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Interview Summary Sheet — Title Page

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Interviewee's surname:	BUNDY	**Title:**	PROFESSOR
Interviewee's forename:	ALAN RICHARD	**Sex:**	MALE
Honours	CBE, FRSE, FRS, FREng, FACM		
Occupation:		**Date and place of birth:**	18TH MAY, 1947, ISLEWORTH, MIDDLESEX, UK
Mother's occupation:		**Father's occupation:**	

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Professor Alan Bundy CBE

Interviewed by

Troy Astarte

18th February 2020

At the

School of Informatics,
Edinburgh University

Hello, my name is Troy Astarte and I'm interviewing for the Archives of IT on Tuesday 18th February, 2020. The time is 14:45 and we're recording in the School of Informatics at Edinburgh University. My interviewee is Professor Alan Richard Bundy, CBE, FRSE, FRS, FREng, FACM. He is Professor of Automated Reasoning in the School of Informatics. Professor Bundy was born on 18th May 1947 in Isleworth, Middlesex. Throughout his long illustrious career he has worked mostly as a researcher in artificial intelligence, mathematical reasoning and representations of knowledge. Alan helped set up the UK Computing Research Committee and has been the Vice-President of the British Computer Society, among many other contributions to important bodies. Welcome, Alan.

Thank you.

So, let's begin by talking about your early years. Your parents' backgrounds were in the print industry and you said your mother was a typist, is that the connection, is that how they met?

Yes. No, no, they met at a dance in Hounslow. They both, both their families lived in Hounslow, different parts, but Hounslow is on the west side of London, it's near Heathrow Airport. Their parents had both lived in east of London, were Cockneys, and independently - they didn't know each other – but independently moved to Hounslow and that's where my parents met. Yes, I'm not- I'm trying to think, it would have been just before the war, I think. Yeah.

Okay. And you said you went to a 'sink' school. Can you explain what that is?

Well, I mean the area that we lived in, I was born, as you say, 1947, so two years after the end of the Second World War, so that was still very influential. My father's education had been disrupted by serving in the forces and so had essentially what was a labouring job in the *Radio Times*. His father had been a compositor, which is a much more important skill. So they were not rich and we lived in Brentford, which at that time is a pretty, you know, slum would be too strong, but it wasn't a very salubrious area of London. And so we lived, we shared a house with my aunt and uncle and their two children so, yeah. I was born in, you said Isleworth, it was West

Middlesex Hospital which was in Isleworth, big hospital in that area, yeah. So I don't think, you know, so their careers weren't overlapping in any way. But yes, they met, they met at a dance.

And so at school you said that you remember technical drawing.

Yes, that was in the secondary school.

Okay.

So yes, I mean yes, the question about the sink school, I mean the Ealing Road Junior School was not a top school of any kind, it was- and it was very crowded, I mean, and I didn't get on terribly well there at first, I was what they call a late starter, so I was in the B stream for most of my time there and was only put in the A stream because the teacher that I had in the B class decided that he would do some IQ tests, and I came out rather well in it and they suddenly realised that, you know, that they hadn't recognised my talents. And he told my father, he told my mother that it was because my writing was so appalling that they hadn't really been able to read what I wrote, so they didn't, they couldn't really assess me. So I went up into the A stream rather late in the day and that class had forty-one students in it, so you can see the disadvantage, and only eleven of those students passed the eleven-plus and went into grammar schools. So, you know, it was not a high performing school, that's really what I meant by saying it was a sink school. You know, I mean if you think there were four grades, you know, A, B, C, D class, and in the A class, which was forty-one people in it, only eleven passed the eleven-plus, you know, you can sort of, I mean normally about twenty-five per cent of students would pass the eleven-plus. I wasn't one of them, okay, so I went to a secondary modern school. And the school I went to, which was actually just behind our house in Brentford, was pretty rough. You know, I remember lots of fights, I remember sort of cowering in the background so as not to get involved, but there was lots of fights. And there were fights in the evening as well. I didn't dare go out in the street, there were gang fights involving knives and bicycle chains, and even a gun on one occasion. So yeah, so it was… Fortunately my parents saved up and moved to Heston, which is near Hounslow, which was a much nicer area then. Ironically it's gone down, downhill, and Brentford is now quite gentrified, so… Yeah, the street that we lived in in Brentford is Clifton Road, which might not mean anything to you unless you were a Brentford supporter, but that was the street of where the Brentford football ground was, and I remember, you know, on a football day that our street was sort of twenty deep across of men and boys walking to the football ground. I have no interest in football, by the way, I've just completely… complete waste of time, you know, for me to be there. I went twice in those grounds, that was all.

[0:06:01]
So when did you move from there?

So we moved in '58. So just after I'd moved to the secondary school, so I was at the Brentford Secondary School for about six months and then we moved to Heston, and I went to a secondary school there into the first year. And I began to do better at that stage, you know, academically. So, you know, I clearly shouldn't have been in a secondary modern school, that was because of the history. I used to regularly come first in the class for most subjects. But it was only when the end of GCSEs, I got about six GCSEs, and at that stage I moved to the grammar school. And in fact, I mean that was accidental in the sense that it wasn't on my, sort of the career route that the school had planned for me, I would have worked on a lathe, I would have been a lathe operator at that school, that's where I was heading. But my, the uncle, in fact the one that we used to live with, was a careers adviser officer for the council and he said well, you know, you should go to grammar school, so I did at that point, then I sat A levels. And at that point, that's when I did the technical drawing A level along with physics and maths, both pure and applied maths, so those were my A levels.

Would you have been happy going into the lathe operating route, or did you…

No, I…

… you wanted something different?

I think I would have been bored by it, and also I'd be unemployed because that kind of job has been automated now, it doesn't exist any more. So I'm in a career which essentially made that job that I would have taken redundant, so that wouldn't have been very good for me. You know, I'd have probably found some route up in industry or something, I might have made something of myself, but not what I have done now. So I owe a lot to that uncle, actually, I always say that. Making that, you know, suggesting that career move for me. But, one of the effects of not having gone to a grammar school from the start was that at that stage most universities required you to have a foreign language GCSE, and I didn't have one. And so my choice of university was very restricted, which is why I ended up at Leicester. It was the choice between London, which would have meant not moving away from home, Hull or Leicester, so I went to Leicester. [laughs]

[0:08:33]
Right okay. Just before we get to university, when did your interest in mathematics begin? Was that whilst you were at the secondary school or once you came to grammar school?

I think even at the junior school I'd always been interested in mathematics and certainly through secondary school, I was interested in logic particularly, I'd always had an affection for logic, so when I did my first degree in pure maths at Leicester, I wanted then to go on and do a PhD and I wanted to do one in logic and fortunately the head of department there was a logician and so he took me on as a PhD student. And I did a PhD related to Gödel's incompleteness theorem, actually. But I wasn't, I wasn't terribly happy with the state of mathematics at that point, I felt that the motivation of, you know, what sort of mathematical topics you pursue was a bit arbitrary. I mean my kind of caricature at the time was that mathematical machinery was built to answer some interesting question, but then that machinery itself became the subject of investigation and that sort of recursed to several levels deep, to the point at which you began to wonder, you know, why this was an interesting thing to look at. And that's why I was attracted to computing, because I could see that this was an area where logic was applied and where there was a clear motivation, and particularly, you know, given my background in mathematics, looking at automated reasoning was an attractive proposition because I thought I could use my knowledge of mathematics and my interest in logic, and I did know a little bit about computing by then, that I could put all those things together. It wasn't unusual, by the way, to come from a non-computing undergraduate degree into a job in computing because there were not many computing degrees at that time, it just didn't exist. And so, you know, when I came here most of the people had done their degrees in other subjects: mathematics or psychology or, a lot of physicists actually, there have always been a lot of physicists in computing. It's different now, I mean now one would be able to do a degree in computing first. But I mean one side effect of that is I've never really learnt the basics of computing at undergraduate level, so I mean I tend to find I know a lot about the latest thinking but I don't actually have the underpinning background, which is a strange situation to be in but it's, I think, probably common in my generation because of the route that we came up.

[0:11:35]
So, can I ask about when you first started becoming interested in logic, you said that was when you were still at school.

Yes.

What kind of mathematics and logic were you being taught at the time? Can you remember?

I don't remember that I had any courses in logic as such, I think I was probably self-taught, actually.

Right.

Yeah. I just followed an interest in that. I didn't know a lot about logic until I went to university, but yeah, it was always, it was always something I was aware of and interested in. I remember, and actually an early interest in the relationship between logic and computing, because this was a time when the logic gates were being built out of electronic circuits and there was interest in that, and writing away to some company – I can't even remember which it was – that made these circuits and asking for, you know, circuit diagrams and things, and I got a fairly shirty response actually, because this was a trade secret. [laughs] I hadn't realised what I was straying into there.

Okay. So, at Leicester you studied mathematics and then mathematical logic. Do you remember what was the first time you had an encounter with a computer?

Yes, I think at school we had, in the secondary school, I think in the grammar school we had some courses on Fortran. And then at Leicester when I was doing the maths degree, one of the maths lecturers there was very interested in computing, was teaching computing and got a computer in the basement, which we were allowed to use, and I did some sort of voluntary extracurricular work on that, but I mean at that stage it was all cards, you know, so one would have to type up these cards and they'd be sent in a deck to the computer for batch processing. And then you would find, you know, there was an error in the second card and so on. So it was very frustrating, actually, and what one was able to do was very simple. But I did remember in my PhD I was looking at logic of my supervisor, Goodstein, which was a very simple logic for arithmetic and there was a definition there for prime numbers, and I remember programming that on the computer and it was incredibly slow. I mean it was not an efficient algorithm at all, but it did work.

Do you remember what the computer was?

My goodness, no. It would probably have been an ICL machine, I would think, in those days. It's too long ago. This would have been, I mean my PhD started in '68 and finished in '71, so, and I went to do the undergraduate degree in '65, so this is quite a long time ago, my memory is a bit hazy on these things, I'm afraid.

[0:14:44]
Okay. And you said the connection between logic and computing was something that interested you. Can you expand on that a bit?

Yes, I mean I think what was interesting to me about logic was the ability to reason non-numerically, you know, so to reason, have qualitative reasoning via, you know, axiom systems and so on. And at university I got interested in building some little robots, so we built sort of Grey Walter like autonomous robots out of Lego and various electric motors and so on and set it running round the department. And one of my lecturers there pointed me to the work at Stanford University on Shakey the Robot and STRIPS and so on, so I thought that was very interesting that one could, by writing effectively sets of axioms, actually control a robot, that seemed a pretty exciting thing. Not that I got into robotics, as it turned out, because I felt I was more in my comfort zone doing automated theorem proving. But yeah, so I don't know, it's hard to say why one is fascinated by a subject. I mean there's not necessarily a rational reason, but I think I've always, I was always attracted to the more sort of qualitative reasoning aspects of that, yeah.

Do you remember whose work in particular you were looking at around that time?

Well, we looked at Grey Walter type robots. I remember one of the electronics magazines had sort of diagrams to show you how to imitate his work. And then the STRIPS stuff, and so on. And of course there was the connection with Turing, given the sort of logic that I was doing to do with undecidability and so on, I was sort of aware of Turing machines and that sort of thing. But I mean I wasn't aware of a lot of the stuff that was going on really at that stage. I mean it wasn't as common knowledge really as it would be now. It was really only when I came here to Edinburgh that I actually found out more about this stuff. I mean in fact, I think the first seminar I went to here was by Nils Nilssen who was visiting from SRI at that point, who was of course the main guy behind Shakey the Robot and so on. He was talking about STRIPS. So I probably at that stage didn't realise quite how privileged I was to be sitting in that lecture.

So was that once you'd already moved to Edinburgh or did you come to visit here for that particular seminar?

No, this was when I joined here. I'd never been to Edinburgh here until I got the job, I'd never been to Scotland before until I got the job here. Yes, I think there's an anecdote about that in my book, about how I, Bernard Meltzer, who turned out to be my boss, came to give a seminar to the logic seminar at Leicester and I approached him to see whether he was interested in employing me, essentially. So I'll tell you that story… you've read it already, but…

No, go on.

But, you know, a nervous PhD student, so I carefully rehearsed what I was going to say. I was going to say to him, do you have any logicians in your group at Edinburgh, and then I expected he would say, no I haven't, then I would say – that's what I thought – did you want any? But what actually happened was that I said, 'Do you have any logicians in your group at Edinburgh?', and he said, 'No, I suppose that was obvious from my talk'. And I said, 'Yes, that's what I thought, do you want any?' So the dangers of being over-rehearsed. But nevertheless, when I applied to him he had a couple of positions and, which was good timing for me, so I applied and came here to be an RA in his group. And that, looking back, was a spectacular group. You know, there was, Kowalski was there, Pat Hayes and Bob Boyer and J Moore, you know, all gone on to have glittering careers and made major contributions to artificial intelligence and theorem proving and so on. So that was, I was very lucky to be in that community. And of course there were, we were actually in a separate unit that Bernard ran, the Metamathematics Unit, but adjacent to us and very strongly connected was the Department of Machine Intelligence and Perception that was being run by Donald Michie and Christopher Longuet-Higgins, and originally Richard Gregory, although he'd gone by the time I got there. But that was also quite a hard time because the professors in that group were busy arguing, they're notorious for the bad relationships between them. So it was a bit like being in the Chinese curse of living in interesting times and that led to a lot of political trouble and was really only resolved by 1974, about three years later, when we created the Department of Artificial Intelligence, of which Bernard became the first head of department. And I remember coming out of our first general meeting and Bernard saying to me, 'Well that was boring', and I said, 'Yes, thank god'. [laughs] Because up to then general meetings had been riotous, I mean it had been very unpleasant with all these professors arguing amongst themselves. So that was good and, you know, I was lucky to get a lectureship. I hadn't, you know, I was only an RA, I hadn't really intended to stay in Edinburgh, I expected that I would have to move on at some point. But getting the first lectureship actually that was issued in the Department of Artificial Intelligence, and the other one eventually went to Gordon Plotkin, so that was very distinguished. And it was a very small department: Bernard Meltzer, Robin Popplestone, Rob Burstall, who you mentioned, and Jim Howe who, they were the only permanent staff. There were a lot of research fellows and PhD students but there was only those six. And after the Lighthill Report we went down to four, but now have recovered spectacularly.

[0:21:25]

So you mentioned Gordon there, and I've spoken to him before, and he mentioned this, he called it 'inter-department politics', and he also mentioned that there was a bit of tension and friction at times, but he said he felt that there was also a lot of collaboration that went on and some of the competition was actually quite healthy. So would you agree with that?

Well, I think the political tension wasn't healthy. And I wouldn't call it inter-departmental, I would actually call it inter-professor, because I think the arguments were between the professors and at one point the university set up a court level committee to consider our future and the initial rumour was that they were going to split us up, they were going to divide the different bits and pieces amongst existing departments. And it was the research fellows and the students who felt that there was a camaraderie and that we had interesting collaboration between the different research groups and that we wanted to stay together and that we felt that there was a subject of artificial intelligence that we didn't want to see diluted by people going into psychology and computer science and engineering and so on, which was what was predicted. And so we got together a petition and – one from the RAs and one from the PhD students – in which I played a role as a typical agitator, and we sent these to the court committee and it actually changed their view. So they realised that there really was a community of artificial intelligence amongst the more junior members of the department and that the problem was at the top. And so they decided to create a department of artificial intelligence and some, you know, some of the people, the professors left and apart from Bernard and Jim Howe, who got on fine. So the other, Longuet-Higgins and Donald Michie, well, Christopher Longuet-Higgins went to Sussex and Donald had his own little unit which was separate from the Department of Artificial Intelligence. It was a bit ironic that not only was this the first department of artificial intelligence in the world, but we had two. [laughs]

[0:23:56]

So you mentioned a little bit about the fact that a number of people who worked in this group went on to have really quite notable careers, what would you attribute that to? Do you think there was just a really good culture there, or…

Yes, I think so. I mean partly Bernard Meltzer was very good at picking good people and so he recruited some very good people, and there was a very open atmosphere and he gave us our heads, so you know, he didn't have a tight programme that he wanted us to contribute to, so he more or less let us get on with, within the sort of scope of the remit of the group, he let us get on with our own thing and I think that was very good at quite a young age. You know, I mean we were mostly in our twenties, and so we developed that independence and free thinking at that point which we were able to rely on later. So yes, and I think, you know, we were in at the beginning of things and so there were lots of interesting directions that hadn't previously been explored that we could become involved in. And, you know, we did in the end quite different things, but each in its own way successful. So I think, I've always been inspired by the way that Bernard ran that group and tried to adopt a similar methodology within my own research group. And I think that's worked, I think we've had successes, and certainly people say to me that they feel that it's a very good place to work and healthy atmosphere and so on within the group. So I think I would certainly think that that was partly due to the way that Bernard recruited and ran the group.

So about picking a good group of people and giving them the right amount of freedom to set their own direction?

Yes, yes. I think that's very important, to give autonomy to people very early in their career. And I often contrast it with the German system where, you know, you don't really get the ability to run your own group until you're about forty and I think, you know, by then probably things have got a bit stale and I think, you know, having somebody who at twenty-four can have his own research group and his own PhD students and own RAs and so on, you know, I think that's a very healthy situation to be in actually, yeah.

It's a lot of responsibility for somebody, quite early career though, I suppose?

Yes, but if you pick the right people then I think they will rise to that occasion and, you know, they will make mistakes, but I think they will make something of that opportunity, yeah.

So how would you go about identifying those right people?

I think that's very difficult actually. And I'm not sure that I've mastered it. I've certainly made some mistakes. I meet people sometimes that tell me that they interviewed me and I didn't accept them. So, you know, some quite famous people, so I'm not sure that I've got it right every time. And I think it's good to talk to people, but then there's research that say that interviewing is not that successful actually, you've got to look at their achievements, look at what they've managed to do, not just exams, but I think research achievements, if that information is available, if they've done projects and so on. Because often, you know, you can get people who are spectacularly good at exams but they don't really get on with research, and vice versa. So it's not an easy thing, I don't think I have a magic formula, unfortunately, sorry. [laughs]

[0:27:46]
So, you've been here at Edinburgh since, what, '73?

'71.

'71. Okay, alright, so nearly fifty years.

Yes.

Obviously it would be hard to pick from such a long time, but any particularly standout projects from that time?

I think the work that we did on inductive theorem proving and particularly the rippling technique, looking at ways in which one can manipulate formulae to turn them from one shape into another so that they're useful to you. I think that was a major achievement. I think some of my early work too, I mean the first project that I got funded was the MECHO project where we were looking at mechanics problems stated in English, typically from the sort of A level syllabus, in which we translated the English into logical formulae and then extracted equations which we then solved to find the answer. So that I think at the time was extremely novel, nobody else was really working on that. There had been some work on understanding mathematical English and solving problems, but I think we got deeper into it than anybody else had done previously. And I've sort of gone back to that area a bit, you know, I'm now, moved away from theorem proving a bit and now looking at the way that information is represented and particularly at the moment I'm interested in what happens when the representation is faulty and how one can automatically repair a faulty representation to make it more accurate. Yeah, so…

Were you, was J Moore working with you at that time?

We never worked directly. He was there when I arrived and the other, I said there were two posts going, the other one was for Bob Boyer. And they were both from Texas and they hit it off immediately. It's the closest working relationship I've ever seen. I did of course talk to them and we had interesting discussions, so some of the stuff on inductive theorem proving that I'd done as my PhD was kind of useful for them to know about some of the techniques. I particularly discussed generalisation, I remember. And so, you know, it was very interesting to work with them, but I wasn't working as closely as those two were working together. And of course what they initiated there was what's now generally called the Boyer-Moore Theorem Prover, but it's official name is ACL2, but, you know, they initiated that in the sort of early seventies at Edinburgh, '73 I think they started doing that work.

Yeah, I asked because I remembered J telling me about his early PhD work on children's stories language processing and I wondered if there was a language processing connection there, but…

Not really. By the time I came to Edinburgh he had moved on, so he initially, he came from MIT, he had worked with people like Charniak who had done stuff on children's stories and Bobrow had done stuff on natural language processing and so on. And I think MIT then was emphasising that one way to get a handle on AI was to look at the way that children learn, and so that was where the sort of children's stories stuff came from. But I was talking to him about this actually just the other day and he said that he worked for Bernard Meltzer as a programming assistant helping build automated theorem provers and he rapidly realised that that was much more interesting to him than the children's stories, so he changed supervisors and changed projects and he actually worked with Rod Burstall. And so by the time I came he was really working on theorem proving and in fact he worked closely with Kowalski, because Kowalski had invented this SL resolution which became the basis of Prolog programming language and this idea of using ideas from theorem proving for programming, thinking of them as programming languages, that was a big discussion between Kowalski and Pat Hayes who was then there, and Kowalski's collaborator at Marseilles, Colmerauer. And so J's job was to build a theorem prover for SL resolution. But then, you know, when he started collaborating with Boyer they moved into this inductive theorem proving. I'm still actually quite close to J because he lives here in Edinburgh for half the year. He has a flat up on the High Street and he and his wife and my wife and he are friendly, we often go out together, so I'm probably closer to him now perhaps even than I was then. And it's interesting to sort of share stories and backgrounds and the different ways in which our careers have developed.

[0:32:59]
Yeah. Something else that struck me about this connection between, you've done work related to theorem proving and then also about representations of knowledge, and so I was recently teaching at the University of Amsterdam, doing a history of computing course there, and there was one group who were looking at theorem provers particularly in the Netherlands, and they were looking at the work of Dick De Bruijn on Automath.

Oh yes, yes.

And his focus was also, he was also interested in this representation of particularly mathematics, and I wondered, is that something that you were aware of at all?

Yes, I was aware of it. We talked about it a bit. The atmosphere at that time was that that this was a bit odd, you know, that he was using what for us then was a very strange logic. I mean now one can put it in the family of dependent type, theory type logics and see that those ideas have become much more mainstream. But at the time they seemed a bit off-centre. But yes, I mean he's been very influential, particularly representation in mathematics and so on and probably come more back into fashion now than was apparent then.

[0:34:18]
Okay. So you gave a few of the projects that you were, you mentioned a few of the projects that you were, that stood out for you. One of them that you haven't mentioned was the ECO Project.

Yes.

Could you tell me a bit more about that?

Yes, that's an interesting story, I think. So in the MECHO Project the sort of thing that was driving me was how was it possible to go from an informal description of a problem to a more formal one, what was the process in which one automatically formed a logical representation. And one of the, probably the key thing there was what I would call idealisation, and that was where one took an everyday object and idealised it into a physical one. So if you took, for instance, a ship floating on the sea, if you were talking about a relative velocity problem then you would idealise that as a particle, something without any extent moving on an infinite horizontal plane, and you'd be interested in the relative velocities between various ships. But if it was Archimedes' problem then you would see it as having some kind of extent, not necessarily interested in the exact shape, but you would be interested in some kind of vessel floating on liquid. And those are very different idealisations of essentially the same object. I mean the same, you know, a man for instance could be represented as a particle on the end of a pulley or it could be the fulcrum of a ladder, you know, of a see-saw, something like that. So I was interested in how one would decide what was an appropriate representation. But in the physics domain it turned out that it was more or less fossilised into the problem, so there would be all sorts of, I mean particularly in textbook problems, there would be all sorts of clues, you know, so the words 'relative velocity' or Archimedes Principle or, you know, something of this would trigger you to know how you were supposed to represent this. And I found this rather unsatisfactory because it kind of, it sort of side-stepped what was the important problem, how one would independently decide this and I think in an engineering project, for instance, I think that's a large part of the problem, is deciding how to think about the problem. And then I went to a training course that the university insisted that new lecturers take, and there were people, new lecturers from all sorts of subjects. And I got, I had to give a presentation and I chose to talk about this particular project. And there was a guy there from what was then called Forestry and Natural Resources whose background was ecological modelling and he was used to building Fortran programs to describe the way that energy moves around in an ecological system by difference equations and he said that he was very interested in my work because it provided a sort of interface for a human who didn't know a lot about differential equations or Fortran to describe the system that he was looking at, the ecological relationships in ecological terms, not in mathematical terms, and then be assisted to formalise that. And so we decided that we would apply for a research grant together to do that, and then this idealisation problem was much more interesting in that domain because it wasn't fossilised into the problem, but it was very much you could build queues from the questions that you were asking. So if you were interested in the relationship between different breeds of sheep or where they were in different parts of a field, different parts of a farm, then that decided how you would break up the scene, whether you would have different types of sheep or different ages, or whether you would divide the land up, how you would divide it up, just arbitrarily in a grid, or in terms of the different land types and so on. So, that was a much more useful angle on to that and that project went on for about six years and I felt that that was much more productive than the rather sort of staid, fossilised thinking that was in applied maths textbooks which I didn't find so helpful at getting to grips with these problems of idealisation. So that has been a sort of secondary theme in my research for a long time, how representations are, how it's even possible to form representations and particularly how one idealises the world. And that, so I've come back to that a bit now in thinking about how representations might be faulty and how one might see how to repair them where, for instance, the predictions from some theory of physics don't match the observations that you do experimentally. So how do you then decide, or how are you going to change this theory of physics so it's a better match to the real world. And what was interesting about that project, which we called GALILEO, was that there are lots of accounts in the history of science that one can look at to see how physics theory's changed when exposed to the facts. And so you can look at the discovery of latent heat, the discovery of dark matter, Galileo's work on, say, how pendulums work or when you drop weights and feathers and things off the side of the Tower of Pisa, this kind of thing, give you lots and lots of case studies and we were looking for sort of common patterns in which these physical theories would be repaired and whether we could extract general lessons from that, which I think we did. So that was very exciting for me. And now I'm looking at much more general mechanisms that would apply across a diversity of fields, not just in physics, but… And there's applications for this, of course. I mean, you know, there are all sorts of representations that are used in computing and many of them, you know, implementations on the web, for instance, are full of errors and so one wants to think about how one could automatically repair that. How you would diagnose that there was an error, how would you repair it, and so on. So that's the sort of thing that I'm interested in now.

[0:40:44]

So do you think that computing is particularly good at or helps develop particularly useful tools for choosing good representations?

I think it, I treat it as a sort of acid test. So if I can understand some cognitive process well enough, the acid test is do I know enough to automate it now, could I, you know. And I think that's a very tough test. You know, it's easy to sort of wave your hands to say, oh I think I've got this theory of consciousness, or whatever, but unless you could build a conscious machine, you don't really have a viable theory and nobody does. I mean that's [laughs], we don't even know what the right question is to ask about consciousness, let alone be close to the solution. But I think it's good to have this extremely good hard test and until we have something, you know, which is an even better vehicle than computing, that's where I would put my attention. So, you know, I'm not saying that this is the last word, but it's the best stuff, it's the best equipment that we have now to ask these questions about cognition.

Do you think that questions of representation are one of the main ways that computing can contribute to the other sciences?

Absolutely, yes. I mean I think if you're going to automate anything or provide any kind of computational aid to other sciences then you're going to have to try to represent their knowledge and so, you know, using logic, for instance, and using computational tools is one way to look at that. And of course there's also statistical tools that one can bring to bear and that's currently the major fashion, but I think it's not class worked and I think that's going to be the complete answer, I think there's a role for more symbolic reasoning in combination. And fortunately I think the field's moving in that direction now, there's this, John Launchbury's ideas about the Third Wave of AI where you bring together the symbolic and the sub-symbolic. In fact I'm just going to a workshop next week about AI and scientific discovery and I think, I'm sure that there'll be a lot of machine learning people there and I'm going so I can tell them that that's not the complete answer. There's this lovely quote I got about the nature of science that, you know, it's not just finding out new facts, it's finding out new ways to think about the world. And that's really, I think, one of the things that's driven my whole career, actually, trying to think about new ways to think about the world, and I think computing has served as a very good vehicle for that. I think even if you go back to the work that I did on rippling, it's a way of thinking about manipulation of formulae at a much higher level, at the meta level, and thinking about the shapes that you see there and how you can convert one shape into another. And the kind of shapes that you recognise are novel. I think maybe a lot of mathematicians have an implicit intuitive idea, but computation forces you to make that explicit and I think that's then very valuable because you can then not only make better theorem provers but you can teach more, better, because you have a handle on the concept that you're trying to get over, it's not just learn from me in an apprenticeship relationship, but here's the concept you need to be consciously aware of in thinking about this problem.

[0:44:26]

Okay. So we've talked a lot there about relationships between computing and sciences, have you had much in the way of industry connections in your career?

Not too much. I think I've always wanted to be at the sort of cutting edge and discovering new techniques and new ways of thinking about the world, and so a lot of my work has been more strategic and long term and it's not always been close to application. That's changed a bit recently, I'm actually working with a couple of industrial projects, a small start-up here called Brainwave was interested in the work on correcting faulty representations. And I have another project which I've not talked about, which is drawing conclusions from the web, doing inference from web knowledge and at the moment Huawei are funding that. So I guess more recently I've become closer to industry, but…

Do you think that's because the industry, bigger companies now are more seeing the value of this longer term strategic research?

I think there has always been that attitude in the States. So if you think about the history of AI, companies like Xerox and IBM and so on have always taken a long view. And you can see that now with Google and their funding of DeepMind, you know, that they're taking this longer view. There hasn't been so much that tradition in the UK. Hewlett-Packard had a good lab at Bristol at one point and I actually consulted for them, so I did have some relationships with Hewlett-Packard at that time. In fact I was even on their advisory board, the international one, at one point. So I think some of the big multinationals have taken an interest but most of the companies in the UK have been too close to market. Now, if you look at the ecology of research in Stanford, for instance, or in Palo Alto, you see traffic of people doing pretty much pure or strategic research moving between academia and industry and back again. There hasn't been that tradition in the UK and I think we've suffered for that, I think that's been a negative in UK industry in relationships with academia.

[0:47:08]
Is that something that you hoped you could change whilst you were part of that board in HP?

Ah well, for them I didn't need to because, you know, they have always, they always took a long-term interest and the group, the lab that they set up at Bristol did and I worked with some of those people and I felt that flexibility. Unfortunately, you know, HP downsized in Bristol, they closed three-fifths of that lab and the three groups that they closed down were the ones that I was most interested in. And one saw similar things, you know, BT closed the Martlesham group, well, downsized it, so lost a lot of people there. Yes, it's been more difficult, I think, in the UK, unless you were doing stuff that was very near to market, which has never really interested me. You know, I want to do, I want to show that one can understand in computational detail things that would surprise people. That's, I think looking back, that's what really drives me. In the article you mentioned I described it as viewing computing as art.

Yeah. It's a bold stance.

And, you know, I think one of the functions of art is to surprise you, to make you think about things that you previously didn't even consider and I think that's what, that really drives me, is to surprise people. So whenever somebody says, oh you couldn't possibly automate that, that's like a red rag to a bull as far as I'm concerned. I actually – I'm trying to think – Roger Penrose wrote these very negative books about AI, *The Emperor's New Clothes*, for instance, and he came up here, I remember giving a talk, and he recounted a mathematical proof about hexagons and viewing them three-dimensionally and so on, and said, this is the sort of thing that a machine could never do. So I started a project to do that and had a lot of fun reasoning about diagrams and manipulating diagrams directly, not just using them as an adjunct to formal proof, logical proof, but actually reasoning directly with diagrams, which was the kind of thing he was talking about and one can do that, so that was a good example of being, being driven to do this, you know, the challenge. Okay, this is something that computers can't do. Oh yes they can.

And did you show it to Penrose?

Oh, we, yes, I've discussed it with Penrose, but…

Is he convinced now?

No, of course not. [laughs]

[0:50:10]

So you talked a bit about ups and downs there with connections with industry and that reminded me of the standard narrative in the history of AI of winters and summers, and I thought, do you think that's a, is that something that you observed here as well, it's a beautiful narrative.

Oh yes, I mean, you know, I mean the Lighthill Report was something that came out…

'74 was it?

Earlier really, I mean in think he did most of the work in '72 and it was, I think the book itself was published in '73 and I went to the Royal Institution lecture where he was confronted by Donald Michie and McCarthy and…

Did you know that's on YouTube, by the way?

Yeah, yeah. I have it, I've taken a copy. In fact I've given a couple of talks recently about the Lighthill Report. My head of research institute said would I talk to our institute, to our lunchtime informal seminars, because he wanted the PhDs to be aware of that. I think, you know, one thing that drives it is over-expectation and I think often, I mean in the very earliest days people like Newell and Simon came up with this famous list of goals which they thought were going to be solved in ten years, and far too ambitious. Interestingly, some of them have been solved more recently, but you know, many, many, well, an order of magnitude longer than they anticipated. But what I've observed is it's often not the academics now that come up with these over-expectations, it's the user community, particularly from industry. You get people from, you know, captains of industry who suddenly get carried away by the potential for AI and completely exaggerate what is possible. You know, Elon Musk would be a good example. Worrying negatively about, you know, the so-called singularity and so on, and it's mostly a lot of nonsense. And so you get these exaggerated expectations and then of course they're not met and so then there's a lot of disappointment. So the big one of course was the Lighthill Report and, you know, I mentioned that our small department had even further shrunk and become very small for a period and that was really a direct result of Lighthill and the decision to cut funding to AI as a result of it. But we survived and then with the Alvey programme, you know, we grew again in the eighties and became very big and successful. But then there was another sort of downturn in that expectations were not met and so there was another winter, but not to the same extent. And people ask me, you know, could it happen again, and I think to some extent that it could. So I mean I think one of the dangers that I see with the AI successes is that people over-generalise from them, so people's knowledge of intelligent agents are from the animal kingdom, humans and other animals, and the animal kingdom generally is generalist. We can deal with novel situations, have a wide range of abilities, not necessarily highly expert, but can deal with a wide range of different environments. If you look at the successes of AI, you know, take something like AlphaGo, you know, plays a brilliant world class game of Go, but it can't do anything else, it can't even move the pieces on the board, you know, the human has to move the pieces. Self-driving cars, very successful at driving cars, but you know, they can't play chess or Go and they can't answer general knowledge questions like Jeopardy does. So what we're looking at is what I call idiot savants, you know, they're really brilliant in a very, very narrow area and, but not able to deal with anything outside that area. And I think the lay public looking at that expects it to be a much wider range of ability, and so there's a danger that something will be applied outside its area of expertise. So, you know, so take something like some medical diagnosis system for heart diseases and then somebody comes along with cancer. You know, it's going to diagnose it as a peculiar kind of heart disease, not cancer. So that could be quite dangerous. But I think, you know, the expectation that we'll build these very general intelligences is unrealistic and so there might be a backlash on that, but it won't be the same extent as the Lighthill one, because at the time of Lighthill we didn't have industrial successes that we could point to, whereas now we can. So, you know, there have been applications of machine learning which have been transformative in medicine, in self-driving cars, in image recognition, speech recognition and so on. And so we have those successes we can point to, so I don't think there's a danger that suddenly all the funding will be removed because people will still want to fund those successes, but there will be a period of disillusion when they find, you know, when people realise the limitations of these systems and how easily they can be fooled and, you know, the strange kind of mistakes that they make. I mean now there are well documented cases of image recognition, for instance, which will, I don't know, recognise a car as an ostrich or something, you know, so very strange mistakes that we as humans find very difficult to relate to.

[0:55:44]
One of my favourites is I saw a particular image classifying AI that had made the connection between grassy fields and sheep and so assumed that any time it saw a grassy field there must be sheep there, which led to some very amusing situations.

The one that's my favourite, which I think illustrates the kind of dangers here is that the American army wanted something to recognise tanks and to classify them as American tanks or Russian tanks. And it was very successful and it did well on the test domain, and then somebody realised, I'm not sure how this was discovered, that what it was actually discriminating on was the resolution of the picture, because you can imagine that the American tank photos were taken in very high resolution contexts, very close up and so on, where the Russian tanks were photographed with a long distance, you know, lens. And so, you know, you could imagine how that would have worked out on the battlefield.

Yeah, absolutely.

Not good news for the American tanks, I think. I mean hopefully it won't come to that but you can see the kind of danger that the discrimination- I mean, you know, of course it was successful on the test set, because the test set was constructed the same way, so that algorithm worked perfectly well, so appeared to be very successful. So, you know, those are the kind of dangers I think. And there will be some kind of accident that will make the headlines that, you know… I mean we've already had crashes of self-driving cars and part of that is of course human error in their design. But, you know, people will be very sensitive to that.

[0:57:36]
Okay. So, in 1998 there was the merger of the different departments here at Edinburgh into the School of Informatics, and you became the first head of that school, is that right?

Yes. Originally it was called the Division of Informatics, but yes, so we renamed it to the School of… I used to joke that we were called the division because we were so united.

[laughs] But what interests me, actually was, perhaps wrongly, it wasn't the school thing, it was the informatics name that struck me as being quite… much more common in Europe than in the UK.

Yes, yes. So we had a very interesting discussion about this because what we were uniting was a department of computer science, a department of artificial intelligence and a centre for cognitive science, so I mean something almost on the humanities side. And what was driving that merger, I mean apart from pressure from the university to have bigger and fewer units, which has been a driver across the whole university sector, what was driving us academically was the feeling that computing was now pervasive, that it was influencing other disciplines, particularly our understanding of human systems and human society as well as having practical applications in building hi-tech kit. And we wanted to, we didn't want to call ourselves the department of computer science because we didn't feel that that reflected the breadth of our vision. And so we were looking for a term which would not just mean we're looking at artificial systems, but that we're looking at natural systems from a computational viewpoint. And I think the feeling was, because there were subjects like health informatics and so on, you know, a variety of ways in which informatics was used to emphasise the application side, that informatics was a better name. I don't think it was perfect, but I don't think there, there wasn't an obvious alternative. So we wanted to present ourselves as much broader than just another computer science department. And I think at that time that feeling was current. I mean we could look at Amsterdam, for instance, we could look at Cornell as other departments internationally that were fuelling that same driver. And I think that's been successful, I mean, you know, at the beginning it was pretty tough, I can tell you. I mean as head of that new division, I mean my joke about being united was not idly meant, I mean some people were, found it a struggle to be ripped out of their comfort zone and put into this bigger unit. I had some very angry conversations with people, but you know, I have a sense of humour, so that was the way to try to disarm some of the more violent reactions. Yeah, but what encouraged me actually was seeing alliances across the traditional boundaries of the departments focussed on things like teaching, for instance.   You know, I mean each of the old departments had people who were very keen on, interested in teaching and they got together and talked about the teaching of the new school and found common cause. You know, and there were other kinds of alliances. So another good one was we had this computer architecture group, one of our research institutes, and they were, you know, one would think of those as pretty hard-nose computer scientists, more on the sort of engineering side of the subject, but they started looking at machine learning as a way to decide what to put in a computer cache, for instance. So, you know, that showed the potential for taking ideas from one of the old departments into another. And that was always very refreshing when you saw examples like that. And in fact, I mean some of our concerns from the AI point of view was that we were sort of, we would lose our identity as an artificial intelligence department and that that would become less prominent, but actually the opposite happened. So actually when I look at the research that was happening across the different research institutes, then AI was becoming quite prevalent, you know. So there was one group of robotics and vision, our group, looking at automated reasoning, the computational linguistics people using AI techniques for natural language understanding and so on. Even the theory group looking at algorithms that were non-deterministic and heuristic based and so on, so looking at things like complexity of those. So yeah, it was actually, I think the time was ripe, actually, for that and I think it was a very successful move. And certainly as a, you know, this tradition, this move towards having fewer units, I think the university as a whole went from something like forty-two departments to twenty-one schools in the space of a year or so. And it meant that one could give more autonomies to the schools, so things like hiring decisions, financial decisions and so on were delegated down, devolved down to school level from what had been faculty level. The hierarchy was shortened, we'd had sort of five layers and now we only had three within the university. And so we were much more the masters of our own fate, so that was very empowering. So I think generally that was successful. And we were also very big, I mean we were, when it came to RE and then ref time, we were the biggest research oriented department in the country, still are, by quite a margin.

Okay, alright.

And attracted, you know, spectacular people from across the world. If you look at our staff and ask what country do they come from, incredibly diverse. There was this exercise at the time of Brexit, I don't know if you remember, there was a sort of day of, you know, something like a day without us, kind of thing, and they did this exercise of getting into the atrium all the staff and then the people who weren't British left and they took another picture, and it was like, I don't know, twenty-five per cent. So seventy-five per cent were not British nationals at all. So I think that's also very healthy and one meets, I have, you know, students from all over the world, we have staff from all over the world. It feels like an international centre.

[1:04:45]
So we'll move towards some of the sort of wrap-up questions now, a bit broader. You've had a number of positions that have seen you be parts of councils or committees that are national, perhaps even international, how do you see the state of the UK's academia at the moment?

Wow. I think…

Quite a big question.

Yes. I think it's generally healthy, certainly in computing I feel that, I think that we're in a healthy state. You know, I think there are some very interesting research projects going on. Of course we're feeling the pressure from the teaching point of view because we're getting huge numbers of students, you know, I think you were saying yourself that it's difficult to find lecture rooms that are big enough for some of the classes that we run now and people then complain of over-work and so on. But I think those are the problems of success. I've been at the other end, I know what the problems of, you know, when you get so small you're no longer viable, I've been there, and I know which I prefer. So, you know, I think the funding has been a bit up and down, I think pressure all over the world now where the number of researchers has increased and the funding hasn't kept pace, so I think we're all finding it more difficult to get funding. But then, you know, there's much more interest from industry now in funding. My funding has moved pretty much from EPSRC to industry in the last few years and I think that's not uncommon. And of course, you know, there's a threat from Brexit, we don't know what's going to happen about European funding, so that's a bit of a worry. And of course with such an international staff, there's a worry about what will happen to them, although I think recent pronouncements from the government suggest that they want to protect science. But, you know, some people I think will be worried about the uncertainty and will leave anyway. So that's, I think that's a danger. But, you know, when I think back to the seventies and where we were then, looking now, I mean what I see around us, we just opened this huge data science centre next to us, we've had huge investments from Westminster, Holyrood and from the Edinburgh council into that. We are collaborating as never before. I mean that was a thing actually that characterised our move to a school, you know, we had already had strong connections say, with linguistics, which are just next door, and to a lesser extent with philosophy. But our connections with every other school in the university increased. At one point I ran a seminar series here called Computational Thinking. That was independently of, whatsaname?

Don't remember the name, but I know the person you're talking about.

Yeah, anyway, I mean I just came up with that name, but what I was interested in was how other subjects, other disciplines, use computational ideas and I think I asked just somebody senior from every other school in the university, not just the sciences, but you know, architecture, economics, linguistics, philosophy, psychology, and biology and geology. I didn't expect much from geology, but I got something very interesting from geology actually. And every one of them was saying well, we think about our hypotheses in different ways now, we think about them in computational terms and the way we evaluate them is more computational and the terminology that we use is more computational. And so it was quite profound and deep, the way in which computational is influencing the subject. I'll tell you the geology example because I think that, because that was so surprising. So the guy I got was a very senior figure in the university and in the Royal Society and he said in geology they used to build linear models, not because that was a good fit to the environment, but because it was all they could deal with mentally, okay? But now with computers they can build non-linear models and that's been a revelation because of course non-linear models hold all sorts of surprises and so, you know, you find out things that you really hadn't expected. So, you know, I think that was one of the most profound examples from there. So, you know, we were lucky in that the principal here was a computer scientist, in fact he used to be in the Department of Artificial Intelligence, he was a friend of mine, and I think he encouraged. But even before his time I think we had encouraged the sort of pervasion of informatics across the university so that this whole university thinks in computational terms and has strong relationships with our school. And that's very healthy and we're very delighted. And you can see the realisation of that in the Bayes Centre next door, you know, there are physicists there, there are mathematicians, there are high performance computing people and, you know, the theme is data science and machine learning and that's having a big influence on the region. You know, our school has record numbers of spin-outs. When I was head of the school, in 2001, a Scottish government report said that a quarter of all the spin-outs in Scotland across all disciplines came from our school.

Wow. That's impressive.

It was impressive and it's one reason that we got them to build this building, because when we went to Scottish Enterprise and asked for a donation they said, you know, we'll give you fourteen million provided you'll take another five million from us to build a business development centre with business and development executives to try to encourage more spin-outs. So that's one reason that we've been spectacular. We have, you know, Skyscanner is a unicorn from our school, for instance. It's a billion dollar company. And, you know, and there are spin-outs all over the city. More than Cambridge, by the way, and people don't believe that, but we are more successful than anybody else really. So it's, so I think we're certainly in a very healthy situation and I think that's true across the country actually.

[1:11:24]

And do you think that, we talked about teaching and about lots of students coming through, do you think that here at Edinburgh and maybe more across the country if you know, do you think we're adequately preparing students for getting into industry and finding the right kinds of jobs?

Hard to say. I mean it's certainly a driver and that's why so many people want to do data mining and data science and so on here, our machine learning classes are huge.

And also the robotics group and that's driven by student perception of where the jobs are, which I think is probably an accurate perception at the moment. Whether we're really preparing them for those jobs, it's very hard to say. I think we're doing what we can and certainly our students have always been in high demand in industry, you know, our best students always used to go into the City and work on financial algorithms and so on, and I think still we have very high take-up of our students across the different industries. So yeah, I think generally it looks like we're certainly preparing people for the jobs that are out there. I don't hear so much complaints now from industry. I mean always used to be a complaint that we didn't prepare people with the tools that industry wanted, but that's a very short-term view, because those tools will only be popular for a few years and then what you really need is students who are future-proofed by having a deep understanding of the field and the theory and so on so that they can learn new stuff. I think a lot of people in industry didn't used to appreciate that. I don't hear those complaints so much, so whether people are taking a broader view now, I don't know, but I mean I never- so I never thought that was a valid criticism, that was a criticism but I didn't think it was a valid one.

[1:13:33]
Okay, so final question then. When I was reading the introduction at the beginning I included a lot of honours that you've been bestowed.

Yes.

So some of them are from societies like the Royal Society and the Royal Society of Engineers [Engineering], what do you see the roles of those kinds of, those big groups of people that are sort of across the country and across industry, academia? Do you see them as having an important funding role?

Yes, I mean particularly the Royal Society is taken very seriously by the government. So I was just in fact – the President of the Royal Society sends all the Fellows a regular newsletter – and recently there's been a lot of discussion about Brexit and about funding and so on, and it's quite clear from that that they have the ear of government. And one can see the result of that, you know, so Boris Johnson's recent announcement that he was going to double science funding and so on and relaxing the rules on immigration for scientists, I think, I can see the influence of the Royal Society there very directly. And I think similarly with the Royal Academy of Engineering, that because of the importance of engineering I think they're taken very seriously. So, for instance, the government subcontracts certain jobs to these societies so – I don't know if you know what a Teir 1 visa is, it's for people of exceptional talent or exceptional promise. So the job of making that judgement is subcontracted to those two societies and I know that because I'm one of the people who gets asked to write reviews on them. So you see some absolutely spectacular people, it's really amazing what talent we- and these are, you know, these are people from other countries in the world who are attracted to come and work in Britain on really interesting research projects so we're clearly inspiring some of the best people in the world to come here. And I think, you know, the government is open to that and again, you know, the recent announcement by Johnson on these global visas is a move in that direction, I think he's seeing those TR1 visas sort of broaden out so there's a bigger class of them, that can be offered to attract good people like this. So certainly this government – and I'm not a fan of this government – but in this aspect they seem to have understood the importance and I think the various learned societies, especially the Royal Society and the Royal Academy of Engineering – by the way, it's Engineering, not Engineers. So, you know, that's actually quite important. I remember – name's gone again – making the point that, you know, this is not a trade union for engineers. The job of the society is to promote engineering, or in the case of the Royal Society, science. Not to promote the careers of scientists and engineers. Sorry. I heard you say that and I had to…

That's okay.

I had to correct you.

And the ACM is the Association for Computer Machinery, so it's not even about people at all.

Yes. Yes, unfortunately named, I think. I think that was, I mean, you know, it's an old society and I think at that time, I mean it shows how the perception of computing has always been, the public perception has been very much on the hardware and not on the software, and really the hardware, although that's important, particularly with Moore's Law and so on, it's made a lot of things possible that wouldn't have been possible before, I think the intellectual art of it for me is in the software, is understanding the processes. Certainly I, given the opportunity I would change the name. [laughs]

[1:17:31]
Absolutely. Okay, well I will give you one last opportunity, is there anything that you think that I should have asked you that I didn't ask or any last remarks you'd like to make?

Well, you pointed out that I've been in, I've had a lot of these positions on various committees and societies and so on and that's true. And I think even at school I had a kind of exaggerated sense of responsibility, you know, I was always the guy who'd volunteer to be the monitor. And so I mean that gets me into situations where I get a lot of work to do that perhaps I wish I hadn't. But I think I do feel a sense of duty to society and it's served me well actually, because by being willing to volunteer and get involved in various academic societies, it actually has promoted my career and brought me a lot of these honours in the end, so I got rewarded from it. So I mean a good example is the first thing I really got involved in was IJCAI. I was at the conference in '81 and they were looking for the next programme chair and the guy that they had in mind withdrew at the last minute and I think…

This is a conference series on AI.

This is *the* major AI series, it's been running since '69 so, and I went to the second conference in '72 when I first came here. And so being the Programme Chair of that conference is really one of the most prestigious things to do, and I was quite young then. But one of the people on the committee said well, he thought Alan Bundy would do a good job and could be drafted in. And, you know, because I immediately said yes, I'll do it, I got to be Programme Chair of the next conference and then I got to be Conference Chair of the one after that, and then I became the Chair of the Trustees, you know, and so I suddenly became in a position of some prominence. And I think, you know, I'm pretty reliable and well organised in those kind of situations, so having shown that I can do it successfully they invite me to do something similar. And so I've always, as a result of that, played a prominent role and I think a lot of my fame is probably from being willing to do those kind of jobs. And so… And I made friends and that's probably why I got some of the awards that I got, and so on. And a similar thing, you know, when I was on the Scottish Scientific Advisory Council, you know, I volunteered to be on that and I picked a topic which was to with telehealthcare, which worked out really well and we managed to get together a lot of the different stakeholders in that area and make a difference. I remember I went to see Nicola Sturgeon when she was Health Minister and fortunately she was receptive to the proposals that we made and I think that that's one of the reasons that Scotland is ahead of the curve in this area compared, say, to England. It's good to work in the Scottish context because it's a small country and the number of layers to get to the top are fewer and so you can get all the stakeholders around one table and get them to agree, which is what we did. We had a big meeting here and got agreement. Interestingly, one story there, we decided to use a computational technology, which was clickers, you know? And we put some questions up and asked a group of about a hundred stakeholders what were their answers, and one of the answers was, is it time to mainstream telehealthcare now or do we need more research. And the majority was now and I think without that technology we probably couldn't have got that agreement, you know, it wouldn't have been obvious that there was a majority to do something now. And because there was such widespread agreement we did actually get stuff done, like joining healthcare and social care together in Scotland. And so it was good to feel that one could have that kind of influence. I don't think I would have got to see the Health Minister in England, you know, it would have been much more difficult to speak to people at the top like that and make an impact. And of course, you know, I think Scotland can be more nimble as a result of that, we can move quicker and we often do, and I don't think people quite appreciate that, actually. It wasn't my impression when I came here, but now I've worked in the system I can see that. So yes, I think, I think I've kind of talked myself into these situations by volunteering when I perhaps would have been wiser not to, but you know, I've benefited, I got fellowships of all these societies and… I joined, I'm a Fellow of more societies- I'm actually embarrassed to write down the number of societies I'm a Fellow of because, because it looks like I'm pot hunting or something. But, you know, when I was at the UK Computing Research

Committee people like the BCS and the IEE said well, you've got to be a Fellow, because otherwise we can't fund you. So I was sort of forced to join, in a way. So that's why I ended up with- my son-in-law ordered me to write down all my post nominals for my grandson and, you know, it was like… it's embarrassing.

[laughs] Lines and lines. Okay, so if you're interested in studying these, taking forward these ideas of computing, representation tools as applied to science and more generally across society, come to the UK, and come to Scotland and come to Edinburgh then.

Yeah, absolutely. Thank you for the plug. Yes, yes, we'll buy that, yeah.

Okay, thank you very much.

Okay.

[1:23:41 recording ends]