# Mike_Todd_Interview

LES TROTTER: I'm Les Trotter. And I'm fortunate to be here today talking with Mike Todd, a colleague for some 40 years. And we're in the building where we've been colleagues for 40 years. We're in Ithaca, New York at the OR Department. And I'd like to talk with Mike today about his career, but more broadly than his career, how things have set him up for his career-- how his initial training led him in the directions that he ultimately went into.

And I'd like to start with that, Mike, to start about-- start talking about your life not from the day that you were a tiny baby, but from the day that you started in school. And when did you first give evidence of strong interest in technical work and mathematics and this sort of thing?

MIKE TODD: I went away to private schools at the age of eight. This is the traumatic British experience.

LES TROTTER: Already at eight years old?

MIKE TODD: At eight years old, yeah, got on a train and disappeared for 10 weeks or something. And the education was superb there. The mathematics was good, but rather rote. I did well in it. But from 8 to 12, I was probably more leaning towards Latin and Greek than towards mathematics. And then I went on to Marlborough, which was a public school.

And there somebody decided for me that maybe I should be a mathematician. So we work in the science of decision making. But it's important to realize how much serendipity comes into these things. We just go in directions that we didn't expect at all. So I had absolutely superb math teachers or maths teachers at Marlborough.

I was doing calculus at 13-- projective geometry at 15 and a little bit of a point set topology at 17. So there, I really got into it. And the teachers, as I said, were superb. Social development was not so strong or a little bit weird, but certainly by the age of 15 or 16, I knew I was going to go into the mathematical side.

LES TROTTER: It's fantastic very early exposure. And even though the decision was made by somebody else, it sounds like it was at least consonant with where your interests really did lie because you evidently didn't resist.

MIKE TODD: No.

LES TROTTER: You went right along.

MIKE TODD: Well, I don't know how easy it was to resist at that time. But a classics training would have maybe prepared me for work in the foreign office or something. I could have been a spy. I could have been working for the Russians. Who knows? But I don't think that would have been fulfilling as my career eventually turned out to be.

LES TROTTER: Very, very interesting. Was there also the same type of central influence that came from the school that convinced you to go to-- you were an undergraduate at Cambridge-- that convinced you to go there and to study mathematics?

MIKE TODD: Probably. My father had also gone to Cambridge. And I went to the same colleges as he had. He was an engineer and went on to work for Marconi and English Electric and General Electric, even though it was always the same company. It just got swallowed up again and again. But he was interested in mathematics, but practical engineering as well. He wrote a paper elucidating Shannon's theorem and traveled around the world selling radar systems to the Norwegians and so forth.

LES TROTTER: But he had been a student at Cambridge as well.

MIKE TODD: Yes.

LES TROTTER: Several years before.

MIKE TODD: So I went to his college, which wasn't particularly strong in mathematics. But there it was much less personalized, but clearly very dramatic power in mathematics. The lecturers were not people who you would generally recommend, except one. John Conway was there. And he came in and gave a hilarious class on the foundations of mathematics.

But it was totally an outlier there. People were writing down on a board at a terrific speed, which I learnt from them basically the contents of a book. And it was stimulating, but not nearly as stimulating as it should have been. And I was a good student. But there were lots of other things at Cambridge that I was interested in as well. So I wasn't a superb student.

LES TROTTER: It's a very interesting-- today we think of things like flipped classrooms. And this is everything but. This is mathematics in its rote-st sense.

MIKE TODD: Exactly. We even had one person who insisted that we wear gowns to lectures. And I don't think I ever did this. But I was tempted to go in a bathing costume and a gown. But this is England after all. So it's not that warm.

LES TROTTER: Oh much more much more conservative than that-- not just the weather. I was interested to know as well whether there was-- whether there were individuals that may have had a particular-- not just played a role in sending you along a right path, but maybe had a big impression on you in terms of their relationship with mathematics. Was there anyone like that that was-- I guess the right word is mentor-- that actually served as a mentor to you?

MIKE TODD: Not really a mentor. But I was hugely impressed when I first went Marlborough, the public school, with Douglas Quadling, who later became quite a distinguished figure in mathematical education. And he was just terrifically inspiring. He gave us a problem set over a winter break I remember that had a French poem in it. [SPEAKING FRENCH], dot dot dot.

And it just said, elucidate the following verse. And it took me a week or so to realize that the number of letters in the words were the decimal expansion of pi. And that was neat the way those things combined.

LES TROTTER: That's very, very nice.

MIKE TODD: But as I say, people were teaching projective geometry. And I had a one-on-one when I'd sort of run out of other things in point set topology. So it was just an environment where if you weren't the David Cameron type, you actually could learn a remarkable amount.

LES TROTTER: So this is fantastic in terms of an opportunity for learning by personal interaction as well. As you just said, when you went beyond what was in the book, you could have one-on-one sessions. And that's a great opportunity for any student.

MIKE TODD: Yep.

LES TROTTER: Do you have similar memories from Cambridge?

MIKE TODD: Not so much. The organization of education there was these large lectures, which had maybe 150 students in them-- which were, let's say, largely rote. There were also tutorials once a week, but because Clare didn't have a strong mathematics tradition, usually you were talking to a grad student maybe from Trinity or somewhere. And Trinity had a huge mathematical footprint. But there was no one in particular there I remember as-- Cambridge was, in a sense, a letdown. The material was fascinating, but it wasn't as exciting as it had been.

LES TROTTER: How about friendships? How about other students that were interested in mathematics as well that were there? Do you retain memories for sure. But do you retain contact with any--

MIKE TODD: Very few. One I kept contact with for a number of years. But now it's all slipped away.

LES TROTTER: Did this person go into mathematics as well.

MIKE TODD: He went into computer work. And then came over to the States. And we knew him-- he was up in Canada for a while. We knew him there. He went to Maine. So we kept some contact with him. But he didn't continue in mathematics.

LES TROTTER: Well, this raises an obvious question. And that is how did you come to the decision to come to Yale after this and to continue in mathematics after what was not an incredibly positive experience when you were an undergraduate?

MIKE TODD: This was, again, one of the serendipitous things. I happened to go to Clare, which I told you didn't have a strong mathematical tradition. But it did have a strong US connection through Paul Mellon. So the Mellon foundation had set up these fellowships between this little college in Cambridge and all of the Yale undergraduate colleges with an exchange of two students each year. I think it's now gone down to one.

And I had been supported at Cambridge by Shell. I did some reasonable things with them over one summer. And it was a research position. But I was basically a sort of dogsbody there. But they suggested, well, maybe you'd like to go to business school afterwards. And it didn't sound too exciting to me. But the opportunity to go to the States for a couple of years sounded terrific.

So I applied for this. And I won the fellowship, which was terrific. And I was regarding it then as a couple of years before I launched into a career maybe with Shell. And then I went over to Yale. And things changed from there. But in fact, the year before, Yale had a Department of Industrial Administration. And that's what I applied to.

And it was very much a traditional industrial engineering program. But in the meantime, it had changed to administrative sciences. And they'd hired all of these OR people. And it was just a terrific environment. And it was just pure luck that I came at the right time.

LES TROTTER: Another serendipitous occurrence at least for you with a basic and internal interest-- internal commitment to mathematics and coming to Yale University and maybe not realizing that there would be any way that you would realize that or be able to build on that. But then being involved in administrative sciences where there was the mathematics of decision science as it was going on that must have surely been on the right wavelength for you.

MIKE TODD: It was a perfect fit because at Cambridge I had not been too wild about applied mathematics, which was sort of traditional fluid mechanics and not interested in numerical analysis because of an incredibly dry-- even among all of the other lectures, this one just really got no interest in me at all. And so I wanted to do something pure, but I didn't really want to do you know totally abstract work.

And the administrative sciences was perfect. So I came over-- went to the department. They actually hadn't heard of me because the paperwork hadn't got in. So they admitted me. The first semester I took linear programming with Harvey Wagner. I took dynamic programming with Eric Donado. And the following semester I took a course in mathematical economics with Herb Scarf.

And those three really inspired me to actually turn from a social, enjoyable couple of years to actually continuing a career in the field.

LES TROTTER: And those three can immediately attest to the fact that there is more than the organizational side of operations research. There was some mathematics to do as well. And that must have pulled you in quite a bit.

MIKE TODD: Yeah. Yeah.

LES TROTTER: That's fantastic. I wonder, of course, there were other people that were there as well at the time. And I'm thinking of not just Harvey Wagner and the ones that we normally associate with operations research. But I think if people like Herb Scarf. And I'm thinking of people like Martin Shubik and also people, like as I mentioned to you earlier, Tjalling Koopmans. And I wonder the extent to which there might have been some interaction with them or at least knowledge of the fact that they were around other than you said you had a course from Scarf.

MIKE TODD: Yes. I'm not sure who suggested that I should take that. But it was clear that was using mathematical programming tools to solve fascinating problems. Koopmans I saw in the halls, but I never talked to him. And I-- I don't think he taught courses so much. I don't know if he was so involved. Scarf was definitely interested in the administrative sciences program. But at that stage, he had so many students in economics it was an interest. But he didn't have students from OR.

The year after I came, Ward Whitt came. I think Matt Sobel maybe came that next year. I took courses with both of those. Bob Mifflin came maybe the following year. I took a course in non-linear programming from him. In economics, Don Brown was definitely interested in OR-type things. There was a special seminar on economics with theory-- uncountable number of traders. so there was a lot of excitement going on up at the Cowles Foundation.

LES TROTTER: Very, very interesting. And, actually, when you mentioned a course with Herb Scarf, that's the first-- you said tools. But I instantly thought algorithms.

MIKE TODD: Yeah.

LES TROTTER: That's really the first-- you had this great training in mathematics, but much of it was classical mathematics. And I wonder if this was really your first exposure to algorithmic mathematics in a big way.

MIKE TODD: Basically, yes. As I said, I took this one course in numerical analysis at Cambridge, which left me totally turned off. When I worked for Shell for a summer, I used some statistical tools. That was the first time I fed punch cards into a computer algorithm.

Certainly that was Wagner, Denardo, and Scarf that first year. And that constructive idea was just terrific. And the idea that a purely existential result like Brower's fixed point theorem tied in with combinatorics through Sperner's lemma and tied in with algorithms through the Lemke-Howson idea to actually compute these things was dramatic. I always loved the combination of different techniques that come together. And computing fixed points certainly had that plus terrific applications.

LES TROTTER: Very, very beautiful confluence of things that came together to then give ideas about other things. I wonder if the fact that the algorithms and the mathematics-- the fact that it had an influence-- a direct influence on the reason that you were there originally-- a direct influence on what Shell was doing for instance and this sort of thing. Did that play any motivational role.

MIKE TODD: No. It just worked out terrifically.

LES TROTTER: Yeah, by the way, this is very, very interesting for me to discuss. Like I said before, we've been colleagues for 40 years, but these are some of the things that you and I have never sat down and talked about. And to me, it's quite interesting as well.

The time when you were there, I'll ask the same question about colleagues. But now colleagues that were on the faculty, but graduate students. Do you have other students that were there that had played a big role or in terms of your acclimatization to the United States , but also in terms of what was going on in administrative sciences that you kept in touch with.

MIKE TODD: Not really that I kept in touch with except for two colleagues here at Cornell who I think I overlapped with; John McClain, who's now at the business school here, for a year or so. Joe Thomas may have been before me. But they both went through this program and got PhDs and went on to careers here. I wrote a paper with Harvey Wagner and Claude Duguay, who is a French operations researcher. And I've lost touch with him. There was another Englishman who came over.

But I don't think he ever finished his PhD. I think he was doing the same as me and coming over for the social part of it. In fact, there were a very large number of British graduate students who came over the same sort of year and a couple of them worked with Herb Scarf in fact. But I kept touch with them for a couple of years after I left, but not after that.

LES TROTTER: Were there other students that were in the same niche as you that were interested in combinatorial mathematics, abstract mathematics, and how it came together in various ways-- students that had these same sets of interest or were you unique in that regard?

When I think of the administrative sciences in those days at Yale, there was still a big organizational behavior component that was right there and was right up front. And, of course, that could dominate the avenues that one might take. But it surely didn't for you.

MIKE TODD: No, it there was certainly probably 50% of the students who were interested in more of the operations research. And probably more in math programming and some in game theory than the probabilistic side. But I don't remember any others who were more into the-- I mean, Herb Scarf students got very much into computations, and in fact, did some consulting with the European community when it was setting up its framework for doing things using fixed-point algorithms, which rather terrified me.

I remember, I think it was John Dennis who told me that numerical analysts always have this scary feeling that maybe someone is using their finite element code to design an aircraft and would they fly in it. And the same sort of feeling came up with these algorithms to compute economic equilibria. There can be several economic equilibria. The modeling is very sort of suspect. It's beautiful mathematical theory. But to have a large economic block decide on its policy based on some of these computations I hope they were taking other things into consideration as well.

LES TROTTER: Interesting. And, of course, one thing I was going to going to ask earlier. Of course, Yale was incredibly well-known at the time, not just for administrative sciences, but for the Cowles Foundation and the fact that these individuals like Tjallings Koopmans-- his initial work was seminal for all of operations research, essentially was associated with a meeting, I believe, of the Cowles Foundation in 1948 or something like this. I just wonder if there was any of that electricity in the air-- if there was any of that you felt was there that maybe you didn't connect with instantly because of the economic aspect of it, but maybe the mathematical aspect.

MIKE TODD: I am not so sure that was so much a focus of Cowles at that stage. I think the excitement in mathematical economics and game theory was sort of dominating what was going on there. But certainly I think the tradition of Koopmans meant there was more contact between those mathematical economists and the administrative science than would otherwise have been the case.

And Shubik was a member of the Cowles Foundation and taught game theory classes in administrative sciences, for example. He may have been the only direct one. And he continued that after administrative sciences moved through several changes and eventually, unfortunately, operations research, as a separate department, disappeared at Yale. But Shubik has been there for all these years and kept contact with that group.

LES TROTTER: That was Yale and clearly a formative time in terms of building the set of tools and channeling the interests that would have an influence-- a tremendous influence on the way your career would develop later on-- your research career would develop later on. When you left-- you left Yale. And was there a period of time before you came to where we are today-- came to Cornell.

MIKE TODD: I spent two years at the University of Ottawa.

LES TROTTER: Ah, now I remember.

MIKE TODD: This is also serendipity. I think the dean of the faculty of commerce there had been calling around a whole bunch of places saying, any young people who might be interested. And I got a call from him basically offering me a job. I was going to get married. I hadn't finished my thesis. So it was probably a rather bad decision.

LES TROTTER: Ah, so you left Yale before your thesis was complete.

MIKE TODD: I went up there as a lecturer for one year and as an assistant professor for one year. It was a very interesting city, although Ottawa has a huge inferiority complex compared to Montreal and Toronto, but it was the seat of government-- fascinating cultural city-- very long winters. Ithaca is just a walk in the park.

And it was an interesting two years. But it was very hard to teach in quite a heavy load and finishing a thesis at the same time. And when that was done, Gordon Bradley, who was my thesis advisor at Yale, said you should be considering some other jobs and suggested a couple. And I applied to just two-- the Kellogg School at Northwestern and Cornell.

And I got offers from both and came to Cornell. And, again, very serendipitous. It's just a fantastic environment. And it was just a wonderful choice for me and certainly helped me so much in my research career.

LES TROTTER: So that was the right thing at the right time. And you came then here to a place with milder winters, although you'll have to do something more than just say a few words to convince me that it's a walk in the park compared to the winter in Ottawa. But you came to a place where there was certainly strong appreciation, motivation, and emphasis on the mathematical side of decision science.

MIKE TODD: And really, that had only developed in the last seven or eight years I think at Cornell before it had been part of mechanical engineering in a separate program. But I think Bob Bechofer hired a number of people in the late '60s. And when I came, math programming was basically led by Ray Fulkerson, who was this intellectual lodestone, I think, of the whole department and George Nemhauser , Uma Prabhu and Howard Taylor in probability-- Bob Bechofer and Lionel Weiss in statistics. It was just an incredibly strong department and has continued to be a very strong department.

LES TROTTER: Strong department and a very strong emphasis on the mathematical underpinnings of everything that was ultimately going on up here.

MIKE TODD: Yeah.

LES TROTTER: This was, in a sense, it was serendipitous. It was the right place for you to be in terms of intellectual development. How do you view these years now in terms of the evolution of your intellectual path and in terms of the environment here at Cornell? Did it continue to be the right place all of these years?

MIKE TODD: It certainly did. And I had great advice from a whole bunch of people over the years. George Nemhauser read my initial NSF initiation grant and gave me some suggestions.

LES TROTTER: Is that right?

MIKE TODD: When I came here, I realized that, in fact, I'd started to implement some complementary pivot algorithms both for linear complementarity and for computing fixed points and realized I needed to know more numerical linear algebra and came back to numerical analysis, which I disdained earlier. And I came in contact with John Dennis and Jorge More who were both in computer science, but with very strong connections to OR and algorithms for complementarity problems in non-linear programming.

And I think it was John who told me at one stage-- you'll know when it's time to switch areas, just trust yourself because I was not knowing if I should continue in the same place or keep switching around. And so I made a few transitions over the years. My thesis was basically on the combinatorial underpinnings of complementary pivot algorithms without concentrating so much on fixed point algorithms. When I came here, I was looking at linear complementarity problems.

But I came back to one of the fundamentals of Scarf and Kuhn's algorithm, which is the triangulation or the subdivision of space that is used in making these approximations. And I got into computing with those, developing new triangulations and so forth-- looking at the linear algebra involved in that. And all of these things came together. I was doing quite a bit of computing then, even computing economic equilibria despite my reservations. And it really gave a focus to the theoretical questions if you could actually see these things coming out in real time and see the power of these algorithms.

LES TROTTER: You must look back in hindsight and think that you were very fortunate to have-- this is great advice from someone who was an older colleague at the time, John Dennis, who's essentially saying to thine own self be true and follow your own feelings about where your intellectual interests should evolve and how it should lead you rather than listening to the clamor on the outside. And certainly when I look back to the extent that I'm aware of paths that you have taken, it's always been impressive to me that evidently much of it did come from inside-- that much of it-- much of the motivation for why to look at so and so and what the next problem was.

MIKE TODD: I think so. I feel bad that I didn't initiate something like the ellipsoid method or interior point methods. Those were just incredible things for the field. But I hope I managed to elucidate them and extend them in some ways. And, again, those were both tools that just went so far beyond the traditional simplex method-- that combinatorial way of looking at things.

And I found enough interest in the simplex method, even though we teach it to undergraduates and they do it mechanically. There are so many nice unanswered questions there. But these new algorithms just had such a nice geometric flavor, some analytic flavor, some Riemannian geometry flavor. It was just amazing to see those tools being used.

LES TROTTER: It's part of the real beauty, isn't it? That the simplex algorithm is so simple that you can describe it and students instantly understand it. Then two minutes after that, you can be talking to them about problems that are research problems. And in a sense, that simplicity as well may be one of the things that pulled you along-- or accessibility to.

MIKE TODD: The simplicity is there. But the analysis of some of these things.

LES TROTTER: Is hard.

MIKE TODD: So I worked for a while on trying to provide a probabilistic analysis of various pivoting algorithms.

LES TROTTER: You did, absolutely.

MIKE TODD: And came up with-- and this, again, is how things move around. I was still doing some work in combinatorics and oriented matroids and along with Bob Bland who came up with the first algorithm for linear programming in oriented matroids. I had another one because I was interested also in quadratic programming.

And that algorithm turned out to be related to lexicographic rules. And when people started looking at probabilistic analysis of the simplex method, I naturally looked at this algorithm and came up with a quadratic expected bound for the expected number of steps taken.

Remarkably, there was so much excitement in the area it was simultaneously discovered by Adler and Megiddo and by Adler, Karp, and Shamir. So Adler independently proved it twice-- didn't realize it was the same algorithm. But there was a fundamental flaw. It gave a great deal of insight, but the probabilistic model led to linear programming problems that were almost always unbounded or infeasible in large dimensions.

And that was distinctly unsatisfying as a model. And the beautiful work of Spielman and Teng in the 2000s on smoothed analysis is just a wonderful way to explain why the simplex method works so well. But it is horrendously cumbersome analytically. Earlier stuff was much more combinatorial in terms of the probabilistic, but didn't explain things as well. And it would be lovely to have a simple treatment that explained as well how the simplex method works.

LES TROTTER: So a nice explanation or a nice exposition of why the simplex algorithm on one hand is so easy to describe, and on the other hand, it's so difficult to analyze or to analyze in a global way.

MIKE TODD: Well, I think Danzig said that intuition in dimensions higher than three isn't worth a damn. And, yet, I think he had a huge amount of that. But just what convex polytopes look like is just amazing.

LES TROTTER: It's out of sight, to make a bad analogy. But this is very interesting to think about the span of these things over your career-- over your research career. I wonder-- and certainly there was some things that were new in a sense in terms of things, like you said, the ellipsoid method and interior point methods. I remember at one point, I presented an algorithm to you that was an interior point method. You came back to me an hour later and said, oh, yeah, that was Von Neumann.

So you wonder the extent to which there hadn't been some thought of this before-- before this time. And certainly people like Von Neumann thought about many, many things in the beginning of the algorithmic stage. But the point of all of this is-- I'm leading to a question that is do you think that there's that-- do you think open territory like that still exists?

Open territory to the extent that not only selling someone on the simplicity of the description of some things that have already gone on and then maybe can be extended in certain ways, but things that are brand-new-- things that would be brand-new ways to look at-- look at problems of this type. Do you have any-- do you have any feelings of that?

MIKE TODD: Because they're brand new, they're not very easy to anticipate, right? But if you look at the history, every time we thought-- I think in the late '70s, people were blase about linear programming. They certainly wanted to understand its complexity more. There were very sophisticated codes. I don't think anyone anticipated that there would be competitors to it. First, from a theoretical point of view with the ellipsoid method and, later, from a theoretical and computational view.

I don't think people suspected that. And it helped the simplex method enormously because people I think had got very complacent about the codes that were around. And when these competitive methods came up, they had to step up the game, which I think led to Cplex and Gurobi and so forth.

LES TROTTER: The same question about operations research in general and the mathematical underpinnings. Of course, many of nuts have already been picked up. And the fruit that's on the ground has already been picked up. But the way you're describing it at least something like linear programming is that there may be things in the future that we're not even on the verge of realizing now. Do you have this feeling about the general mathematics that supports operations research.

MIKE TODD: I think probably even more so. I think I've stayed in more traditional realms of optimization-- different sort of models, but still a single objective function-- usually convex feasible region. But I think the other part of the name of our department is operations research and information engineering.

LES TROTTER: Absolutely.

MIKE TODD: And I think the interaction with computer science, the interaction with learning, the interaction with web things-- revenue management. There is so much going on now that the data isn't all given. You're controlling things. You're doing things over time. Problems are getting enormously larger. And operations research is really very exciting. Game theoretic techniques are coming back again. Game theory, I think, had left a while for quite a period during the '80s and '90s maybe. And now it's really back in the mainstream.

LES TROTTER: A whole new breadth of applications. It really-- just the change in name of the department here emphasizes that. Operations research and industrial engineering-- most of the initial applications were industrial. But now information engineering-- really encapsulates the fact that many of the applications now and potentially in the future may come from the information side of technology.

Just to close back on when you were 18 and 19 years old many, many years ago and maybe a year or so older when you went to Yale. And this vista opened for you. And you immediately bought in. So you could see that happening again today. You could see still the excitement that's there for the potential for research and development into the future. You can still feel that.

MIKE TODD: Yes, I think very generally in OR. I remember it more as in mathematical economics and particular in algorithms in mathematical programming. The whole idea of polynomial time algorithms was starting to get-- really get its impetus at that stage or a couple of years later with Karp's work.

There was a seminar that Gordon Bradley ran where we looked into matroids. And I was introduced to Jack Edmonds' work. And he was also talking about good algorithms, good characterizations. But it took a long time think before the general population really got into polynomial time algorithms.

And the very weird position that linear programming was in because of duality, you have a good characterization. But polynomial time algorithms, even now people suspect you don't have that because it's not really a combinatorial method that people are using. It's a method that is basically an infinite iterative process. But in the case where you have integer data, you can truncate it. And that isn't as satisfying as finding a purely combinatorial algorithm, which has been done for several special cases. But the general case still eludes us.

LES TROTTER: Very, very interesting. And I could give you an example that is right in tune with what you're saying that I'm teaching a linear programming class now and a few days ago, we talked about complementary slackness. And we talked about the fact that you have three conditions-- primal feasibility, dual feasibility, and complementarity. And you get optimality.

And I said to the students now you think this is a mathematical theorem. Or maybe because we can motivate it, it's talking about economics with respect to equilibrium and things like that. But it's not either of those. It's a theorem about algorithmic design.

MIKE TODD: Choose any two.

LES TROTTER: You hold two-- you get two of these to hold and you work on the third one. And we can give algorithms of each type. Now, to use this to amplify what you said, I would never have said that to students 30 years ago. But today, it's not just that I say it to students. It's the way I think about it. So things have exactly the change-- the phase change that you talked about has come about-- no question at all.

I also wanted to change gears a little bit and take some time to give you a chance to talk about other interests other than academics. And I know because we've been friends for so many years, I know something about your other interests. I know about motorcycles. And I know that you're not a bad baritone player.

MIKE TODD: I am a bad baritone player. But I still play it.

LES TROTTER: Or maybe you call it a euphonium.

MIKE TODD: Euphonium. It's not appropriate. That eu part isn't how it sounds when I play it. Yeah, I think I'm the three M's-- math, mountaineering, and motorcycling. And the mountaineering has certainly gone away. But I was doing a lot of rock climbing in Cambridge. When I came over, I joined the Yale Mountaineering Club. And we did some local rock climbing and did a little bit of snow and ice climbing on Mount Washington.

I've basically given that up. But the motorcycling has continued for a very long time now. I'm a member of a local gang. We get together on Sunday mornings and terrorize the neighborhoods.

And that will continue. Though I'm getting older and feebler, it's just wonderful to get out and do that.

I used to ski more. I used to play a little tennis. I used to play a lot of squash. But having a bad back causes you to cut back on some of these things. Eating a lot also cuts back on some of those things as well.

LES TROTTER: This is one of the things that I was going to bring up that you didn't mention. And that was cuisine. This has been one of your interests for years and years. And it's not-- you said eating a bit more. So this was on the side of quantity.

MIKE TODD: Quantity, yes, certainly. There's been conferences around the world. And I try to take full advantage of those to-- we had a memorable trip around a meeting in Oberwolfach where we tried to hit two and three-star restaurants in Alsace. It was a three-star restaurant in Brussels that I went to with Bill Pulleybank. I've tied to eat well at different places I've gone and eat unusual things-- donkey in China and buffalo in Brazil.

LES TROTTER: On that same trip, I remember that you took care of our rental cars. We ran for the airplane. And I remember that more than the restaurants. But at least you remember the restaurants.

MIKE TODD: And the wine tasting, yes. But conferences are always a wonderful way to both get the intellectual excitement and contact with people, but also meet some wonderful colleagues. I think optimization has been terrific over the years. My early people I looked up to Scarf and Kuhn working in fixed points. Edmonds I met in, I think, the first INFORMS meeting I went to-- Ray Fulkerson and George Nemhauser.

But people I met at conferences and people who I'd read about their work and hadn't met them for the longest time-- colleagues from Russia-- Leo Khachiyan, who came to visit here for a wonderful semester. Yurii Nesterov and Arkady Nemirovsky came and visited here a few times. And Nesterov came for longer again. And these are people with just incredible technical tools, but also totally charming people. You couldn't ask for someone more modest than Arkady Nemirovsky.

LES TROTTER: Wonderful people. And you're only telling half the story. They probably wouldn't have been as excited to come here if it weren't for you. They were very, very interested in coming here. And it was for research reasons as well. And maybe we can close on that note.

That was certainly something that I wanted to point out. And as I said, it's been a tremendous experience for me to be a colleague of yours for 40 years. And as an interview, it's nice to go back and think over-- think through the things that we've had in common over the years. But it's also an honor to speak with you like this-- thanks.

MIKE TODD: It's been a pleasure. Thanks.