Doron Zeilberger Interviewed by Ron Aharoni

[This is a (lightly edited) English translation of an interview with Doron Zeilberger, conducted by Ron Aharoni, from the Technion, Israel, that appeared in "Net-gar", an excellent Hebrew on-line mathematical magazine for Youth, `http://net-gar.net/`, edited by Ron Aharoni.]

When did you realize that you wanted to become a mathematician?

I was born in Haifa, in 1950, but we soon moved to nearby Kiryat Motzkin, where my parents and my younger brother lived until I was 14, when me moved to Holon. From first grade through sixth grade, I was not particularly good at school math, and did not particularly like it. This changed in seventh grade when we had an inspiring and charismatic mathematics teacher called Devora Segev, who made math fun.

Every summer, my brother and I took the train from Kiryat Motzkin to Jerusalem (all by ourselves, starting when I was age 9 and my brother, Gil, was age 7, something that would have shocked my American wife today), to visit, for about two weeks, my aunt "Doda Gitti" and her husband, "Dod Hans", as well as their children, my cousins Matti and Ada, who were five and seven years older than me. Of course, we looked up to them.

My uncle Hans, who was a lawyer, was also interested in many other things, in particular, he was a member of the Amateur Astronomy Society of Israel, and hence got their newsletter, that I devoured, and fell in love with Astronomy, and was sure that I will be an astronomer when I grew up.

The same Uncle Hans and Doda Gitti, being *yekes* [German Jews], subscribed to the German magazine *Stern*, that had "math puzzles" where one has to uncover a multiplication (or addition) problem where every digit has been replaced by a certain picture (similar to the *otiot umisparim* puzzles that still appear today in Israeli dailies, where one replaces digits by letters). He taught me (when I was about eleven) how to solve them, and I got really good at them, but I still wanted to become an astronomer.

When I was in eighth grade, there were two turning points that changed my life. The first one was a Hebrew translation of the book "Mathematics for the Million" by Lancelot Hogben, that I found in my cousin Matti's bookshelf and that I read cover-to-cover, teaching myself (following the book) everything up to and including calculus, plus plane and spherical trigonometry, and basic probability and statistics (BTW, I strongly recommend it to everyone).

Just as importantly, my cousin Mattti, who was also interested in math (and later got a PhD in Chemistry) subscribed to the great-grand-daddy of *Ne-tgar*, called *gilyonot lematematica*, edited by Professor Joseph Gillis z"l (1911-1993) (who later also initiated the Israeli Math Olympiad, that today is named after him). This periodical had many fascinating articles, mostly written by Gillis himself, and also an extensive "problem section" that contained challenging problems. I fell in love with mathematics, and we lived (well at least I did, I am not sure about math) happily ever after.

In high-school I loved mathematics so much that I ignored all the other subjects. I was addicted to *gilyonot lematematika*, and also read very advanced University level texts, in English, that were mostly way too advanced, but I still understood them partially. Since I ignored all the high school subjects except math and physics, I was kicked out of high school, after tenth grade, failing all subjects except math and physics.

To my parents' dismay, I decided to get a job as a messenger boy, and got to know the streets of Tel Aviv inside out. As a compromise to my parents, I promised them to study for an external High School Equivalency diploma, but mostly did math problems in my spare time, submitting my solutions to gilyonot lematematica, and doing rather well, in spite of my "day job".

After a year as a messenger boy, my father, Yehudah, who was an English high school teacher, took a sabbatical leave in Cambridge, England, (something very unusual, still today, most high school teachers take their sabbatical [if it still exist today] in Israel), and took my mother, myself, and my brother with him. There I passed the entrance exam for a one-year intense British high-school matriculation, called "A-level", that was given in a local community college in Cambridge. To my luck, in Britain, one specializes after tenth grade, and I only had to study three subjects, "Pure Math" (that I aced), "Applied Math" (that I also did well in), and Physics (that I barely passed).

This way I got a British High School diploma, and came back to the academic track.

After the year was up, when I was 18, Aug. 1968, my family returned to Israel, and I was due to be drafted to the Israeli mandatory military service beginning February 1969, so had six months to "kill". I approached the above-mentioned Joe Gillis, asking him to be an "intern" at the Weizmann Institute, and to my great delight he hired me, the ostensible reason being to copy-edit the *gilyonot*, but this took only one day, and the main reason was to help his then PhD student, Nadav Liron, with Fortran programming (done with punched cards) [Nadav later became a Technion math professor]. After I learned Fortran, just for fun, I wrote a program to compute the determinant of a matrix. Somehow Nadav found out and was either angry that I did something that he did not assign, or did not like my coding. He then "fired" me, and Joe Gillis assigned me to another grad student, Nira Richter-Dyn (now a distinguished math professor at Tel-Aviv University), who worked with her advisor Professor Pinchas "Pini" Rabonowitz. This turned out to be much more satisfactory. Nira asked me to write a Fortran program to evaluate numerically a certain "error" in numerical integration. Instead, I found a closed-form *analytic* expression, that lead to my first publication, joint with Nira, Pini, and another grad student of Pini.

In February 1969, I was drafted to the Israeli army, and assigned to the Artillery corps, and like with many recruits with high IQ, after basic training, was sent to an army course where we trained to be "technical assistants". In that course, we learned how to compute the trajectories of cannon balls using *purely graphical* methods. I got a little *in trouble* when, in the final exam, I "cheated" and used trigonometry, and the Pythagorean theorem, but they were also impressed by my "advanced" knowledge.

Right after finishing the course, I was assigned to an artillery battery in the Sinai desert, and since it was during the *war of attrition*, there was lots of free time. Most soldiers whiled away the time playing backgammon or cards, or reading newspapers and trashy novels. Instead, I enrolled as an *external student* in the University of London (a precursor of the "Open University") and studied, all by myself, using their correspondence course, for the degree of B.Sc. in math of the University of London.

Since I got a *First Class Honours*, I felt that I was ready to go for a Ph.D., and decided on the Weizmann Institute. I looked up the math faculty, and looked up some of their papers. I especially liked a paper written by a young Senior Scientist named Harry Dym, read it carefully, and asked to be his research student. To my great delight, he agreed on the spot, and admitted me to the "direct track", skipping the masters. I finished my PhD four years later, at the relatively young age of 26 (for an Israeli who served in the army).

What are the Satisfactions in a Mathematicians' life? Are there also disadvantages?

Professional mathematicians, and more generally, all faculty members in universities and colleges, are very lucky that they can make (at least a modest) living by doing what they *love* to do, namely research, and that they would do, in their spare time, even if they did not get paid. Most of us professors have to teach a course or two per semester, and some of us do not like it, so for those people, it is a drawback. But many of us, myself included, *love* to teach, and share our love of math with our students, so this is also a great satisfaction (provided that the teaching load is not too high).

A minor annoyance are students who argue about the grade, and try to intimidate you to raise their grade, what is called *grade-grubbing*, but this is not a big deal, and, with some experience we learn how to handle, and politely refuse, such requests, unless the students have valid claims. A much bigger nuisance is the competitive atmosphere, and the pressure, in order to survive academically (at least before one is a tenured full professor) to apply for research grants, and to submit our research articles to *"peer reviewed"* - as "*prestigious*" as possible- journals. Since many of the "peers" are not so nice (since they are *anonymous*) one often gets rejected, many times with nasty, patronizing, "reports", whose contents show that the referees, or reviewers, missed the whole point.

But, *asymptotically*, like in my case, once one is fully promoted, one can once again attain a peace of mind, and decide **not** to play that game. With today's internet, where one can have a website, it suffices to publish in your own website, and, even more importantly, in the most important venue for mathematical (and other) knowledge, `arxiv.org`. This would guarantee that your papers will be accessible "for ever" (well, at least, as long as in "real" journals), and the future would decide the "significance" (and correctness!) of your work.

Were there mathematicians that influenced your work?

Many! I have already mentioned Joe Gillis, whose *gilyonot lematematica* got me hooked for ever. My advisor, an eminent analyst, Harry Dym, was also a great influence, even though, I very soon "defected" to the discrete camp. He gave me a certain 'continuous problem', and I tried to tackle it by first solving the discrete analog, hoping to later take the *continuous limit*. I fell in love with the discrete, for *its own sake*, and got many "discrete analogs" of famous results in complex analysis. I never bothered to go back to the continuous case.

I should also mention Professor Yakar Kannai, who, in addition to being a distinguished expert in **both** *partial differential equations* and *mathematical economics*, is a very talented teacher. He introduced me to the beautiful theory of so-called *D-modules* of the (now) Tel Aviv University famous mathematician, Joseph Bernstein, that while, officially, "analytic", was really algebraic. This formed the *seed* to what later became *Wilf-Zeilberger algorithmic proof theory*.

Other great influences were the French combinatorialists Dominique Foata and Xavier Viennot, and of course, my great *guru* and collaborator, Herbert Wilf, and there were many other ones.

What is the Place of Beauty in Your Work

Beauty is only *skin deep*. Most beautiful mathematics is so because it is *simple* (at least after you see it). While it is pleasing to the mind (like a beautiful person is to the eye), one should not over-rate it. The goal of mathematicians should be to discover *mathematical knowledge*, that is *deep*, *significant*, and *useful* (either for science, or for further mathematics). Such mathematics, especially the kind of *computer-generated* mathematics that I and my computers do, is often "ugly" to human eyes, but to my eyes, it is even more beautiful, or if you wish, *meta-beautiful*.

Your Wikipedia page says that you are an Ultra-finitist. What does it mean?

You, Ron Aharoni, in addition to being a great combinatorialist and a great math-education reformer, are also a great thinker. You have a love-hate relationship with *philosophy*, stating that it is mostly *garbage*, based on misunderstanding *circularity* and *self-reference*.

I have a similar feud with the notion of *infinity*. The notion of infinity did some good, but lots of harm. I believe that if one replaces *infinity* by "*infinity*" (in double-quotes, in other words, making it a (finite!) symbol, one can rewrite most of mathematics in fully finitist terms, and the rest is not worth doing!

Finally, tell us about your "controversial" vision of the future of mathematics, and how it should be done

Current mathematics is the way it is, because, until recently, it was done by purely human, *paper-and-pencil*, means. Another factor that held it back was the *religious-fanatical* insistence that all mathematical knowledge should be proved *rigorously*. This is all going to be obsolete very soon. Using computers will expand our mathematical horizons (almost) infinitely, and we would be able to find so many fascinating new knowledge, and very soon would have to abandon our hang-up for (*alleged*) absolute certainty, and learn to live with facts that are "only" %99.99999999999999999999 certain.

Do you have any final advise for young (and not so young) aspiring mathematicians?

Learn how to program a computer, well! For mathematical research, the best is to use the high-level *symbolic-computation* systems like **Maple**, **Mathematica**, and the emerging (free!) **Sage** (based on Python). When you have to solve a problem, resist the temptation (like little children) to solve it *all by yourself*, but instead, think how to *teach* (i.e. program) the computer to do it. This will often enable the computer to solve many other similar, but far harder, problems, way beyond the scope of humans.

In other words, you can get much more out of your mathematical talent by *thinking* how to *teach the computer* to do problems, rather than trying to solve them by yourself, using pencil-and-paper. Of course, you are welcome, in *your spare time* to do math the old way, but this should be for *recreation only*, like solving a Sudoko problem. People should not get paid for doing things the old way!

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