Remembering Professor Helena Rasiowa

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Mathematicians, also often computer scientists, discuss and point to their genealogy. I do not mean here the dukes and counts among their forbears, but rather scientists of the past, their advisors, and the advisors of those, and all the way to the beginning of science in the late medieval and renaissance eras. There is a site, at the North Dakota State University, where the relevant information is stored and the information needed to produce directed graph of genealogy of a mathematician can be collected.

It so happens that the genealogical information of Professor Helena Rasiowa and mine are similar - for we had the same advisor, Professor Andrzej Mostowski, a great logician, a student of Kazimierz Kuratowski and Alfred Tarski. I guess the "parentage" could not be better in Warsaw. There was a significant age difference, in fact the very first lecture at Warsaw University, Mathematics, I took (this happened in October 1960) happened to be a class in Algebra and Professor Rasiowa was a lecturer.

This fact does not qualify me to write about Professor Rasiowa. But during 22 years at Warsaw University (in different roles; first as a student, then as a teaching assistant, graduate student, and faculty) I interacted with Professor Rasiowa, although I never worked in her scientific group. Her younger collaborators Cecylia (Ina) Rauszer, and Andrzej Skowron were coauthors, an much later, already after we moved to United States, I became a coauthor of Professor Rasiowa.

While working at Warsaw University, there were no direct scientific contacts with Professor Rasiowa - I focused on the research as done at Professor Mostowski group, but, in the hindsight, there were some signs that logic, and more precisely, foundations of mathematics, are becoming more applied (which was the direction pushed by Professor Rasiowa and her group).

My first excursion into this area occurred when Andrzej Ehrenfeucht (who was my scientific supervisor at the time), together with Zdzisław Pawlak and Robert Bartoszyński organized a seminar at the Mathematical Institute of the Academy of Sciences. Andrzej Ehrenfeucht was another of Professor Mostowski students, Robert Bartoszyński was a probabilist, and Zdzisław Pawlak was an electronics engineer, the designer of one of first Polish computers. The seminar was very different from everything I saw at the University. It was informal, and, essentially, everything that had anything to do with the computers was

accepted as relevant. We read papers by Hao Wang (who was using computers to prove tautologies of "Principia Mathematica"), papers by Turing, by Davis and Putnam - all classics. It was opening to the participants new vistas. Seminar was also strongly influenced by potential applications to Medicine. Of Professor Rasiowas group, Ewa Orłowska was taking part in the proceedings. I was, of course, attending (I met Andrzej socially, and he encouraged me to attend.). Talking to Pawlak was (although I did not realize it then) a sign of things to come.

Working with Ehrenfeucht provided me with a subject of an M.Sc. project. The net effect was that I completed my mathematical education in four years.

No, I was not a prodigy. Actually the reason was different. The Ministry of Higher Education decided that only M.Sc. in Mathematics could teach mathematics in High Schools. The net effect was that hordes of High School teachers who did not have M.Sc. in Mathematics inundated evening and weekend programs at the universities. In panic, the leadership of the University provided an opportunity to the students of the fourth year of mathematics. It was enough to pass a certain number of classes (in addition to regular program) and become an M.Sc. in Mathematics in 4 years (plus vacation). Moreover for those qualifying, there were jobs as T.A.'s (of course in the evening and weekend programs). I took the bait, and enlisted. Among the classes I selected (noncommutative ring theory, partial differential equations, extensions of functions, were mathematical logic, of course taught by Professor Rasiowa. Before the examination, Ina Rauszer told me "You surely will be asked to prove completeness theorem; you need to prove it via Rasiowa-Sikorski Lemma (including the proof of thereof.) But for the proof of the lemma, you need to give the original Rasiowa and Sikorski proof. The proof by Feferman and Tarski is *not* acceptable..." There are various proofs of Rasiowa-Sikorski Lemma. It is Baire Theorem on Category in disguise, and there are several other proofs (such as construction of filters closed under a denumerable family of suprema, or Cohen's proof of the existence of generic sets in posets.) Warned in advance, I worked out with Ina the *correct* proof. The exam, during the vacation, was held in Professor Rasiowa home. I provided **the** proof. Afterwards the domestic served coffee and cakes.

It should be mentioned that Rasiowa-Sikorski Lemma was a central point of the work by Professor Rasiowa and Professor Roman Sikorski on algebraization of logics. The plural here refers to the fact that not only first-order predicate logic (and its subsystems such as propositional logic and intuitionistic logic were investigated, but also logics from large family of modal logic were considered.

The successful exams after the fourth year of studies resulted in an offer of a teaching job at Warsaw University. I joined Professor Mostowski group. published my M.Sc. result and started to work for my Ph.D.

However, the second half of the 1960ies was a time of significant political troubles in Poland. After Middle East war of 1967 many people were kicked out of the University. Entire years of University classes were suspended or even drafted to the army. Professor Mostowski hid me (not a joke!) in the Mathematical Institute of the Academy for a year.

The repressions meted at our students were a serious problem for the lead-

ership of Mathematics Program. Professor Rasiowa was a Dean of Mathematics and Physics and, as a result, in the very center of events. Only her tact and an ability to persuade both sides of the conflict saved the Mathematics program at the University. I am sure she paid a serious price for her mediation.

Saved by Professor Mostowski, I returned to the University after 1968 vacation, defended my Ph.D. (Professor Rasiowa was on the Committee) and in 1970 I went as a postdoc to Utrecht in Holland to work with Professor van Dalen, and to write a habilitationschrift. I did that, but the real result of the stay there was a realization that the Foundations of Mathematics can, and therefore should, assist Foundations of Computer Science. The reason I understood that was collaboration with Henk (Hendrik) Barendregt, still a graduate student at the time, but already writing his magisterial book on λ-calculus.

Coming back from Utrecht, I visited Janusz Onyszkiewicz at Aarhus University in Denmark. It was clear there that logicians there are thinking about Computer Science and that it is going to be a major area for research in Foundations.

Soon after I came back, I started to get a series of phonecalls from Zdzisław Pawlak. Eventually, I got curious. It turned out that Zdzisław was concerned about logical foundations of databases. In the past, a person to be asked for an advice would be Andrzej Ehrenfeucht - but he emigrated to United States and, eventually, settled in Boulder, Colorado. So, I had to do what Andrzej would do (were he in Warsaw) - help Zdzisław. I was not the only mathematician to take part in that research project, several mathematicians (including Ina Rauszer, Andrzej Jankowski, Witold Lipski (who in the process became my Ph.D. student), Beata Konikowska, and others) took part in the research. In the process we even organized a semester of research in Banach Center.

This was my first serious investigation in Foundations of Computer Science (various other activities followed, of course).

Around that time Professors Pawlak and Rasiowa founded a journal, *Fundamenta Informaticae*. Like their predecessors who founded in 1920ies *Fundamenta Mathematicae* Pawlak and Rasiowa realized that the logic-based approach to Foundations of Computer Science required a place where research devoted to the area could be published. Of course, even today, *Fundamenta Informaticae* go strong.

Actually, *Fundamenta* were not the first publishing initiative undertaken by Professor Rasiowa. In the past she served as an Editor-in-Chief of *Studia Logica* where philosophical and mathematical logicians provided a joint perspective for Foundations.

Professor Mostowski, the Ph.D. advisor to both Professor Rasiowa and me died in 1975. In 1976, during the Logic Colloquium in Oxford, Professor Rasiowa, large group of Warsaw logicians and myself attended. On the morning of my presentation, Zbigniew Ras, the son of Professor Rasiowa came to me and told me: "Mother told me to lend you a tie"; she correctly suspected that I would not have been tactful enough to be properly clothed for the occasion.

In the perspective, looking back, it is clear that the mass departures by intellectuals continued throughout 1970ies and 1980ies, till the fundamental political

changes of 1989. Such phenomenon was not unique to Poland - which lost thousands, maybe tens of thousands of educated people. Warsaw University, and Mathematics and Computer Science were not exceptions. Many people spent longer or shorter time abroad. I was not an exception and so were numerous of my students. Actually, of my 13 Ph.D. students supervised in Poland, 8 emigrated. Add to this me, and you see a small dimension of this phenomenon. And so, after tribulations in a variety of places, I landed in 1983 at the University of Kentucky where I taught another 30-plus years. I was not the only one; several others, Mirek Truszczyński, Jurek Jaromczyk, and Greg Wasilkowski joined me there. Several other colleagues from Warsaw visited for longer periods of time, including Ina Rauszer for a couple of years, and Stan Szpakowcz.

Among many others who left Poland was the son of Professor Rasiowa, Zbigniew (Zbyszek, Zbig) Raś who settled in Charlotte, NC, at the University of North Carolina, Charlotte. This certainly created a good reason for Professor Rasiowa to visit United States.

In the meanwhile my interests evolved (after all this is what happens to scientists). Before I left Poland for good, I worked with Zdzisław Pawlak on an universal algebraic interpretation of uncertain information, called "Rough Sets", that became popular research topics in various research places. The second preprint on this topic was published by Zdzisław and myself in 1981. But my interests, while in Kentucky, redirected to mathematical foundations of common-sense reasoning that I studied extensively collaborating with Mirek Truszczyński, Jeffrey Remmel, and Anil Nerode. This research led to creating a knowledge representation formalism called *Answer Set Programming*. But I did not forget Rough Sets, for they tie with the most beautiful areas of Algebra, and inspire a variety of methods useful in data mining. Of course, such interests always result in papers, in this case with Professor Rasiowa, Andrzej Skowron, and others.

I benefited from the fact that it is not too far away from Lexington, KY, (where I live) to Charlotte. I visited Charlotte to work with Professor Rasiowa, and we also invited her here, to Lexington, for lectures and joint work. From a personal perspective, a large social meeting at our house attended by various members of Polish diaspora, and with Professor Rasiowa presentation on her WWII war memories (including memories of her survival in a church bombed by Germans during Warsaw Uprising of 1944) were a highlight of one such visit.

Zdzisław also visited United States and we met in Charlotte, but also in Nashville, as he was receiving Zadeh Prize during the ACM meeting for his work on Rough Sets.

In 1994, Professor Rasiowa and Ina Rauszer left us. That was a tremendous loss for me, both on scientific and personal level. In 2005, we celebrated their life during the meeting at Ruciane-Nida.

Today, we have a better yet perspective of the accomplishments of Professor Rasiowa. The algebraic methods in logic became a standard tool of logicians, in particular in Foundations of Set Theory. A real triumph of intuitions that led Rasiowa and Sikorski in their work.

Out of necessity (after all this is supposed to be a *short* summing up of

Professor Rasiowa work), I left several aspects of her research not covered. But, I hope, I provide the personality and research of Professor Rasiowa and her influence in rebuilding Foundations of Mathematics in Warsaw after WWII, in turbulent, and demanding times.