HOUSE OF COMMONS

Education Committee

Oral evidence: Fourth Industrial Revolution, HC 1007

Tuesday 11 December 2018

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Watch the meeting

Members present: Robert Halfon (Chair); Ben Bradley; Marion Fellows; Trudy Harrison; Ian Mearns; Lucy Powell; Thelma Walker.

Questions 59 - 121

Witnesses

I Sir Anthony Seldon, Vice-Chancellor, University of Buckingham, Professor John Baruch, Director of the Centre for Education for the Fourth Industrial Revolution, Leeds Beckett University, and Professor Mary Stuart, Vice-Chancellor, University of Lincoln.

II: Simon Peyton Jones, Honorary Professor of the Computing Science Department, Glasgow University, Duncan Baldwin, Deputy Policy Director: Standards, Association of School and College Leaders, and Professor Danaë Stanton Fraser, Professor in Human Computer Interaction, University of Bath.

Written evidence from witnesses:

Association of School and College Leaders

Centre for Education for the 4th Industrial Revolution, Leeds Beckett University

Examination of Witnesses

Sir Anthony Seldon, Vice-Chancellor, University of Buckingham, Professor John Baruch, Director of the Centre for Education for the Fourth Industrial Revolution, Leeds Beckett University, and Professor Mary Stuart, Vice-Chancellor, University of Lincoln.

Q59 **Chair:** Good morning, everybody, and thank you very much for coming. For the benefit of the tape and those watching on the internet, could you kindly introduce yourselves and your titles?

Professor Baruch: I am John Baruch. I am the Director of the Centre for Education for the Fourth Industrial Revolution at Leeds Beckett University. I also work with Tsinghua University in a similar centre in Beijing.

Professor Stuart: Hello, everyone. My name is Mary Stuart. I am Professor of Higher Education Studies and Vice Chancellor at the University of Lincoln. I lead a project on the 21st Century Lab, which is looking at education policy in the 21st century.

Sir Anthony Seldon: Good morning, everybody. I am Anthony Seldon. I am Vice-Chancellor of the University of Buckingham. I have run schools for three to 18 year-olds and now I am running a university for 18 to 87 year-olds. I have a span of interest in education all the way through. I wrote "The Fourth Education Revolution" and I founded the Institute for Ethical AI in Education.

Q60 **Chair:** Thank you for coming. I will start off by asking: is our education system fit for the fourth industrial revolution and the march of the robots?

Professor Baruch: I think the answer is very clear that it isn't. Exactly detailing how and why is more complex because it involves personal confrontations with what it is doing. What we see is that most of the rest of the world is going in the opposite direction to us. What we need to do is to prepare our young people, and our older people, for the sort of world that will produce wealth and that, in many people's view, is innovation with the sciences and technologies that are available, building on the explosion that is taking place in those sciences and technologies. In order to be innovative and creative, you do need things that we call hands-on, building models, doing things like that, and you also need practical science. There is quite a number of other things you need but those are the basis of it. Also you need project work.

All those three things are being eliminated from our school curriculum, or made very difficult for our schools and schoolteachers. To answer your question, most of the rest of the world—and what I see in the rest of the world, certainly in the world that we met at the first "Education for the

fourth industrial revolution" workshop that we organised in Beijing—is going in the opposite direction to the UK.

Professor Stuart: I don't think it is fit for purpose, in the sense that we still have this very unholy divide between academic and vocational. That seems to me to be really unfortunate because so much of technological advancement is highly skilled and very developed, and the notion that somehow vocational is lesser is not helpful. We need to consider better permeability between different sectors.

Also we need to consider better permeability between the world of work and education. That is something that we are absolutely passionate about at Lincoln. We work with employers all the time and it is the employers who are helping us redefine our curriculum to ensure that we are meeting the needs for the 21st century. Yes, it is AI and robots but also the challenges that big data and the cloud and the fog present to us and, alongside that, how various forms of AI are integrating with each other, because that will completely transform our industry. One of our major partner organisations, Siemens, has several factories that basically do not have any human beings in them at all. The AI, the robots and the algorithms control the production of products completely. That is the kind of scale of change that we are seeing.

I don't think we yet within education—although there are positive signs, such as the potential of institutes of technology, which I know are out at the moment that people have put in bids for. There is potential in T qualifications, but there needs to be more integration between the different sectors to ensure those T qualifications are meeting the needs of the 21st century.

Sir Anthony Seldon: I acknowledge and agree with the very considerable expertise and wisdom of my colleagues John and Mary. We are miles off the target here in this country. I write about government. I am the historian of the Cabinet Office and Downing Street. I founded the Institute of Contemporary British History. Let me tell you very clearly: the British Government understand, to some extent, AI in transport, retail, health sciences and other areas, but they do not begin to understand the impact of AI, for better or worse, in education. They simply don't. Why don't they? They don't because they are focused on the short term, on the deliverable targets of Ofsted reports and A-level results, which by the way is a very good thing. Exams are really important but they are not all important.

Our DfE officials, our Ministers, our education establishment are in hock to an ideology that is so all-pervasive that they do not even see what it is. They think that this stuff is all going to be a long way in the future. They are not looking at what is happening in California, in China, as John was saying, in Uruguay, for example, where Rose Luckin is currently. They are simply not there and they think that they are doing a good enough job. They are not. They are not doing a good enough job for

employment, as John was saying—the jobs that these young and not-so-young people are going to go on to do. They are not doing a good job with their mental health. One-third of young people are coming out of schools with some kind of mental health problem. They are doing a bad job for the one-third who are failed by the system at the moment. That is not the failure of the children and young people; it is the failure of the system that will brand them failures for the rest of lives.

To cut to the chase, if we use AI it will educate people much better for the jobs that we need to have, which will stress the human skills alongside the algorithmic skills, the sequential skills, which exams are testing people for. It will help them to live with themselves and be better members of society and better members of families. It will help them to find more meaning in their lives. We have an education system that is full of well-intentioned, very hard-working, very sincere people who are not paid a lot of money for very tough work, and I salute them. We need, however, to recognise—and I am so glad you are talking about this—that we need to change.

We need to start embracing this tsunami coming towards us. If we do not get on top of it, it will infantilise our children and it will be the big tech companies that will make a lot of money. It will strip the heart out of our schools, out of our young people, as Amazon has done to our high streets. A small number of people will make an awful lot of money and it will rip the soul and the meaning out of what it means to be fully human. I am so glad you are talking about this.

Q61 **Chair:** When you say in your book—a very good book, I might add, one of my favourite books—

Sir Anthony Seldon: It says that Rob is a utilitarian.

Chair: It does, which I regarded as a compliment. What you argue for is that we need to teach different kinds of intelligences: practical intelligence, emotional intelligence, creativity. How does that work in practice in our schools? What would you do to change the curriculum, the syllabus? I know you say AI is going to do some of this but how would it work in practice?

Sir Anthony Seldon: At the moment, because we have a third education revolution model, we are having to spend 80%, 85% of our time in factory education with classes of 30 who are all moving at the same pace in every subject. The curriculum simply is an imposition. Education means you lead out those talents that are inside every single human being. You ask the question that Gardner asked, not, "How intelligent is this student, measured by our exams?" but, "How is this student intelligent?" The AI technology will help develop the intelligences latent within a child. You tell a child that they are a failure at 16 and they will become a failure. They will look for the rest of their lives at themselves, "I failed, I am not intelligent."

We need a new vision of intelligence that embraces precisely those skills, including the entrepreneurial skills that John and Mary were talking about, the creative skills, the emotional skills, the physical intelligences that will create far more rounded people who will be able to play more productive roles. The technology individuates learning and it draws out a far wider range of aptitudes inside every child. It is not the fault of any school or any teacher that it is the way it is at the moment. But if we have a system, as we can see in the schools in California and elsewhere, where only 30% of the time is spent learning maths, language, English and physics, it is so much quicker. It is all personalised one-on-one with a child with their playlist when they come in in the morning: "You are going to do this and then you will do that." It is much quicker, so that allows a lot more of the school day to be given over to project work, sports, the arts, debating, oracy, creativity, public service, volunteering. It develops a much wider range of the aptitudes of young people.

Professor Baruch: Can I interrupt and give you an example? What we are trying to do when we say, "You are the top" is we give people an exam in which they have to regurgitate what the teacher has told them weeks or so beforehand. But what is the point? If your exam is just about regurgitating the issues that you have been told about, robots are much better than that. Nobody wants to employ people who can just regurgitate things. They want people who are creative, innovative, can do projects and solve problems. Exams is the major way in which we judge our young people and forcing our schools to follow this path, as you said, is going in the wrong direction.

Q62 **Chair:** What I am trying to understand is—you gave the Californian example—how that works in practice. If you were Damian Hinds or Nick Gibb and you had the magic wand, what would you do to change the curriculum?

Professor Baruch: Louise Archer at University College has developed the idea of science capital. What you do is introduce young people to science in all sorts of ways. They have produced a whole teaching raft for primary schools upwards as to how you raise the issue of science with young people in the teaching. At the other end of the scale in universities we want to see young people presented with problems where we do not know the answer. What we say to people in exams is, "Produce the right answer and you will get good marks." In reality, in industry, in so many places there is not a right answer. There might be many different right answers.

What we want to say to our young people is to sort it out, so in their first, second and third years at university they work with local companies on little projects—the companies call them projects, we call them research—where we do not know the answer. We are taking the roof off. Nobody knows the answer: "It is up to you. You are going to sort this out".

That does a number of things. First of all, it shows the young people what the real world is like out there, and secondly, it starts to build the

confidence to innovate. If they have never had to innovate, never had to say, "I think this is the right way to do it," they are not going to do it when they leave and do it with industry. Putting this in, giving them the confidence to innovate, giving them the experience of failing, is a really important part of the process.

Professor Stuart: We have an academy chain in one of the left-behind places—let's use that term—in the south of Lincolnshire. We have a campus with primary school, secondary school, an integrated sixth form that has students who do a mix of things. They can do apprenticeships, A-levels, the whole mix. We also have a higher education campus that is our plant for automation with the food industry. The kids get an opportunity to engage with the employers to do the little projects that John was talking about. They get an opportunity to try out different aspects of their own abilities, because it is not just A-levels or just vocational, and they get an opportunity to engage in creative activities, because the school runs Easter schools and winter schools and does things outside the curriculum. That is a real example of using the current system but bringing in employers and other opportunities, but the day is longer and the weeks are longer because they include these other aspects. If the curriculum changed, it would not be necessary to have that expanded bit, but it is possible to do it now.

There are also examples in the UTC movement where they are doing some of that work with the employers, small projects, doing exactly that—asking, "We have got a problem here. How do you, in a team, solve that?" What employers tell me is that one of the biggest things they are looking for is team working. If our education system is too focused on individual achievement, we will miss out on those different skills that people bring to solve problems. If we are talking about anything to do with the fourth industrial revolution, we need people who have different skills to bring to a team to solve problems.

Professor Baruch: It does the wonderful thing of recognising the value of diversity. You work in a team and you learn to listen to people. Boys and girls just listening to each other is a first step, but also disabled people and others working in a team. It is a wonderful experience for young people, especially at school, and we impose it on them at university.

Sir Anthony Seldon: I think it is brilliant what John and Mary have said about what their universities are doing in Leeds and Lincoln to have a much richer kind of education and involving left-behind communities and people. But in answer to your question, Chair, about what is the curriculum going to be like, we are now here. In 20 years' time we are going to be there; this future that we are describing will happen. Getting from there to there is not easy but when we are there there will still be English, maths, physics, chemistry, biology, astronomy, language, history, geography, social sciences.

You will still have all of that but, as the Committee will know from their own experience of being in school classrooms, the way of learning is painfully inefficient where you have one teacher, and maybe a teaching assistant, and a group of 20 or 30 people. Everybody learns at a different rate and they need different things. If you have a question, the teacher can't be there to know that you have it and then you miss the point of that verb translation. In a state school day, 85% of the day is given over to lessons, terribly blunt.

With the new technology only some 25% or 30% will be given over and the same amount, but often far more, learning will take place in that much shorter time because it will be you, the students, with the interactive technology going at the right pace, challenging the students, knowing when they lose attention, watching their eyes, looking at their mouths, listening to their voices, coming back, a joke here, a prod there, "You are off mission," bringing you back on, always challenging them. That same technology will be there in the evening, the weekends, the holidays for the children to make their own progress in each and every subject.

We can give to Nick Gibb what is Nick Gibb's but we can also give to the child and the world what it means to be human. We can do the academic curriculum far better at three times the rate and far more efficiently and in a way that, as John said, is far more open-ended because the students engage themselves. They are on the money all the time and they are learning that the technology is interested in their answer, not just necessarily what the right answer is. The wrong answer is often more interesting in terms of learning than the notion of what the right answer is, which is the best that examiners can do in the constraints.

What do we do with the 70% of the day? Precisely what John and Mary have spoken about. We can have children singing, dancing, painting, making music. They can be playing sport. They can be out in the community. They can be helping read to elderly people; they can be reading to younger students. They can be doing project work. They can be doing entrepreneurial work. They can be making their own businesses. They can be thinking, "What can I give to society when I leave school? What is it that I love to do and what can I be doing now?" It completely frees up schools, if we get it right, to become remarkable places that are in the interests of the many, not in the interests of the narrow companies.

Q63 **Lucy Powell:** You have joined the Labour Party there—the strapline, "For the many, not the few." Most of what you are saying is music to our ears, but my fear is that this is such a long way from where we are now, notwithstanding some of the small examples. We are interested in the systemic approach and what Government can do. I have a 14 year-old and some younger ones as well. How can we take some steps that, say, my 14 year-old might benefit from before he leaves school, particularly with the curriculum and what is happening at the moment? Your vision,

Anthony, is absolutely right but my fear is—which is what happened over the last few years—that any space that is created just gets filled with more rote learning and even bigger poem compendiums and even more formulae and more maths in the A-level or whatever.

Sir Anthony Seldon: They are learning the words of the poem but not what the poem means. Learning the words of the poem is not knowing what a poem is; it is not understanding, developing wisdom and empathy. You can repeat everything but you might as well learn a telephone directory.

Q64 **Lucy Powell:** Exactly. That is what I am saying. I can look anything up on my phone if I want knowledge, but what I need to know is how I apply that knowledge.

Sir Anthony Seldon: I will come back on that.

Professor Baruch: I think what we are not recognising is how fast this revolution will take place. We have the AI. It is being implemented in all sorts of ways and it will be driven by the enormous gains in productivity. You can use it in so many industries that employ lots of people, in the service industries just as much as self-driving cars, robotics in surgery, for instance, in medicine, but also lawyers and accountants. The same sort of thing will happen.

Q65 **Lucy Powell:** What could we say to DfE Ministers tomorrow in a report that said, "These are some things you need to do in the next year, two years" to change this terrible direction of travel that you are talking about?

Professor Baruch: The first thing is talking to Louise Archer about all the work that they have done there, about making science at the centre of what we are trying to do, because that is where the wealth area will be driven. That is where the new economy will come about as the technology collapses the old economy, which is what happened in the first industrial revolution. In the first industrial revolution we had starvation and destitution. The reason I am involved in this is because I want to build a new economy so that there are jobs for the young people to go to. What we can say to them is, "Get your finger out and get learning science. Start investigating and looking at the sorts of science that excite you." There is an enormous range, whether it is looking at the stars or looking at the oceans. There is an enormous range of things they can do and the people at UCL have mapped out the ways of bringing it into schools.

If you are going to talk to the Ministers, change the way in which we do exams, bring back practical science, bring back the hands-on experiences that children use. We know that when they do things with their hands it changes their brains—how they think and what they are thinking about.

Q66 **Lucy Powell:** A couple of other people have said that as well. We had a session in Portcullis House where people were saying the same. What

about bringing back more project-based work, or not bringing back but taking that to a different area, so that we are not just going on with these exams with regurgitation of knowledge?

Professor Stuart: I think it is project-based work and helping kids in schools to work together, and it is helping. It is not something that they necessarily can do, so we could encourage more about the social skills that young people need to develop in how they learn to listen to each other, to take ideas from each other and to grow that. Expanding projects is learning to do as much as it is learning to know, and we need both.

Q67 **Lucy Powell:** There is an argument that that somehow is less rigorous, less tough.

Professor Stuart: What we perhaps do not have, and I think this relates to some of things Anthony has been saying, which are really relevant, is that intelligence is not one thing and perhaps the problem—and I am sorry, Lucy, this is not going to give us an immediate solution and I do understand you have a 14 year-old and you want something.

Lucy Powell: He is just doing rubbish GCSEs, let's be honest, but we will do our best with it. It is not rubbish as in not good, but it is boring.

Professor Stuart: I know what you mean, yes. We need to know how to test different forms of understanding and at the moment we are a bit too fixated on one form of testing. That is something that we need to do more on. There is quite a lot of research on different types of intelligence, as Anthony has said, and you can test for them. In the future world we will need people who have an understanding of lots of different things.

Lucy Powell: Yes, because we will not get away, even in the medium term, from a testing and accountability regime.

Professor Stuart: Verification is a challenge.

Q68 **Lucy Powell:** Even the Art GCSE now is 50% exam. It is mad, isn't it? Another angle on that as another question, often what we hear in education or from people talking about it when we talk about AI is that we need more children, more people doing programming, computer science and so on. What we have heard during the course of this inquiry is the opposite—that we need to focus on what humans can do and not try to replicate what robots can do better. We need a greater understanding of the creativity, the language and so on. Is that something you agree with?

Professor Baruch: Programming will increasingly be done with robots. I am doing two projects, one in Tanzania and one in China, in which we use the grandparents. We say that grandparents know a lot of science. They don't know that it is science, but if you take cooking, personal hygiene, there is loads. We want to get the kids to think like scientists: "Why does this happen? How can we explain it? How can we test it? How can we produce a model for it?"

In Tanzania we are setting up a radio programme of 12 minutes a day, like "The Archers", which was set up to train people, and we are setting it up with mobile phones. We are getting the grandparents or the child carers and teachers to register and we will chase them up on the mobile phones: "Did you understand this? Did you get this?" The programmes will be in a Tanzanian village where the teacher has come from being a big scientist in the West to help her village. You will have all the scandal of a village community, kids in the town and all that, but once a week we will do a science project that they can do in the Tanzanian environment.

We are doing a similar thing in China but we are using WeChat. We are sending out little blogs every day, including science, and with the parents and the grandparents, who often have a lot more time than the parents—and often kids are left with their grandparents in China and in Tanzania—we are using other ways to excite the kids with science. I think the general view is that the wealth will come from science and getting people to be innovative there.

Sir Anthony Seldon: I hope we are clear that we are here currently and we are going to a world here, and Britain is behind many other countries in getting there. Your challenge is what you do next. We are saying that we are not getting rid of the curriculum; we are keeping those subjects but we are going to teach them in a much more interesting, engaging way, where they are actively learning rather than passively learning the right answers and then repeating them at the right time in the right way, which is only a very shallow form of learning.

The best report on this is David Deming's Harvard report, which shows conclusively from 2015 that the very skills that the education systems in the world are teaching are precisely the skills that algorithms will be able to replicate. We can do all that in a much more interesting way. Rather than dominating all of school and much of university life, we can get it into a far more engaging and briefer form, and then we have much more of the day for this kind of activity.

I am just going to add three quick points on science. I completely agree with John: science is just wonderful. For me it was dull because we spent half the lesson getting the equipment out and then about 10% trying to mess the teacher up, and then 40% putting it all away and trying to be perverse. Now, on the technology—I will not mention names of any companies here—there are fantastic technologies that 14 year-old children can involve themselves in, where they can do incredible experiments that you never, ever do, where you can mix things together, you can make things happen; you can be going inside a volcano and seeing what is happening. The way that this technology can immersively make a scientist of every single child is wonderfully exciting.

Secondly, I am on the board of the Royal Shakespeare Company, and we saw some new technology that allows children to be in Shakespeare's sonnets and to walk around them in a way that is magical and entrancing

and will delight every child who at the moment is turned off by the obscurity of the language, which seems to be very remote to them. I would say we are one-ten-thousandth of the way this technology is going to impact beneficially on our young people if we get it right.

Thirdly, what else can we do? It will allow more time for visits. Our son is taking his comprehensive children, year 11s, to the National Archives today, and what a great thing to do. It is very hard to get the time from the headteacher to do that. What do you all remember best from your schools? I bet it is the school trips. It is two things, from my experience.

Q69 **Lucy Powell:** I went to school during teachers' strikes.

Sir Anthony Seldon: Two things kids remember. One is school trips, and the second is when things go wrong. The more they go wrong, the more you remember it. That is fun. We have to drive it. Your Committee can drive the DfE, can drive the whole of Whitehall, by saying, "We need to be on this journey," for precisely the reasons John and Mary are saying. We are going to fall behind other nations, utterly unnecessarily, and fall behind economically and entrepreneurially. The mental health alienation of young people who feel school is not for them: how dare a system brand a quarter or a third of young people failures because they do not have within them—it is not that they do not care. It is not that they are not trying.

Q70 **Lucy Powell:** Then they have to keep resitting it anyway.

Sir Anthony Seldon: They do not understand what is required of them by this remote system.

Professor Baruch: One thing we cannot forget is that for the vast majority of children—certainly for quite a lot of adults—it is the teacher that is really important. A lot of the motivation comes from the personal relationship that the child has with the teacher or the parents or the people who are teaching them. We have to remember that. Although computer games and all this sort of thing to introduce the science are really important, the teachers also can bring out the point. You get a kit. It is much, much better if someone understands what is going on. When you are doing things, it brings out the points. A teacher or a parent. In reality, it means that for students to do really well, they do need a teacher who brings out the point all the time.

It is that student-teacher relationship that the technology really has to empower and support, but it does give us all the sorts of things that Sir Anthony is talking about of personalised learning and that much greater power to the teachers to see that they are structured and exactly what the kids want, but never forgetting, at the end of the day, what motivates little Joey to go in and to take on board these things is really what the teacher or the parents are saying to them.

Lucy Powell: Can I just put on the record that my 14 year-old is at a school that has a very rich curriculum and loads of practical science? He

is very lucky, but most are not.

Q71 **Ian Mearns:** In a nutshell, to clarify this, are you all saying that the curriculum as it currently is delivered is inappropriate to the needs of all of our children?

Professor Baruch: Yes. The arts and drama are very good. It is all there, but there are big sections missed out and there is the wrong emphasis.

Sir Anthony Seldon: Ian, children should love learning. We are human. We love to learn. I noticed in the first state school that I did my teaching practice in that the year 7s and year 9s—the younger children—were so enthusiastic, but by the time they were 14, 15 and 16 they had grown cynical, and that does not need to happen. We need to give every child a sense of what they can do, who they are and how they can contribute to life.

Q72 **Thelma Walker:** I can feel the passion from the three of you about this subject. I am really enjoying listening to what you are saying. I agree with so much. We have touched on this already, but fast-forward 20 years and let us go to a classroom in our country, teaching and learning. What would you want and hope to see?

Professor Baruch: The most important thing is what Sir Anthony has just said.

Sir Anthony Seldon: I think John was going to say what I was going to say better than I would have. Who needs AI?

Professor Baruch: If the Government need to do something, it is to change the culture of learning so kids love learning. In Tanzania they love learning. In China they love learning and they like going. If we are going to change it, we have to find a way that kids will love learning. It makes an enormous difference.

Q73 **Thelma Walker:** What are the barriers at the moment? I am not just talking about the curriculum. What are the barriers to children loving learning and teachers loving teaching?

Professor Baruch: At the moment the kids in the schools do not see the relationship between what they are learning and their future lives, particularly in terms of jobs. They see the gig economy. Even at university, "What are we going to get? Perhaps if I get a First in chemical engineering, Shell might take me on." Most of the rest are saying, "What on earth is the point of all this?" That is why a vision of what the future economy will be like is so important, and bringing out science. Then that gives a vision for why you are learning and to say, "Yes, we can be creative."

Q74 **Chair:** Mary. Are we all right to call you by your first names, by the way?

Professor Stuart: Yes. At the beginning I talked about permeability. This relevance point exactly illustrates why permeability really matters. For young people, and indeed for adults, to understand and to love learning, they need to see its relevance. They see its relevance by things being permeable between different parts of the education system, by hearing from slightly older peers about what was inspiring or exciting for them, what they have done with it, by experiencing the world of work and how that is changing, by being involved in projects, as we were saying. That is why permeability is important.

In 20 years' time, I would hope we had an education system that was not quite so boxed into, "You do this from this age to this age, and you get a validation at that point," which is one way of testing, but that it was more fluid in terms of people being more involved and education being at the heart of a whole society, not being somewhere where you go and park your kids while you go off to work.

Q75 **Thelma Walker:** The AI would be enhancing the role?

Professor Stuart: AI would definitely enhance that and I think it would not just be something that was at school. We are working with an organisation that is developing an AI product, which is to help young kids learn in the home, where their parents can interact through what they see their kids exploring in the AI, very much like Anthony was talking about earlier. Again, the permeability has to go across.

We know the children who do well in our system also tend to have an environment at home that encourages them, that gives them other things beyond what they are getting in the classroom.

Thelma Walker: The soft skills.

Professor Stuart: That enrichment thing. I would like an education system where that was more permeable and where we were also helping adults to learn again.

If we are going to have a different education system in 20 years' time, we jolly well should be teaching teachers differently.

Sir Anthony Seldon: Again, I am in total agreement with my colleagues. We need to have, Thelma, classrooms without walls. We need to involve families more. Amanda Spielman was completely right about this. We cannot expect our harassed and hard-worked teachers and teaching assistants and others in schools to do everything.

It is very odd in this country that we exclude parents so much. Parents need to be part of that whole learning process from the bottom up, so that we can learn moral values and ways to be. We need to have young people who learn how to live socially with others, that you do not go around with knives—this is not civilised or acceptable behaviour. It is not kind and decent. Character education has been at the heart of education for 5,000 years until about 30 years ago, where the idea of values in

education got stripped out because somehow it was getting in the way of getting more A grades at GCSE and was seen as a distraction. This is profoundly wrong, so we need to help young people live with themselves so they can be free of mental unwellness and live with other people socially.

We need to have porous walls to the community. The community needs to be employers far more, people of all ages, all different disabilities, coming into the school so people can see the richness of life, and then to employers beyond. The technology will assist that because the learning of the curriculum, as we are saying, will be done far more effectively, not 85%, but 25% to 30% of the time learning your maths and your English and your physics, chemistry, biology, science and languages much more quickly. Then you have all this wider time to do these broader things, including learning.

Q76 **Thelma Walker:** As far as the technology is concerned, what are the challenges for a teacher? I remember well the interactive whiteboards we introduced to schools when I was acting headteacher, and there was funding for that, but different members of staff were at different levels of accessing it. That was a massive challenge across the country. That is just one example.

Sir Anthony Seldon: As I am sure you will have noticed—I noticed—it is the children who say, "Look, Miss, what you need to do is this."

Thelma Walker: I have been there.

Sir Anthony Seldon: When one's younger members of staff do it to oneself, it is very unfair of them to do that, but they do. That symbolises a kind of wall, where young people can do far more than we ever think they can. We absurdly patronise young people. They can take far more responsibility. If we treat them as badly behaved, nothing creates worse behaviour among children than telling them that they are bad. Nothing is more self-fulfilling than telling somebody that they are a failure. We need to have that far more positive approach in schools and we need to help teachers not to be afraid. As Mary said, teacher training is very important.

Most of the people coming into teacher training now know this. They have grown up with it and they love it. It is not hard for them. It is very different. Even just in 10 years there has been a big change. For those already in it, just help them through. You know as a head how to coax people rather than to make people threatened, but coax them into making those changes.

Professor Baruch: Can I come back to your point about what it should be like in 20 years' time? One point that we just mentioned was about adult education and continuing learning. One of the things that surprised me is that many adults are better innovators than the young people from

school. They have got away from the education and they have lots of ideas. The real problem with adults is a lack of self-confidence in doing it.

Q77 **Ben Bradley:** I was interested in the comment about permeability and that connection with work. The University of Lincoln has Siemens on site. The University of Nottingham has Rolls-Royce, for example, in the big engineering centre. You talked about UCL. We have a level of independence in our schools sector in terms of academies, free schools and people who can choose to do different things. Are there examples within schools as well of where that is happening in a positive way, or are we so far behind that we are just not seeing it?

Professor Stuart: Certainly in my part of the world where, as I say, we have an academy chain and we also sponsor a UTC, the UTC works with about 25 companies in the region, and those companies will set projects for the young people in the school and there is quite a bit of permeability in that environment.

In our academy chain, because it is located in the heart of Britain's food industry—if you have ever had a takeaway pizza it will have come from that part of the world—it works with all of those companies there. That, of course, is not just food; it might be a whole range of other things. There are examples. Those are the ones that I know best because we sponsor those, but I do know that there are other ones.

What you do hear, though, generally from teachers is that they do not have time in the curriculum to do that, just as they do not have time in the curriculum to go on school trips and the like. As I say, what we have done with ours is to say to them, "We think this is so important that let us look at having some additional teachers. Let us look at expanding what you can do in other periods of the year so that you have a slightly longer school engagement time."

Professor Baruch: One of the problems is the league tables because the schools totally are dominated by the league tables, and they are determined by examination results. I agreed totally with what Mary said, but that happens.

The other slight problem we face with our education system is that the universities and the subjects that are studied are decided by 18 year-olds, because they choose what subject they are going to go to and they then pay for that. What 18 year-olds want to do determines the future of our nation and the future of its skills, and that is because of fees. We really need a system in our universities in which the people who know and the politicians determine where we want the country to go and where we want people to be trained, not the 18 year-olds who decide, "I want to do this sort of degree."

Professor Stuart: This is the first time we might be slightly disagreeing. If we are going to have people who love things, they must have some level of choice in what they want to study. I do think that there is a real

need for us to continue. Science is creative, but so too are creative disciplines. Certainly Anthony and I have been talking a lot about those other forms of creativity, which are vital for social cohesion and for a more integrated society, which I am sure is something that we all want. It is really important that we think about those other disciplines as well, not just science. I love science, but we need all of them.

Sir Anthony Seldon: The arts are essential for mental health also. When the child expresses what is inside them, when they are swaying in a dance or singing, they are letting go and they are finding richness. They are expressing themselves. If you suppress the ability of a child to express themselves, then they get bottled up.

I would love it if this Committee were to recommend entrepreneurship. This is not a right-wing capitalist thing. Every country on earth needs to be able to generate an income and to have people productively and satisfyingly engaged in work. If you are a head, it is very hard to give over time for a business to come in. What do local companies do? Do they come and give a talk, and people give a talk in assembly who do not know how to address 14 year-olds? If there was more encouragement, and entrepreneurship was part of every single child's education as part of their journey up through school—and that involves creativity, because every entrepreneur is creative and they have made mistakes—then that would be a very great thing. Then you could have practical inputs from local employers into the school who then know what it is that they are doing, rather than just giving a talk on something or other, which misfires.

Q78 **Ben Bradley:** I totally agree with you. I have worked quite closely with Baker Dearing and the Edge Foundation around UTCs and that model, which I am really supportive of.

What you said about arts and that creativity leads me on neatly to the next bit. I am also a big fan of sport in that context and how coalfield communities like mine have engaged—particularly working-class boys—in education, and it is those things that bring that out and that engagement. What is the real challenge? Places like Mansfield, a coalfield community, tend to be top of the list when it comes to the impact of AI on jobs. What is your assessment of what those challenges are and how the education system has to address that particularly and what you called "left-behind" communities?

Professor Stuart: Yes, we share that context. PwC's recent report talks about nearly 50% of jobs that we currently have disappearing by 2040. The kids who will be the young people of 2040 are about to be born. If you think about that, 50% of the current work that we have will be disappearing. It certainly and absolutely will affect what we might regard as low-skilled jobs, but an awful lot of this revolution is going to affect what we term as middle-tier technical jobs.

It is not simply factories that will be automated. Accountancy will completely transform itself. Law will completely transform itself. There will be a lot fewer of those kinds of jobs for which people currently go to university in order to get degrees. It will be completely different. We need to think about the full range in that context.

I absolutely believe, though, that the jobs will be replaced, in which case we need to be thinking about a curriculum that enables people to feel confident to continue to learn, to love to continue to learn. There is not going to be one career for anybody. There might not even be four or five. You might be switching around quite a lot. Fundamentally, we need to educate for confidence to learn again and again and again.

Sir Anthony Seldon: It is not just the quantity of jobs that might go down. Mary is an optimist. I do not know where John is. I do not know about it. It is also the quality of the job that is left. What is the value in being a surgeon if all the detailed work is being done far better? If you save up and go on a London black taxi ride, the driver under their steering wheel has Google, which is taking them far more efficiently and effectively. They have been deskilled. Deskilling and the de-quality of life is very frightening and it is going to grow. I talk about it in "The Fourth Education Revolution". This is a very big problem.

Before Jeremy Heywood died, I spoke to him about the things that he wished Government did better. One is long-term thinking. We are not, as a country, thinking about the impact, particularly on the left-behind areas, of the jobs that are no longer there. There may be alternatives, but the quality and the life satisfaction is precisely why we need to have an education system, as Mary and John are saying, which is far more nourishing, far more deeply satisfying and far more engaging for young people, so that they have acquired lifelong habits.

Very few children after the age of 16 will learn how to dance or play sport—football maybe, the higher skill levels, or learn how to play the piano. It should not just be the posh children. At the moment we have a ridiculous inverted education system. The best-off children have the best-rounded education in the arts, in character, in all the sports, who get it anyway largely at home; and those who are least well-off, who come from the most disadvantaged backgrounds where there is not the same degree of concentration, have the least. What is going on there? AI will massively help.

Q79 **Marion Fellows:** I declare an interest. I was a former further education lecturer. I have been fascinated by what you have been talking about this morning. May I just say one thing? There is no such thing as UK education. Scotland has distinctly different education. I could say things like Curriculum for Excellence and all of that. I will not to any great depth, but I have got it in there.

As a further education lecturer in my past, I really want to know: what do you think are the biggest barriers to adults engaging in lifelong learning?

Professor Baruch: It is about where they can get to and what they can do. At the moment, confidence for them to be innovative and entrepreneurial is lacking. They have no experience in that. What happens in FE courses is that someone says, "We need more people who can code," so you get a load of courses teaching people primitive coding and not how to think. Really, for lifelong learning, we need to engage with the passions of people who are adults. They do have passions. Feeding those is a very good way.

If I may refer to it, when we talked about left-behind communities, there is no lack of talent in the left-behind communities. It is lack of us feeding them, lack of us giving them a vision and lack of our education system supporting them. We will need them.

Mary talked a bit about being an optimist. Whether you are an optimist or a pessimist depends on whether you have the vision and whether this country can do the education system that means that they can innovate with the society and the technology that is available. If we go around the world, there are many countries with 50% unemployment. That is not because they have done all the wrong things; it is because they do not have the science and the background to build the economy.

With the direction that we are going in at the moment with the gig economy and not interfering and not having a direction or a 20-year vision, as Sir Anthony is talking about, we will grow the gig economy. It will accelerate, with its uncertainty, its lack of security and everything bad that goes with it. There is no law that says Britain will always be on the top, and I hear that a lot in China, because it was on the top in 1600, far in advance of what Britain was. By 1900 it was totally humiliated. The same thing can happen to Britain.

Professor Stuart: Marion, in answer to your question, I think there is a complex of reasons why it is difficult for adults to engage. As someone who also is an ex-FE lecturer, it seems to me that first there is the confidence thing of, "Can I walk through the door?" in this context. Secondly, it is about, "Is there something I want to study?" As an adult you are more choosy because your time has so many demands on it, and that is really quite complex. Some of it also might be, "Is it at the right time that I can do?"

There is a big thing, and I would want to say this. There are some employers who are absolutely fabulous at getting their workforce to be involved in education, and there are some that really, really are not. In that sense it is a bit of a lottery in terms of where you end up, whether there will be training opportunities or whether there will not. Our university has not seen any drop in our adult education numbers, and that is because we have worked hard with employers. We have used, in England, the range of policy environments that we have that benefit adults. We have degree apprenticeships. We have used those kinds of things that have come on stream, and they are hugely beneficial both to

the employer and the people we call students. It is a range of things that might stop people.

It is less now about issues like childcare because there are more facilities than perhaps there used to be when I was younger, but it is still a barrier if you are a single carer. It is quite varied in terms of that.

One of the problems that you face as a Committee is that things are complex. How do you end up saying, "Here are three things, and this is what would make a difference"? We have in England the apprenticeship levy. I personally think one of the things you could say in terms of adults is make that beyond just apprenticeships because—

Q80 **Chair:** We are running over time. We could listen to you for hours, but we need you to be more concise.

Sir Anthony Seldon: Very concisely, Marion—they have said it all—there are two points to stress. If you tell a child at school that education finishes at 16, whether in Glasgow or Penzance, they will come to believe that. Children will believe what they are told. If you say that education is lifelong and if you develop and nurture their curiosity, and if you develop all their different intelligences and make them realise what a delight learning is and physical movement is, and song and dance and sport and volunteering, helping other people, and that school is merely a beginning, it is an awakening, not an ending point. The world now comes to all those who can afford a computer screen and an internet connection. Whether it is astronomy that they want to learn about or history of art, it is there. Obviously it is better to do it socially, but there is a lot that you can do, pioneered by the OU and others, in your own room.

By the way, every single school in the country should teach history of art to all the students, so that they can enjoy that and understand world architecture and art. There is no good reason why you cannot do that. You can do it in assembly, developmentally, all the way through. That develops that interest.

Q81 **Marion Fellows:** I want to talk more about university. Mary has said something about it. What role do universities have in providing opportunities for adults to retrain and to upskill? A lot of the stuff that is done, as my own experience tells me, is when factories go down and suddenly FE colleges and universities go in, and it generally is FE. What opportunities are there for adults to do stuff like that at university?

Professor Stuart: Universities have a real role in their localities. Not all universities take that responsibility seriously. We certainly do, and lots of others do. What that means is that they need to be involved in the policy developments. Local enterprise partnerships in England have responsibility for skills. It is important that universities are there and are helping to develop that policy. They need to work with further education. There needs to be a permeable, symbiotic relationship. Some things FE is good at and some things universities are good at, and the partnership is

what really matters in that context. It is about understanding the locality and forward-planning so you know what your companies in the area are thinking about, so that you are not there just when an industry is closing down, but you are there throughout that journey.

Professor Baruch: I totally agree. In this situation, Scotland is different from England. In England, if the firm closes down and they want to carry on with their studies, they have to pay for the fees to go in.

The important thing is opening up people to innovation and having a vision for where this nation is going and where wealth will be. You are probably fed up with me talking about science, but I think it is there, and also the entrepreneurship. It is very important to teach adults the ability to be creative and the self-confidence. They are creative, they have all the ideas, but they do not have the self-confidence to put it together. This would have to be part of the funding for when companies go down, as to how you deal with and look after the workforce. I think universities and FE colleges are very important in dealing with this, but they do need to think about the curriculum. It is not about teaching them coding; it is about teaching them to be innovative and creative with the potential for new entrepreneurial directions.

Q82 **Chair:** Thank you. Just one final question. The traditionalists will say you have to teach academic rigour, it teaches people the fundamentals, you have to learn to read a map before you can understand GPS, and there is the right and the wrong. If you say, "We need to teach motor intelligence and creative intelligence"—something I have a lot of sympathy with—those on the traditionalist side of the argument will say, "That is very subjective, depending on who is doing the teaching," whereas we know what multiplication tables are. We know what teaching geography and rivers and so on is. How would you respond to what the traditionalists say?

Sir Anthony Seldon: The answer is that we do both, and the best schools in the country do both. They get great results. They are at the top of the league tables. They give to the league tables what is the league tables', but they also take their responsibility for nurturing the humanity of a child, their creativity and their social intelligences, emotional intelligences and wellbeing.

It is now seven years since I was summoned to No. 10 to talk to Michael Gove about why his education policy was totally wrong. I said, "It is not totally wrong. It is very right. It is necessary that we do all this hard academic bit, although we need to do it in a much more imaginative and creative and engaging way for young people. But we also do the other part, too." I sent them a list of 50 state schools that did both, and that was seven years ago. Zilch happened. There was no learning. There was no appetite to learn from the schools that give your cake and eat it. Both are important, is my answer.

Q83 **Chair:** On the other side of the equation—I am very sympathetic to what

you are saying—with the other kind of intelligences that you are talking about it is a lot more subjective, depending on who is doing the teaching. The traditionalists say, "We know this is what we should teach. This is how it is done. One and one equals two." The other intelligences are much more subjective and it is harder to measure performance, and it is harder to decide how it should be done, because each person will have a very different view on how it should be taught.

Sir Anthony Seldon: That is true. What is kindness? What are good empathetic skills in working with other people? What is quality speaking in public? Just because we cannot measure everything doesn't mean that it doesn't have value, and any society that reduces everything to measurability will suffer, because human beings don't fall in love with each other because of checklists and league tables. We are hardwire, left-brain stuff but we are also right-brain stuff, and we need to do both. The good news is that the best schools can do both, and we need to be celebrating those, and others need to be learning from them.

Professor Baruch: We are missing out the vision. If mummy and daddy have a vision for where little Joey or Amarad can go, then the best schools do very well because Amarad and Joey and Linda go along to the schools, thinking, "That is where I am going." The left-behind communities do not have a vision, and we nationally do not have a vision in our schools because most people say, "We are going to school, but why?" It is totally right. If you have the vision, you say, "Yes, you have to learn Greek because there is good reason for it" or, "You have to learn further maths because there is good reason for it." Without the vision, whether it comes from mummy, daddy, grandpa or whatever, the kids are alienated. That is what we are seeing in the majority of our schools today.

Q84 **Chair:** Mary, do you want a final word?

Professor Stuart: I would absolutely endorse what Anthony was saying. We have to do both, and the best schools do.

Chair: Thank you very much.

Lucy Powell: My son is at one of those schools. People are tweeting about what I said now, so I do not want to be in trouble, but he is definitely at one of those schools.

Chair: Thank you so much. A lot of what you said will form our evidence. We really appreciate it. We could have sat here for three or four hours easily.

Examination of Witnesses

Simon Peyton Jones, Honorary Professor of the Computing Science Department, Glasgow University, Duncan Baldwin, Deputy Policy Director: Standards, Association of School and College Leaders, and Professor Danaë Stanton Fraser,

Professor in Human Computer Interaction, University of Bath.

Q85 **Chair:** Good morning. Thank you very, very much for coming. Sorry about the delay. As you could hear, that evidence was fascinating and very valuable. I am sure yours will be as well.

Just for the benefit of the tape, can you kindly introduce yourselves from our left to right?

Duncan Baldwin: Good morning. I am Duncan Baldwin from the Association of School and College Leaders, which represents 19,000 school leaders throughout England, Wales and Northern Ireland.

Professor Stanton Fraser: Good morning. I am Danaë Stanton Fraser. I am a professor at the University of Bath, and I do work in human-computer interaction, looking at all sorts of new technologies like virtual reality and internet of things, and particularly in the design and evaluation.

Simon Peyton Jones: Hello. I am Simon Peyton Jones. I work at Microsoft's research centre in Cambridge, so you should think of me as an academic computer scientist, but I have become deeply involved in school education and computing. I am chair of Computing at School, which was the organisation that was at the epicentre of the recent reform in computing education. I am a school governor. I am a parent. I am a Fellow of the Royal Society. I should just say I am not speaking on behalf of Microsoft here. I have the other hats I have described.

Q86 **Chair:** Thank you. Understood. Are we able to call you by your first names? Are you happy with that?

Professor Stanton Fraser: Yes.

Simon Peyton Jones: Please, yes.

Q87 **Lucy Powell:** Thank you very much for coming. I could see you nodding ferociously through parts of that last panel. It was fantastic, wasn't it? Do you want to give as an opener some of your reflections on what we just heard then, and what you think in terms of the school system and the curriculum and the direction of travel—whether that is right or wrong, and what could maybe change?

Duncan Baldwin: We were just reflecting on what our notes say and the fact that Anthony and other colleagues have said it all.

There were three words that were in answer to the question about what is standing in the way. For me, they are funding, accountability and workload. Those are the issues that are preoccupying schools and school leaders at the moment. Any attempt at the moment to move any agenda on would always get stuck on those three things.

If we take accountability, for example, much of what was being said, which I completely agree with, all comes down to the role accountability plays in directing the direction of travel in schools and how subjects are taught and the pressure that teachers are feeling to get pupils—your kids, my kids—through those qualifications without the luxury, or indeed now the money increasingly as well, to deliver on quality and breadth and all of those other things that we want youngsters to experience. Accountability is a key driver, and from that then flows teacher workload. This is an area where I think teacher workload can be helped. I am sure we will be coming back to that later on.

Professor Stanton Fraser: I was dying to join in. Particularly when you were talking about, "What would you do? What would you change at this point in time?" I was thinking of a number of things. The entrepreneurship is a really good point, and I had it in my notes as well. At universities we are thinking very much about how young people at universities could join small and medium-sized enterprises. It is not just about big industry; it is about creative industries. It is about getting them to think creatively. We are doing a lot to think about our courses in terms of entrepreneurship. That is really important in the school curriculum. In schools that I work with, you see that the best teachers are those who are bringing some of those skills out in the children.

I would really want to join up—we did not talk about that so much—industry, academia and schools much more closely. We work in a number of consortiums. We have just got one of the industrial strategy creative clusters. That is very much about doing live performances with lots of interdisciplinary work—I am a psychologist, computer scientist—from the arts. We are working with the Royal Shakespeare Company, as was mentioned earlier. The idea is that we have skills development workshops within those for under-18s, and we start looking at how to integrate schools right through to jobs. It is really important that we do not just do that at university and industry, but it is universities, industries and schools all working together. That would be a really important thing.

The other thing that comes to mind is that we do not see many of our very technical graduates going into teaching. Having a broader skill base within our teaching profession—I was talking to a number of academics who were saying they had not written a PGCE application, any application for a school for a graduate, at all. I have not ever. The technical graduates are not going so much into teaching, and that is such a shame. That is what we need. If we do not have the technical graduates going in to do things like coding in the curriculum, we have to think, "How do we give the right skills to our teachers?" I don't think even people going through teacher training now are necessarily au fait with the technologies that they could be using within the curriculum.

Simon Peyton Jones: Richard Riley once famously said that one of the aims of education is to prepare young people for jobs that do not exist yet, using technologies that have not been invented, to solve problems of

which we are not yet aware. I like that because it sets a very aspirational frame for what we are trying to do.

I would respectfully disagree with some of the comments that were made earlier about computing. The new computing curriculum is not about replicating robots. Let me go back to what Sir Anthony said about what it means to be human. One of the things I think it means to be human is to have agency in the world that surrounds you, not be subject to things that other people are doing but to be an agent. That means understanding something about the world that surrounds you, and that is why we teach children natural science and mathematics. We teach it in an instrumental way because it will lead them into good jobs. Many of them will not become research scientists, but they need to understand something about the world that surrounds them.

In the same way, we need to teach computing or computer science in a foundational way because it helps children understand the world that surrounds them. That is not about computers. It is about computing. It is about information, computation and communication. These are foundational things. The whole skills/knowledge dichotomy is a bit of a false choice. As the earlier panellists were saying, we need to do both.

When we are talking about the fourth industrial revolution, there is everything to play for here. In computing, there is an incredibly intellectually rich foundational discipline. There is a subject that has great practical engagement. At school you can create stuff that nobody has ever built before. That is amazing. That engages you with teamwork and all the stuff about hands and brains that your previous panellists were talking about, and it leads you to great, well-paying jobs. What is not to like?

The change in the national curriculum says in black and white—I think we are the only country in the world that says this—that children from the age of six should learn computer science as a foundational discipline in the same way that they do natural science. That is not just coding and it is definitely not replicating robots, please. I am happy to elaborate on that. I will be briefer now.

Q88 **Lucy Powell:** My 14 year-old is doing computer science GCSE but you have to have a very high level of maths to do it, so I would question whether it is that accessible to everybody.

Simon Peyton Jones: There is plenty more to say about that.

Q89 **Lucy Powell:** Let us just delve into that a little bit further, and I want to come on to a point about workload. I guess the point was that if you look at it simplistically, the response to the rise of the robots is, "We need more and more computer scientists," yet what we have been hearing through the course of this inquiry and from others is that we need to bring out the human characteristics more than replicating the robots. Is that something you would agree with?

Simon Peyton Jones: We need more people who understand something about how these robots are built. If you just think of them as magic made by people in Asia or somewhere else, that do things to you and somehow will magically do the right thing, you are probably going to be wrong. I am acutely aware that the whole AI scene is a bit of a wild west at the moment. It is amazingly effective but there is a lot of "suck it and see" going on. If children understand something about how things work, they will have the proper level of scepticism sometimes and an appropriate level of trust with these machines. It is not about replicating what they do.

This applies very much to hairdressers and lawyers, not just to the future computer scientists. That is why we need this foundational knowledge. Incidentally, yes, there will be a lot of high-paying jobs in this area and I do want the UK to be at the forefront of that technology as well, but I am really thinking about breadth here, not just training a sort of élite group. Do you see the distinction? I want to do both.

Q90 **Chair:** Does it matter that just 11% of students in England take GCSE computer science? Should it not be higher than that? Are you arguing it does not matter?

Professor Stanton Fraser: It might change, mightn't it, with computing in the curriculum?

Simon Peyton Jones: You are absolutely right that only 11% of children in this country take GCSE computer science. Remember that there was not a GCSE in computer science at all until 2010. Then numbers rose very sharply, but they are now plateauing.

This comes back to what Duncan was saying about accountability. I call it the incentive structure that we place schools in. The larger point that I would like to make around this is that we are seeing a narrowing of the curriculum, which affects computer science as well as the arts.

Q91 **Chair:** Danaë, do you believe that is worrying or do you not think it is a problem, only 11%? I think personally it is.

Simon Peyton Jones: Only one in five of those are female.

Professor Stanton Fraser: Bath is leading a new Institute of Coding and one of the things it plans to look at is gender in coding and encouraging more girls into coding.

Back to the robotics, we have been doing some projects very recently in schools with small robots. They are affordable. We took them in. Teachers started integrating them into the curriculum. Children from primary school through to secondary school are using them. That is what we want. They can code within the interface of this robot, starting to integrate those types of technologies to make learning exciting, because then you are learning about maths; you are learning about science. It is not about the robot; it is about what you are learning through it.

Q92 **Chair:** What percentage of students do you think should be taking computer science?

Duncan Baldwin: I do not have a view. I question the premise of your question, if you don't mind. The trouble is we want more of everything, don't we? We want more science but we also want more arts and we want more drama. I think it is very difficult if we say we need more and more of subject X; we always then suffer later on because we actually needed students who had gone through subject Y.

Q93 **Lucy Powell:** Do you know how many do GCSE psychology? When we were at Warwick University, many of the people working on the automation of vehicles were psychologists because it is about how humans interact with the robots. Maybe—probably—there are fewer psychologists than we need.

Professor Stanton Fraser: It is the interdisciplinary teams I think we need. We need the computer science but we need the psychology and the sociology. We need to pool all that together, which is what we do in our research projects. We work in design partnerships with schools, teachers and industry. That is what makes the products successful and become integrated and used. That is really what we need to be doing, which is what I meant by my first point—getting industry, academia and schools working together. That is really, really important.

Q94 **Chair:** The point is 11% of students, as we have discussed, but it is only 20% of those 11% who are women. I think that figure is too low in terms of GCSE computer science. Certainly, the number of women is appalling.

Lucy Powell: I do not know that it is too low. I do not know if you can say.

Simon Peyton Jones: Could I reframe your question? You are focusing just on GCSE and computer science, but the subject is called computing, the national curriculum subject, and it covers more than computer science. I would like to see a much larger proportion of students taking a digitally or computationally relevant qualification at key stage 4, whether it be a technical award or a GCSE. I would like to see that proportion be high. At key stage 4, age 16, you are taking quite a lot of qualifications. I do think one of them should be in that space. Do not fixate on GCSE computer science. That is what I am asking.

Q95 **Lucy Powell:** All GCSEs could be done on computers, couldn't they? That is a whole other world. We focus on handwriting and not on word processing.

Professor Stanton Fraser: We have been doing some work looking at that assessment. Assessment is mainly on paper still. That is quite surprising. We have been looking at maths websites and looking at what motivates children to learn, and that will change. As assessment becomes online, that will be a completely different thing, and it is a slightly different—

Simon Peyton Jones: It is important to separate two things. One is a subject discipline that we would like children to know to equip them for their lives, and the other is a base of technology that can enhance teaching and learning and assessment right across the curriculum. Sir Anthony was speaking about that too. They are not the same thing.

Q96 **Lucy Powell:** A quick question for Duncan. One of the things we have been talking about and getting to is that the curriculum needs a big overhaul. The idea of another overhaul would, on one level, probably tip most teachers over the edge. What is your view about the balance of satisfaction in what people are teaching—I think there is a lot of dissatisfaction at the moment—versus having to do a whole other overhaul?

Duncan Baldwin: The impact of recent reforms, led by accountability measures and also reforms in the qualifications, means that teachers have had to do a phenomenal amount of work—and their leaders—just getting through those and doing the best by youngsters who are doing it.

There is a feeling that we are ending up with a curriculum that is too narrow, and this is why I always worry about there not being enough X in the curriculum because then there is not enough Y. We could talk about modern languages, for example, where entries are falling, possibly in response to one of the accountability measures that we have at the moment. If the question is about, "Should we reflect on how policy is driving which groups of subjects people are following?" I think that is a welcome question. The profession would welcome that one.

If you are talking about, "Should we redo all the GCSEs again because they need some more work?" that would not land so well at the moment, although that does not mean to say that there are not things deeply concerning about the new GCSEs that we have ended up with. For example, the actual grading system itself and the impact of that on young people. You were speaking earlier about a third of youngsters who do not get English and maths and so on.

I was working in a school on results day, and this is the first year that reforms of GCSEs have hit en masse—English and maths the year before—and I did not know the youngsters in the school but I did see youngsters and their grades. One of you spoke about this earlier. Because of the nature of the assessment at GCSE now, there is a much stronger emphasis on writing, even in art, dance and drama. Whereas youngsters may have been able to excel previously in their chosen subjects, because of the emphasis on writing, those youngsters were still in the twos and threes. This comes back to, for me, the exciting part about AI and the systems that colleagues have spoken about, where we can use those systems efficiently to address the deficits in literacy and numeracy fundamentally to help children excel elsewhere.

Just on the computing question, we were very supportive at our school and worked with Simon's colleagues at the time to move that in because we think it is a great subject.

Q97 **Lucy Powell:** To the EBacc, yes.

Duncan Baldwin: No. To move computing as a subject into the mix at GCSE. It gives a lot to youngsters. Any subject that can hold up its head and offer something really compelling to young people for a career or for personal fulfilment is fine. Computing clearly does that. For me, it is about the thinking. It is computational thinking that is so powerful an asset. That is not necessarily reflected in the basket of stuff that they might do elsewhere, nor would it be necessarily reflected if we were talking about a very EBacc-y curriculum. The teamwork, the creativity and so on is not necessarily there in those subjects.

Simon Peyton Jones: Lucy, could I very quickly respond? Please do not just focus on the curriculum and reform that. As Duncan said, it is the incentive structures that surround schools and the accountability measures—they drive everything. I think the curriculum is not too bad. You could leave that entirely untouched and just deal with the incentive structures, and you would see quite a different educational system.

Q98 **Lucy Powell:** Yes, exams within the curriculum. The curriculum itself—

Simon Peyton Jones: That is what I mean. They are part of the incentive structure, how we assess, how we drive school behaviour.

Q99 **Chair:** At the moment, design technology is not part of the EBacc. You would need more than incentives because you would want to put that in the curriculum, wouldn't you?

Duncan Baldwin: It is in the curriculum but it is not in the EBacc, but then again neither is RE and neither is music. Here is where you start banging your head against the wall, isn't it? You can have some subjects that you feel deliver for youngsters, but by putting them in a basket and by publishing them in performance tables you inevitably drive behaviour in schools via their leaders and their curriculum and so on because accountability drives behaviour, badly. There is the place to look.

Q100 **Ian Mearns:** I like the terminology "incentive structures", I must admit, but I think you missed out the word "perverse".

Simon Peyton Jones: "Unintended consequences" is a nicer way to put it.

Q101 **Ian Mearns:** Indeed. We recently visited Germany and Switzerland to learn about their dual education system. I am wondering, from your perspective, is a great emphasis on vocational training critical to preparing students for a more automated economy?

Chair: So many students in Germany and Switzerland go off to do vocational education and apprenticeships. It is an amazing system. In

Switzerland it is nearly 70%; it is extraordinary really. The whole culture is very different. Should we be doing that here?

Ian Mearns: I am posing the question because I thought what happened there was very interesting indeed but there were, from my perspective, aspects of social conditioning built within it, I think, as well. Carry on, please.

Simon Peyton Jones: It is not something about which I am experienced or well-versed. You should speak to my brother who is recently retired as HR director of Siemens and is deeply involved in the apprenticeship sphere; he would be a very good witness for you. I do think there is a broad spectrum we should not think—again just sticking to computing, it is a mistake to think computing is for some kind of intellectual élite, socially challenged males working in windowless rooms with glowing screens. It is a very diverse creative thing and attracted a very wide range of people. The whole vocational thing is a bit of an image problem, almost. It is a cultural thing—sounds a bit oily-raggy but it is not at all. There is a huge diversity and if we could get the culture right—that is a problem I do not know how to fix.

Q102 **Ian Mearns:** I understand that, because you think about computer people and what would the stereotype look like?

Simon Peyton Jones: They do not look like that.

Ian Mearns: They do not look like the guys that I see in the computer games development company in my constituency, who are like the cast of Fraggle Rock, frankly, but they are really great guys. They are really interesting.

Q103 **Chair:** Should we move to a much more vocational education system that should be embedded in the curriculum, in which students would have that choice from very early on—a more continental system of education, as in Austria, France and Switzerland?

Duncan Baldwin: We have had ongoing, similarly continuous goes at revising vocational qualifications and their role and relative weight and standing compared to more academic subjects for years and years. We are going through another iteration of it with T-levels—at a 3 end of things, admittedly—but we are expecting another look at these technical awards and all these sorts of things at level 2 as well in the new year. The question of trying to address parity of esteem is as old as the ark, isn't it—as old as Noah—and we haven't got there yet.

Q104 **Ian Mearns:** Have we gone too far away, though, from the balance between vocational and academic within our schooling system, do you think?

Duncan Baldwin: I think so. I was talking about the grades that youngsters got a little while ago, and their opportunity to excel. There is concern about rigour in those qualifications, which I understand, but at the expense of rigour have we also lost the real benefit of those pathways

and those qualifications as well, which help youngsters develop all sorts of different attributes?

Q105 **Ian Mearns:** The crucial question from my perspective is that without that vocational stream within our secondary schools in particular, are we trying to deliver a curriculum that is inappropriate for the needs of many young people?

Duncan Baldwin: You want a choice. You want to be able to offer breadth and we come back to the constraints of the incentives through accountability. As long as there is an EBacc agenda—mission—that works against schools offering more vocational subjects, as indeed it does more arts subjects and so on, schools cannot offer breadth in the way that they think they should. Then, of course, there is money, because the funding to deliver these courses is lacking too.

Simon Peyton Jones: We have seen the opposite of that. We have seen a narrowing in multiple ways. With the loss of AS-levels, for example, students do just three A-levels; they may start with more and then drop one, and some schools are starting key stage 4 in year 9 instead of year 10. Somehow, incrementally, for all sorts of unintended reasons, the curriculum has become narrower, and that is moving in exactly the opposite direction to the one that Duncan is suggesting.

Q106 **Chair:** Would it be better, given that students have now to stay in school until 18, to move the EBacc/GSE to an 18 year-old version and just have tests at 16? You would have a much wider curriculum encompassing creative, vocational and academic education all at 18, rather than just three narrow A-levels.

Duncan Baldwin: There cannot be many jurisdictions left—or ever—that finish at 16. I would certainly support that; raising the participation age, of course, worked in that direction.

One area where the technologies that we are talking about in this piece of work can help is to facilitate assessment, including external public assessment, when students are ready to do it. The assumption that they are all ready and all honed to take their GCSEs all at the same time in May when they are 16 is just flawed. You can see that if you look at the maths and the policy about retaking maths and retaking English and so on; youngsters are not all ready to get to a certain point at that point. We are at a point now where testing—online testing—is so powerful and so adaptive and so on, that there is no reason why we could not work towards that. This would help, I think, do two things.

There is a bit of a stranglehold on the school system by awarding organisations. They are delivering on the agenda but schools spend a lot of money on those qualifications; putting them through a cheaper way of delivering that, through online testing when students are ready, would save money and have a much better impact on youngsters. That would be true particularly, I think, for those students who are in that third—that

forgotten third. If there were tests that were available that were not English literature GCSE but reading with a purpose and communication and so on, that could be accessed when students were ready, even before 16 but certainly from 16 and 17, that would do a lot to help the problem that we have created with reform.

Simon Peyton Jones: We might usefully draw on work that the Royal Society is doing at the moment on broadening 16 to 18 year-old education. Education is jolly complicated so I am quite cautious about just saying, "Oh, yes, if we only assessed them at 18 it would all be fine." The Royal Society has a multi-year project about thinking hard about what we could do to reduce the silo-ing effect of A-levels and broaden that so that students studied maths, science and arts, and creative arts, right through to age 18. There is quite a lot of thinking going on there that you might want to take evidence on.

Q107 **Chair:** So you think in principle what I am suggesting is the right way forward—is that what you are saying?

Simon Peyton Jones: I am sorry—in principle?

Chair: That in principle, having a wider curriculum at 18 and moving away from everything done at 16—you know, big GCSE—is the right way forward? I have not heard your view, but would you extend it to universities? If someone, let's say, does a history degree, they would do a balancing science degree and vice versa. If they are doing a science degree would you ask them to do an arts or a creative subject at the same time? Do you want to go first?

Professor Stanton Fraser: For universities, most of our students have placements, and part of the reason is that they go off and do different things during their degree. They are psychologists but in their third year they might go to industry.

Q108 **Chair:** That is not in every university.

Professor Stanton Fraser: No, it is not at every university; I am just giving an example. An interdisciplinary approach is actually what most of us are looking for. I am a psychologist but I could say I am working on science at the boundary of education. It is important to not just have one subject, so I like the idea of broadening out the A-levels, but I am with Simon about the curriculum. I don't think it is that the curriculum is completely broken; I think it is actually what we are doing within the curriculum. I have seen some really exciting things—really exciting science lessons—but there are just snippets of them. We work with sensor companies doing realtime sensing with teachers, getting expert scientists across the world doing really nice experiments, and that really engages children. That is how we use this technology, to make the curriculum exciting.

I think it is about how you factor in the use of these technologies. I do a lot of work on virtual reality. We could integrate that in really exciting

ways in the classroom. It does not have to be expensive now. Those are the sorts of things we should be looking at.

Duncan Baldwin: The point was made earlier, wasn't it, about efficiency of delivery. I absolutely agree with that. If you take a body of content in whatever subject it is, the fact that our model for so many years has been one teacher to many pupils is inefficient. It must be ,by definition. Now that the systems, the various learning platforms that now increasingly use AI, are available, the delivery of that content can be much more effective. It will then give you opportunity to be more creative within the discipline of the subject. My fear, though, given the circumstances that we are in at the moment, is that the fact that you can deliver that sort of stuff more efficiently will be used to offset what we have at the moment, which is a crisis in school funding and teacher recruitment. We have teacher shortages—

Chair: We are doing a separate inquiry into school funding, as you know. School and college funding.

Simon Peyton Jones: It would be churlish of me not to remind you.

Chair: We are not ducking away from that subject.

Q109 **Marion Fellows:** Rapid change is just phenomenal and will continue to be a feature. Do you think that lifelong learning could become more significant than education in schools?

Simon Peyton Jones: More significant than education in schools? You caught me left field there. My instinct is probably not, because at the moment we do devote really a lot of hours, a lot of full-time attention to children and their education. Adults by then are bringing up families and having jobs, so it would be hard for them to devote as much time. What I thought we were going to talk about was: is lifelong learning going to be important in the future? Absolutely. I would hope that we so infect children with a love of learning, as the previous panellists talked about, that they will want to go on doing that for the rest of their lives and it would benefit them to do so.

Duncan Baldwin: I think where we are moving to here, with this technology, is that there are three areas where it can impact on adult learners. The first thing is, as I have spoken about before, being able to catch up on key skills that you may have missed. It is quite difficult as an adult to acknowledge that there is something you could not quite do, particularly if it is literacy-orientated. These platforms do these things in a non-threatening way—a supportive way.

There is the opportunity to catch up with your skills. There is the accident of geography, so if you are in an isolated community where access to adult learning is difficult, the systems we are talking about here reach everywhere. If you want to learn Chinese in a coastal area of Lincolnshire or whatever, you can, through these systems. So they break down the barriers.

The third thing is that, as I have said, the type of testing that is now possible potentially breaks down all age barriers at school, so that children would be tested when they were ready, but also as adults. This is an optimistic area; I am optimistic about it, as far as adult learners are concerned.

Professor Stanton Fraser: It is not at all my area, but in terms of teachers, when coding came into the curriculum we saw, in primary schools in particular, how difficult it was for people to suddenly have to grasp that. It was exciting and complicated. That level of lifelong learning—how we do that, how parents understand what children are learning in schools as we become more technologically advanced—is really important.

Q110 **Marion Fellows:** Here is another interesting one. Whose responsibility is it to provide lifelong learning? Is it universities? Is it employers? Is it further education? Is it just schools?

Simon Peyton Jones: There was a time when schools received public funding to offer adult education. I am a governor of Chesterton Community College in Cambridge, which offered quite a rich adult education training programme, but when the funding for it disappeared, they could not do it any more. It was pretty cheap in terms of pounds per course, but the school just could not justify spending all that money. It is one of those things where for quite a modest investment, as it were, we as a nation could leverage or unlock quite a lot of creative energy from people who live in an area but who may work out of a school base because the school is not used for all hours of the day. I think that was a lost opportunity. I really regretted it when Chesterton closed that down because the funding disappeared.

Q111 **Chair:** Did you give money to local schools?

Simon Peyton Jones: How did it work? I think the money came initially to the county council or the local council. All I know is that they ended up employing a full-time person who was based at the school. They probably worked with the local authority. Again, I am not prescriptive about how; I just think it is not going to happen—you are saying who is responsible—unless we unlock at least modest sums of money to make it happen, but there is so much creative energy and enthusiasm from people who would love to teach basket-weaving to their friends. We just need to unlock it; we do not need to pay for it at cost, as it were.

Professor Stanton Fraser: It is also whether you see it just as courses. You could see it as much broader. I can give you an example. An AHRC project, a very large hub, created 80 digital projects of academics and industry, and then a massive public engagement—not just a small public engagement: 6,000 people come through the doors and they get involved in all the projects, integrate with the projects. It could be things like that, en masse, as well as courses—a combination. It could be universities, it

could be industry, but in perhaps different ways, really engaging people in lifelong learning.

Duncan Baldwin: I know it is not the schools at the moment. They can't; they just can't. So it can't fall in the court of schools.

Marion Fellows: It all comes back to funding, doesn't it?

Q112 **Ian Mearns:** In terms of this adult education aspect and how we are going to gear up for that, because it is going to be necessary, it seems to me that the profession out there needs a massive injection of resource for continued professional development, CPD. We have not seen any sort of initiative coming from Government that is gearing up towards that at the moment.

Simon Peyton Jones: Particularly for teachers. Happily there is some good news here, which is that the Chancellor, this time last year, announced £100 million across the UK to support CPD for in-service computing teachers. That has been a huge shot in the arm. It is only just starting to gear up now but that has been, and will be, a real help. It is absolutely not job done, but at least in some localised places there is some good news on that.

Duncan Baldwin: You need to be cautious about how that is done. Your colleague mentioned whiteboards, which is the classic example of how not to do it. "Here is your whiteboard—get on with it." Surely we have learnt from that. Even if there was a lot of money available—sorry to bang on about money—to fund something like this, there are many ways you can waste that money, as we have shown in the past.

Q113 **Ian Mearns:** I remember as a school governor seeing the salesmen coming round from the companies 20 years ago. They were whizzes on these things but they did not then stay and train the staff how to use them effectively, which was a problem.

Simon Peyton Jones: Can I just inject a note of caution about the use of AI for tutoring? I do think there is huge potential there for offering more personalised learning of the kind that Anthony was talking about, but I do not think we are even close to saying we could teach physics three times as fast just by deploying some existing AI tutor. We are not even close to that. AI is not magic, it really isn't. It is just more computing and it is hard to get right. Education in any case is complicated and students differ a lot. There is rich potential there, but it is absolutely not the case that suddenly we will teach physics twice as fast and will consume the benefits by not paying teachers any more. It will take real effort; it will take investment; it will take evidence. Rather than just saying, "AI will do it all," we need to conduct rigorous, research-based evidence that asks, "Do children learn more quickly or more effectively using some of these platforms than not using them?" We don't really know that yet. We should be doing that research.

Q114 **Chair:** How do we find out what is genuine AI that is going to benefit

teachers and students and what is not just snake oil?

Duncan Baldwin: Can I give you an example of something we have just started? You are aware that schools have a large amount of data that sits in their management systems about all sorts of things to do with pupils. We have just started a bit of work at our school, connecting little hubs of schools in four local authorities in the north-west together. They are sitting on data that tells them something about their pupils. It costs them some money to repackage that data and then they send it down here, and the next time they see that data it is coming back to them to hit them over the head like a club of accountability. If you take attendance data, for example, a secondary school can have half a million attendance marks throughout the year, it sees from down here 91.7%, so one average, which is the crushed output of half a million attendance marks. I think those marks may well tell important stories, have important connections and important learning about the young people who were attending or who were not attending, but a school cannot do that on its own; it needs to have a way to connect the data and it needs some of the techniques that are now available—some of the big data techniques—to look at that data.

We are working with those schools. We are taking the data out to a safe place. We are constructing visual dashboards to look at that data, so that schools in, say, Liverpool—which is one of our hubs—can compare attendance and non-attendance with particular types of youngsters in, say, Manchester or Tameside where we are working with that. What is particularly important here is that this is the profession leading that piece of work. We must be guarded and must be very careful about ethics with all of this data—we have seen so many stories of where that goes badly wrong—and we must guard against commercial interest in this data as well. That is why I think we have a central role to play there.

Q115 **Chair:** Just briefly, would you concur with that or do you have anything to add in terms of avoiding the snake oil salesman working out what is good in terms of AI?

Professor Stanton Fraser: I absolutely agree with you about saying things are put away in the cupboards and the whiteboard issue. I was on an advisory board just after that and it was all around mobile technologies and how we were going to use mobile technologies in the classroom. I think you have to be really careful about that. It is about the integration of its data. It might be small robots, but it is how those are integrated with researchers in industry in order to implement them with teachers in the classroom. Handing them technologies does not work; that is not the way to go.

Simon Peyton Jones: Please take into evidence—I keep banging on about the Royal Society—the report it produced last month called "Harnessing Educational Research". We don't have enough capacity in this country among our academic researchers to study what is happening in our classrooms. So, as Duncan says, it is fruitless to expect individual

hard-pressed teachers to come up with magical new ways of teaching. We have got to do cross-school trials.

Q116 **Chair:** Who should be doing that?

Simon Peyton Jones: The report is full of recommendations about what we should be doing.

Q117 **Chair:** In your view, who should be doing it, in a nutshell?

Simon Peyton Jones: We should be funding educational researchers and making sure that they are working on things that are of fairly immediate relevance to teachers, not on filling the pages of academic journals. Fairly directed research, if you like.

Ian Mearns: I am afraid to say that, many years ago, I was part of a funding organisation through the Local Government Association and we had the National Foundation for Educational Research. They insisted on doing pure research and it was not about doing research that was meant to be towards helping policy development. I am not really sure we can afford that any more.

Q118 **Chair:** The point on ethics that you made was very important. I know the Government have set up a data ethics body and so has Anthony Seldon, who was here before. At the moment we have the internet and we have a privatised surveillance society in a way, because the ordinary citizen does not know for the most part what their rights are. It is very important that we do not fall down the same hole as we have with the internet in general.

I will just ask one final question. In terms of the advance of robots, AI, automation, what subjects would you say should be compulsory for students in secondary school?

Duncan Baldwin: Again, I think that is an incomplete question because it depends for how long you might study them and to what depth.

Q119 **Chair:** Through secondary school. What subjects should be compulsory?

Duncan Baldwin: Up to the age of 16? This would be my opinion. I certainly think English, maths and science should be compulsory. The minute you then start mandating subjects beyond that is when we start recreating the problems we discussed earlier. There is a very strong case for more youngsters to do computing; of course there is, but when you do that fewer youngsters do art, and fewer youngsters do music, and fewer youngsters do German.

Q120 **Chair:** You could have many different science disciplines, so maths, English and science are the only ones you would say should be compulsory?

Duncan Baldwin: That is where we have been. In my professional life we have been through various iterations of Governments saying, "This portfolio of subjects is compulsory." A while back it was those subjects

and then it was modern languages and, interestingly, technology not that long ago. Now, effectively, we have said that it is actually humanities instead of technology. Whoever is making that decision is not getting it right, because we have had two different versions from down here.

Professor Stanton Fraser: I think it is really clear—I would be surprised if we did not all agree—that you have to teach the basics. You have got to have a foundation in maths and you have got to have a foundation in English, and to some extent science; but we could be more creative. At the moment we have history and computing. Those things can come together; you can use virtual environments to look at historical places. This is an easy example, but you can draw those together so it does not have to be as clear cut as, "You have to do these six topics." We could think a bit more imaginatively, as we do at university level and research level, about what people are learning at this age—and going into A-level, as you suggest, as well.

Simon Peyton Jones: You mentioned particularly AI and the rise of the robots and so on. I do think that to have agency in that world, the children do need to understand something about computing. I wouldn't advocate for everybody being forced to do a computer science GCSE; I would advocate for all children studying some aspect of information, computation and communication as a subject until age 16.

Chair: Would you agree with that?

Professor Stanton Fraser: I absolutely agree, yes.

Q121 **Chair:** When you say science, do you mean that or any kind of science?

Duncan Baldwin: You just have to be slightly cautious. Computing has been bundled in with science from the point of view of accountability measures. I think that was possibly helpful to give it a leg up, if you like, at the time. I am not sure it is helpful necessarily all the way through because I think it blurs biology, chemistry, physics and so on. I am a very strong advocate of computing because of the thinking it gives children, but I am also a very strong advocate of art, drama and modern languages, and all the rest that we need young people to have. It is breadth, richness and diversity in the curriculum that really, really matters, rather than a menu of things that are more important than others. That has proven to be wrong and damaging.

Simon Peyton Jones: I think there is an underlying message about breadth rather than narrowing. We have gradually narrowed and I think we should be going in the other direction.

Chair: Thank you very much. That is really helpful and we are really grateful for your time. I really wish you well in all the work that you are doing. Thank you.