Bob Kowalski

Interviewed by

Elisabetta Mori

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Welcome to the Archives of Information Technology. It's the 10th of January 2020, and we are in the London at the British Computer Society. I am Elisabetta Mori, an interviewer with Archives of IT. Today I'll be talking to Robert Anthony Kowalski. He is a logician and computer scientist, a distinguished Research Fellow and Emeritus Professor of Computational Logic in the Department of Computing at Imperial College, London. He was elected a Fellow of the Association for the Advancement of Artificial Intelligence in 1991, a Fellow of the European Co-ordinating Committee for Artificial Intelligence in 1999, and a Fellow of the Association for Computing Machinery in 2000. He received the IJCAI Award for Research Excellence in 2011. He received the Japan Society for the Promotion of Science Award for Eminent Scientists for 2012-2014.
[01:06]
Welcome Bob. Where and when were you born?

I was born in Bridgeport, Connecticut, in 1941.

Can you describe your parents, what were their occupations?

Well, Bridgeport, Connecticut is a working-class town, full of factories. And my, my father was very independent, so he, he tried, and succeeded, in forming a business of his own. My mother worked in a factory, because she wanted to be independent of my father. Neither one of them completed high school. For a long time I thought I was the first member of my family to, to finish high school and to receive a higher education, but, I later learnt that my uncle, my mother's brother in Poland, became a professor, much to my own surprise. So, I guess, given the opportunity, working-class origins can still lead to higher academic achievement. My father grew up during the Depression, and I think, for a while, if, if you believe what he was telling us, he was probably homeless for a while in New York City, but he was very aspirational in wanting to overcome his, well, in order to survive really. And he managed, over time, to, to set up a business of renovating houses with investment from other people, and that turned out to be quite successful, and in particular he managed to recruit against our will his children to help him in the process. So I, I must say, I had a difficult time with my father, because his goals and my goals were not always in complete alignment. And indeed, I would say it was my mother who played a very important

role in, because she was the peacemaker as she would put it herself. So she would try to reconcile the problems that my father had with me, and that I had with my father, by explaining to each of us how it was that we wanted to do things differently from each other.

[03:24]
Have you got any siblings?

Yes, I have two brothers. One became an academic, or, like me, he works, worked in, now retired, in fluid dynamics, and the other managed to get along much better with my father than I did and joined the family business, yeah, so, but everybody's retired now.

What was your family life like?

The family life. Well, I, I was quite a, a shy boy. I, I used to… I didn't really play very much with other, other children, but, it was partly because I was positively drawn to learning about the world as a whole. I mean there were so many things that, that excited me, you know, that I could discover by reading magazines or books, that, I must say, I hate to say it maybe but, the company of some other children wasn't always as, as fascinating as… But nonetheless, I mean I, I think it was a happy childhood. My grandmother in particular, my father's mother, who lived with us for a long time, she, she gave me a lot of encouragement. And I remember, again, she didn't finish school, and, she used to read the dictionary to educate herself, and I think there was a, a feeling in the family that, that education was something that was very important to pursue.

[04:53]
Which schools did you attend in Bridgeport?

Well, I, my primary school was, a Polish, a parochial school, parish school, run by Franciscan nuns mainly. And they were great. They… I suppose they too, I felt, I think they were very kind. They, they made me want to be kind and made me want to… They made me want to, be good, [laughs] I guess. I was an altar boy, I was a

patrol boy, helping, you know, other children cross the street. I wanted to be a priest for a while.

What about high school, what was your favourite subject?

Well, I went to a Jesuit high school, an all-boys Jesuit high school. And, my favourite subject there was, was Latin, only because, I was encouraged by my teacher to do extra work after, after school hours, and we trained for Latin Sight Translation contests. And, you know, much to everyone's surprise, myself included, I did very well, and our team did very well. And that made me feel that I was perhaps destined for higher academic achievement. So that, that had a, a huge impact on me.

Where were the influences on you at this time?

Well, at that time it was the, the Latin teacher, Father Welsh, who, who had that influence on me. But at the same time, going to the Jesuit school, I, I felt that I was being kind of sheltered from other areas of, of knowledge, and, I… I, I began to read much more widely than, than the courses we were, we were given. And after a while I began to resent that our education was so limited.

[06:59]
When did you get introduced to logic?

I left high school, and at the University of Chicago I took a mathematics course. First of all, I failed the English placement course, so, I was forced to take a remedial course in, for no credit whatsoever. Finished the year with a D in English writing skills, but an A, maybe even an A+, in mathematics. Now the mathematics course had a small element of propositional, mainly propositional logic, and it occurred to me that the propositional logic that was introduced to me in that course was maybe the key to understanding what was wrong with my English for one thing, and what was puzzling me about various things I had learnt when I was at school, high school, when I was reading broader subjects including philosophy from Jones' guide to philosophy, a book that I uncovered and started reading, which exposed me to various philosophies which were very intriguing but equally puzzling, because they all made sense, and yet

they all contradicted one another. So, I was a very troubled young man at that time, and I did get the feeling that logic would help to, to find the ultimate way to truth in these matters, and that, that's what got me started on logic.

[08:35]
And what brought you to leave the University of Chicago in 1959, and what did you do afterwards?

Well, I left Chicago, I guess for personal reasons. Living away from home wasn't as easy as I thought it would be. It was just a difficult time, and I ended up leaving in my second year after only a couple of months, spending the rest of the year working in a chemical factory, and then decided that that wasn't a good idea either. And eventually went back to school, commuting from home, at the University of Bridgeport, for three years. And believe it or not, and I, I must say that they were one of the happiest periods of my life actually, because, the University of Bridgeport was a very working-class, had a very working-class clientele of students, who were all wanting to better themselves, and, I think for the first time in my life maybe I felt that my own academic interests were, admired to some extent, and, which was not the case in high school. In high school you were only admired for athletic achievements. But I was able to be myself at the University of Bridgeport, and, and to work academically in a fulfilling way. So, you don't always have to go to the highest academic institution in order to receive a good and, and, education.

[10:16]
And, what brought you to Stanford University in 1963?

I guess also, at the University of Bridgeport I did a lot of independent… I mean that was what was great for me, in a way. I didn't have to spend all my time studying the courses that, that I elected to take, and I could independently educate myself, in logic primarily as it turned out. And, so, I didn't have any formal logic courses at Bridgeport, but I did learn a bit of logic at least. And I, and I went to talk to some of the professors at Yale University in New Haven, not far from Bridgeport, and they advised me to, to apply to Stanford, and Berkeley, and Wisconsin. And I eventually went to Stanford. And also I had a friend who had gone to do an undergraduate

degree at Stanford, and he was very encouraging about his view of my prospects there, yeah. So I, that was what it was.

[11:18]
And in 1964 you participated to an exchange programme with the University of Warsaw, and, what are the memories of that year?

Oh. Well, I mean that was quite exciting of course, and, partly because Poland and Warsaw in particular were renowned for their work in, in mathematical logic. So it was, it was exciting for, for truly academic reasons, but at the same time, it meant that I would be able to meet my grandparents in Poland who I had never met before, and my uncles as well. And learn a bit of Polish, which I had never managed to do as a child. So, that was a very exciting year. But unfortunately I didn't pay as much attention to my studies as I, as I might have, because I ended up meeting my wife who was quite distracting, and is still rather distracting I have to say. And that's how…

When did you get married?

Oh, we got married in Poland, so, [laughs] it was a rather swift affair, after knowing each other for only two months or so. But, it's lasted until this day. And it has produced three wonderful daughters, who in a way combine many of the features of their parents, so that's nice too.

[12:33]
What are your memories of Warsaw?

Oh. Warsaw in those days, remember that was a communist period. And when I had gone to the Jesuit school, the communists were the enemy, and, and you know… So I went to Poland thinking that, that communist Poland would have a policeman on every street, you know, with a shotgun in his hands. And it turned out to be much freer than… Mind you, I, I have since realised and learnt that the Stalinist period was much worse of course, and even my own family in Poland suffered during that period. But nonetheless, I mean Poland during the communist period was not the, the ogre that the Jesuits had led us to expect. So that was, that was one aspect. And it did

influence me when I returned to the States, and when I contemplated, you know, what was happening in, in Vietnam at the time, and it distracted me from going back full-time to my studies, and I started to become very active in the protest against the war in Vietnam.

And what did you do in particular to protest?

Well, being a shy person, as I've already pointed out, I, I was not at the forefront of activities, but I was, I think, quite active behind the scenes, and I, I dreamed up peaceful ways of, of protesting against the war. And the scheme I helped to develop was one which involved bombing the streets of California with leaflets explaining, you know, what was happening in Vietnam, and that these leaflets in Vietnam were, were napalm, not like, you know, the innocent pieces of paper they were in the States. So, I, I became very active. And I, I also became very distressed by the reactions that, that I experienced from those people who supported the war and who supported the President and, you know, who would advocate statements such as, 'My country, right or wrong'; 'I will follow my President, no matter what my President says'. To me, this was so illogical and so immoral, I just couldn't cope, and, I, I resigned from the protest movement simply because of the inability to deal with the kind of response that, that it evoked in those who felt threatened by protest against the war. I ended up, you know, leaving Stanford, abandoning my PhD, because I felt mathematical logic was not logic, and mathematical logic didn't address the real human problems that were taking place at the time. And I ended up for a year working in Puerto Rico, which was as far as I was able to get away from mainland United States.

[15:39]
What was your life lie in Puerto Rico, what are your memories?

Well, before going to Puerto Rico, I studied Spanish, and when I got there I discovered everyone wanted to speak English [laughs], to improve their English. So I, I learnt… I knew less Spanish when I left than when I arrived. I don't have very many memories, except for the fact that my first daughter was born in Puerto Rico, and that was a great event. I also, another important aspect of it was that I realised that, although I was acting chairman with only a master's degree from Stanford,

having dropped out of the PhD programme, I discovered that if I wanted to have the influence that a chairman ought to have, I needed to have a higher degree. So despite the fact that mathematical logic at Stanford was mathematics and not logic, I would need to get a PhD anyway. And I had a friend who was on the academic staff who had done studies at Manchester and Sussex, and he, he said that Britain would suit my personality much better than America, and he, he was responsible for encouraging me to apply to British universities, which is what I did. And I was very lucky in that I, I was offered a studentship at the University of Edinburgh.

[17:11]
And this was October 1967.

That's right, yes. So I arrived in Edinburgh in October 1967. For the nine months I worked in Puerto Rico, living very frugally, I was able to save half of my salary. With half of that salary I was able to buy a car, travel to Poland, and on the way back from Poland with my uncle, the, the Polish professor, arrive in Edinburgh, ready to start my PhD. And I remember vividly, it was a very rainy and wet day, and there I was, with my family, in front of, I think it was No. 9 Buccleuch Place. And there on the sign was, where I was going to do my PhD, it said, 'Metamathematics Unit, Department of Computer Science'. And when I saw computer science, I thought to myself, this is not what I had been expecting. And my heart dropped, I must say. The last thing I wanted to do at any point in my life was to do computer science. But I very quickly had come to the conclusion, I had already dropped out of Stanford, I had dropped out of Chicago; I wasn't going to drop out of another academic degree. I was going to stick with it, and as soon as I got my PhD, I would do what I really wanted to do. Not that I knew what that was, but nonetheless, I was going to stick with it, and I think, that's what happened, I did stick with my PhD, yeah.

[18:40]
Who was your supervisor in Edinburgh?

My supervisor was Bernard Meltzer, who was originally an electrical, electronic engineer, who became attracted to work in artificial intelligence, and in particular to automated theorem proving. And, I was particularly lucky in that year, when I first

arrived in Edinburgh, that Alan Robinson, who had developed the resolution principle, which was a very hot technical development at that time, was on sabbatical in Edinburgh, and visiting, or staying as a visitor in the Metamathematics Unit of Bernard Meltzer. And, much of my work was inspired by the work that he had just done. So I was able to dive directly into a PhD at the cutting edge of that particular subject. Now as it turns out, given the mathematical logic I had learnt at Stanford, I thought that automating mathematical logic didn't make much sense. The intentions of the, of Bernard Meltzer and Alan Robinson was to apply the automation of mathematical logic to the proof of mathematical theorems. And I thought, that's a crazy idea. Again, oh, I wasn't going to finish, I wasn't going to pull out of a PhD because of it. I was going to, you know, stick with it. I didn't think it was a goal that was particularly laudable, but nonetheless I, I thought I could, I could give it a shot, so to speak. But I didn't think that the technical approach that was being proposed could really be taken very seriously compared with what I had learnt at Stanford. I suppose I was a bit arrogant, you know, coming from Stanford to Edinburgh, but it only took me about, a couple of months, though, before I, I realised that I had been mistaken, that in fact, the work that was being undertaken by Bernard and by Alan was, was genuinely sensible work, and, I soon got, got into, into the swing of things, and everything went quite well. I was able to finish my PhD in just a couple of years really. And I was able to work with really outstanding people. Pat Hayes in particular was starting his PhD at the same time as I was, and one of my very first papers was a joint paper with Pat. That was a great time really. Despite the fact that I hated computer science.

[21:30]
And how did you get to know Alain Colmerauer?

Well, so, I finished my PhD in 1970, and as I said before, my intention was to get out of computer science as quickly as possible. And so I applied for jobs elsewhere in the UK, and I remember applying for a job in a mathematics department at Essex University. And I almost got it really. But I didn't get any of the jobs I applied for, not that I applied for that many. And then, I ended up staying in Edinburgh for another five, four or five years, four years. Another four years. [pause] Ah, but that was a great time. That was, having finished my PhD, and Bernard was really really

good, I, I wish I had, I had have known how helpful he had been at that period in my time, because, he allowed me to continue the work I was doing on my PhD under the support of a research grant, but at the same time to explore all those other ideas that had been, you know, troubling me, you know, since, since back in my first year at Chicago. So I could spend like, half of my time doing one and half of my time doing another. And as it turns out, the work, you know, both, both areas of work kind of came together when I started my work that involved Alain Colmerauer. So basically, the result of my PhD attracted Alain Colmerauer's attention back in, or down in Marseille shall we say. He had been working on question and answering systems, and was planning to use, beginning to use, resolution systems of the kind Alan Robinson had developed. And he had learnt about the work I had been doing surrounding my PhD, and he invited me to come and visit him, and give a talk in Marseille, and, during my first visit in the summer of 1971, a long time ago now. And during that visit, we spent four, four days together, [laughs] four nights and days, we, you know, it was a, almost a marathon meeting during which we had wonderful discussions. So anyway, that was it. And, that resulted within the next year or so in the Prolog language that Alain developed, and the contributions to logic programming that I worked on and developed.

[24:11]
So, what did the background of the development of logic programming, who were the main contributors?

So we have to go back again, before I met Colmerauer. The… Right. So, this going back during the period of my PhD. Around 1969, researchers at MIT were, I can't, there's no other way to describe it except to say, they were attacking resolution. They were attacking it as a, a very stupid idea, that would never work, that logic alone would never solve any interesting problems, and that what was necessary was, maybe a controlled kind of logic that, that, a procedural representation of knowledge. Anyway, Pat Hayes, with whom I had already published some, some work, went to visit John McCarthy at Stanford, and, and learnt about the work at MIT there. And when he came back to Edinburgh, he said that he and I should abandon the book we were writing, which had already at least about 100 pages, because it was worthless in the light of, of the developments that were taking place at MIT. So this was quite a,

quite a, a difficult proposal to be put before me. And it was obviously a huge challenge, you know, how could resolution be so good, and now be so bad, so much so that we had to abandon 100 pages of a book that we had been writing? So there was a period between 1969 and 1971 during which Pat Hayes and I just, mostly independently, tortured ourselves with, with trying to understand how procedural representations of knowledge could be good and logic representations could be good, but both not be possible at the same time. And, so, the development of logic programming which eventually came about, came about through an attempt to reconcile these two opposites really. Pat had his own way of thinking about the reconciliation, and I began to develop my own way of, of thinking about that reconciliation. And my work was supported by Colmerauer's activities at the same time. That turned out to be quite successful in that it resulted in a very well developed language, Prolog.

Who chose the name Prolog?

[laughs] Well that was, suggested shall we say, by, by the wife of Philippe Roussel, who was the PhD student of Alain Colmerauer during this period of time. And Philippe was the guy who did most of the implementation under Alain's inspiration shall we say. So yeah, there was, a family effort I suppose you could, you could call it, yeah. Nice name, yeah. And of course it meant programming *en logique*, it didn't mean programming in logic.

[27:42]
So your experience in Edinburgh ended in 1975 when you finally moved to Imperial College in London. Who or what brought you there?

[pause] Right. It was just one of those things with… A vacancy had arisen at Imperial College. Manny Lehman, who was in charge of the computing half of the department, because there was a Department of Computing and Control, and he was, Manny was in charge. He had been writing around to people to see if they might be interested, or know of somebody who might be interested. And he had written to Rod Burstall at Edinburgh, who suggested that they contact me, and, I was contacted. I applied, I was interviewed, and, there was an extended period of time during which

objections were raised to my lack of computer science credentials, which were very legitimate objections I have to agree with. But nonetheless I, I succeeded. And I went as a reader, which is the equivalent of an associate professor in the American system. I was recruited to be the Reader in Theory of Computing. [laughs] Not knowing very much about computing. And then I, I also had to teach courses in computing, in subjects I had never studied. So that was, quite a, a challenge, as you might possibly easily imagine.

[29:19]

So the first few years in Imperial College involved learning, [laughs] more computing than I knew before I arrived; teaching subjects I, I didn't know very well; trying to acclim-, assimilate into a computer science department, which was quite a difficult thing for me to do. London itself? London itself, I think, I think I was too seriously involved in my work to think too much about London except to the extent that it affected my family. So we, we managed to settle in a very convenient part of London, convenient for schools and whatnot, you know.

[30:04]

And in 1978 you started a course of logic lessons for twelve-year-old children in your daughter's middle school.

Yeah, that's right.

Can you tell us more about this experience?

I thought it would be good to communicate with my children a little more [laughs] than I had up until now, and, what was on my mind then was logic, and it did seem to me that logic was something that children could understand, and would benefit from understanding. And I started to develop examples of logic that would be understandable to children. Little stories about dragons. For example, a dragon is happy if all its children can fly, green dragons can fly. Things of that nature. And, I, I talked with some of the teachers in the school, and we agreed that it might be of interest to try some of these lessons out using Prolog in school. So, we did… That was quite interesting. I didn't realise how much trouble it is to keep children from misbehaving, and, and how hard it is to keep their attention. It is quite a task. But

nonetheless, the work went well enough that we were able to get research funding to continue it, and we had several research grants, and for a while that was quite successful, not only in the school that I had been working with but other schools took on the project as a whole. It was a time when that was quite a, a successful activity.

So this project had an impact?

There was a series of conferences called The PEG Series, Prolog in Education I guess. Prolog Education Group, yeah. That fell apart towards the, I don't know, end, maybe mid-Eighties or, end of the Eighties. But, nonetheless, there were quite a few people for a while who were excited about the idea, and I think rightly so.

And also Micro-Prolog.

Yeah, so, so one… So at Imperial College we developed a Micro version of Prolog which was used in the school environment. And in fact, we, I think we also invented some English-like variants of Prolog which, which looked more like, well, more like English than, than ordinary Prolog does anyway.

[32:28]
In 1981 MITI in Japan announced the Fifth Generation project. And this leads us to the question, what was the Alvey Programme?

Right. Right. So the Alvey Programme was the British response to the Japanese Fifth Generation project. The Japanese Fifth Generation project, which was announced in 1981, had three main goals, one of which was to develop logic programming as the software for a highly parallel computer focused on AI, artificial intelligence, applications. Now when the Japanese announced the project, they approached the British, French and German governments for, collaborate, offering collaboration. [laughs] All of whom refused. And, the British government in particular set up a competing national research objective, but without taking the Japanese proposal to work on logic programming very seriously. So that, that created a, a huge difficulty for our logic programming group, because we could see that it was being used as the basis of the Fifth Generation project in Japan, but being ignored in, in Britain. And at

the moment, at that time, I was the most senior academic in the logic programming field in Britain, and the burden fell on me to argue the case for logic programming.

Why do you think the British government refused to collaborate in the first place, and why do you think logic programming was not considered as prominent in the British project?

I suppose the British government probably felt that the technology that Japan was proposing to follow, they didn't really support it particularly. I was not, I was only a reader, I wasn't a professor, and there were many professors much more well-established than me. I wasn't even a British national [laughs], never mind anything else. So I, for purely technological reasons, there were good reasons why the British government wouldn't want to collaborate with Japan. Why didn't they choose logic programming? Well, all the, all the established academics who would be consulted, would have been, would have favoured other technologies, other approaches to, to computing other than logic programming. So, that meant both that our own work was, was not promoted for one thing, within the Alvey Programme to begin with, and I in particular had to fight quite hard to try to convince the powers that be that it was at least worth a certain amount of support, you know, along with the other support that might be given to other technologies in the UK.

[35:27]
And in 1982 you were promoted to professorship, and, what else happened during the Eighties?

Well during the Eighties, we were in the difficult position also because there were a lot of requests from Japanese institutions for visitors to come to our group. So that put me as head of the group under a lot of pressure to decide whether to accept these visitors or not. We were given no, no guidance by, from anyone. So it was a, it ended up being a, a personal decision I suppose. And we did accept three visitors quite soon after the Japanese Fifth Generation project started. And during the whole period of the ten years of the Japanese Fifth Generation project, later extended to two additional years, so for a total of twelve years, during that period I had quite a bit of interaction with the Japanese people, researchers, as well as with the European research computer

centre that was set up in Munich by, by the, three countries. So basically, another reason why Britain didn't collaborate with Japan was because they decided to set up a European counterpart, and that was the ECRC, European Computer Research Centre, in Munich, headed by Hervé Gallaire.

And you were involved?

I… Yeah. So I, I… Gallaire was, was a, another logic programmer as it turned out, and his vision of what ECRC should do was, was pretty much in alignment with both the Japanese and my own, my own particular way of thinking about these things. And, so I, I did some, I did have some interactions with them.

[37:21]
Talking about Europe, and European projects, you were also involved in the European project Compulog.

Right. Right. So that was, that was towards the end of the Eighties, I can't remember the year, maybe it was '87 or so, roughly around '87. I think we started writing the research proposals around '87 and we, the grants maybe came in around 1989 perhaps. But Hervé Gallaire was one of the people helping to write that initial grant application for this. It was called a Basic Research Action, and it involved the thirteen most active centres doing work in logic programming in Europe, two of which were in Britain, one in Edinburgh and ourselves at Imperial College in London, and then, others throughout Europe, including Marseille of course, and, several in Italy. And I was, I coordinated that project. And I think that was for three years initially and then, it was later extended to another three years. But at that point, I already had another source of funding, so, that was taken over by another person.

[38:33]
Yes, because in 1990 Fujitsu supported a five-year project at Imperial focused on abductive logic programming.

Right.

So, would you like to talk about…?

Well, yes. So that allowed me to work full-time for a while on research, and it supported a teaching replacement basically for, I don't know if it was a full five years, but for a substantial part of that period of time. So, we, we have, you know, to some extent a dilemma where, on the one hand I should be supporting British research, but at the same time, Britain is not so inclined to support it itself. And, whereas the Japanese company was. But of course at that time Fujitsu was buying ICL anyway. [laughs]

Exactly.

So, the two were almost, entwined. Yeah.

So you have got some kind of a recurring relationship with Japan.

Yeah. Yeah, so, I've got good relations with Japan, indeed. I'll be going to Japan next month for a seminar series, for a workshop. I think we have to also ask, you know, what came of the Fifth Generation project. The Fifth Generation project unfortunately… A lot of people get the Wikipedia article, Fifth Generation project, and can see that the consensus is that, that either it was a failure, or it was ahead of its time. [laughs] What kind of consensus is that, you might ask. The… So it was a failure, in its own terms at least, and certainly by the end of the project it did not achieve its objectives. On the other hand, you can say, many of the technologies that it was pursuing were appropriate and would eventually have the impact that the Japanese were hoping for. There were some serious mistakes that inevitably take place in any kind of project. The dialect of logic programming which they chose was perhaps not high enough level, it was too closely associated to the computer architecture that they were working on. Moreover, their computer architecture was too different from mainstream computer architectures, and, the progress that might have been made. But the original idea I think, you know, could have been more successful, and the original idea to some extent may prove to be more successful at some time in the future.

[41:12]

In the course of your career, you worked with several PhD students. Can you name some of them?

Well I, I suppose one, the first PhD student that I worked with, who really was very influential in the logic programming field in particular, was, was David Warren, in Edinburgh. I think it's fair to say, he was a PhD, and important to say, he was a PhD student actually of Donald Michie, who was very important in Edinburgh, in the development of Edinburgh artificial intelligence. And Donald was very supportive of the early work we were doing on logic programming and Prolog, and he was so supportive that he allowed, and even encouraged, David Warren to switch his PhD from one supervised by Donald Michie to one in effect supervised by me, and by my supervisor, Bernard Meltzer. So, he was… And he, he is responsible for many of the fine details of the, of the Prolog language. It was his, you know, he made it a practical, a practical system. So, that's number one PhD student.

[42:20]

Number two PhD student was Keith Clark, who probably taught me more about computer science than I taught him. He was the guy who, who helped me to teach my first courses when I came to London. He was at Queen Mary College, and he had already written a book about the course I was supposed to be teaching, so he was a great help. But he at the same time… So he, as a student he wasn't much of a student really. He was just somebody I could put down on a piece of paper as, as a student. So he's very famous.

[42:54]

And then, Marek Sergot, another PhD student, was very important, because, together we developed work on the application of logic programming to law, to legal reasoning, and also to reasoning about time, causality. So I suppose, if you ask me at some stage, you know, what achievements I am proud of, I would say, obviously my work on logic programming, but also my work with Marek on the application of logic programming to law, and to causal reasoning to develop what's called an event calculus, which has proved to be very influential in knowledge representation. So, Marek is the third person who immediately comes to mind.

[43:44]

And about the same time as Marek was a student, another student, Fariba Sadri, started to work with us. And in fact she did much of the coding of the British Nationality Act, which was our main application of logic programming to legal reasoning. So, she was a very important addition to our, our work, and we did a lot of work together. And I'm still working very closely with her today in what I like to think of as my most important work of all, which we'll come to at some point; I, I hope you'll ask me about that.

[44:22]

And I also had another very successful PhD student, Francesca Toni, who worked with me on argumentation, and she too is very prominent in her field. And, that whole field of argumentation has also proved to be a very important current trend in artificial intelligence. That may come up or not, maybe when we talk further.

[44:51]

In 1997 you became head of the Department of Computer Science. Did you expect it?

Yes and no. OK. No I didn't, but yes I did expect it, because, the Department of Computing was in utter turmoil, and caused in part by the Alvey Programme, because there were so many competing groups with competing technologies all wanting support, at the expense of other groups. And this was taking place throughout the United Kingdom. But… And, and Imperial College was a microcosm of that conflict. So our department was really, yeah, a tortured department. So something had to be done. Not that I was able… Yes, so, something had to be done. One of the things that was done, was to constitute an advisory committee to the head of department, and I was one of three advisers to the head of department, bringing together some of the community [laughs] that was causing the trouble in the first place. But that wasn't enough unfortunately. And the head of department decided he had had enough of it, and wouldn't continue. And to my surprise, the rector asked me to be Head of Department. And having had this experience of acting as an adviser to the head of department in this little committee of ours, I thought I would give it a try, and see whether I couldn't bring a bit of logic to reconcile the differences in our department. So I did get to try.

[46:23]

So what happened when you tried to apply logic to the practical problems of the department?

Well, I honestly and really did try to apply logic. And my version of logic was that, we should, we should agree to some rules. Let's agree to some rules which we would apply, not rigidly, but we would apply them to everybody, whether they were your friends or your enemies. So everybody would, would, would be subject to the same rules. People didn't like that. [laughs] They, they didn't like that. They, they liked the idea of negotiating. I mean, OK, so, yeah, they were used to fighting, number one, but you know, if you're, if you're going to start fighting, they would be willing to consider negotiating. OK, you want me to have a, a smaller office, OK. 'As head of department, your office is, I tell you, your office is too big, we don't have enough space. So I want you to move to move to a smaller office.' They don't want to do that. The rules should be rules, and they should do that. What they wanted to do was to argue, 'Look, let me keep my office, and instead, what I'll do is, I'll teach an extra course.' [laughs] So this was the kind of logic that, that people wanted. And, I didn't realise it at the time, but that's a legitimate logic as well. It wasn't what I had in mind, and I didn't adjust quickly enough. So, I eventually, quite quickly actually, decided I had better retire from that, both head of department and the Department of Computer Science at Imperial College.

So, this was the main reason? Were there other reasons, when you decided to retire?

For retiring?

For retiring.

Well, the main reason for retiring was that, I really wanted to be a logician, not a computer scientist. I wanted to be a logician who would help other people to think more clearly, and to express themselves more clearly, and to be more effective in their lives, with or without the aid of computers. And, yes, I could do that in a computer science department. I, I had been doing that in a computer science department, but I always felt that I was cheating, that I really ought to be a, a software engineer, or an information technologist, and not a person concerned with human thinking and human

betterment along such lines. So I thought that I had earned enough as Head of Department, and as an academic, that I could afford to live on half of my salary for the rest of my life, and I could indulge myself in the things I always wanted to do. And so I was able to retire at the age of fifty-eight, and do some of those things. And I'm very glad I did. And I think, younger people were able to then be recruited into the department on a salary less than I was receiving at the time. So I think, people should be encouraged to retire early, and to continue their research without needing to have a salary in excess of what is needed for everyday, everyday living expenses.

[49:47]
So let's talk about your life after your retirement. You turned to writers' workshops.

I actually did my first writers' workshops with PhD students in the department, and…

But also in Japan.

And in Japan. But my first ones were in, at Imperial, and I had had some people who still remember those at Imperial, and were pleased with the way that it went. So basically, the idea was that the PhD students at Imperial, and later in Japan when I, when I held them, would present the abstract either of their PhD or some research paper, and the rest of us, most of whom were not experts in that field, would try to understand it. And we would try to see if we, if those abstracts could not be rewritten in a manner that would make them intelligible. And that involved deciding how much detail to present in an abstract, what order in which to present the information, how to link statements one to another. And they were practical examples of, of using English in a logical way to convey information and to be… And that was very rewarding. And as you say, I then have done this over a period of time in Japan as well. And that, I would say, of all my teaching, that's the teaching that was most enjoyable, if only because I learnt as much as, as I taught, and that's always a very good way to, to be doing education.

[51:34]

In the late 2000s you had another chance to apply computational logic to practical problems, and in particular I am talking about your collaboration with the WHO, the World Health Organisation, and UNICEF.

Yes, that, that was and still is to some extent, you know, a really nice project that we've been working on. So, the… I was contacted by someone from the World Health Organisation, Tony Burton, to help deal with a problem they had had in giving the official estimates of infant immunisation coverage throughout the countries of the, participating in the United Nations. They… The problem is that, the World Health Organisation and UNICEF need to produce official estimates of the coverage that, each year, and they get the information they use for deciding what that coverage is from countries which report on their health programmes, the public health programmes in those countries, providing them with the statistics. But at the same time, they also get information from international surveys, which are conducted independently of the governments, and there are sometimes conflicts, conflicts between what the international surveys say and what the countries say. And the World Health Organisation and UNICEF have to decide what to believe. And… Because they're authorised, they're obliged to, to produce these official estimates. And over the years WHO and UNICEF have developed some informal rules, not very mathematical, but informal rules to, logically decide whether the government reports were more credible, or the international survey results were more credible. And, the, the rules were continually being questioned. Government ministers of health would argue, and complain to the head of WHO, that they were being unfairly misjudged and, disregarded. So, we, we were tasked with, with developing a more rigorous approach to the informal one, which, which the WHO and UNICEF had been using. And we were considering a number of alternative, rigorous, approaches, one being a logic programming approach, another being an argumentation approach of a kind I had also worked on with Francesca Toni, and a third being, a production system approach which is associated with expert systems. So there were these three approaches. And the last one is particularly important, because it's related to the work I've been doing over the last twenty years or so, but after a lot of soul-searching, and a lot of argumentation you might say, among ourselves, we settled for a logic programming representation, which turned out to be very helpful and very useful. And it's still being used today, as far as I know, yeah.

[55:00]
Would you like to spend a few words about the work you led in the last 20 years?

Right. Well, the first ten of those 20 years I, I focused to a large extent on the book that I published in 2011.

And the book is, Computational Logic in Human Thinking: How to Be Artificially Intelligent.

Yes. So that book is the fruition of my early retirement, and it does exactly what I had been hoping to do: write a book to show how advances in, in symbolic approaches to artificial intelligence were usable by human beings in order to enhance and improve their own intelligence. So that, that went, I think quite well. In parallel with that, and working primarily with, with Fariba Sadri, I've been working on a system which attempts to reconcile the logic programming way of thinking about both logic and computing with the production system model of both human thinking and computation. So we have two competing models, in the same way that in the early 1970s, in the same way that procedural representations and, and logic-based resolution approaches were seen to be in conflict, and then reconciled with logic programming, in the same way production system model of human thinking, the production system, condition-action rule, event-condition-action rule, for dealing with computational problems, has been an alternative and in conflict with the logic programming view of both the use of logic and, and human thinking. So, I've addressed, together with Fariba Sadri, much of my computer science oriented work towards reconciling those two approaches to computing. But also viewed as models of human thinking, because they both have been, well, not so much logic programming, but, but production systems, have been used as a cognitive model, but also been used as a model for computation. [pause] So, that, that's all we've been doing. We've developing an approach which combines production-like rules with logic programming rules, but gives them a logic which is coherent and which is, which is such that, that the logic programming rules are like the beliefs of an intelligent agent, and the production rules are like the goals of an agent. And, one of them alone, either leaves you with an agent which has beliefs but no goals, or goals

but no beliefs. So… This is something that I regard as the most important of my contributions to computer science. Not that it's been recognised as much of a contribution, but I'm hoping that in time, you know, it will have more of an impact than it's had so far.

[58:10]
So looking back at your whole life, what do you think are the key decisions you made, positive or negative, and what difference did they make?

Well I think the, the main characteristics of my work I think has been to take seriously the arguments against it. So if I take a position that logic is great, and then somebody argues very strongly that it's, that it's rubbish, I don't just ignore them any more. I mean I try to understand what arguments they have against the approach I am taking, and seeing if there isn't any way in which we can find truth in both points of view. So, that's been my strategy, to learn from my mistakes if you like, but to have my mistakes pointed out by, by them. So I'm willing… And maybe it's been… I sometimes have gone a bit too far by provoking [laughs], provoking the opposition, and challenging them, by stating too strongly my, my beliefs in what I think is the case. Not making it apparent enough that I am willing to consider the arguments against what I am proposing, and that I'm willing not only to consider them but to make changes. So that can be quite a tricky matter, to both stand by your, your beliefs, but at the same time be open to, to arguments against them. You know, modify them to the extent that might be important. And, I've done that at least twice, once with, with logic programming, and once again, more recently, with this reconciliation of logic programmes and production rules and production systems.

[59:58]
What are the proudest achievements of your career?

OK. So achievements, versus successes. [both laugh]

Both.

So, I've been quite successful with logic programming, the event calculus, and to some extent legal reasoning, the application of logic programming.Yeah, so I think they were genuine achievements.

And also successes.

Yes. I think the only achievement that is not yet a success is this most recent work which… And also, I guess I haven't been as successful as I would have liked in having the work on computational logic be taken up outside of the computer community. Although I must say, the best referees, or the users rather of my book, have been by philosophers rather than by computer scientists. So, there has been some take-up there, yeah.

[1:00:51]
What do you think are the biggest challenges and opportunities for computing and AI in the next ten years?

Well, I, I tend to think more in terms of, what will the world of computing look like in 50 years?

OK.

I think the problem is that, that if we look only ten years ahead, we're going to see more of the same, and, you know, a natural evolution of where we are at the moment. But, if you look 50 years ahead, I think, it, you could begin to question whether the, the kind of languages that we have in computing can continue to be so low-level, and so machine-oriented. And if they're going to be more human-oriented, they're going to be very different I think from the way they look today. And, I think the challenge will be for computer technologists who love machines to somehow, [laughs] to somehow think more about people, and, and make their languages more congenial to people, more intelligible to people. I see no reason why computer programs should require specialised education to be understood. I mean, they, they may be difficult to write 50 years from now, but the shouldn't be so impossible to understand by

stakeholders who are not computer scientists. And I think that's a challenge that will be a challenge, not a technological challenge, it'll be a psychological challenge.

And also on the perspective of the education…

Much of my education was, was reading that I had done outside of my, my formal lecture courses. And I think that, even today, formal lecture courses are, are missing some of the most important skills that, that people need to learn in order to think clearly, in order to be able to transfer their abilities from one domain to another domain in this world which is changing so rapidly. And there are some skills which are obvious, but are untaught. You know the ability to think clearly, and to express yourself clearly, is, is not something which is taught. If it's taught at all, it's taught by osmosis. You teach Latin, you teach mathematics, but you teach them not because you need to learn Latin to get along in the world order. You need to learn about differential equations in order to be able to decide how to spend your money when you have some free time on the weekend. There are skills, I believe these skills can be taught, they can be taught. I learnt them, because, I got a D in English writing skills at Chicago, and yet, you know, I'm doing reasonably well today, much better, and I think I learnt it, it wasn't something that just happened by accident. I learnt how to improve my… And in the course of learning how to communicate more clearly, and more, I also learnt how to think more clearly, I believe. Others may disagree with me of course. And I think that those skills can and should be taught. I think it's desperately important that they be taught. And I think that, they won't be taught, because it's just too much out of the, the space of, of problems people are considering. You know, there's too much of an inertia in the educational system, there's too much inertia, it'll… Yeah. But maybe in 50 years things will have changed. But then, it does depend on, on, you know, people's psychology rather than technology.

[1:04:40]
What advice would you give to students and young people?

Well, if they're to follow in my, [laughs] in my footsteps, in my case, you know, what are some of the lessons that might be applicable to others? I, I have found it very difficult, but at the same time very rewarding, to try to reconcile my, my social

obligations to get at my own personal goals. So, I, my personal goals involve logic for human affairs. My social obligations have required me to teach computing. I have worked very hard to be a, a good citizen, and fulfil my social obligations, but at the same time not sell my soul and abandon my personal beliefs. And I think that that's something I would recommend to others. I think I've, I think it's important that we both, that we don't selfishly only do what we see as good for ourselves, but at the same time, even if it goes against the grain, you know, go ahead and, and contribute to society, following the rules of society, even if we don't completely adhere – even, even if we don't completely believe them ourselves. You know, we have to strike the right balance.

Thank you Bob, it's been a real pleasure talking to you today.

Thank you.

[End of Interview]