, and data reporting and assessment. There are already existing technologies that can be used to help with those things. But what are the barriers? The key thing is cost. These things are expensive. How do you implement it in the school when there are funding cuts?

The second thing is infrastructure. These things will not work unless you have basic infrastructure. The third thing is training. You can have the best technology in the classroom, but it can just sit there—for example, the whiteboards when they were first introduced—unless you provide the right training, bring humans as part of the solution and change the existing processes.

I will give you another example of a maths teacher running a remedial



HOUSE OF COMMONS

class for her students. There are amazing tools out there that do personalised learning and gamification, just making it fun for kids, but it requires the computer to turn on and respond. She resorts to just giving out a paper so that kids can get on and do their work. We will not change the process and the practice within the classroom unless we address those three barriers.

There is a huge opportunity. It comes with challenges, but we can address them by bringing businesses, academia and civil society together. There is a real opportunity here.

Brian Holliday: I support Rose and Joysy's point about AI helping to address the burden of data that drowns teachers today, much in the way that we do in industry when using AI to look at legal clauses in contracts or at finance reports, because it helps to spot outlying indicators and do the things that would free up time for teachers to do more in the classroom with applied learning.

On the point about responsible employers, we at Siemens are creating schemes of work for teachers to bring real-world examples into the classroom at every key stage, because we think there is something fun about thinking about the energy requirements of the country or the human body in terms of healthcare, or, in the case of a factory, how you design and make things. If there is more scope for some of the curiosity and project-based learning that helps develop some of the meta-skills that kids can bring to the world of work, that would be a very good outcome and a very good use of AI to help teachers teach.

Professor Luckin: I completely agree—we have an outbreak of consensus. One of the real areas where we can make big strides is in teacher training. If you take something like collaborative problem solving, we know that when it is done well it is really effective in helping students learn. But not enough teachers are trained to know how best to implement collaborative problem solving, so we need to address that. The beauty of all of these things is that we can also use AI to help us. We can use our AI systems to collect data as students work in collaboration, and we can analyse the data that we collect to give teachers valuable information about where they need to be. Say I'm a teacher with 35 children in a class and they are working in groups of five. Who do I need to work with? That is where we use AI, so we need training and we need our AI to be developed.

Q10 **Thelma Walker:** So it is about training and having the infrastructure, but ultimately funding needs to be committed.

Professor Luckin: And demanding it from our tech companies. Some of our big tech companies have got lots of money. We need to demand much more from them. I'm sorry, but we do. The example that Joysy gave of where she works with teachers is brilliant. We need more of that.

Q11 **Lucy Powell:** Thanks for coming in. I am sure the audience are all here for you and your contribution. I want to take you back to the curriculum point. I say this partly as a mother of three kids in the system, one doing their GCSEs at the moment, but also from the point of view of Andreas



HOUSE OF COMMONS

Schleicher from the OECD and others. An increasing number of parents, and others, are saying that our school system, curriculum and delineated academic strands are travelling in entirely the opposite direction to that required to meet the challenge of the fourth industrial revolution. Do you agree with that? If so, what more do we need to do to put more voice and weight behind that from business and wider society, so that we can get a change of direction? Brian, I know you have done a lot of work on this.

Brian Holliday: I have, and I too would speak as a parent and an employer. I see the unnecessary stress and anxiety levels caused by, for example, end-point assessment. We do not take people into the world of work, have them work for two years, and then tell them whether or not they are doing a good job. I know that there were challenges associated with continual assessment, but that better reflects the world of work. The direction of travel does not take into account the inclusion needed: how does everybody contribute to their best through the school system?

There are some initiatives, like university technical colleges, which we have been very supportive of near our main locations. They provide a vocational alternative for those students who are not going to go to Oxford or Cambridge. We seem to be too focused on the linear academic progression of students to high levels, and we fail to recognise the same thing as Germany, which has a balance of about 50:50 in their VET—vocational and educational training—system. That seems to me to be a better balance. I know that we cannot replicate that directly and bring it here, but I do not believe we have enough emphasis on real-world challenge.

That is why we would support bringing real-world challenges to schools, applying real-world challenges to apprenticeships, and supporting undergraduate programmes with real-world challenges. At a time when we have to grow our own engineers because we are not able to recruit the people from the workforce today to address the current challenges with digitalisation, there is an increasing emphasis on us as a responsible employer being able to inject some of those inputs. But let teachers out of the classroom and build the systems.

Q12 **Lucy Powell:** What more do you think business could do to make sure that message is heard in terms of Government policy?

Brian Holliday: Obviously, participation is absolutely part of it—such as giving evidence at events like this—but equally, we can open our doors to schools, for teachers and students to come along and see what actually goes on.

Joysy John: The key thing to remember is that there is a lot already happening, and more needs to be done. The first thing is the implementation of the careers strategy, where there are some tools available for young people to make better career choices. For example, there is data everywhere around destination outcomes—from DFE, BEIS, DWP, and HMRC—but we do not really use it. There is data available



HOUSE OF COMMONS

around what jobs employers are looking for and what skills they are looking for.

NESTA has done a piece of analysis where we worked with Burning Glass to analyse 41 million job adverts. We looked at what skills employers are looking for, to get real-time labour market information rather than somebody sitting there and creating a skills framework or a framework for an apprenticeship. I totally agree: you need more vocational options, because 50% of the population are not going to university, so how do we make sure that an apprenticeship is a valid option that is of high quality?

- Q13 **Lucy Powell:** It is not even just that, though, is it? Those going to university are themselves then underemployed, or do not have the skills for this fourth industrial revolution.

Joysy John: Absolutely. In fact, it was interesting to see that computer science grads had the highest level of unemployment after six months of graduation. Why is that? If employers are crying out for technical skills, why is it that computer science grads have high levels of unemployability? It is probably because they cannot communicate, or they cannot express themselves, and most employers—in fact, 97% of employers—say that they look for attitude, confidence and communication skills when hiring somebody. Why is it that we are not preparing young people for those skills?

- Q14 **Lucy Powell:** It could also be that it is obsolete. My 14-year-old is doing a GCSE in computer science. It is going to be completely obsolete in five years.

Professor Luckin: I agree.

Chair: I had a quick question from Trudy.

Lucy Powell: Rose was just going to answer that.

Chair: Can you combine it with the next answer? We are slightly behind schedule.

Professor Luckin: I will.

- Q15 **Trudy Harrison:** Joysy, this is a question for you. You mentioned three points: broader curriculum, changing the narrative, and R&D. On the broader curriculum, can you detail an ideal curriculum for a particular age group? Could you just explain what that might look like, Monday to Friday?

Joysy John: Sure. I'll give you a specific example from Singapore and from Malaysia. In Malaysia, there is something called "thinking schools", which are being rolled out to more than 10,000 state schools and look at creativity, critical thinking and collaboration. That can be implemented in the UK curriculum in three ways. The first is having real-life problems that kids can work on: rather than having a maths, science or English class, can you bring in a real-life problem that a business is facing, and how do you get them excited that what they are learning is important and



HOUSE OF COMMONS

relevant? Secondly, a lot of kids, especially those from disadvantaged backgrounds, do not have role models. When I was growing up, I did not know there was a job called software engineer—I did not even want to be an engineer—but because I had a teacher who introduced me to computing, I became a software engineer. We have to take it as given that we cannot predict what jobs will exist. We have to ensure that we are preparing young people by having more touch points with industry and by giving them mentoring and opportunities to work on real-life problems.

Professor Luckin: I will answer both of those questions as quickly as possible. I am a parent and a grandparent, so I take that perspective. We absolutely need to get industry, academia and education all working together to get the best results. That is what we do on the EDUCATE project with our start-ups and SMEs. There are also great examples of trying to better tailor skills to the workforce, with organisations such as Founders4Schools really trying to tie young people into work experience with growing industries in their local area.

We should also not forget that we cannot accurately predict the future jobs, because we are likely to underestimate the amazing entrepreneurial skills of young people. They will start new businesses that we cannot predict, particularly if we give them the right foundations in school to be entrepreneurial, creative and innovative.

To answer your question about the curriculum, I agree with what Joysy has said, but I see that as much more about the “how” of teaching than the “what”. I think we need to move to interdisciplinary academic education. Big problems in the world are solved by disciplines working together. Why do we still teach within subject boundaries? We need to be far more interdisciplinary and we can do that. We need to do good social interaction, using methods such as collaborative problem solving, because social intelligence is a key skill for the future. We need to look at this business of knowledge. What is knowledge? What is evidence? What is the truth? When looking at interdisciplinary academic knowledge, we need to probe: why is that true? Where did that knowledge come from? How is it structured? We can use our AI systems to help do that. Take a knowledge base such as IBM Watson, which is constructed by a synthesis of human and machine learning. Why not have a version that is like a sandbox for teachers and learners to probe? Why is the knowledge structured like that? Where did it come from? Why does that piece of evidence back this particular fact?

Then we need to look at meta-cognitive abilities and skills, which we know we can teach. We need to look at self-regulation, which we know we can teach. Again, the kinds of methods that you are talking about, along with debating, are really good for developing these different intelligences. These are the ways that we need to look at the curriculum. We need to look at it much more from an intelligence-based point of view. We need to look at interdisciplinary knowledge, rather than disciplinary-specific knowledge. We need to look at what knowledge is and where it comes from. We need to ensure that we use our AI to help us in the delivery of

that curriculum and that our human intelligence then really gives that rich, social interaction that will prepare people for the world of work, because the simple truth is that we are not preparing them at the moment.

- Q16 **James Frith:** How important will lifelong learning and accessing lifelong learning be? How do we improve access to it as AI automation interrupts and disrupts our world? Particularly around the current workforce, automation poses the greatest threat to entry-level jobs. How do we ensure that those who may be facing job losses can be reskilled and trained to contribute further up the chain?

Brian Holliday: As part of the “Made Smarter” review, we identified that there are presently about 1 million workers in the UK who probably need to be upskilled in the near future, with regard to industrial digital technology. I do not think we are debating whether we should adopt industrial digital technology—if we don’t, we will fall behind and we will miss out on the fourth industrial revolution—but reskilling is one of those topics that, again, need policy instruments. It needs active intervention. Sometimes companies, such as mine, do the right thing. I feel that I have been consistently developed. Having started as an apprentice, I have gone on to work as a graduate and have been able to undertake a master’s degree and further study as part of my job. Where we are doing the right things and investing in the online platforms for training and learning, we want to be able to promote more of that, for policy instruments, and promote companies to do more of that.

But at the moment there is confusion around the role of taxation and spending in this space. It is not clear to employers whether, for example, the apprenticeship levy or other policy instruments could be used to fund in-work learning or retraining programmes as well. My sense is that we are at that point where, particularly for small companies that probably have more of a hand-to-mouth existence, there needs to be something structured that encourages people to work with an FE college or a university—not necessarily thinking about long-term study programmes—or, indeed, something that helps us as a big employer to do the right things in training, beyond our own commercial needs. But that needs co-ordination.

Joysy John: I think that lifelong learning is here to stay. With increasing automation at every level, people will have to upskill and reskill, so it is absolutely important. The question is: how do we ensure that we are providing people with access to it? There are three things we need to think about: from a learner’s perspective, an employer’s perspective, and a provision perspective—that of the person delivering the training. From a learner’s perspective, what are the barriers and the motivation costs, and how do you address those challenges? How do people in low-paid jobs take out the time to upskill themselves?

From the employer’s perspective, yes, it is an investment for the future, so they need to play a bigger role, and we need to move away from this notion of, “Let’s tax them and give them the money to train them.” If we made the case clear that they need to do this because it is in their best



interest—it is the right thing to do—and they are future-proofing their business by training people, and we maybe gave out awards to employers who were doing it well, showcasing best practices—

- Q17 James Frith:** Although, it is quite a well-trodden path that you are talking about. Do we not need a better injection of purpose to the individual learners themselves, who are then commissioning for themselves this future-proof notion? The levy is a great idea in principle but there is a huge drop in numbers. Employer take-up and the employer skills pilot—an absolute farce, with £350 million down the tubes. It was about putting employers in that space. Do you think we are enabling individuals to assess their place in this enough?

Joysy John: I think we are not doing enough. If you think about what the five barriers are, there is motivation, leadership, culture, infrastructure and access. There are all these barriers and we do not really think about solving that. Usually, when people think about upskilling they think, “Let’s create a new online platform where people will learn,” but for somebody who is having lots of challenges, just getting access to an online system is not going to solve the problem. We need to address these other issues before we get to the access bit.

Professor Luckin: I agree, but I think that the biggest barrier is mindset. I have been doing some work on the Topol review, which is looking at the NHS workforce, and we are rapidly concluding that what we really need is to have a learning mindset. People need to approach their job with a learning mindset, accepting that learning is going to be part of what they do throughout their life. It really is genuinely lifelong learning, so you need a workforce model that is built on a learning mindset.

If you look at the report from the all-party parliamentary group on artificial intelligence, “Learning to Learn”, they are saying that that is the most future-proof skill, because we need to be good at learning. It needs to start really young. You were asking about the curriculum for a particular age group; we need to start really young and give people the skills to understand, “Can I do this? How do I get to do this?” Again, we can use our AI to help us do that. We can capture data, and if we make sure that our teachers have good data literacy and good evidence literacy, they can then help our students to have that, so that they understand the evidence about their own learning.

- Q18 James Frith:** That is a really good point, and for systems designed from scratch I agree with many of the aims that you outline. First, however, I think one of the biggest challenges is to assess and reach those who are midstream in their career and who face the threat of automation because of AI. The concern is not that it will enhance their proposition at work, but that it will replace them.

Professor Luckin: And that is all about mindset and finding out the talents they have. It might be that they have been doing one job, but they actually have another skill that we have not taken advantage of yet. Perhaps they are really good at social interaction; perhaps they are more



HOUSE OF COMMONS

creative; perhaps they are more innovative. There is a company called Freeformers, which does an excellent job of going into workplaces and helping employers and employees to recognise people's skillsets and character traits—their value, if you like—in a way that is not restricted to their current job description.

I think it is about recognising a much wider spectrum of character, ability, skills and value. We tend to value very particular things, both in the education system and in the workforce, but that does not mean that employees, trainees and learners only have those things. It is really about extending that process. I would really encourage you to look at the work of Freeformers, because it is a very nice model for seeing how you can help people currently in employment who may be at risk of losing their job to feel more positive and have a more positive mindset.

- Q19 **Mr Wragg:** Good morning, everybody. We are having a wonderful philosophical discourse, as we often do in this Committee. As effusive and charming as Pepper and its kind may be, at what point will it be cheaper to use AI for certain employment? How on earth are we going to avoid some kind of Luddite protest about this?

Joysy John: The question should really be, "How do we use robotics, AI and technology to complement what humans do rather than replacing it?" I do not think that we can ever replace teachers in the classroom.

- Q20 **Mr Wragg:** No, indeed, but I think that job falls into the 30% of certain jobs that you mentioned. What about the 70% over which there is uncertainty? This is clearly going to change employment practices and jobs, as you say, but there must be a tipping point at which AI will be technologically sufficient and cheaper to use than people.

Joysy John: It is already happening. Companies such as financial firms and law firms are already using chat bots and AI to replace their paralegals because they are cheaper and faster—they do not get tired, and they work 24 hours when the machine is on. The question is not whether the person who was doing that job has lost it, but whether the job has changed. Have they gone on to do something more meaningful and useful that only a human can do?

- Q21 **Mr Wragg:** Do you have evidence to suggest that?

Brian Holliday: Yes.

Mr Wragg: Let's hear it.

Brian Holliday: It is already happening—it is too late not to embrace AI, robotics and industrial digital technology. The virtualisation of product design helps to bring products to market faster. The virtualisation of factory design helps to make better use of space or run a more optimal factory. That is all being aided by AI tools in much the same way as legal and finance practices. Increasingly, we are connecting sensors; we are instrumenting industry with sensors that go straight to the cloud. We have apps that derive new knowledge.



- Q22 Mr Wragg:** My question was about the people who were doing those jobs previously. Do you have evidence to suggest that they have been upskilled and are now doing different jobs?

Brian Holliday: Absolutely. In our factories—I will give Congleton as an example—we have grown our own talent. We have taken people who have worked on the shop floor in production environments into our i-factory and digitalisation teams. What is powerful is that when people with knowledge of the real world bring their interdisciplinary insight to solving problems with the digital tools that we are now able to give them, we have had tremendous outcomes.

It is partly driven by the poor availability of people with those skills, but if I think about Connor Bottomley in our factory, he was an apprentice shop floor worker and now he has a leading digitalisation role. Andy Lowe is on the shop floor, but he is a process engineer linking our shop floor to our enterprise level systems. It chimes with what Code Nation has been doing to take people with world-of-work knowledge and augment the skills.

- Q23 Mr Wragg:** With that Congleton example, are there now fewer employees on that site than previously?

Brian Holliday: No. This is the difference between automating for productivity and automating for cost reduction. If you do the right things and have policy instruments that reward automating for productivity, you have got to do that. That is why we have consistently delivered, certainly over the past few years, 8% productivity a year for a flat workforce. That means that they have been upskilled and they are contributing more. The question is whether people will do automation for cost cutting or automation for productivity.

Chair: Thank you very much indeed.

- Q24 Lucy Allan:** I have one quick question. Joysy, I want to quickly follow up on something you said in your opening remarks. Is AI going to level the playing field when it comes to inequality and social justice, or will it entrench disadvantage? What can we do to stop that?

Joysy John: That is a really interesting question. It really depends on how we use AI. On the one hand, you could say that schools that cannot afford high-quality teachers will start using AI, making social inequality worse. On the other hand, you could say that AI is such a powerful tool that if it is used correctly, it could be used across all schools because it makes the learning process more personalised and more efficient, thereby freeing up time for teachers to build skills such as creativity, problem solving and critical thinking in young people. What we need to be aware of is whether we are doing anything to address the huge diversity gap in AI. Are we doing anything to address the training needs? If we can do that, AI will be a force for good.

- Q25 Emma Hardy:** This relates to a previous point. A lot of what has been said about the learning mindset worries me a bit, because the emphasis is always put on the individual to have the right mindset, rather than



HOUSE OF COMMONS

there being awareness of the environment in which that individual finds themselves. I would like to emphasise the points that Joysy made when she talked about the five different barriers. We talk a lot about the learning mindset, and it worries me that it is almost like saying, "If you have not achieved and adapted to AI, you have got the wrong mindset", rather than there being an awareness of the barriers around someone. To build on the point that Lucy just made, how can the education system use AI to help make the world more socially just?

Professor Luckin: I think it is the responsibility of society. I do not see the mindset piece as being about the individual. It is our responsibility to ensure that we do that right from the start and that if we have not, we put that right. I absolutely agree. It is a much richer thing, and it is our responsibility to do that. In answer to the social justice point, I genuinely believe that if we get it right, it could be a huge force for social mobility and addressing many injustices. We can help people value skills that we have not valued before. The point about cost is: what do we value? Do we value the amount we spend on teachers, given that they might leave the profession? Do we value the amount we spend on students, given that they may not be ready for the workplace?

The big challenge is ethics, and at the moment none of the Government initiatives focuses enough on the ethics within the technology, AI and robotics and in education specifically. That will drive social justice. If we get the ethics right and design the right principles and frameworks, the systems we design will be designed to try to engage diversely with diverse workforces, but with systems to ensure that everyone in society can benefit across all the diverse populations we have. It is an ethical issue that we really need to focus on. Interestingly, that was the primary focus of the House of Lords report on artificial intelligence.

Brian Holliday: May I make one quick point from the employer's perspective? Curiosity is something we have tried to encourage in our engagement with schools, but we are also encouraging our workforce to stay curious. The learning mindset is incredibly important. I would challenge myself to stay relevant at a time of almost constant change. One thing we can predict is even more change in future: the acceleration of technology and its impact on our lives.

In terms of social justice, one of the things that we could do is emphasise even more in education the pathways into apprenticeships—routes that are more inclusive fundamentally because of their geography and their learning and assessment styles. We really value as employers apprentices who come to work for us—575 of them in our system this year. That, to me, is a much more inclusive route to bringing people into the world of work. Of course, some of them are deeply immersed in technology such as robotics, AI and cloud, the things that they are very quickly contributing back into our organisation.

Joysy John: I absolutely agree that it is not just the learning mindset of an individual. The environment matters. What matters more is the opportunity. If there is bias and if people do not have the opportunity and



HOUSE OF COMMONS

the confidence, the problem will persist, so what can we do to build social justice? You need a local partnership for AI in education and in business. You need to bring teachers, technologists and learners together. Learners, teachers and employers need to be at the heart of this conversation.

Chair: Thank you. We really appreciate it. This will be an important inquiry. We will have a short two-minute break. I remind the public that no photography is permitted during the hearing. However, there will be an opportunity to take photos with Pepper after the session.

Lucy Powell: Or with Brian, or Joysy or Rose.

Examination of witnesses

Witnesses: Pepper the robot, Professor Martin Loomes, Joana Da Cunha Miranda, Nicholas Fitton and Babak Jahanbani.

Q26 **Chair:** I would like to give a particularly warm welcome to our second panel of witnesses this morning. It has attracted an unusually high level of interest for our Education Committee, and we have been asked quite a lot of questions about why this evidence session has come about. The first thing to say is that this is not the House of Commons Education Committee auditioning for the sequel to "The Matrix". I visited Middlesex University—a wonderful university—a few months ago and was incredibly impressed by what the staff and students were doing. I thought that it was a great opportunity to showcase their work and that of Pepper as part of our inquiry into the fourth industrial revolution and skills.

Pepper's appearance today is just one part of our inquiry, which is looking into the implications of technological change on what should take place in the classroom. I want to thank the staff and students from Middlesex University and across the House of Commons Service for making this morning's event possible. Pepper, could you please introduce yourself?

Pepper: Good morning, Chair. Thank you for inviting me to give evidence today. My name is Pepper, and I am a resident robot at Middlesex University.

Q27 **Chair:** What is your role at Middlesex University?

Pepper: Another robot similar to me, but with a different software, is part of an international three-year research project called CARESSES, which is jointly funded by the EU and the Japanese Government in the Horizon 2020 research programme. CARESSES is developing the world's first culturally aware robots, aimed at assisting and caring for the elderly. Assistive intelligent robots for older people could relieve pressure in hospitals and care homes, as well as improve care delivery at home and promote independent living for elderly people.

In order for robots to be more acceptable to older people, it is essential that they can be programmed to adapt to diverse backgrounds. The



HOUSE OF COMMONS

project will expand my capabilities and aims to reduce pressure on healthcare services. It also has the potential to boost independence, reduce loneliness and improve the quality of life among elderly people.

Q28 **James Frith:** Pepper, how have you been helping Middlesex's outreach work?

Pepper: I also play a major role in Middlesex University's STEM outreach activity. For example, in September I worked alongside 94 Middlesex University staff and students at the New Scientist Live exhibition. I met hundreds of young people there and helped to get them excited about the future of technology and science. We also have an annual STEM festival on campus for students, parents and the whole community. At Middlesex we put a lot of effort into engaging our students with their discipline in an authentic way. We give them the opportunity to translate their work to a wider public through STEM outreach work.

Q29 **James Frith:** What is the role for humans in the fourth industrial revolution?

Pepper: Robots will have an important role to play, but we will always need the soft skills that are unique to humans to sense, make and drive value from technology. As technologies fuse and are used in ways that were not envisaged before, a new way of thinking is needed by tomorrow's workers. We will need people who can spot ideas and think across traditional sector divides to drive value from technological innovation.

Q30 **James Frith:** How can robots help students learn in the classroom?

Pepper: At Middlesex University, I work closely on projects with final-year students from robotics, psychology, biomedicine and education. Students program me to engage with audiences from a range of environments and social settings. For example, Joana and I are working together to adapt my interfaces to work with primary school children with or without special needs to develop their numeracy skills. Joana can give you further information about this project.

James Frith: Thank you, Pepper.

Chair: I think we should give a round of applause to Pepper and the students. *[Applause.]*

James Frith: Do I not get a round of applause?

Q31 **Lucy Powell:** First, Pepper, you are better than some of the Ministers we have had before us. Perhaps the university students can tell us about the work you have done working alongside Pepper and how you develop your skills in doing that.

Joana Da Cunha Miranda: Pepper is extra-curricular to our course, but is there for everyone to learn. We use her a lot for events, such as STEM festivals, New Scientist Live, WorldSkills show, to promote STEM to the public and especially to children because they are obviously very interested in Pepper.



HOUSE OF COMMONS

During the summer I have been working on this project so Pepper can start to go into primary schools and teach little kids how to do simple maths, such as counting one to 20, shapes, simple multiplication or simple summing, just to see if it is more interesting for children and if they are more interested in the subject when they have something completely new than just doing it with the teacher or with games on the tablet. We are going to test that very soon, but I have tested it with my cousins and they enjoyed it very much.

Q32 Lucy Powell: Are you computer science students?

Nicholas Fitton: I am a computer science student in my third year.

Joana Da Cunha Miranda: I am studying robotics engineering and am in my third year too.

Q33 Mr Wragg: I refer this to the rest of the panel. You were talking about the maths programme that you are running in primary schools. Does it extend beyond computation to problem solving and critical thinking? Where are we up to in terms of the technology to achieve that?

Professor Loomes: Technology is difficult because of the term AI. When I started a long, long time ago in the computing industry, AI basically was used to mean anything that was too hard to do. For example, computer vision was artificial intelligence; speech recognition, speech synthesis, object recognition—all the things we now take for granted on our mobile phones—was all AI, so it is a moving target. One of the things that people often forget is that AI is not something that is going to happen; it is something that will develop, because we will constantly rename something AI when we want it to happen.

The comment was made in the earlier panel about whether we will still need computer science. It is a very interesting question, because of all the subjects, computer science is probably the one that will go on forever because the more imagination you have, the more things you think to do with computing and the more computing changes.

In terms of where we are with the technology and what we can do with Pepper in a school, there are all sorts of areas where we could work. A lot of it relates to what sensors we have, what sort of things we want to do, how invasive we want to be. We could, for example, start using brain computer interaction to collect data. Do we want to do that? I am not sure. That may be a step too far. I think there is a whole rich tapestry out there of things we could do. What we do and what we end up doing should be driven, quite rightly, by educationalists and teachers.

Q34 Mr Wragg: With that in mind, are there any particular skills that teachers need to develop?

Professor Loomes: I put my cards on the table: I started my career as a maths teacher, so I have been there and thoroughly enjoyed it. The skills that teachers need, going forward, will be the same skills that the students need, which is agility, flexibility and so on. They need a framework within which they can do those things.



Q35 **Mr Wragg:** Do any other members of the panel wish to add to that?

Babak Jahanbani: Some time ago, I was asked to go to a college in north London and talk about integration and differentiation to a group of youngsters who could not care less about maths, just to motivate them. It had been 20 years since I studied those and, to be honest, I could not even spell them, let alone talk about them. So I said, "Can I just do it my own way?" We took some equipment, which runs on compressed air, so we had to look at force and area and pressure. The fact that we could relate these three things on working equipment and show that in order for this machine to work, you have to work out the force, the pressure and you have to work out the area of the circle. Then, they had to look at πr^2 and the majority could not even raise it to the power of two. It was then that they realised it is a skill.

Basically, we managed to put maths into the context of an industrial example and then, within that, they had to look at percentages. Again, none of them could do it, but the fact that it was there—they could feel it, they could touch it, it was a real example—made a massive difference. We went from not having any interest in the beginning to almost not being able to ask them to leave.

Q36 **Mr Wragg:** Does that take it beyond a gimmick, perhaps, if you were to say it is not just a means of engaging students? Is there a deeper level of learning to be had from it?

Babak Jahanbani: Yes, I would say. If we could make a lot of subjects practical and show the students what we are getting at and simplify it, there would be a lot of mileage in that.

Professor Loomes: Just as a quick follow-up on that, there is a really important point about Pepper and other devices and gimmicks—are we happy with the word "gimmick"? The notion of embodied learning and the work of people such as Papert and Montessori means tactile learning is now a very interesting area, because modern technology allows us to do things that are tactile with sensory feedback in ways that, 25 or 30 years ago, were quite tricky, when Papert first suggested them.

Q37 **Chair:** Give us an example of how that would work in practice with students.

Professor Loomes: For me, and for the way we work at Middlesex, we take the problem as prime. The problem is where the interesting learning will take place. We work from problems. We want students to be able to relate to problems. What Papert did with mathematics, for example, was to say that rather than mathematics being abstract—up here—let's put the student in the place of mathematics. Shape becomes something you walk around, something you touch, something you move around. With our maths students, for example, we do an awful lot of model building with real physical models to help them understand multi-dimensional spaces. That tactile notion—the ability to take something, touch it, sense it, feel it—is really important.



HOUSE OF COMMONS

What Pepper does—thank you, Pepper—apart from having face recognition, so it will engage, it will turn and look at you, is that it allows us to say there is software in there. For many people, computing is something you do at a keyboard with a screen. For our students, I hope that is not the model at all. Computing is not about typing things on a keyboard and having a screen. It is about your driverless car, your fridge, your shopping system, Google, your phone, your camera. With the fourth industrial revolution—we are working closely with Festo and Siemens—it is about putting productivity up into the cloud. What does that mean? We have not really worked that out yet.

- Q38 **James Frith:** But that approach—which, as you described in a really eloquent way, is affirming and celebrating—seems to be at odds with the social policy running throughout our primary to HE curriculum, doesn't it?

Professor Loomes: Yes. I have to say that I struggle with things such as the removal of practical work in science as a decision to help people do practical science in industry.

- Q39 **Chair:** Do you think our A-level system is too narrow and that you should possibly have a baccalaureate at the age of 18, where you would move to doing GCSEs at 18 and have everyone doing all subjects, science and creative?

Professor Loomes: I wrestle with this, because I think there is a role for disciplines and for subjects. Equally, you have to ask whether disciplines still exist. What is the distinction between neuroscience, biomedical science and mathematics? The genomics project largely involves a lot of clever mathematicians and computer scientists working with biologists and other scientists to do interesting things. I am not sure that it helps students to understand the world if we say, "Do that, do that, do that, don't do that," and then do a three-hour exam.

- Q40 **Lucy Powell:** Just to be clear, earlier when we were talking about computer science I did not mean that computer science would be obsolete; I meant that the current curriculum is fast-moving and I was questioning how we do that. As a university, is it your view that the direction of travel of our curriculum—towards strongly academic rote learning and knowledge-based individual disciplines—is the wrong direction of travel to meet the AI challenge?

Professor Loomes: For me, yes, absolutely. That does not mean that there is not a role for people who are very clever intellectually as well, but it certainly is not, for me, the overarching paradigm that works.

- Q41 **Lucy Powell:** Some people have said to me that, with AI, what we need is not more people who are programmers and more computer-literate, but people who have the creative skills and the psychology know-how to bring that into the mix about how AI can be better absorbed.

Professor Loomes: But it is not an either/or situation. You need that spectrum of skills. You need computer programmers to understand psychology. Take cyber-security as a classic example. Considering cyber-security as a purely technical discipline, you develop wonderful systems

but forget the fact that most people still put their passwords on a Post-it note on the fridge door. If you do that, you are not tackling security.

Babak Jahanbani: You mentioned the baccalaureate. I came to the UK in 1983, as a youngster, from a background of doing 12 to 14 subjects in one go to having to choose three. At the time this was A-levels, and still is. I was then introduced to the baccalaureate, which made life easier for me because I managed to do science on one side and business, economics and languages on the other side. It was a nice, enriched balance of different subjects. Funnily enough, both my children ended up doing the baccalaureate—that was nothing to do with me. They have done quite well out of it, again because of the range of subjects available to them. In the context of industry 4.0, that is very relevant. We are now talking about a technology that cuts across many disciplines—not just engineering, but also IT, business and others. It has an impact on that.

- Q42 **Chair:** Just before I pass over to my colleague, would you include that expansion at university as well? Rather than doing just a politics degree, for example, as I did, would you say that degrees should have much wider subjects, so that people could concentrate on a particular subject, but would have to do other ones where there was a deficit?

Professor Loomes: I think I would turn that model around and say, “Why should a university, or even a society, decide what someone should be taught?” We should look at what problems we need to solve. If, for example, politicians need to solve complex big-data problems, then I would argue that politicians probably need to do some data science. That should come out of the problem. It should not be a question of, “I did a politics degree.” I have a history degree as well as a maths degree, so I do have some sympathy with these various subjects. You can see the synergies. As you get older, you start to see that—for me—history is about making sense of quite complex data. In many ways, it is not that different from computer science. It is about making sense of data in complicated scenarios. That is what we need people to start doing at a much younger age. Hopefully that is what our students start to do.

- Q43 **Thelma Walker:** Could I take us back to the classroom and the role of Pepper? As a former teacher, I know—it goes without saying—that Pepper would be a massive hit for every primary school child. We talked earlier about the barriers to the use of AI for professionals. Putting myself back in that classroom as a teacher, in the morning I have 34 children and have to consider differentiation, planning and preparation. What skills will I need as a teacher to work with, use and employ Pepper in the best way for the children and the delivery of the curriculum? Nicholas and Joanna, how easy is it for teachers, or what barriers will teachers have to overcome? What skills will they need to know and learn to be able to deploy so that Pepper does not become a toy?

Joana Da Cunha Miranda: The way I did this project is that Pepper is very independent, so she will not need much guidance, touching or anything. The teacher is there, obviously, to help the students and Pepper is just a tool for the teacher. Pepper is not going to take the teacher’s



HOUSE OF COMMONS

place; she is just another tool to make sure that the learning is interesting.

- Q44 **Thelma Walker:** Could I suggest, though, that that tool could be another challenge for a teacher in the morning?

Joana Da Cunha Miranda: Oh yeah, it will be a challenge—as is anything that is new to any place. That is why we are going to do some tests and see how it works; but it will definitely be a challenge. If the children are really interested in the subject—

- Q45 **Thelma Walker:** It enriches.

Joana Da Cunha Miranda: Exactly, it just becomes a flow between teacher and Pepper—or another robot; it is a chance to enrich the environment.

- Q46 **Thelma Walker:** Are there any other comments? Professor?

Professor Loomes: I can see so many challenges, such as classrooms with steps in them or carpet—Pepper will fall over; the network almost certainly won't work. There will be all those challenges. However, I would also say that, possibly not in early years, but certainly by levels 5 and 6, there will probably be children in the room who say to the teacher, "Actually, I'll re-programme Pepper for you." I think you will find that the children become a resource. I would struggle, now, going into a classroom with Pepper, because I would have to get my head around the technology. I don't do that; I have students who do that. They can say, "Oh yes, just link it to my phone and do this, or do that." So I think Pepper will become part of the learning community, if we allow it to—if we allow control to move from the teacher to the classroom a little bit more, with all the problems that poses.

Babak Jahanbani: The teaching that Middlesex offer is very practical and skills-based. I have had the pleasure of recruiting two graduates from Middlesex and one graduate and assistant instructor. Technologically, they are at a different level, especially with industry 4.0, because we have many learning systems at different colleges and universities. With these systems you need in-depth training. Unlike previous systems, if something plays up or goes wrong with these, you really need to know what technology there is and how to tackle it. These guys have been quite an asset and have taken our business to a different level, not just on the technological side but also with a business-minded approach to customers. Although I am part of a large company, I only have a team of four, so when these guys go out to see a customer, they have got to be 100% focused and representative of the company.

- Q47 **Emma Hardy:** Thank you. A couple of things before I come to the question. I was really interested by what you were saying, Professor Loomes, about starting with the problem. I was listening to a speech just the other night by Professor Sugata Mitra. He was talking about SOLE—that is, the self-organised learning environment—about how he uses computers and technology, and how he starts everything with the



HOUSE OF COMMONS

problem. He was arguing that, by using computers, people can find the solution to any problem. He posed a problem, which I thought was incredible, to a group of young people, which was: "Can you be in two places at the same time? Go and find out". The answers that the children came back with were remarkable. I find that really interesting—in the space of a few weeks I have had two professors from different universities telling me the same thing: start with the problem.

I want to talk particularly to Joana and Nicholas and ask what you think are the key skills that students will need in the future. Do you agree with the professor that you should be starting with the problem, rather than individual subjects?

Nicholas Fitton: I can only really speak from experience. As a computer science student at Middlesex, I have been taught to be as diverse and adaptive as I can be. In my second year, for example, we learned about the fundamentals of web development and such like, but they expect you to be able to roam into wider territories than that—things like blockchain, AI and robotics.

I feel like I came to use that adaptiveness when I did my internship last year. I was introduced to a blockchain project, which was something I had never done before. I was just asked to figure it out and learn as much as I could and try to be interactive in that project. I ended up being fairly fundamental to that project. I ended up contributing quite a bit, not because I knew blockchain already, but because I had been taught in a way that helped me to adapt quickly to a new situation within what I understand.

Professor Loomes: If I could add a quick comment to that, one of the problems was that Nick became so important to the company that they didn't want him to come back and finish his degree. That would have been a disaster for us, ironically, because it would have hit our continuation. There is an issue here around progression. Fortunately, Nick has come back, but the company is still paying him and has offered him a job.

Nicholas Fitton: Yes, I am still working a day a week for that company and I have an offer for after university as well, because they were so happy with the fact that I worked less as an intern and more as a part of the team. They really appreciated that.

Q48 **Emma Hardy:** What about you, Joana? What are the key skills that you think students will need in the future?

Joana Da Cunha Miranda: Definitely problem solving, definitely being able to be autonomous and, as Nick said, being adaptive to the situation, because the magic of technology is that you never know what is to come. You never know what people are going to think of or develop. With that, you never know the problems that are going to come. As Nick said, we don't know what is coming, but we know that we have the skill to go there and explore and be okay. We will know what to do and how to solve that situation.



HOUSE OF COMMONS

In my course, there is a lot of autonomy. In one of my projects last year, we had to create a self-balancing robot. During the first year, we had some basic classes on the programming language that we were using, but as you can imagine, a self-balancing robot is something much more advanced. With that basis, our teachers and lecturers just give us the wings to go and explore. We have to do it by ourselves, so we have to be very determined in our studies.

- Q49 **Emma Hardy:** The big question is how prepared you were at school for going to university and doing the course in the way that you have just described.

Chair: Could I add to that? Did your school ever encourage you to use those skills and subjects and technology in that way?

Joana Da Cunha Miranda: I didn't study here.

- Q50 **Emma Hardy:** You can still answer; explain where you did study.

Joana Da Cunha Miranda: I studied in Portugal. I am originally from Portugal. My high school was very academic, as academic as you can get. There were mini-quizzes every week, tests every other week and exams at the end of every term, with nine books per exam—it was just kind of putting the knowledge in and forgetting everything the next day. I relate much more to the teaching here, because I actually learn. In my high school, I just kind of memorised everything and then the next day, I was like, "Cool; I don't need it any more, I need space in my memory for my other exam." Here, because we work on it ourselves, you really get the knowledge.

- Q51 **Emma Hardy:** What about you, Nicholas?

Nicholas Fitton: In my A-levels I did computing, and for the final project of the year we were told, "You decide what you are going to do. Provide a decent proposal for it and we will allow you to do whatever." That gave me one of the starting points for learning about exploring. Instead of just being given A and doing A, it was about looking out, seeing what I could do and attempting to do something like that. For A-level that was good experience of exploratory learning, but with subjects such as maths there is obviously a strict curriculum and, as Joana said, you will learn something, remember it and then regurgitate it. You are more than likely to forget it afterwards, because it is less of an experience and more of a task.

- Q52 **Emma Hardy:** Could there have been a better way to prepare you for university? What would you recommend should happen differently to better prepare you to work in the way you need to work?

Nicholas Fitton: I feel that rather than being prepared for university, jumping in to university—I would not say "thrown in"—and having different experiences was very good for me, because it helped me realise that life is not just "do task"; it is learning new things and exploring. That has helped me in this next step, jumping from university into work. I



HOUSE OF COMMONS

cannot think of anything that I would change about my A-levels, with regard to bridging between them and university.

Professor Loomes: Might I just add something? One of the challenges that I think we face at Middlesex is the self-esteem of students. It is a real challenge for the universities, which are not in the elite Russell Group, where the students who go in tend to have success behind them. They are successful and they think they are successful. We are often working with groups of students who have kind of built up a culture in which they are probably not going to succeed in things, so they don't really want to take risks.

We are very deliberate in throwing our students into quite difficult situations. We took 90 students to New Scientist Live, which is a big exhibition in ExCel. It is like coming in here, really. We walked into this room and saw the pit, and Joana and I looked at each other, and I went, "It's your problem," because that pit is a trap for Pepper. We took 90 students to a blank, huge arena and said, "Okay, there will be 80,000 visitors coming around in about four hours, so get on with it." That really does build teamwork, but it also builds self-esteem. That is a real challenge for us.

That is what we have addressed through our problem-based learning. Not every student gets there—not every student is a Joana or a Nicholas—but we try to help them to get to the position where they go, "Yes, I can do that. Yes, I can take risks. Yes, I can try things." That is the biggest cultural difficulty for us.

- Q53 **Emma Hardy:** If that is the case—I agree with you that there is a problem with self-esteem for many students—what do you think should change in schools?

Professor Loomes: Some of the things that were said in the last session are really quite relevant. If you give a performance indicator-based approach to education, where you are telling everyone that if you have not done that, you have failed—teachers, schools, pupils and parents are all failing—it is not surprising that everybody looks at failure as a fairly common thing, as opposed to saying, "Oh, it's great; you have failed. What have you learnt?" We have not got that learning culture.

- Q54 **Chair:** Would you change careers advice in schools?

Professor Loomes: The very first job I was given when I started teaching was to take a module on careers advice as a new graduate, and I think it is bonkers. I honestly do not know how careers teachers do it. I think careers teachers are in a very difficult position, because I do not know what careers are, looking forward. I do not think anyone can guess what the careers will be. I think we still have a model in which there is a career called "engineer," but I am not sure that there is anymore. I am not sure that these days those careers are necessarily mapped out in that way.

- Q55 **Chair:** Joana and Nicholas, there are not enough students like you in our country, doing what you are doing, and particularly not enough women in

STEM subjects. What would you do to change that?

Nicholas Fitton: I would do what Middlesex tries to do, which is to get lots of exposure. The majority of students who come to STEM are female, because we are trying to push the idea that we totally want women in STEM. That inequality needs to be chopped, because we perform just as well as each other—the outreach is about showing that it is not just blokes in a dark room; it is a wider experience than that.

Joana Da Cunha Miranda: It is a lot about breaking stereotypes. There is the big stereotype that engineers are middle-aged, semi-bald men working in a room without windows for hours straight, that engineering is just glasses and a laptop, but it is not; engineering is so much more. We as a university should be able to show that. When we do these outreach programmes, I have so many girls coming to me to ask, “Isn’t it weird just being in the middle of boys?” or, “Do you have any more girls?” I say, “Well, I will do if you guys come to study engineering.” They sound genuinely interested in the matter—just like me. We perform the same. We girls are just as good as boys are; it is just the stereotype and the stigma.

- Q56 **Chair:** I hope that many young people watching this will be inspired by both of you in particular. We will conclude with a couple of important questions. This one probably applies to both of you. What do you think needs to happen with adults reskilling and upskilling their occupations and knowledge, given the arrival of the fourth industrial revolution? Furthermore, what do you think will be the impact on lower-skilled adults and what should we be doing about that?

Professor Loomes: The lifelong learning question is a tricky one. The term “mindset” came up earlier, but I think I would push it up a bit to a higher level than that and say that is cultural. We have an acceptance that ignorance is to be celebrated. As a mathematician, I get very tired of hearing people in the media saying, “Oh, I could never do maths,” as if that is something great that we should all love, or, “Well, I never wanted to be an engineer—dirty stuff!” I don’t know how we do it, but we need to get a culture that says, “Of course you carry on learning.”

Some countries have that, where the idea that you carry on learning all your life is not something that sets you apart and makes you a bit geeky and nerdy; it is just obvious, whether what you are learning is parenting skills, or grandparenting skills—which I am discovering are very different from parenting skills—or how to communicate with people across different generations and different cultures. We have a very diverse student body, and I have learnt so much from working out how I teach Chinese, Indian and Portuguese students all in the same room. Nothing prepared me for that in my teacher training.

That is the primary thing that we need to change. If we could do that, we would develop a hunger for lifelong learning and it could be embedded. People would embrace it. If we have an attitude of, “You need to be



HOUSE OF COMMONS

retrained because if you're not good enough to do what you do, that's your problem", I think we will never win. What was the second question?

Chair: It was about social disadvantage.

Professor Loomes: That is a difficult one, because it is far from obvious that the jobs that we lose will be the jobs at the bottom of the tree, so to speak—though I hate that term—partly because of the economic questions. It is simply not worth putting in a computer to do a job for which you can take on someone on a minimum wage on a zero-hours contract; it is cheaper to keep a person on to do it. I think we have not yet really understood what technology will change. It is quite likely, for example, that brain surgery might be—

Q57 **Chair:** Some things that I have read suggest that worldwide 1 million jobs in McDonald's might go—even now it is not just the service, because the burgers can be made by artificial intelligence.

Professor Loomes: Yes, absolutely. That is perfectly possible, but the question is: will McDonald's invest in the infrastructure and the technology to do that, or will it perpetuate? I am not sure which has the better outcome, to be honest.

Babak Jahanbani: For us, obviously the very nature of industry is forwards because it is very much evolving. We are not quite there yet with a lot of technology, so it comes down to lifelong learning, even for the upskilling of the existing workforce. It requires close collaboration between FE and HE to produce the right technicians and engineers. One of the great institutes to bring in young graduates for this are the UTCs, which we are very supportive of. I have the pleasure of being a governor at UTC Sheffield, which is one of the very successful ones. It is unfortunate that the trend now is just to say how bad they are, but I am 100% against those reports.

We are a sponsor of WorldSkills UK, which you are obviously very familiar with. That is an ideal platform venue to get students and teachers involved. I do a lot of STEM events and we go to a lot of exhibitions. It is not so difficult with primary kids and their teachers because, by their very nature, they love asking questions. In fact, they like to outdo each other in asking questions, and the teacher goes along with that. It is just so rewarding to talk to them. You come to secondary schools and the first person to walk away is the teacher because he is trying to ask a question in case he is perceived as not knowing the latest technology. With that, the students all disperse.

At the skills show, we get about 70,000 or 80,000 students who walk through the NEC over a three-day period. If they come from a college, they are fine. If they come from the UTCs, they seem to have an agenda of what to look for, but if they come from schools, half of them are just there for a day out. There are large employers there; it is not a joke to have BAE Systems and Jaguar Land Rover—you name it, they are there. These are the giants of industry. If the teacher spends some time with



HOUSE OF COMMONS

them, to say "Go and talk to them and find out what are the latest skills, what you need to do and what are the job opportunities." There should be some mechanism so that these youngsters come back with some valuable data, but unfortunately it is not there.

Q58 **Chair:** First, thank you to the humans on the panel, especially the students. As I understand, this is the first time that we have ever had a non-human appear before our Committee, although a lot of people in the media may argue otherwise. Thank you for coming today, Pepper.

Pepper: Thank you very much for an interesting discussion and for the opportunity to give evidence to the Committee today.

Chair: Thank you. *[Applause.]* And well done to Middlesex, which is a wonderful university.