HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Diversity and inclusion in STEM, HC 95

Wednesday 18 May 2022

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Watch the meeting

Members present: Greg Clark (Chair); Chris Clarkson; Dehenna Davison; Katherine Fletcher; Carol Monaghan; Graham Stringer.

Questions 252-362

Witnesses

I: Dr Claire Crawford, Research Fellow at the Institute for Fiscal Studies, Professor Dame Athene Donald, Master of Churchill College and Professor Emerita of Experimental Physics at the University of Cambridge, and Dr Jasper Green, Her Majesty's Inspector, Schools and Subject Lead, Science, at the Ofsted Curriculum Unit.

II: Clare Hayes, Deputy Head, Hyndland Secondary School, Jane Lunnon, Head, Alleyn's School, and Mark Turner, Headteacher, Skipton High School for Girls.

III: Professor Ulrike Tillmann, President, London Mathematical Society, and Rachel Youngman, Deputy Chief Executive, Institute of Physics.

Examination of witnesses

Witnesses: Dr Claire Crawford, Professor Dame Athene Donald and Dr Jasper Green.

Chair: The Science and Technology Committee is in session. We continue our inquiry into diversity and inclusion in science, technology, engineering and maths. Before I introduce our first panel of witnesses, our colleague Carol Monaghan wants to declare, if not an interest, then an association with one of the witnesses.

Carol Monaghan: Thank you, Chair. One of the witnesses in the second panel, Clare Hayes, is a former work colleague of mine at Hyndland Secondary School.

Q252 **Chair:** I will introduce our first panel of witnesses. I am very pleased to welcome Dr Jasper Green, subject lead for science at the education inspector, Ofsted; Dr Claire Crawford, a research fellow at the Institute for Fiscal Studies who has produced some important work on the participation of women and girls in science and maths; and Professor Dame Athene Donald FRS, who is the Master of Churchill College and Professor Emerita of Experimental Physics at the University of Cambridge. Thank you very much for coming to help us with this important inquiry.

Perhaps to start with, we could consider the context and some of the figures and evidence around the participation of girls in science at school. Dr Green, would you summarise what you know from your extensive reviews of every school in the country, or at least in England, when it comes to participation in science?

Dr Jasper Green: Thank you very much for inviting me to speak. I think we are seeing a broadly positive picture at key stage 5, in the uptake in science over time and in STEM A-levels. For certain A-levels—physics, for example—the participation of girls is significantly less than boys. For example, in 2021, 23% of girls entered physics, so there is a clear minority there in relation to boys. Computer science is another area where females are significantly under-represented relative to boys; 15% of entries at A-level were female.

We know that, across the full education landscape, pupils from socioeconomically disadvantaged backgrounds are significantly under-represented, both in triple science and at A-level. We see those gaps very early on in their education; for example, the year 6 sample tests at the end of primary school show that just 9% of pupils eligible for free school

meals are estimated to reach the expected standard in science, compared with 21.2% of their peers. Those are some of the key headlines.

In terms of the work we have been doing at Ofsted, we have completed a research review, which really explores the literature around high-quality science education. The next step of the work is to explore how science is taught in England's schools, but we have not completed that work yet—we will be able to add further evidence when we do.

Q253 **Chair:** Are you able to say anything about the trends in the data? You spoke about girls' participation in science and maths subjects. Is their participation increasing, or is it stable?

Dr Jasper Green: Over time, it is increasing, but by quite a small amount. If we think about 2017—the current 2021 data is plus 2%, in terms of girls' participation.

Q254 **Chair:** Plus 2% from the previous year?

Dr Jasper Green: Over the time since 2017. There are increases, but they are small. In computer science there is a bigger increase: plus 6%. So there are increases, but they are slow, and the gender gap—in physics, for example—has been around for a long time.

Q255 **Chair:** I will come to some questions to each of the witnesses, but I want to go into the figures a bit further, Dr Green. From your purview of schools across the country, have you drawn any conclusions or made any observations about types of schools or types of settings where participation is higher or, conversely, lower?

Dr Jasper Green: It is still quite early. As we know from work done by the Institute of Physics, the observations are that in all-girl schools the participation in physics is much higher—nearly two and a half times higher. We know some of the challenges around pupils choosing when to do triple science, for example.

In English schools, you can do either triple science, as you know, or double science. If that choice comes too early, what can happen is that you end up disadvantaging certain groups. You haven't had sufficient time to develop their scientific knowledge to meet the criteria to do triple science. That is one of the areas that research and our own workers identified: if that decision comes too early, say in year 8 or year 9, then you are potentially discouraging a number of pupils from doing triple science. That has an impact on those pupils who go on to do A-level, because a high proportion of pupils who do triple science go on to participate in A-level science.

Q256 **Chair:** We have heard evidence in this inquiry that restricting choice—in other words, giving less choice to students—especially at an early age but also throughout their career, is a good way of maintaining interest in, and the propensity to, continue with sciences. Is that something that you recognise?

Dr Jasper Green: That is true, I think. That is what the research shows. Where there is a choice, if pupils don't make that choice, or the choice isn't made for them, they believe that perhaps science is not for them because they are not selected. Therefore, you lose those students prematurely. Where there is choice, that can lead to certain groups that are perhaps already under-represented being selected against.

Q257 **Chair:** Does that lead to a house view on the part of Ofsted, in terms of observations, advice and feedback to schools, that more choice can have, in this respect at least, some negative consequences?

Dr Jasper Green: The inspection framework is clear about the curriculum narrowing. If we saw pupils' educations being narrowed—for example, if GCSE came down too quickly and that removed some of the breadth of the key stage 3 national curriculum—that would be picked up on inspection. It is up to schools to choose when they make those decisions about triple science and combined science, but it is the rationale behind that choice that is important. Have leaders thought carefully about, for example, whether they are monitoring which pupils are not taking triple science? Are they aware of that? Are they recognising the challenges of selecting triple science, for example, at the end of year 8 or even year 9? Have they thought carefully about the curriculum? There are ways in which you can design the curriculum so that essentially all pupils study all the content, and then that decision to do triple science can be delayed to year 10 or year 11.

Q258 **Chair:** Dr Crawford, you wanted to come in on the statistics. Is that right?

Dr Claire Crawford: I was going to complement what Dr Green was saying. He mentioned some numbers since 2017. If you look back a decade, the picture looks even more positive, particularly at GCSE level. A decade ago, girls were about 15% to 20% less likely to do triple science than boys, whereas now it is about 2% to 3%. There is still a small gap, but it has closed a lot over that decade. With respect to the A-level statistics, it was already the case that girls were more likely to take biology, for example. They have now become more likely to take chemistry than boys; they were less likely 10 years ago. Maths and physics, which are the focus, are of course outliers—particularly physics.

Maths and physics are the two most popular subjects to take among boys. Even for girls, maths is the third most popular subject to take at A-level. There are still significant numbers of girls taking maths in particular, but still relatively fewer than boys, for whom it is a very popular subject. Physics is much less popular for girls, but still more popular among them than, say, English is among boys. It is not that physics is the total bottom of the pile, but obviously relative to boys for whom it is a particularly preferred subject.

Q259 **Chair:** Taking physics as an example, from your studies of the data, have you identified any types of setting in which there is higher participation of girls in physics compared with others?

Dr Claire Crawford: Picking up on the point that Dr Green was making, single-sex schools are a clear outlier. Girls in single-sex schools are much more likely to take physics, maths and further maths than girls in mixed schools. From the international evidence, I would say that probably quite a lot of that is because of the different types of people who tend to go to girls schools as opposed to mixed-sex schools. Girls in single-sex schools on average might be higher-attaining going in. Those students are also more likely to take maths and physics than lower-attaining girls. From the international evidence, it is hard to conclude definitively that single-sex schools causally raise the participation of girls in science, technology and maths.

Chair: So it might be a selection effect. Thank you very much. Let me turn to my colleagues, starting with Carol Monaghan.

Q260 **Carol Monaghan:** Dr Crawford, you have spoken about the differences in science. How do we account for the differences, for example, in the number of girls taking physics compared with chemistry and biology?

Dr Claire Crawford: A lot of the evidence now is splitting the STEM subjects into two groups: those that are more maths-based like physics and maths, and those that are more life sciences-based like biology and, a bit more arguably, chemistry. They do see very clear distinctions. The research that we did focused exclusively on maths and physics, and we asked girls in some detail—these were high-achieving girls, those who were predicted to get an A or an A* at GCSE level—about their choices and why they might or might not do maths and physics. A majority reported enjoying the subjects, more so in maths than in physics, but they also found the curriculum quite content heavy. They found it very focused on exams, rather than being able to delve into topics of more interest to them in more detail. There were also more concerns about the quality of teaching that they were receiving in physics as opposed to maths, which points towards the fact that there is a general shortage of physics teachers in particular.

Q261 **Carol Monaghan:** Can I ask specifically about that? If we are talking about the quality of teachers, did you do any research around whether these teachers were physics-qualified, with a physics or engineering degree?

Dr Claire Crawford: Not in our study, but we know that in general, the evidence would suggest that there is a benefit to being taught by someone who is a specialist in their subject. We know that physics is a particular area where there is a shortage of teachers in the UK, but also more broadly. There is some evidence that if you provide support to science teachers who come in with a specialism in biology or chemistry to become a bit more up to speed on physics, that can help to improve things. Providing support for specific pedagogical tools that you might use in the different science disciplines can also help.

Q262 **Carol Monaghan:** You talked about all-girls schools—in fact, both you and Dr Green have talked about that. Was your research able to pick out

other areas where schools were doing well, or would that come down to a more granular, school-by-school basis?

Dr Claire Crawford: I personally haven't been involved in any research like that. There is evidence out there that looks at different school characteristics; I am very happy to share references with the Committee afterwards, if that would be useful.

Q263 **Carol Monaghan:** Perhaps I can ask you that question, Dr Green. Other than all-girls schools, is it individual schools that are, as it were, centres of excellence in this regard?

Dr Jasper Green: Where it is done really well, I think it is. There will always be, in some schools, particular teachers, for example, who encourage high participation in A-levels, but when those teachers go that is lost. But where there is a systemic culture built around participation, that is where it lasts. Other schools where we might see lower participation are very small sixth forms where there may not be sufficient demand for physics, and therefore it is ineffective in terms of costings to run certain qualifications.

Q264 **Carol Monaghan:** I come from a Scottish background, and in Scotland you would look at some degree of equalising timetables among local authority schools so that if there wasn't a demand, students could go to another school for that particular subject. Does that happen in England as well?

Dr Jasper Green: It does happen where, for example, sixth forms are shared across different schools. Where schools might not be able to offer A-level physics, for example, there are various options available such as bringing in expertise from elsewhere or pupils attending a different school. So, yes, those processes do take place, especially where there is capacity, such as where there are groups of schools working together.

Q265 **Carol Monaghan:** Dr Crawford, turning to you again, how does the picture for girls compare with other under-represented groups, particularly in physics—children with disabilities, those from ethnic minorities, or from different socioeconomic backgrounds?

Dr Claire Crawford: The evidence on those groups, in STEM particularly, is perhaps less readily available than it is for gender, but I would echo what Dr Green said in his remarks earlier: we know that those types of groups are disadvantaged generally across the education system. That is true both in STEM subjects and in non-STEM subjects. I am not aware of evidence that shows that there is a particular disadvantage for these groups in STEM subjects. Perhaps one of the other witnesses would like to add to that.

I think, in general, as Dr Green was saying, there are large gaps in attainment which emerge very early and, given the selectivity of some of these courses, the fact that you have to have a reasonably high level of attainment in order to be able to progress there, addressing those gaps earlier in the education system will help to ensure there is a pipeline moving through into those subjects at A-level and beyond.

Q266 **Carol Monaghan:** Do either of the other witnesses want to come in on that?

Professor Dame Athene Donald: To broaden the discussion away from those later years, the evidence is that the fact that most of the images one sees of scientists or physicists are white males is relevant, and this starts really young. The sort of message that society gives is that they are white males. There is evidence to show that if you are black or a woman, you do not see yourself fitting in and some of the problems we see in later years are because girls and some ethnic minorities, although not all, have already thought, "I don't belong and I don't fit in." The fact that the national curriculum has no women scientists named, for instance, is pretty damning. We should be looking at this idea of, "Is this for me?", much earlier because the decisions made at 14 or 16 will subliminally have been made much earlier.

Q267 **Chair:** Thank you very much indeed. To continue that line of questioning, Dame Athene, you have very kindly given written evidence to the Committee amplifying your point that there isn't anything biological about the differences in preferences and they are conditioned through early experiences. Could you say a bit about the research that has led you to be so clear about that?

Professor Dame Athene Donald: There was some work that came out of the States that looked at children's attitudes when they were five, six and seven and this idea that, around the age of six, girls started thinking that you had to be really, really smart—that was the phrase used in the paper—to do some of these subjects and, by and large, they thought girls weren't, and you could see it in the choices they made about what games to play. When the researchers gave them different types of games and said, "These are for the smart", the girls would opt out. That happened at about six.

The same research group in the States looked at the proportion of men and women doing degrees. There was an absolute inverse relationship between the idea of brilliance—I am afraid I cannot remember how they defined brilliance at that point—with subjects like physics, philosophy and economics, which were all regarded as being subjects you have to be brilliant to do, having the lowest numbers of women doing them. There seems to be this sort of societal belief. How many times have I been told, "You must be really smart to be a physicist."? You think, "Why is that different from being a linguist?", but somehow our society believes that.

That conditioning is never made explicit, but I think that teachers at every stage can fuel that accidentally, which is a real challenge. The way teachers in the classroom respond to boys and girls answering questions, for instance, can feed through, back to this belief that a girl does not fit into this subject. I think that is why single-sex schools do so much better. Of course, there are selection differences, but no one says to them—this is my experience; I went to a girls school—"Girls don't do physics". If you go to a co-ed school, it does not have to be the teachers but it can be your peers who say, "That's not for girls."

Chair: Graham Stringer has some further questions on this theme.

Q268 **Graham Stringer:** Indeed. There is an enormous amount of good will in this area. There is no dispute about the objectives: we make a bit of progress, go back a bit. You served on David Willetts's committee in BEIS. Was that a useful exercise? Did you learn anything from that committee about what to do and what not to do?

Professor Dame Athene Donald: There were two committees in which I was involved with David Willetts. The one I think you are referring to is the BEIS diversity committee, which looked at much later years. It was looking at trying to get women into positions of seniority, so it was a very different thing.

At that time, there was also—I do not think it still exists—a joint BEIS-DfE committee. Ministers—David and, variously, Nick Gibb and Liz Truss—came to it. Representatives from lots of organisations came. At that point, I was chairing the Royal Society education committee, which is why I was there. That absolutely discussed it. It was a time of a lot of changes in the curriculum. Points such as, "Why are there no women mentioned in the national curriculum for science?" were made very strongly, and they seemed to fall on stony ground.

I think there are things that schools can do. Ofsted can also raise this up the agenda. One of the proposals the IoP—the Institute of Physics—made then, and I think is still making, is that gender equity should be part of an Ofsted inspection: at every stage, what is your school doing? Is it, as Dr Green said, monitoring what is happening? That matters just as much for boys as for girls. The work of the Institute of Physics shows that there are subjects, such as psychology and biology, that boys are opting out of. Schools could do more to make sure that inclusion really means inclusion, and that you do not have those differences in the way subtle messages are given.

Q269 **Graham Stringer:** This is half serious, half not serious: would it be useful if the adverts for smart meters had Madame Curie on them rather than Einstein, in terms of the images of white, male scientists?

Professor Dame Athene Donald: It would be different. Most members of the public cannot identify a single woman scientist, including Marie Curie.

Carol Monaghan: Or even you?

Professor Dame Athene Donald: No! I personally wouldn't want either of those—they are not good role models. I do not think Marie Curie is going to strike a chord with many people, because her life was so extraordinary, but we need to broaden the images.

Q270 **Graham Stringer:** As I say, that was half serious, but I think it gets to the point. You have talked quite a lot about early years choices that children make—or perhaps do not know they are making—subconsciously. You are the master of a major Cambridge college. Do you think your selection procedures could draw more people from under-

represented groups into one of the best science universities in the world?

Professor Dame Athene Donald: Churchill College is very proud of its widening participation work. We have always been ahead of the curve, right from the foundation, as far as I can tell; we are very conscious of that. Our statistics are good. When I came to the college, our statistics on gender were not good. If you don't know, Churchill College is by statute 70% STEM, so our intake has to be 70% STEM. Our gender balance was not good when I came in. It is pretty much 50:50 now. It just needs attention, because there are so many talented people out there.

Q271 **Graham Stringer:** That is impressive; I didn't know that. I once had a constituent from a socially deprived area who found the interviewing process at Churchill intimidating. Have you changed the interview style and culture? How have you achieved those figures?

Professor Dame Athene Donald: I hope we have changed the style. I think it is much less an interrogation and much more trying to draw out what people know, not just pin them down on a specific question.

To be honest—and I know my colleagues in Cambridge do not like this—we would do away with the interview for exactly that reason. We think it is intimidating to those who come from disadvantaged backgrounds. We think it is much easier if you have been to a school that has a track record of sending people to Oxbridge; those people will be better prepared. That is not a view that my colleagues in Cambridge are willing to accept, I think it would be true to say. There is discussion at the moment about it.

The pandemic meant we did interviews online, and there was a slight difference of opinion as to whether that was less intimidating. I think we felt it was, but the mathematicians found it quite difficult to assess people in an online situation, and again, you've got the danger of some people having better technology than others. You do not want that to be feeding in.

Q272 **Graham Stringer:** Thank you; that is very helpful. You have had a most distinguished career in physics. Is there any personal experience you could help the Committee with, where you have found either discrimination or areas where you could improve the process, apart from the selection process at Churchill?

Professor Dame Athene Donald: I have not been a fellow at Churchill that long; only when I have been master. In my life, I have definitely come across situations where I felt that I was treated differently as a woman. I think most academic women would say that.

I know you have had evidence from other people about the differences during a university career—grant funding and things like that—so I do not want to reiterate that, but again, there are subliminal messages that I fear would be true in Parliament too: the idea that if you speak out as a woman, you are dangerous, shall I say. Behaviour that is seen as normal in a man is somehow regarded as slightly odd as a woman, and I think that is as true in academia as in any profession.

Q273 **Graham Stringer:** That is really interesting and helpful. Dr Green, in terms of your knowledge, are there any regional differences? Are there areas where more girls choose to do physics, maths and chemistry—any areas of the country that do better than other areas of the country?

Dr Jasper Green: There are performance differences within regions. I do not actually have the data on that, but there is some variability. In terms of uptake of the A-level subjects, they are broadly similar across regions when it comes to the sciences. I was looking at some data a few years ago, and there was a higher percentage of pupils doing mathematics in London. Based on experience, the bigger differences are within the same region—the differences between schools in the proportion of girls taking physics, for example.

Q274 **Chair:** Thank you very much, Graham. You will know that in our last session, one of our witnesses was Katharine Birbalsingh, who is a headteacher and the Government's social mobility commissioner, and she reported some quite striking figures on participation in physics among her students. She told the Committee that she runs a successful school, she has very good teachers, and there is no sense in which there is any discouragement of girls from studying physics—indeed, quite the opposite; this is a school that offers lots of possibilities—yet that was, as it were, the revealed preference.

What is your analysis of what is, as I am sure Dr Green would agree, a successful school by objective measures, yet has this striking difference? I think she told us that 84% of A-level physics students were boys, and therefore 16% were girls. What is your reflection on that?

Professor Dame Athene Donald: It would seem to me that probably they just have not thought about it. To go back to the points I made earlier about the internal messages that girls may believe, if teachers are not actively trying to counter that, they may not realise that the girls are being driven by things that are not their natural choices.

In my generation, I know lots of women who said, "I would have loved to do sciences at A-level, but my school discouraged me." I do not for one moment expect that still to be true, but there is a difference between active discouragement and not active encouragement. She talked about 16% of girls doing physics A-level, but the national average is 23%, so she is below the curve, as it were. I would assume that is because it has not been an item on their agenda.

That comes back to my point that if Ofsted made gender equity an issue, every school—primary schools as well—would have to think, "What are we doing? Without thinking about it, are we giving boys different games to play or different tasks?"

One of the things that the Institute for Physics has picked up on when observing classrooms is that teachers are more likely to ask boys to answer a question. There may be all kinds of reasons for that, but that immediately says to the girls, "We are not really very interested in you." It is not active discouragement, and it is clearly not about bad teachers; the

Institute of Physics phrases it as a "whole school ethos", and that needs to be taken into account.

It would be interesting to know whether there is equal gendering in some of the subjects that, typically, the boys do not do in school—I do not know.

Q275 **Chair:** Thank you. Dr Green, could you perhaps address what Dame Athene said about Ofsted having a role in this? Is that something that you have considered?

Dr Jasper Green: To pick up on one point about girls' participation in A-level physics, I think it can be very hard to tip the balance. In a school where there is a large uptake of physics by boys to begin with, a girl in year 11 may find that she does not want to be a minority. I think there is something around having a shift—to get so far along the road—for that pendulum to swing, and then there would be further uptake among girls.

I think Ofsted is addressing this, but we are really focusing on the quality of education and are very much thinking about the curriculum. We know, for example, the importance of starting early and looking at early years; that is a focus of inspection. We know the importance of an ambitious curriculum that is not narrowed and, drawing a bit on what the panel said, of ensuring that it is rich and paints a really authentic understanding of what science is. It is about people learning the true diversity of science, not just fair tests or science that is carried out by males, for example.

We are focusing on the quality of education; we are focusing on early education; we are focusing on subjects. I think all those moves are the rights ones to encourage wider participation at A-level.

Q276 **Chair:** Perhaps those moves are necessary but not sufficient. Dame Athene's point was that having that as an explicit part of the assessment may make an extra difference. In fact, you sort of conceded the point by saying that there may be a chicken-and-egg issue whereby if you have a heavily male-dominated class, girls may be put off choosing that class. Looking explicitly at the balance could cause some greater pressure to address it, which may be part of the cure. Would that be fair?

Dr Jasper Green: I think it is a really complex problem to untangle because some of the factors that influence that may have occurred very far down the line; some of them are embedded in culture. I think it is about middle leadership being aware of those aspects, so absolutely, as part of the inspection, inspectors looking at science may ask questions about—

Q277 **Chair:** But to make it explicit; to make it clearer than it is at the moment. All these things are complex, but if we think this is important and significant, what could Ofsted do to make a difference? Dame Athena has made a suggestion. Is that being considered?

Dr Jasper Green: That would be a decision that sits in the policy team, not with me. The focus of the new methodology would not allow that to take place because the methodology is such that it really explores quality

of education in relation to the curriculum, and how that curriculum is taught. It could be an aspect of future frameworks, but as I said I think there are a number of challenges to it, and it would be something for the policy team to provide more information on.

Chair: All right. We are going to talk a bit more about potential solutions. Notwithstanding, as Dr Crawford said, that there have been some improvements in recent years, the fact that we are having this inquiry attests to the fact that, in the Committee's view, there does not seem to have been the scale of transformation that we had hoped for. We therefore need solutions that go beyond what has been tried before, but we recognise that that is not necessarily straightforward. Let me turn to Chris Clarkson with some questions on this.

Q278 **Chris Clarkson:** Thank you, Chair. I want to pick up on that theme. We have drilled down to the fact that early intervention is important. How do you think the current national curriculum stands against that? Do you think it does enough to promote science in early years? If not, why not? Is it a resourcing issue? Is it simply a lack of political will or interest in STEM? I am interested to get your thoughts on that.

Dr Jasper Green: There has been a real refocus on the early years with the new inspection framework. I think there is sufficient detail in terms of what pupils need to learn. A key shift now is around thinking carefully about what pupils learn in the early years and ensuring that that connects and prepares pupils for what they will go on to learn in year 1 science.

There is further work to do to ensure a coherent journey for pupils and to ensure that those gaps that have been identified—in key stage 1, for example—are closed early on. It is around developing expertise of subject leaders to develop curriculums that are coherent and that prioritise the most important knowledge for pupils to learn. The statutory guidelines provide sufficient detail for schools to do that.

Q279 **Chris Clarkson:** When we talk about developing expertise, will it be a case of upskilling existing teachers or of plugging those gaps by finding more people who are highly qualified in the STEM subjects to teach early years? We know there is a serious shortage, especially in areas such as physics.

Dr Jasper Green: First, there is more research to be done on the curriculum and science education about what a good early years curriculum looks like and what fundamental knowledge pupils need to be learning, so there is work to be done there. It is about upskilling and developing the expertise of those teachers who work in early-years classrooms.

I do not think it is necessarily taking complex ideas of physics, chemistry and biology and just sticking them down lower; it is about ensuring that pupils develop age-appropriate understanding of science and that they develop and remember that knowledge and can build on it.

Professor Dame Athene Donald: The lack of teachers with STEM qualifications in primary school is a problem. The evidence says that teachers do not necessarily feel comfortable with some of the curriculum—even without going into detail about complex ideas. I feel that, say, mandatory CPD could be a solution to enable teachers to have the time.

There are resources available, such as STEM Learning, to help teachers, but some schools, particularly in disadvantaged areas, do not have the resources to let the teachers do that. That would help give teachers the confidence to teach the curriculum. It is not about the curriculum in that case; it is about supporting our teachers so they can deliver.

Q280 **Chris Clarkson:** So continuing professional development could be applied to all teachers at that stage just to give them the confidence? I think that is a fair point.

In terms of how these interventions work, what sort of timescales are we working to? What sort of metrics are we using to measure how effective this has been? Obviously, Dr Green, you have identified that there needs to be a better approach to plug those gaps, but what sort of timeframes are we looking at?

Dr Crawford said that over the past decade we have seen a reduction in the number of girls doing science. With the gap between the number of girls and boys doing physics, for example, are we looking at over a decade? Are we looking at over one year or over five years? What would success look like, and what would failure look like?

Dr Jasper Green: That is the key question. If we are serious about this, the interventions need to be longitudinal or they need to track students over time for probably 10 or 15 years, because we see that the gaps that appear early remain. We therefore need to track that from year one in the early years all the way up to participation at A-level and beyond. That level of detail is important, and there has been work on that, such as the ASPIRES study. That has been beneficial in terms of informing our knowledge base of these issues.

Q281 **Chris Clarkson:** In practical terms, what is that going to look like? Are you going to follow a particular cohort as they enter secondary school and through to A-level, or are you going to track three or four cohorts?

Dr Jasper Green: I think cohort studies are important in that sense. On the TIMMS 2019 data, although they are different students—they are year 9 in 2019—you can go back and see how they performed in year 5, and you see a relative decline in that cohort. It is that timescale that you need—at least five years.

Dr Claire Crawford: This is a case of the leaky pipeline. In other areas that I study, particularly with regard to socioeconomic background, you lose qualified students from under-represented backgrounds at each stage along the way. There are gaps early, and they widen over time.

You lose more people at A-level, at university, into STEM careers and so on. We are not talking about a single intervention or package of

interventions focused on just one cohort that we start on early and then follow through. There are things that we can do now that will affect progression into STEM careers, university or A-levels for those who are at that point now.

Alongside that, we simultaneously want to start early with the cohorts that are just coming through now, and then sustain those interventions right through the school career and into the labour market to try to address the challenges at each point along the way.

Q282 **Chris Clarkson:** In terms of those early interventions, I am particularly struck by what Professor Donald said about people seeing themselves in those careers. Do you think that is an important part of it? For example, my constituency has a fairly low socioeconomic attainment level. If more people saw people from their background participating in this, do you think that would have an instant impact?

Dr Claire Crawford: There is certainly good research evidence on the benefits of role models—people who look like you, whether it is socioeconomic background, ethnicity or gender, doing jobs like STEM. There is good evidence that that encourages people to think more seriously about those options. They are more likely to take those subjects at university and perhaps progress into those careers.

We do not want to overestimate how successful that could be on its own. That would probably go alongside a package of things to address some of the points that my colleagues have made about girls and boys with equal ability—girls think they are less able than boys even though they have the same kind of underlying achievement. That is a problem generally for girls across a lot of subjects, but particularly in STEM.

We also need to address the kinds of unconscious bias. Different approaches that teachers might take—different pedagogical approaches—can help. We should make sure there is no unconscious bias in the way educators interact with boys and girls and those from different backgrounds.

A package of small things could combine into something greater. I echo Dr Green's point: one of the things we found in our research is that girls seeing themselves as a minority either in education or in a career is a significant barrier to wanting to pursue that.

There is certainly evidence that in workplaces that are dominated by one gender or the other, in both directions, the minority gender can experience more harassment or perceived harassment and things like that. It is not just a question of moving one more girl into physics. We might need to move 10 more girls into physics to overcome those kinds of challenges in a particular school.

Q283 **Dehenna Davison:** We have spoken about the importance of role models, which has come out in other evidence sessions. Chris talked about it there, but as it stands the science curriculum doesn't mention a single female scientist, as you rightly outline. That is outrageous. There

are some incredible examples right throughout history. Why is that the case? Is anything being done to address that so that young people, right from day one, can see that women can make it in science too?

Dr Jasper Green: As for why it is like that in the national curriculum, I could not provide the reasoning behind that. From my experience in schools and from the evidence we are gathering from subject reports, I can see that there is definitely a focus in schools on making sure the science curriculum is broad, reflects a variety of people and speaks to the pupils in the class. It is important that it speaks to all pupils.

All pupils need to see science for what it really is: a diverse discipline made up of lots of different methodologies and research areas. That is coming through, in terms of both the curriculum and how it is taught, such as with the examples teachers use—the images they use in the classroom are much more sensitively thought about.

Q284 **Dehenna Davison:** Do we expect to see specific changes to the national curriculum?

Dr Jasper Green: Ofsted's role is independent of the DfE, as you know, so I can't comment on the planned changes to the national curriculum. Certainly, though, the national curriculum—

Chair: We hope to have the Secretary of State for Education give evidence to the inquiry, so we will be able to pursue that.

Dr Jasper Green: Thank you. The national curriculum is a framework, but schools can certainly go above and beyond it by selecting the sciences they want pupils to learn.

Q285 **Dehenna Davison:** I know that my godkids get the most enthused when external people come in and do demonstrations, and particularly when those people are role models and reflect what the kids look and sound like. Professor Donald, you have talked about the outreach that your college is doing. Do you actually send people out into schools to do demonstrations to try to encourage and enthuse young kids?

Professor Dame Athene Donald: Not the college—the university would do that. One concern I have about a lot of the outreach that is done—science festivals, for instance—is that you are often reaching the people who already have that kind of cultural capital. It is very important to reach out to people in disadvantaged areas, and that is always harder. Someone was asking about geographical differences; in Cambridge, the schools are fantastic and understand these things, but you don't have to go very far into the fens before it is very different.

Things such as Speakers for Schools, for instance, which I participate in, are wonderful for bringing people into less advantaged schools. We need diverse people going in. People from industry can really do good things by going in and talking about their day job. An academic might not be the right person at all. We should think about who gets involved with those programmes and try to make it easier to do that. That also applies to work experience.

There was an Ofsted report a long time ago—I haven't seen a more recent one—that showed just how gendered work experience was. The girls went to the hairdresser and the boys went to the garage. I have no idea if that has changed, but I would like to think so.

Q286 **Dehenna Davison:** Hopefully we can find some evidence on that ourselves in future sessions. This question is, perhaps, a little odd: do you think there should be more of an emphasis on schools enforcing STEM with the subjects they make available, or would that be the wrong approach? Professor Donald, I'll come to you first.

Professor Dame Athene Donald: I do not think enforcement is necessarily the right way to go, because it could backfire. We need to make it available and exciting and put it in context. Another point that hasn't come up is careers advice. We need to explain. That's why it helps to have people from industry come in and answer questions like, "What do you do? Why do you need maths and physics A-levels? What openings does it give? What training does it give?" That, again, should start much earlier on.

Q287 **Dehenna Davison:** Dr Crawford, can I come to you on that same question? Do you think it would have a significant impact on the future take-up of STEM if schools put it as a guaranteed part of their own subject choices?

Dr Claire Crawford: We have seen improvements in the number of schools that offer triple science and STEM A-levels. Coming back to the earlier point about whether the participation rate of girls should be included in Ofsted inspections, I'm not sure that we want to go as far as forcing girls to do these subjects. I'm sure that, if schools had more focus on it, as Dame Athene was saying, to make sure that they aren't instilling any gender biases by default, that would be helpful.

Q288 **Dehenna Davison:** Dr Green, anything you would like to add?

Dr Jasper Green: No, I don't think so. Science is a core subject in the national curriculum, and I think its status may need to be raised at primary. The removal of key stage 2 SATS in science has coincided with a potential deprioritisation of science in some schools. So there is more work to do there, but overall I do not think it would be beneficial to force pupils to do specific subjects beyond the compulsory age.

Q289 **Chair:** Before I come to Carol, I was going to ask some questions about the workplace and employers, and some final questions on education. Earlier in the session you said that a wide range of choice is sometimes associated with people not taking sciences.

It has been argued, and it may be the case, that the knowledge that people have at a young age in early secondary school, when they are making choices, is not sufficient for them to be able to exercise wise choices. We hear all the time that people's choices constrain them in later life. Isn't that an argument in favour of compulsion?

Dr Jasper Green: There is obviously compulsion in relation to how long you need to study certain subjects for in the national curriculum. For example, all pupils need to study science until they are aged 16, so there is compulsion there. However, I think there needs to come a time when pupils are given as much time as possible to develop the knowledge they need to make an informed decision, so at the age of 16, as it is in this system, with appropriate—it needs to be an informed choice. That puts a key emphasis on schools making sure that the careers programme, for example, is sufficiently robust and that teachers have enough expertise to be able to advise students on what they do next.

Q290 **Chair:** A couple of final points on this, which arise from some of the comments made after our previous session. May I put them to you, Dame Athene? Are we looking at the wrong part of the problem? Is the differential participation, between boys and girls, not a reflection of the fact that boys feel less confident in choosing arts and humanities subjects and therefore it produces the statistical effect that we have? Do you think there is anything in that?

Professor Dame Athene Donald: I think that that comes back to the fact that society is quite gendered in the messages it gives—so yes, boys think English isn't for them. That is bizarre as there have been wonderful male writers throughout the centuries, but these messages have somehow perpetuated. Of course, it is not just in schools; it is for the whole of society and the way the media portrays these things as well.

This is going beyond my expertise, but there is the argument that girls mature earlier and that they are more fluent. I don't know whether that is really borne out—it is not my area—but they seem to think they have more choices and therefore if they are being discouraged, passively or actively, from doing STEM subjects, they may stay in the arts and the boys may feel, "Well, I can do my maths. That's fine. I'll stick with that." We need to try to make all our schools as inclusive as possible, so that neither gender feels pushed in either direction.

Q291 **Chair:** Finally, one of the suggestions that is sometimes made about A-level choices is that maths and physics are perceived to be harder than some other subjects. You are the master of a college that admits, as you were saying, undergraduates after they have done A-levels. Is there anything in this? Is it possible that exams in different subjects are not well calibrated and that it is more demanding to get a grade A in physics than it is in some other subjects? Is there anything in that or is it a red herring?

Professor Dame Athene Donald: How do you measure that? If you are really good at languages, then that will come naturally to you, for whatever reason. I find that argument unconvincing, but I don't know how you calibrate it.

Q292 **Chair:** Is there a way to be sure? How could one calibrate these things?

Professor Dame Athene Donald: I have no idea. I would look to an educationalist to comment on that.

Q293 **Chair:** Perhaps Dr Crawford or Dr Green?

Dr Claire Crawford: It is really challenging. Fundamentally, they are testing very different skills and how you equate the levels of those skills is a difficult problem to solve.

A tangential point is that the difficulty doesn't feature massively in students' choices of which subjects they take. The three things they seem to take into account are how much they enjoy it, how good they are at it and what their future career choices require of them. I don't know whether it was Ofsted, but someone, maybe Ofqual, did a piece recently that looked at the difficulty of different subjects. I don't think they found anything particularly striking in terms of subject choice. I am happy to share that report afterwards.

Q294 **Chair:** Dr Green, do you have any feel for the comparability of subjects in terms of the demands that are made for a given grade?

Dr Jasper Green: No, I do not. I know that studies have in the past tried to get a feel for that. Essentially, they took the prior attainment and looked at how pupils performed in different subjects. If they always performed worse in physics, for example, then that might be an indicator that it is harder, but it is obviously really complex, and I think for me to comment further would be anecdotal, so I am not going to.

Chair: We could go on longer, but we have other witnesses that we are keen to hear from, so I thank all three witnesses very much indeed for your evidence, both written and oral, to the Committee today.

Examination of witnesses

Witnesses: Clare Hayes, Mark Turner and Jane Lunnon.

Q295 **Chair:** I would like to welcome our next panel of witnesses, who are all teachers—indeed, heads and deputy heads. I am pleased to welcome Clare Hayes, who is the deputy head of Hyndland Secondary School in Glasgow, which Carol, our colleague, referred to earlier. I also welcome Jane Lunnon, who is head at Alleyn's School, and Mark Turner, headteacher of Skipton Girls' High School. Thank you very much for coming to give us your perspective today.

You all teach students, so you have everyday experience of the issues that the Committee is looking at. Perhaps I could start with Clare Hayes. You heard the evidence from the previous session, and I think you have seen some of the debate that has been held in front of the Committee on what might be the causes of the differences, particularly among girls, in choosing science and maths. How does it seem from your perspective?

Clare Hayes: Hyndland is a truly comprehensive secondary school in the west end of Glasgow. We have young people from the bottom of the SIMD—it would be IMD in England. We have about 20% to 25% from the bottom. We have about 30% from the 9th and 10th decile of SIMD, and we have a bit of a dip in the middle. We are a very unusual school—a bit like having Jordanhill and Drumchapel in the same building.

I looked at our data over the last number of years, and we are exceptionally strong in physics. We have been exceptionally strong in attainment in physics for 25 years, as far as I can remember. We haven't quite cracked the girls in physics thing. We did get very close to it. When I looked back at the data from around 2017, our uptake for young people picking national qualifications at the end of S2 was at 50%. It was 50/50 for chemistry, physics and biology. I think that was a lot to do with our staffing. It was very stable, and we had a good balance of excellent, very experienced staff. We had a good gender balance in the staff. We had a good mix. I think that contributed to the general uptake.

In terms of sustaining that into what we would call advanced higher, we have to work quite hard to keep the numbers up there. Our numbers in maths and physics are very strong. In fact, we probably have one of the largest presentations in Glasgow, but we still don't quite have the gender balance there, so we have got to work quite hard.

Q296 **Chair:** What are the figures?

Clare Hayes: In biology, girls make up about 60%, and in physics it is about 25% to 30%.

Q297 **Chair:** So the phenomenon presents itself in your school as it does in others?

Clare Hayes: That said, the girls that we take in perform exceptionally well. They perform in the top 20%. They are outperforming their peers in that respect. In terms of actually driving the numbers of young people coming into the school, we do have to think about what experiences the young people get—not just the experience in the classroom but in terms of wider attainment. We look for opportunities where we can inspire young people.

Q298 **Chair:** You are one of the strongest schools in Glasgow, and indeed Scotland, in this area. Knowing the students as you do and seeing a greater proportion of girls drop out from their study of physics than boys—it was said that it was broadly balanced at the prior stage—do you have any insights into what drives that?

Clare Hayes: As was mentioned earlier, there is a lack of confidence in girls in their ability. We had our physics exam recently, and I spoke to girls coming out. One young person in my class was really nervous. I said, "You have never scored less than 90% in an exam up until this point. Why do you think that this moment will be different for you?" There is an extreme lack of confidence in what they are doing. But a conversation—a bit of inspiration, a bit of nurture—can persuade that young person that they have performed exceptionally well and maybe they should consider this as a career path. That is something that we have to work with young people on: to provide the role models, looking at former pupils who have been very successful and getting them to come and share their experience with young people. We think that tips the balance for us.

Q299 **Chair:** Is that lack of confidence general in girls compared with boys

across academic subjects, or does it pertain particularly to the sciences, and perhaps particularly to physics?

Clare Hayes: My experience is in science, so I feel it is particular to science. But there is also that conversation that you have with parents when young people are picking their subjects. Quite often, parents will say, "I can't help them if they pick that subject." As a teacher, I want parents to support young people in their learning, but I do not necessarily need them to teach their young people. So we have a wee bit of work to do around family learning, to educate people that young people can pick subjects that their parents have not taken and do not have an experience of, and can be very successful in that.

Q300 **Chris Clarkson:** May I start with Mr Turner and Ms Lunnon? In your experience, how does uptake by girls in STEM subjects differ from other under-represented groups? I am thinking of ethnic minorities and people from lower socio-economic backgrounds. Do you think there is a difference in the rates of uptake? If so, what do you think are the drivers for that? Let's start with Jane.

Jane Lunnon: Hello, and thank you for asking me to give evidence to this inquiry, which is a real honour. I can only speak for my school. In my school, the number of BAME students is relatively small, but they are over-represented in physics at A-level, for example. Of our girls, we have 22% at A-level, so that is about the national average. All our girls will do physics GCSE, but at A-level it would be about 22%, whereas in maths it is nearly 50%—49.7%. We definitely have some work to do in physics at A-level to get it up to the level of the other sciences. Just for comparison, 88% of our girls, so nearly 90%, will do one STEM subject at A-level.

Mark Turner: In terms of ethnic minority profile, we don't really see a particular difference—about 40% of our students are non-white British. Part of that in the A-level is that we are selective in the main school bit, but our sixth form is non-selective. We have a significant number of ethnic minority students who join in the sixth form and, generally, they are joining to do STEM subjects, particularly biology, chemistry and maths—slightly less so for physics.

Q301 **Chris Clarkson:** What do you think the disparity is in physics? We heard from the other panel that sometimes there is a lack of role models and people do not see themselves in that subject. Would you say there is anything in that?

Jane Lunnon: Yes, I absolutely would. I think the main solution is to solve the problem. That is not a very helpful thing to say.

Chris Clarkson: A career in politics awaits.

Jane Lunnon: Alleyn's is a highly selective school of very academically capable kids, although we do have a reasonable socio-economic balance because we have a significant proportion on bursaries. It is interesting that if you survey our girls, even though a lot of them are science-minded and, as I say, the vast majority will do at least one science at A-level, they are

saying to us that physics feels like a male-dominated subject and they do not see themselves there. That is about national messaging as much as anything else, but of course it is also factually true in terms of numbers.

I heard some interesting research by Sarah-Jayne Blakemore recently about the single greatest fear for adolescents. Sarah-Jayne Blakemore is a neuroscientist who is looking at the brain chemistry of fear and risks that adolescents feel most strongly. The electric signals are strongest in the brain for teenagers when they have a sense of being the odd one out or being unusual. It is no good saying, "Pull yourselves together, forge that fight." Their biology and chemistry are also mitigating against girls, in particular, saying, "Yes, I want to put myself in a place where I am going to be surrounded by boys or men." So I think there is a real piece to do around that, to help them see themselves in a physics context, in particular.

Q302 **Chris Clarkson:** It is self-reinforcing. How difficult is it to find qualified STEM teachers at the moment? I will ask this to both of you, starting with Mark.

Mark Turner: We are in a really fortunate position as a school because we have four specialist physics teachers at the moment, and we also have one who leads the science learning partnership, in conjunction with STEM learning. From my experience in other schools and from talking to colleagues across the sector, our experience is not that representative.

Interestingly, our two most recent physics appointments are ex-students of the school. That pathway of role models is so important, as people have said, and we have tried to do a lot of work embedding practical examples into the curriculum, alongside the subject content, such as video clips, mostly of ex-students who have gone into careers directly related to that section of the topic. That role modelling is very important.

I have been in my current school for three years, but from my experience in other schools, the biggest risk to some of the good work that has been going on, and that we obviously want to continue and develop even further, is around the recruitment of STEM-specialist teachers, particularly around physics and computer science. It is a circular thing that happens.

You need well-qualified specialists, who are also really great teachers—those are two bits that have to come together in somebody and through their training—because they then have a wider experience of physics or computing in terms of industry and where that can lead you. They also have lots of contacts and people they will know from their courses. They are often better at engaging with a lot of the resources that are out there, such as from some of the support groups, whereas non-specialists probably focus more on just getting the subject knowledge to be able to deliver that to the students. Therefore, some of that additionality, which is critical in keeping GCSE students that want to study A-level, can get lost.

Q303 **Chris Clarkson:** So are you saying there is material impact from not having a specialist teacher teach the subject?

Mark Turner: Yes.

Q304 **Chris Clarkson:** Jane?

Jane Lunnon: We are very fortunate in our recruitment. Again, it partly becomes self-fulfilling. If people know that you have a very strong science department, which we are lucky enough to have, then people want to come and work there. Anecdotally, without doubt a lot of the partner schools that we work with have issues about recruiting specialist teachers, and of course that matters, particularly earlier on.

May I suggest something? While we are trying to build up attracting STEM teachers into the profession, it could be helpful to look at ways of having a little more flexibility and fluidity around what university academics can do. I am thinking about science communication and coming into schools being part of their profile. Maybe there is a year of teaching in a school as part of a PhD—what an amazing thing that would be. We run programmes like that informally, and I wonder if there is scope for broadening that.

The other problem for recruitment—this will always be the case, as it is very difficult to solve in the sciences—is that the better-paid careers are typically available to people with physics, engineering and maths degrees. In fact, that is part of the concern about children not opting for those subjects earlier. The pay means that the lure of something other than teaching is much stronger. I am an English teacher and if English is your thing—if you love reading books and talking about them—the best thing you can do is to teach in a school, because that is where you get to do that most effectively. But obviously if you are a fantastic coder or brilliant at physics, you can be paid an awful lot of money to go and be brilliant at that somewhere else. That is always going to be a problem for recruiting teachers.

Q305 **Chris Clarkson:** Does that cause regional disparity in availability? We think of the golden triangle; there are areas that suck in talent. Does that make it harder to recruit in certain areas?

Jane Lunnon: Yes. I am in London, but yes. I don't know what the others would say.

Chris Clarkson: How about up north?

Mark Turner: I am in North Yorkshire and I have worked as executive head over another school as well. We have had several posts that have been unfilled for a long period and we have got in long-term supply. I have worked in Hertfordshire and Somerset as well, so I think recruitment is definitely more challenging in Yorkshire and the Humber than in some other parts of the country.

Q306 **Chair:** I asked Clare Hayes about the current experience of, and the statistics on, girls studying physics and maths. Perhaps for completeness, I ask the other two the same question. Mr Turner?

Mark Turner: Obviously we are a girls' school, so we do not have a gender difference, but about 45% of our cohort at A-level study biology,

about 32% chemistry, about 20% physics and about 35% maths—that is over the last four years.

Chair: Jane Lunnon?

Jane Lunnon: At A-level, 87% of our girls, as I said, study at least one STEM subject.

Chair: At A-level?

Jane Lunnon: At A-level. Some 49.4%—so 50%—of girls study maths, 40% biology, 39% chemistry and the big drop is to 8% in physics. That is of our girl cohort. Of the STEM cohort, 50% are girls: 43.3% of the maths cohort; 36.4% of further maths; 62% of biology; 55% of chemistry; and 22% of physics.

Q307 **Chair:** There is this range of 20% to 25% that we hear time and again. Do you have any reflections on that? Obviously you have many more girls in the cohort choosing subjects other than physics. What is it about physics?

Jane Lunnon: It is important to note that the battle has been won with maths, so I think it can be won with physics. That is the first thing to say. I have a couple of curriculum observations. Many of our girls want to be medics. For a lot of them, that is the pathway they have seen from early on; they are motivated by it and it is a vocation that is calling them. If they want to be a medic, they have to do chemistry and, although they technically do not have to do biology, they are very likely to. It is intuitive to choose biology and chemistry.

That means that when we have a national A-level curriculum that says you are going to choose three—potentially four—A-levels, either you are going to put all your eggs in the science basket, or you are emphatically not going to choose physics. Because you have already chosen chemistry and biology, you are not just not being pulled to physics; you are potentially being diverted away from it, because you may well say, "I want to do one other A-level that is not a science." I think that is a really material concern. I was talking to Dame Athene Donald earlier. She was saying that, back in the day, physics used to be a requirement if you wanted to do medicine. I am aware that a number of the physics A-levels now include medical physics. I think that should be mandated across all the A-levels—I think Edexcel is the only board that doesn't do that. It is optional; we should make it compulsory.

I think that is one real specific thing that is driving that number down.

Q308 **Chair:** That is helpful. For completeness, Mr Turner, do you have any views or theories from your experience as to what causes the drop in physics in particular among your girls?

Mark Turner: It is quite similar to what my colleagues said. We have much bigger numbers in biology and chemistry. The reason for that is the

majority of those students are looking to go into medicine or veterinary science, or pharmaceutical.

The other thing is the change with the removal of AS into A-level. Going back a few years ago, the system was you would start four AS levels and then move to three to complete through to A-level. That has caused a significant reduction in the number of students that do physics. Quite a lot of students chose physics as a fourth one and then often carried it on. They had maybe gone in with the intention of just doing it for a year. We have seen quite a significant drop since that change.

Q309 **Chair:** Was that a better way of organising things, in your view?

Mark Turner: It maybe brought some other challenges, but I do think there is something to be said about a broader curriculum offer in terms of 16-18 education. There are obviously other things that international schools and some independent schools do, around the international baccalaureate. There are other models there that perhaps encourage students to keep a broader range until a bit later on.

Q310 **Carol Monaghan:** Mr Turner, can I come to you first? Can I just double-check—you said 20% of your cohort did physics?

Mark Turner: A-level physics—yes.

Q311 **Carol Monaghan:** But that is in an all-girls school. If that were in a co-ed school, we could assume that—it is 20% of girls—would come out as about 10% in a co-ed?

Mark Turner: In terms of the total number of students in the cohort.

Q312 **Carol Monaghan:** Yes. Clare Hayes, what was your figure at Higher?

Clare Hayes: We had about 20% to 25%—it kind of fluctuates.

Q313 **Carol Monaghan:** Jane Lunnon?

Jane Lunnon: About 22%, of the physics cohort.

Q314 **Carol Monaghan:** Of the physics cohort. What about of the entire cohort?

Jane Lunnon: Of the entire cohort, it is 8%.

Q315 **Carol Monaghan:** Okay. So, there is an issue.

Mark Turner, you said a bit about teachers and recruitment. You are a selective school. You have got a comprehensive school and an independent school. Do we have a situation where it is easier for schools that are perceived as being good to recruit qualified staff?

Mark Turner: Yes, and I think I am going to draw on my experience from outside selective. Previously, I worked in mixed comprehensive schools in quite a variety of settings, including different Ofsted categories. I would say that there is definitely something about it being more difficult to recruit into schools that are not reputationally seen. An Ofsted rating does directly influence that, and it is harder to recruit strong fields.

Q316 **Carol Monaghan:** Is that going to perpetuate the issue then, when we

talk not just about girls into physics, but when we look at socioeconomic diversity?

Mark Turner: What you have got to have is a really good quality teacher supply coming through. There are some things around bursaries coming in, targeting STEM teachers in certain parts of the country with a lower socioeconomic profile, which is a really positive move, but what you have to have is the quality and number of teachers entering the profession, because all you do is shift the issue that creates something somewhere else. What we want to do is raise the standards for all students and, particularly, to be able to focus some of that resource on those areas. The teacher recruitment entry into the profession is probably the critical thing in terms of being able to develop the sorts of positive changes that we want.

Q317 **Carol Monaghan:** Jane Lunnon, do you think teachers should have to have a qualification in the subject they are teaching?

Jane Lunnon: Yes, I do, ideally.

Q318 **Carol Monaghan:** Is that something that should change, then?

Jane Lunnon: Obviously, when there is a recruitment shortage—a crisis in recruitment—and you have to have somebody in front of the kids, teaching them, you cut your cloth accordingly. Should we aspire to have qualified teachers in front of every child, particularly in content-heavy subjects? Yes, I think we should.

Q319 **Carol Monaghan:** Clare Hayes, can physics be taught by a non-physics-qualified teacher in your school?

Clare Hayes: No, we would always have a qualified physics teacher in front of certificate classes. In our first and second year in BGE—

Q320 **Carol Monaghan:** BGE being broad general education?

Clare Hayes: Yes. It runs for three years, but pupils personalise their choice at the end of S2. That can be taught by either a chemistry, physics or biology teacher. In the past, we have noticed that, if there is a kind of crisis in staffing—if you have a staff member who is unwell or on maternity leave, which is unavoidable—you need to focus your staff on your certificate classes, and then physics teachers do not have contact with first and second years. So, when those pupils come to do their options and make choices about what they want to do, there is that unconscious bias that was referred to earlier. You are more confident when teaching something that you know well. You are more inspirational when talking about a subject that you are really well versed in and passionate about. Situations like that mean that we have lower numbers coming through with physics because they do not have that really solid grounding and inspirational background when they come to make their choices.

Q321 **Carol Monaghan:** Dame Athene talked earlier about the importance of getting qualified science teachers in primary schools as well. That is an interesting tie to that. Clare Hayes, since you are a physics teacher by

profession, can you tell us a little bit about how you talent spot with younger pupils in the school?

Clare Hayes: As I say, we do our course planning at the end of S2. Young people have had an experience of chemistry, physics and biology on a kind of rotational basis at that point. As part of that process, we track young people so that we know what they are good at, but also so that they know what they are good at. We have learner conversations with young people to talk about their experiences and what they are good at, as well as what they are not so good at and how they can fix that. That is key. There is no point telling somebody just that they are very good or very bad at something—it is the feedback that makes a difference for them.

We have meetings with parents, one-to-one with subject specialists; we have 20-minute careers meetings for every single young person. We engage young people with My World of Work, which is a website that allows young people to say, "Here are my skills," and then attracts them towards different subjects. We do presentations and bring in pupils who have had the experience to let them talk to young people and lead the engagement around "What was it about physics that you really enjoyed?", which they present to young people.

We absolutely have to make sure that young people and their parents are fully aware of what they are good at, so that they make a really informed choice about the subjects they would like to pursue. If they have that kind of career path in mind, which they can get if they have identified their skillset, then we are more likely to get young people coming into physics. They also understand that if they pick physics in our school, they will be successful. We have a very strong track record, and that really helps us.

Q322 **Carol Monaghan:** Is it useful for parents to hear that as well?

Clare Hayes: Yes, and it is a message that we share.

Carol Monaghan: We have heard about the potential difficulties with A-levels, and the fact that doing chemistry and biology only leaves one choice left. Can you say a little bit about the curriculum difference in Scotland? If you are going from national 5, which would be GCSE equivalent, into higher, what options are available for you in terms of subject choice?

Clare Hayes: In our school, we offer eight qualifications at national 5: English, maths, and we would ask young people to pick at least one science subject, at least one technology, at least one creative or aesthetic subject—I am missing one—and then they get two extra choices. It will come back to me, don't worry. Then, when they get to the end of S4, when they have completed their national qualifications at national 5 level, they get the opportunity to pick five in fifth year.

Q323 **Carol Monaghan:** So five highers, as opposed to three A-levels.

Clare Hayes: Yes.

Q324 **Carol Monaghan:** Are the youngsters who are thinking about a career in

medicine picking physics?

Clare Hayes: As you mentioned, because there was that shift, there are fewer people who want to pick medicine picking physics, but they do frequently come back to it in sixth year when they have the opportunity. They would do advanced higher chemistry and biology, and then they would pick physics at that point. We frequently have them picking three independent sciences, and particularly young people who have an aspiration to do medicine would want to do three sciences at national 5. They might only do two of them in fifth year, but then they might come back to do physics again in sixth year, so they kind of get two bites at the cherry there.

Q325 **Carol Monaghan:** We are talking a lot about diversity, and Dame Athene talked about schools being gender neutral. I would like to ask all three of you—maybe starting with Mark Turner—whether diversity can happen naturally.

Mark Turner: I think it has to be a conscious part of your curriculum, and the mechanism for you delivering that curriculum. Obviously, we are in a slightly different position because we are a girls school, but our focus is on women scientists—women scientists from different ethnic groups. That is a big part of what we do; it is a big part of our wider STEM provision, in terms of the club experiences, Engineers of the Future, and these sorts of things that actively expose our students to people in industry from a range of different backgrounds, including different socioeconomic and ethnic backgrounds. It has to be a conscious, planned effort.

Jane Lunnon: No, I do not think it can—sorry, I think it can eventually. For example, to go back to the maths thing, now 50% of our kids who choose maths are girls, because that is what has happened and they can see it there. You can get to a point where that is the case, but you do have to work quite hard.

It is about bringing our, often unconscious, biases and assumptions out into the open and being really considered about it. Our heads of department at Alleyn's have a diversity matrix, and they assess against different characteristics—"How are we delivering in the curriculum against these things?" It has been really illuminating. All our staff had training from a group called UK Feminista, which again was looking at unconscious biases in language that we are not aware of, but are perhaps making a difference. That is what we are hearing, and the national movements that we have all been aware of—Black Lives Matter, Everyone's Invited—have been about our young people saying, "Actually, there is stuff here that you need to hear." I think you have to work at it.

Clare Hayes: Yes, I think you do need to work at it. In the last couple of years, we introduced the Rights Respecting Schools award, and part of that was to explore diversity—to explore supporting every single young person and making sure they were listened to. We take great pride in listening to our young people, and they help shape the school. We use our young people to come back and help support and encourage young

people, but unless we are really conscious about what we are doing, we will just keep going with the same things. We need to make a conscious decision about which direction we want to take things in.

Q326 **Katherine Fletcher:** Thanks for coming, all. I speak as someone who did biology, chemistry and—because I wasn't allowed to do physics because I am very old—geography. It was also because I was definitely going to be a vet when I was 16. That has worked out extremely well as you can see. I think we have touched on this, but I want to get you on the record on one thing and then explore what other solutions are available to us. From right to left, yes or no: do we need to mandate post-GCSE STEM qualifications to students?

Mark Turner: No.

Clare Hayes: No, because I would have hated to have been mandated to do English.

Jane Lunnon: I think we should broaden out the curriculum at A-level, so we should—yes.

Katherine Fletcher: Thank you. I was pure sciences and would have hated to have a language mandated to me, because I just cannot do them, so I am sympathetic. Let us move on to getting inspirational role models and teachers into STEM, specifically in areas where they have perhaps struggled to recruit. I should probably give a shout out to Mrs Barbara Lee, who is responsible for my biology degree—just to get that in *Hansard*. Bless her.

Chair: She would be very proud.

Q327 **Katherine Fletcher:** Possibly—*[Laughter.]* We have a system where we are giving bursaries to teachers, and the system is that the more disadvantaged the area, the larger the bursary available. Mark and Jane, could you comment on that? Is that the right approach or are we at least doing the right thing—going in the right direction? Mark, if I start with you—wrong side of the Pennines, but we'll cope.

Mark Turner: It is right to do that because we need a shift in the workforce in terms of getting to those areas that are really struggling to recruit. As I alluded to earlier, the bursary has to be there because you need a good pool coming through. What you want is a great STEM teacher in every classroom with every class, and you want the very best to be going to the most disadvantaged areas. You have got to have both parts; having one without the other does not actually solve the issue.

Q328 **Katherine Fletcher:** Okay. Are you against us trying to, at least, incentivise some of the more difficult and challenging jobs for those who are at the peak of their teaching opportunity?

Mark Turner: I think that is a positive thing.

Q329 **Katherine Fletcher:** Wonderful. I will try to mix it around a bit. Jane, do you think we are doing enough on bursaries?

Jane Lunnon: As market forces suggest—to what I was saying earlier—if you are competing with very high salaries in other fields, it absolutely makes sense to try to incentivise people as best you can to get the best talent in front of kids. I think Teach First does amazing work. It would be amazing to launch a "teach last" programme, so that people who have been eminent in their careers, like many of you, come back into the classroom for the last four or five years of their working life. That could be completely amazing.

I also think that while we are trying to solve the recruitment crisis, which will take a while because you have to get more people through A-level and all of this stuff has to happen, there are really creative ways that we should be embracing post-covid. We now live in an environment where every single school is connected. Every school can now access things online that they could not before.

In preparation for this session, I had the most amazing conversation with an incredible woman called Becky Parker, who set up the IRIS project. She is a teacher in Kent, but she is also a visiting professor at Queen Mary University of London. I spent half an hour on the phone to her, but I could have spoken to her for an hour. She was so inspiring about making physics real and the kinds of things you can do. I was thinking about Joe Wicks in the lockdown and it struck me: what if there was a Joanna Wicks of physics, running interactive sessions online that anyone in the country—any child at any level—could do? If you got a team of these really inspiring women and, indeed, other minority groups that are already out there doing great things, put them online and then let parents know as well as kids, you would be having an electrifying effect, I think, on the imaginations of young people.

The question is how we can solve the teaching crisis without just waiting for people to be recruited into teaching and so on. We need to think more creatively about what we are doing.

Q330 **Katherine Fletcher:** Sign me up for the one where you put a mento in Coke and demonstrate ballistic effects. I'll do that one. Oh, it's gone—everyone's done it. It is very good.

I love that. Let's pick that thing up. What would you do to get more people interested and engaged? Those are diversity and inclusion words—how are we going to get more people excited? You have a very structured way of doing it, haven't you, Clare?

Clare Hayes: Yes. One of our experiences—this is about bringing experiences into the classroom—was with our sixth-year group. For a number of years, we ran a trip to CERN. It wasn't just a holiday or a jolly; we structured lots of events around that. We would invite visiting staff from Glasgow University to come in and give a wee bit of background about what young people would see before they went. When they were there, we would arrange to meet up with students from Glasgow University who were doing PhDs. Former pupils would come and join us. Actually seeing people doing the job that they would maybe want to do

meant a shift in mindset for a significant number of young people. I think that's the kind of way we need to go, but we need to carry parents with us. Certainly part of our family learning strategy is about keeping parents involved in what is expected, so that when young people are making their choices, they are considering physics very seriously, and so that girls are doing that as well.

To go back to what you mentioned, Jane, you talked about things being online. During covid, we had what we called our West OS partnership. A significant number of schools in the west of Scotland, and universities, got together and did record lessons and put things online. E-Sgoil in the Outer Hebrides—you might be aware of it—also does remote teaching and remote training. So there is a model that allows young people who maybe cannot access a physics teacher in their school to access a physics teacher in another school. There are some elements of good practice that we can perhaps look at.

Q331 **Katherine Fletcher:** If I understand you correctly, you are talking about a slight structural shift in the way teaching is thought of, which is to say you could be taught brilliantly on a specific topic by a qualified teacher who is not within your faculty—is that the right word? Yes. Okay, we have great ideas for inspiration. We have, clearly, inspirational structured engagement with both individual students and parents, and that rolling round of "This is for me." What else would you do or recommend that we look at to increase it?

Mark Turner: It links with the bit about the experience in other places, but I think the bit about embedding into the curriculum, into the sequence of lessons, the actual link into careers and where this topic and being able to do it can actually take you—that is sometimes the bit that is the disconnect between the theoretical side and how it leads on. I think linking in STEM careers and creativity—that is something we have really been working on around computing and engineering as a career. Actually, there are real, direct links with creativity and things like that, because if you are thinking about programming, it's not just about the technical coding aspect; it's also about the look and the feel when you are interacting with it. Projects and other things that weave some of those bits together could, I think, really help develop the enthusiasm.

Q332 **Katherine Fletcher:** I just want to make sure I'm following you. Take my silly example about the mento in the Coke. Rather than somebody who is disconnected delivering that, you could have somebody who is working in—I don't know—fluid dynamics for one of the F1 teams explaining why messing around there leads to a profitable career here. Is that the point you are making?

Mark Turner: I think so. You are seeing the direct relevance of those things that you are learning—how they actually translate into a career in the future.

Katherine Fletcher: I will ask one more question, Chair, if I may.

Chair: Of course.

Q333 **Katherine Fletcher:** I just want to throw this open. I have really enjoyed this discussion, and thank you for your time, but is there anything else that we should be thinking about? Is there anything else—something that is out of the box radical?

Jane Lunnon: Two things, but one isn't really radical. For a long time, we have done lots of partnership work with fantastic schools in our area and shared scientists in residence and so on, but one of the things that we are just starting to explore is VR. The reason we are excited by that is because it brings science and creativity together. We are looking at how we can share that across our partnership schools. One of the things that occurred to us is whether we could have tech libraries; could schools borrow VR Oculus sets from libraries to have those incredible immersive experiences that bring learning to life in a completely different way? That is one thing; the other is much more radical.

I wonder, given the demands of the 21st century workplace, the focus on interdisciplinarity, the sort of skills that are valued by employers—agility, resilience, flexibility, problem solving, creativity—and given that there seems to be a big optics issue, particularly with physics, might this be the moment, post-covid and with fresh eyes, for us to think really radically about our curriculum? Instead of saying, "This is chemistry, this is biology, this is physics," which are only 19th century siloes that were constructed, why don't we just call them "science one", "science two" and "science three"? We would teach topics that bring everything in. There would be a bit of physics, a bit of biology and a bit of chemistry on whatever topic it is. That would really encourage a truly interdisciplinary approach to learning. It is not about dilution; it is still scholarly and rigorous. But it is perhaps a different approach to how we tackle the incredibly creative and exciting world of science.

Q334 **Katherine Fletcher:** That is really interesting. That is effectively what the ARPA/DARPA guys were saying, from the absolute pinnacle of science and academia—we should crash it all together to make it work across the lines. Clare, what have we missed?

Clare Hayes: We—the Scottish Government and the qualifications authority—refurbished the curriculum. We went from teaching 19th century physics to very current day stuff. That really sparked the imagination. Refreshing the curriculum so that we are teaching pupils particle physics and astrophysics and delving into that in the classroom is important because we have found those are the topics that young people enjoy most. Topics such as what is happening in space and what is going on in the big bang. They enjoy independent learning, project work and doing research; part of our advanced higher course is that young people do a piece of independent learning. That is 30% of their qualification, so they have done it before they walk into their exams. It gives them the opportunity to say, "That is my favourite bit of the course. That is the bit I am going to look at. I am going to work at the university and liaise with somebody who is going to be my supervisor." We have had excellent links like that made before. It is about that fresh curriculum, with the opportunity to do it yourself.

Q335 **Katherine Fletcher:** I know we have moved on lots since I was young and thin, but is it fair to say that the idea is, instead of saying "Here's Newton's laws", and your first question is, "Who is Newton?" it is now, "The ball is going to do that," and because you're interested in this, "By the way, these are all the fundamentals that you need to learn to pass."

Clare Hayes: Yes.

Katherine Fletcher: I wanted to make sure that I understood. Mark, do you have anything to add?

Mark Turner: I think there is more that could be done around primary and early years education, as has been talked about earlier. We need real thinking about how we get subject-specific support and expertise in development working right from the moment that students start compulsory education and then carrying on all the way through. As I have alluded to before, there is probably a variability in terms of subject expertise, time and resources when offering engagement with external providers from outside individual schools. There are some interesting things to explore around that. Maybe we could think about a move to multi-academy trusts, and whether that is a strand that multi-academy trusts offer in their accountability measures as a way of making that happen.

Q336 **Katherine Fletcher:** Do you mean almost a curriculum coherence between ages four and 18 within the body?

Mark Turner: Yes. I think there is a lot of stuff around the curriculum that has been talked about, and that sort of development is really important. Primary school teachers do an incredible job, and they teach such a range of subjects. To get that subject knowledge and that kind of additionality about where it applies and where it leads is quite hard. Lots of groups, include the Institute of Physics and STEM Learning, are doing work targeted at that, but that is not universally accessed by all schools, so are there some mechanisms that could make that happen a bit more?

Q337 **Katherine Fletcher:** So use the resources we have got well, as well as look at more innovative solutions? Jane, I think we are out of time. You have 10 seconds.

Jane Lunnon: I was just going to say, strip down the GCSE. It is so full of content that there isn't time to do that conceptualising and making it relevant. This year, because of covid, it has already been stripped down, so let us not revert.

Q338 **Chair:** Thank you very much, Katherine. This is the final one from me. You probably heard the discussion we had with the previous panel about whether the perception that maths and physics are harder A-levels than other subjects is just a misperception or whether the calibration of what is required has gone awry. Mark and Jane, as people who prepare young people for A-levels, what are your views on that?

Jane Lunnon: No, I absolutely do not think that is the case. All subjects will be challenging for some and not for others. There is nothing intrinsically that makes them harder.

Chair: That is clear.

Mark Turner: I agree with that. One of the challenges is a socially reinforced thing, not just at school; it is societal. People perceive maths and physics as being harder.

Chair: It is a matter of perception, rather than reality. What about the Scottish context, Clare?

Dr Claire Crawford: I would just look at the numbers. What is the uptake in senior school? We have two classes doing advanced higher maths, two classes doing advanced higher physics, one doing chemistry and one doing biology. Do we have advanced higher French and Spanish? No, we can't offer that because there is no requirement. Our numbers are really strong, which tells me that young people are not finding maths and physics hard.

Chair: Very good.

Jane Lunnon: And on the girl question, our girls outperform the boys at GCSE and A-level physics.

Chair: I am very grateful to all three of you. You are three practising teachers and headteachers, and you have taken the time to come away from your schools. Clare, in particular, has travelled a very long way, and Mark has travelled a considerable distance, to help us with a very important inquiry. We are very grateful to you for that. Perhaps you would give our thanks to your colleagues and students for letting us deprive them of your efforts today.

Examination of Witnesses

Witnesses: Rachel Youngman and Professor Ulrike Tillmann.

Q339 **Chair:** We now move straight on to our final panel of witnesses. Rachel Youngman is the deputy chief executive of the Institute of Physics, which was just referred to in the previous session, and Professor Ulrike Tillmann is the president of the London Mathematical Society. Thank you very much indeed for giving evidence to us today and for being in attendance for some of the earlier sessions, which will be relevant to our discussions.

Perhaps we can start with physics. Rachel Youngman, the spotlight has fallen on physics, beyond the other sciences. There seems to be a particular imbalance in the take-up of physics by gender. What is the problem that is leading physics to occupy this particular position?

Rachel Youngman: Thank you very much for inviting us today. We see this very much as a society problem. As you heard from the teachers and others, there are unfortunately perceptions, stereotypes and myths about who can do physics, what subject it is and what it leads to. One of the

things I was struck by when I was listening earlier is that, in some respects, there is quite a narrow definition of what physics can lead to, in terms of future jobs and careers.

We did some research when we were in the process of forming the campaign Limit Less, which no doubt we will talk about today. Some of the research that we did was quite interesting. We surveyed 500 businesses in different sectors—not just in STEM, but across different sectors—and 78% of businesses valued seeing a physics qualification at 16. What they see in that are the skills that it gives around critical thinking, working in teams, numeracy—things that are useful in all sorts of different careers. One challenge we see is the perception that if you study physics at 16, your opportunities after that are quite narrow. The image that is presented, unfortunately, is of a solitary white man sitting in a lab. Actually, the work of physicists, or if you have done a qualification at 16, is much more diverse and varied.

I think it is a societal problem. Schools and the environment in schools are a part of that, but we also think that there is much more to do in order to influence those who are influencing young people, and that has to include not just the school environment, but the parents and families who have their own ideas about what physics is and is not, and also the mainstream media and social media, the Government, and local communities as well. It is much more a societal problem than one for physics to solve on its own.

Q340 **Chair:** What are the consequences of this lack of diversity in physics?

Rachel Youngman: The consequences of the lack of diversity are the same for many professions: if you don't get that diversity, do you get as good an output? On the concept of working in teams, you benefit more from diversity of thought, experience and backgrounds. That is the same, whether you are in physics or in different environments.

One other consequence, if you look at the physics businesses rather than academia for a minute, is that we have seen a demand for jobs, but a shortfall and supply problem. Interestingly, 53% of the jobs that are needed are not requiring a degree. Those are A-levels, highers, or apprenticeships at levels 4 to 6. Sometimes, again, it is about understanding and explaining better the different pathways. Of course, that has an implication: if you don't get the numbers and you are pulling out part of your population, you don't get the diversity that brings benefits.

Also, there is an economic impact. We hear that businesses—66% of the 300 physics innovators that we spoke to—are holding back on their R&D and innovation activity. We see this as a social justice issue that we need to fix, because it is right that young people have access and opportunities—physics leads to fantastic, rewarding jobs—but if you want to put it in terms of an economic consequence, there is an impact there as well.

Q341 **Chair:** Thank you. Perhaps I can ask a provocative question. Given the importance of the subject matter, how long standing the problem has been, and the particular difficulties of physics, does the Institute of Physics bear some responsibility for not having persuaded policy makers and others to galvanise the response that has been required all these years?

Rachel Youngman: That is a good question. I think there is always a responsibility on the part of a learned society and professional body to do better, set a gold standard, and really influence change. Over the years the physics community has been incredible in doing two things. The first is gathering the evidence that there is a problem—the percentages speak for themselves, and I am sure you have had those from other people. The other thing is just the experiences that the physics community has been through, and they have shared those.

The problem, as you say, is that we could look at the experiences of 30 years ago and see the struggles that people had—Dame Jocelyn Bell Burnell speaks about it very eloquently—and still see not dissimilar experiences now. The question is: what are we not doing? What are we doing wrong?

I think there are a number of things that we need to tackle, and not just in the education system. There are things that we need to pick out, and I know you have heard from headteachers, but it is also about tackling those issues in society as well. That is where, traditionally, the Institute of Physics probably has not gone further out into society. To give you one example, we should be very firm with the media—in this case, the BBC—when they show their programmes for children about physics and use throwaway expressions such as "all physics teachers smell of cabbage". If you are hearing that, it is just reinforcing a stereotype.

Q342 **Chair:** Is that a thing? Has that been referred to?

Rachel Youngman: That is a thing. It was last year, on their Bitesize programmes. When we spoke to the BBC—

Q343 **Graham Stringer:** Why ever did they say that?

Rachel Youngman: I'm afraid that people do not always think about the consequences. When I spoke to people about it, some people said, "Look, Rachel, have a sense of humour about this." But when a subject is already subjected to stereotypes, misconceptions and ideas that a certain type of person is a physicist, if you start saying things like that, it is just reinforcing them. To be fair to the BBC, we spoke to them and they said, "Yes, you're absolutely right. We shouldn't do that, and let's work together to make sure that is not in the system any more." But those stereotypes are playing out in broader society, where we need to tackle them. That is why our campaign is so important, because it is not just saying that this is a problem that can be solved by the physics community. It has to be wider.

Q344 **Chair:** There are learning societies and professional bodies covering other

disciplines as well. Do you look at what they do and benchmark yourself against them, to see that you are having the same impact and sense of progress as, for example, the engineering profession?

Rachel Youngman: Yes. We work very closely with engineering, for obvious reasons, because of the connection between physics and engineering. They are tackling the same problems as us, which are about stereotypes and the misconceptions of what you do in engineering. People tend to have a very old-fashioned view. We work very closely with the Royal Academy of Engineering and EngineeringUK on the programmes that they are doing, and they also help to inform our campaign, so there is certainly synergy there.

With the other professional bodies and learning societies, we are often classified as STEM, but we all have our own challenges and nuances within that. We have been drawing recently from the benchmark that we think has been set by the Royal Society of Chemistry with their recent report on race. That was a powerful report, and it helps us to see where we should be increasing our own knowledge as well. There is a lot of sharing across STEM, but in terms of comparisons of programmes, a lot of the work we are doing is with the engineers.

Q345 **Chair:** Given the persistence of the problem and the fact that progress has been made in other areas, do you need to do things differently from how you have done things over the last few years?

Rachel Youngman: Yes, I think we do. I know the word "campaigning" has multiple uses in society, but the Limit Less campaign is an influencing campaign, so it is not directed at young people. We are very much directing our efforts at the influencers of young people—as I said, they include the media, social media and so forth. Through that, we are able to repeat some very simple and consistent messages about the fact that young people from under-represented groups can do physics—we can dismiss that myth—and about what it means to do physics, which goes back to the skills that it builds. We can take out some of the myths and barriers that people see. But it is about doing that through others. For the first time, the Institute of Physics is working with the National Literacy Trust. They have huge reach into families from disadvantaged backgrounds—far greater than we could ever have. Like any organisation, we have our bandwidth. There we are able to influence people with our messages, have those carried through the work that they are doing, and make sure that the careers resources and what we say about physics are consistent. That is going out now to thousands of families through them.

There are other examples. YouTube is another one where it is virtually impossible to find physics content unless you know exactly what you are looking for. We have spoken to YouTube about that. There is now good physics content on its New Learning Platform for young people. We are, I think, able to reach much further by the work we are doing.

Q346 **Carol Monaghan:** Rachel, a couple of weeks ago the Committee heard evidence from Katharine Birbalsingh. What did you think about her

comments?

Rachel Youngman: Like many people, we were disappointed and frustrated, because it takes our messages back a step, and what we are trying to do is dismantle those stereotypes. The data does not speak for itself for the messages that she gave. Our percentage of young girls studying physics has been stubbornly low, at 23% or 24%, for a very long time. We want to get it up to 30%, because we see that as a tipping point. It was interesting that in the commissioner's school it is lower. We are concerned about the extent to which that might be because of some of the stereotypes and myths about physics, and girls doing physics.

We have had evidence and seen messages that have come back from the physics community, including from people who have just done their A-levels or Highers—so, recent examples—about the struggle they often had in the school environment; in their physics class, they are put into two teams by gender. The girls are referred to as team fake tan. That is playing into that stereotyping that somehow these gender things are different. I know that Dame Athene said earlier that that is where we need to tackle those problems. I suppose, in answer to your question, we were disappointed and frustrated. Obviously, we also have to recognise that it is an opportunity to talk again about the challenges and how we find the solutions for physics. We don't recognise in what was said the reality of what we see from the evidence we have gathered.

Q347 **Carol Monaghan:** Professor Tillmann, I am asking this a little bit mischievously, but is there any truth in the comments that Katharine Birbalsingh made that girls don't like hard maths?

Professor Ulrike Tillman: I just don't see evidence of that, frankly. Girls, like boys, like challenges. Hard maths is only hard if you don't yet understand it. Mathematics is something that, once you understand, is actually easy. It is illuminating and empowering, and I think girls like that just as much as any boy. I hope that most of our girls and boys like that.

Q348 **Carol Monaghan:** Do you see that a little bit? Do you have evidence to hand on the performance of girls and boys at A-level maths, for example?

Professor Ulrike Tillmann: Yes. The statistics that come through say that, actually, girls perform at least as well—probably a little bit better—at both GCSE and A-level in mathematics. From that point of view, I don't think there is any worry about girls not being as able at maths or not liking it. There is perhaps one thing that does also seem to be different, and this is potentially a cultural thing or to do with psychology and the different developments of the two sexes. Girls tend to prefer to do something with a purpose. If the career path is not laid out before them, or there is not a clear reason why, for example, maths would be interesting for them and how it fits in, they might not choose it as readily. I think that sometimes plays out. Often, it is a shame, because again and again we come across girls, especially, who say, "I wish I had chosen mathematics, because now I am stuck. I cannot do things", and so on. It is very much something that we need to address.

Q349 **Carol Monaghan:** Can I ask about the London Mathematical Society? If we look at, for example, maths professors across the UK, we know that women are hugely under-represented. What work has your society done, and why has it not been more successful?

Professor Ulrike Tillmann: The percentage is something like 12%. It is—

Carol Monaghan: Creeping up?

Professor Ulrike Tillmann: Creeping up very slowly, and it is very difficult to bite into that. There are many reasons for that, as well. The London Mathematical Society has been very active on women and diversity support. It has its own scheme, but it now feeds into the wider Athena Swan scheme that departments aspire to, and that has been very helpful in changing cultures within departments and universities. I think we will see more of an effect there. The London Mathematical Society has been at the forefront of that, and it has received prizes for that.

Q350 **Carol Monaghan:** Can you tell me a little bit about gender diversity in university courses? Do you have those figures?

Professor Ulrike Tillmann: At undergraduate level, the gender diversity is similar to A-levels. It is not quite uniform—on the more demanding courses, or maybe I should say at the high-ranking universities, there tend to be fewer girls as a percentage—but basically, at undergraduate level, it is about 40%. We see a significant drop once we go to graduate students, and again later on.

Q351 **Carol Monaghan:** We have heard evidence throughout this inquiry about that very issue, so thank you for that.

Rachel Youngman, can I turn to you again, please? Physics suffers from the same problems, if we look at the post-doc and professorship levels. What has the IoP done, and why has there not really been a significant shift?

Rachel Youngman: There are a couple of things I would say. Obviously, we have Juno, which you will be familiar with. That was put in place in 2008, so it has been running for quite some time. There have been changes to that: we added a new principle, principle 6, which is around bullying and harassment. It is obviously gender-focused, and it has had some successes. The number of female professors has increased over that time, and the inclusive environment within that has certainly contributed to that. There are some positives to take away.

We now understand that we have to go much further with Juno. This is a physics community-led inclusion scheme, but the physics community recognises that it needs to be expanded beyond gender, particularly looking at other protected characteristics and the problems of intersectionality, where we see much more pronounced challenges. Early work is under way to do that, led by a panel—a steering group—of physicists, and our hope is that that will make a change for people.

Obviously, we hear the comments about what is called the leaky pipeline. I have to say that we find that a really unsatisfactory expression, because it gives the impression that people are dropping out. Actually, it is the system that is pushing people out, so we try not to use that expression, but for the sake of this, we do hear that there are challenges. It was particularly notable that our LGBT+ survey, which we did with the Royal Astronomical Society and the Royal Society of Chemistry, showed a proportion of people who are leaving physics because of challenges with the environment. Our hope is that the expansion of Juno into a next generation, looking at other characteristics and intersectionality, will help.

I think we have to put one caveat around this. It is unlikely that any inclusion scheme or award is going to be the panacea for absolutely everything. There are a couple of things we would say here. One is that we need to get better at data, and seeing that data held and being able to understand it, to see what is going right and what is not. We would say that for the school environment as well as in higher education. The other thing is that, as the community goes through the process of looking at the next generation of Juno, there will be things that come up that probably don't sit within an inclusion award. That doesn't mean we shouldn't tackle them. It might be that there are areas that we should tackle more directly in terms of policy change and so forth, so we hope that will make a difference.

Q352 **Carol Monaghan:** You mentioned data. Can I ask a bit about that? This is about diversity and inclusion in STEM. STEM covers an awful lot. Do you think it would be useful to have more granular data that looks specifically at physics? You mentioned engineering as well. That is very different from the life sciences, if we are talking about gender diversity.

Rachel Youngman: It is, and I think probably if others from STEM—maths is here—were talking about data, they would have the same challenges. Thinking about it from a physics perspective, the lack of data really makes it difficult for us to see and benchmark what works and what doesn’t. There’s something about both the way in which data is collected and the consistency of that across the UK, but also the timeliness of it. Sometimes there is a lag to get some of the data coming through. That would certainly be a massive improvement for STEM, but also very specifically for physics; I think you are right that having it at a more granular level is what is needed because of the nuances for physics.

Q353 **Carol Monaghan:** My final question to both of you: is there anything the Government should be doing in terms of specific interventions or ways in which funding takes place? Are there things that the Government could be doing that would support you?

Professor Ulrike Tillmann: Yes—the list is long. One thing is university mathematics. We are losing people at the sort of mid-career stage. That is where we need interesting fellowships and so on. The maths community was ready to do this with the extra £300 million and we are still waiting for £196 million of that. We need that sort of money in order to implement fellowships like that.

On the data side, I completely agree with Rachel. We lack the granular data. We are also lacking data on ethnicity and other factors of minority groups. That is very much something that would probably be much better collected at governmental level. I wish we could do more as the LMS as a society of mathematicians, but we are very much limited in terms of money. We are asking for an academy, but that needs funding and backing, in some sense, from the Government.

In terms of more specific things, in schools—I should confess I am also the chair of the Royal Society education committee, so some of these points come from there—we need to have better qualified teachers who understand the subject areas. We can possibly do something immediately with CPD. It is known that CPD also helps with retention. CPD should be subject-oriented, I think especially in maths, but I believe in physics and the other sciences as well. There is a really interesting question about how much CPD we do in order to tackle these preconceptions about girls and boys and other things. That is another area of CPD that might be very helpful.

Generally, we should signal the importance of STEM, and within that I have to plead for mathematics, which is one of the foundations of all the sciences. It is the language of science, and ultimately it is more than that. Your Committee, for example, does not have mathematics in its title. As was mentioned before, in Britain, only one in five pupils aged 16 to 18 studies mathematics. On the continent and in most industrialised countries, it is everybody; it is mandatory. We are losing a lot of people. If you don't have the maths background, you are not going to be confident about going into another STEM subject. Indeed, girls and boys do not understand that, even in biology, a lot of university courses now ask for mathematics. They don't take it because it is squeezed out in the three A-levels they are allowed to take, and suddenly they find themselves stuck. There are lots of things that we need to tackle.

Q354 **Carol Monaghan:** Thank you. Rachel, can you be brief? The Chair is giving me eyes.

Rachel Youngman: Absolutely, I will be.

There are a couple of things that I would say. First, on the whole-school equity plan, where the whole school—the governors, the teachers, the headteacher, the parents and the students—works together to create an inclusive environment, there is a lot in that. I will not go into all the detail today, but that is incredibly important. The Noel-Baker Academy is a school in Derby that has recently received a good Ofsted inspection, having before been inadequate. It has spent a lot of time embedding that, and it would be worth looking at what it has done, from how it reflects the curriculum, all the way through, including how it involves the parents and students in that. We think whole-school equity plans need to be mandated and monitored.

I echo what Professor Tillmann said about CPD for teachers. It is about retaining our teachers too. We have to recruit them and retain them.

Subject-specific CPD is incredibly important, from the point of training all the way through their career, as happens in other professions. We have mentioned the data problem, so I will not go into that again. We think those two elements are incredibly important, and the Government can help us.

Carol Monaghan: Thank you, and thank you to Professor Tillmann for pointing out that girls do as well as boys, if not better, in maths. That is really helpful.

Q355 **Graham Stringer:** I will be very brief. Should it be compulsory to study one STEM subject post GCSE?

Professor Ulrike Tillmann: To combine them, do you mean?

Q356 **Graham Stringer:** No. Should you have to do maths, physics or chemistry once you have done your GCSEs—to A-level, effectively?

Rachel Youngman: I think it is about choice. We want to ensure that what the choice leads to is clear, and that girls in other under-represented groups can see the opportunities. I am not sure it is about mandating or forcing people to do a particular subject; it is about showing the reality of what that subject means. That is not the case in physics at the moment.

Professor Ulrike Tillmann: I would probably answer the same way as Jane Lunnon: we need broader A-levels to allow a choice, and then the answer is, yes, they should include that. I might even go further, as mathematics is one of the foundations not just of the sciences but of the social sciences. You cannot do social sciences these days without understanding data and statistics. The most basic things require a mathematical knowledge and attitude.

Q357 **Graham Stringer:** Do you have one priority to improve the situation and diversity? If you could get the Government to implement one thing, what would it be?

Professor Ulrike Tillmann: In general, in science?

Q358 **Graham Stringer:** Something that would increase the number of people from minority groups or girls, who are not a minority group, participating in STEM.

Professor Ulrike Tillmann: I would put a lot of money into the education system and teacher training—that would also help the teachers work with the parents. Companies also have a role to play, but I think I would put a lot more money into education.

Rachel Youngman: Fortunately, I agree with that, so I get to give a different one, and I would say the whole school working together on this problem and really ensuring that there is an inclusive environment. Diversity cannot thrive unless the environment is inclusive for all young people. That is incredibly important, along with what Professor Tillmann has said.

Q359 **Graham Stringer:** Would you follow that up with an enforceable code of

conduct within STEM workplaces, beyond the legislation on anti-discrimination?

Rachel Youngman: I think you have to see that mandated, and I think there has to be a way of monitoring it. A code is one way of doing that, but I think it has got to be mandated rather than left to individual schools. Otherwise, you end up with what we have at the moment, which is a very patchy landscape.

Q360 **Chair:** Finally, just to follow up Graham's question, Professor Tillmann, you describe maths as foundational, and you pointed out that in other countries, people continue to study it in some form after the age of 16. Given the problem that we have, why would you not want that to be a requirement in the UK?

Professor Ulrike Tillmann: There is one problem with requiring it—certainly for tomorrow—which is that we do not have the qualified teachers. As I said before, especially in mathematics, that is frustrating; students can come up with outside-the-box answers, which can be correct, and the teacher might not recognise that if they are not really trained, comfortable and confident within mathematics. It is very important that we have good teachers, so that is the limitation at the moment. We are also supporting core maths, for example, as something that should be rolled out much more. That is another way of getting more mathematics for the 16 to 18-year-olds.

Somebody asked for radical solutions earlier. Here is one thought: we have a foundation year for art; why not have one for mathematics? That would mean, for example, that those students who maybe take a more technical route, or apprenticeships, could come back to university, do maybe an A-level or equivalent for maths, and then, from there, continue their further studies. It would also mean that those who were mistaken in not taking mathematics—perhaps because it didn't fit into their A-level choices—could go to the university. One advantage there is that, at university, we do not have a problem in recruitment; we can recruit maths teachers quite easily. Indeed, it would kill another one of our problems, which is that we do not have enough graduate students, and those graduate students could be supported, basically, by teaching at that level.

Q361 **Chair:** Thank you. Just briefly, for the record, will you just say what core maths is? It is a programme—

Professor Ulrike Tillmann: It is a relatively new qualification—it actually came from Gove, I think, when he was Education Secretary. It is a broad mathematics AS-level equivalent, which also prepares students for maybe the social sciences. It is taking a very broad view of mathematics, including data science, AI, and so on.

Q362 **Chair:** So it is a post-16 potential additional option.

Professor Ulrike Tillmann: Yes. It is a broader qualification.

Chair: It has been a fascinating discussion. We are nearly at the time for Prime Minister's questions, and I know our colleagues need to go to the

Chamber for that. I thank Professor Tillmann and Ms Youngman for their evidence this morning. This concludes this meeting of the Committee.