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Helena Rasiowa (1917-1994) Life and Personality

Abstract. This is a biographical sketch of Professor Helena Rasiowa (1917-1994) one of the leading logicians from Warsaw. She was not only a great scientist but also a great human being. Professor Rasiowa influenced numerous researchers from all over the world, especially by her results in algebraic logic, as well as by her great contributions for the mathematical community in all respects. She was also a co-founder of the Pawlak-Rasiowa School of Artificial Intelligence (AI) [8]. In the preparation of this article we used some articles dedicated to Professor Rasiowa. We also added some personal comments on her personality as perceived by the authors of this article and collected from the letters and articles of co-workers and PhD students of Professor Rasiowa. In particular, this article is an extension of [9].

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Key words and phrases: Logic in Warsaw, Pawlak-Rasiowa school of artificial intelligence (AI), metamathematics, algebraic methods in logic, foundations of computer science logic in computer science and in AI.

The only way to rectify our reasoning is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate, without further ado, to see who is right.

G. W. Leibniz [11]

Helena Rasiowa[1], was an heir and continuator to the Polish school of logic, made famous in the interwar period by famous scientists such

[1] A shorter version of the paper has appeared as [9].



Figure 1: Helena Rasiowa

as Jan Łukasiewicz, Stanisław Leśniewski, Kazimierz Ajdukiewicz, Alfred Tarski and their disciples Adolf Lindenbaum, Bolesław Sobociński, Mojżesz Presburger and Stanisław Jaśkowski. The results of Helena Rasiowa's scientific research have been widely recognized as a lasting and valuable contribution to the world science and have had a great impact on the scholarly development and interest of subsequent generations of logicians, mathematicians and computer scientists. Her influence on the shape of mathematical logic can hardly be overestimated.

She was born in Vienna on June 20, 1917 to very patriotic Polish parents. As soon as Poland regained its independence in 1918, after more than a century of partitioned stateless existence, the whole family settled in Warsaw. Helena's father, Wiesław Józef Gozdawa-Bączalski, was a high-class railway specialist; his knowledge and experience in the field led him to receiving a very important position in the railway administration. Helena graduated from the Aniela Werecka eight-class junior high school in Warsaw. The girl, her parents' only child, had good conditions for growing up physically and mentally. And, indeed, she exhibited many different skills and interests, varying from music, which she learnt at the Fryderyk Chopin Higher School of Music at the Warsaw Philharmonic in parallel to her normal studies in a secondary school, to business management, which she studied for more than a semester after completing her secondary education.

Professor Semeniuk-Polkowska presented in [26] her memories of talks with Professor Rasiowa:

> *She was very talented and liked learning. She was taught French since early childhood, and spoke it as well as Polish. She recollected going on wonderful walks with her family. In Warsaw she lived on ulica Smolna, in a big, beautiful apartment. She was very sensitive, felt the suffering of others, the good conditions she lived in didn't make her less aware of the existing poverty. She felt those problems, the homeless living on the lawns, on the bank of the Vistula. She said she was happy, when the post-war times removed many of the misfortunes, such as poverty, unemployment, homelessness, which people before the war had suffered. Some problems vanished, but others, no less painful had appeared, and she grieved over this too. She recollected the high-school years spent in Ms. Werecka's boarding school on ulica Foksal, the everyday walk there, the lessons, the school dresses-green uniforms and berets, her best friend Irena, and especially her favorite professors. The level of teaching was high, many teachers lectured additionally on the university, or in the nearby boys' Zamojski Gymnasium. She named among others the polish language teacher Professor Pomerowski, the history teacher Professor Tomkiewicz, the chemist, Professor Chorbaszewski. Her thoughts returned also to the beautiful vacations she spent in Stanisławów, where she stayed with her grandfather Bączalski, a greek and latin professor in the local high-school.*

In 1936 she got married.

Finally the most important of her interests, as the future was to prove, took the lead. In 1938, the time was not very propitious for entering a university. She was enrolled in mathematical studies at the University of Warsaw (Faculty of Mathematics and Science).

The next year was to prove how mistaken the many who believed in a possibility of avoiding war were. Rasiowa had to interrupt her studies, because no education was legally possible in Poland after 1939. Many people fled the country or at least, they fled from the big towns, more subject to German bombardments and terror. So did the Ras family, also because of the fact that most high-ranked administration officials and members of the government were being evacuated towards Romania. The Ras family spent a year in Lvov. After the Soviet invasion in

September 1939, the city was taken over by the Soviet Union. The life of many Poles became endangered, so eventually the father decided to return to Warsaw.

Life in Poland was very restricted during the German occupation. In a 1940 memorandum, Nazi SS leader Heinrich Himmler summarized the Nazi attitude to Poles, in particular to their education. He dictated that Poles should be able to write their names, count to 500, and " [recognize] that to be obedient to the Germans is a divine commandment" [24]. All formal manifestation of intellectual life came to a stop. Nevertheless, there were enough courageous people to organize underground life, not only for armed conspiracy against the Germans, but also for the development of all the areas of the nation's life, including education, (and, in particular, higher education among them) which were vital for its survival.

Two years later, Helena Rasiowa established contact with professors of mathematics and physics at the University of Warsaw and resumed her studies at the underground University of Warsaw, in Warsaw, occupied by the Germans. Among her classmates there were well-known personalities such as Wanda Szmielew and Roman Sikorski who, after 1945, significantly contributed to the development of mathematics and logic in Poland. She had the opportunity to attend lectures of renowned mathematicians such as Wacław Sierpiński, Kazimierz Kuratowski, Jan Łukasiewicz, and Karol Borsuk. By attending this university she as well as all students and professors risked being sent to the German concentration camp in Auschwitz or killed by the Germans on the basis of

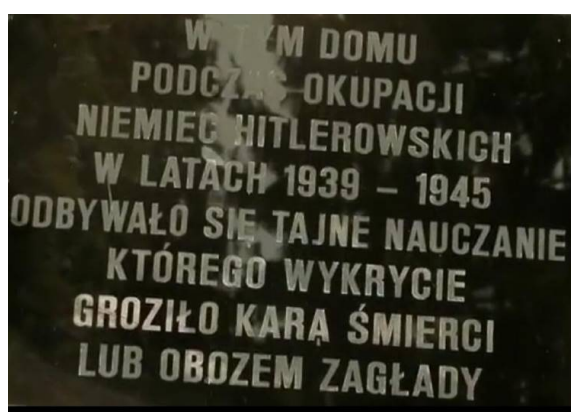

Figure 2: A commemorative plaque on a house in Warsaw where secret education took place in 1939-1945; detection by Germans meant death penalty or sending to a concentration camp for teachers and students

'law' imposed by them in Warsaw. Thus, Helena Rasiowa followed her studies in mathematics, risking her life, as did everybody who dared to conspire during that dark period.

Polish mathematics acquired particular strength in the pre-war years, mainly after the emergence of the Polish School of Mathematics in 1921. The names of Stefan Mazurkiewicz and Waclaw Sierpiński, who were in Warsaw, or those of Stefan Banach and Hugo Steinhaus, who were in Lvov, were well known to mathematicians all over the world. One of the branches which became important at that time, besides functional analysis, set theory and topology, was logic, with researchers such as Jan Łukasiewicz, Stanisław Leśniewski, Kazimierz Ajdukiewicz, Alfred Tarski and others.

Rasiowa became strongly influenced by Polish logicians. She wrote her Master's thesis under the supervision of Jan Łukasiewicz and Bolesław Sobociński. History, however, turned against her once more. In 1944, the Warsaw Uprising broke out and in consequence Warsaw was almost completely destroyed. This happened not only because of warfare, but also because of the plan of systematic destruction, which followed the uprising after it had been squashed down, Rasiowa's thesis has burned together with the whole house. She herself has survived with her mother in a cellar covered by ruins of the demolished building. Recently, her son Zbigniew communicated that his mother was alone in a cellar in Old Town in Warsaw covered by ruins, and when after several days she was able by miracle to emerge alive, she saw on the other side of the street her mother, who could not instantly recognize her daughter because



Figure 3: Warsaw destroyed by Germans

Rasiowa was completely covered by dust. The two women left Warsaw and survived thanks to the help of other members of their family.

The situation of mathematical community in Poland after the war is described by the words below [5]:

> *During the Second World War the Polish scientific community was decimated. In particular, well over half of the actively working Polish mathematicians lost their lives. Many others found themselves in various countries all over the world. Universities, libraries and printing presses in Poland were largely destroyed. The educational system of the country was in ruins and scientific activity was disrupted.*

When the war ended, Rasiowa rewrote her MSc thesis, and in 1945 she graduated from the University of Warsaw with MSc in mathematics. From September 1945 to November 1946, she worked at the Wojciech Górski secondary school in Warsaw, pursuing her graduate studies at the Section of the Philosophy of Mathematics, supervised by Andrzej Mostowski. On November 1, 1946, she became an assistant lecturer at the University of Warsaw, where she worked for the rest of her life. During her work at the University of Warsaw, she was granted various academic degrees and titles, and gradually promoted to academic positions of an assistant professor, associate professor, and then full professor. Her first publications, *Axiomatisation d'un système partiel de la théorie de la déduction* and *Sur certaines matrices logiques*, came out in 1947 [17, 18]. In 1950, she received doctorate in mathematics and science based on her PhD thesis, *Algebraic treatment of the functional calculi of Lewis and Heyting*, under the academic supervision of Andrzej Mostowski. The thesis anticipates the main theme of her future research on algebraic methods in logic. In 1956 Rasiowa received her academic degree *Doctor of Science in Mathematics* (equivalent to habilitation today) at the Institute of Mathematics of the Polish Academy of Sciences. For the habilitation degree she submitted two papers, *viz.*, *Algebraic models of axiomatic theories* and *Constructive theories*. Together these papers formed a dissertation entitled *Algebraic models of elementary theories and their applications*. Between 1954 and 1957 she held a post of Associate Professor at the Institute, jointly with an analogous position at the University, and became Professor in 1957 and subsequently Full Professor in 1967. During that time she wrote about 20 papers, some of which were coauthored by Roman Sikorski, Andrzej Mostowski, Andrzej Białynicki-Birula, and Jerzy Łoś. In 1957, she was

granted the title of a Professor by the Central Certifying Board and in 1967, the title of a Full Professor by the Council of State.

As an academic, Helena Rasiowa represented, with pride and dignity, the Polish school of logic, which was popularized during the interwar period by such scientists as Jan Łukasiewicz, Stanisław Leśniewski, Kazimierz Ajdukiewicz, and Alfred Tarski. Her research from the 1950s (including her PhD dissertation, habilitation thesis and numerous other publications, some co-authored by other well-known scientists with whom she worked at that time) led to a deeper understanding of the possibilities related to the use of algebraic and topological methods in logic. These concerned both the classical and non-classical predicate calculus (including intuitionistic logic, modal logics, and many-valued logics). In the academic year of 1949/50, Helena Rasiowa participated in the lectures by Stanisław Mazur, devoted to "constructive" analysis. At that time, she became familiar with the results of the research on "constructive" models of computation in analysis. That research was initiated between 1936-1939 as part of the collaboration between Stefan Banach and Stanisław Mazur. Later on, Helena Rasiowa and Andrzej Grzegorczyk [6] published lecture notes based on these lectures.

The interest in algebraic methods of logic (including their applications in theorem proving) and models of computations for identifying constructive fragments of mathematical theories were naturally connected with the research of logical foundations of the emerging computer science and studies in the field of AI (*e.g.*, methods of automatic theorem proving). One of the authors of this article has still in his mind a picture from the mid-1960s, of one of the large lecture rooms in the Palace of Culture and Science in Warsaw full of students and researchers attending the seminar on automatic theorem proving organized by Professors Rasiowa, Pawlak and Ehrenfeuht. As a result, in 1960s a group of researchers around Professor Rasiowa started conducting studies in such fields as automatic theorem proving, algorithmic logic and, later, in 1970s, program logic, approximate reasoning, and other domains of foundations of computer science. For approximately 30 years, that is, till the end of her life, Professor Rasiowa continued that research together with her students and collaborators. Her work helped to start many important projects related to applications of logic in the foundations of computer science. Moreover, together with Zdzisław Pawlak, she founded a scientific journal, titled *Fundamenta Informaticae*, devoted to the foundations of computer science. From the very beginnings of that journal in 1977 till the end of her life, she was its editor-in-chief.



Figure 4: Helena Rasiowa and Zdzisław Pawlak

Thanks to her unimaginably hard scientific and organizational work, *Fundamenta Informaticae* managed to gain international renown.

In 1996, in the preface to the Fundamenta Informaticae volume dedicated to the memory of Professor Helena Rasiowa the editors wrote:

> *In the early 70's Professor Helena Rasiowa, convinced that Mathematical Logic and Computer Science would both benefit by exchanging problems, ideas and techniques, decided to create forum for the discipline to meet. Fundamenta Informaticae always been the place where the Computer Science - motivated original research is published. Professor Rasiowa's vision provided a valuable stimulus for the development Mathematical Logic by adding to its problems, primarily motivated by Mathematics and Philosophy, the problems posed by Computer Science. Now, after many years, we admire the correctness of her foresight.*

She was an active Collecting Editor of *Studia Logica* (since 1974) and Associate Editor of the *Journal of Approximate Reasoning* (since 1986).

Her devotion to work bore fruits in the fields of AI and computer science, resulting in the creation of an entire school of students and collaborators, who still continue the research initiated by Rasiowa and Pawlak.

The school is sometimes referred to as the Polish Pawlak-Rasiowa School of AI [8].

The establishment and development of the School culminate considerable contributions of Professor Rasiowa in the development of research devoted to the application of mathematical logic in Computer Science and AI. Much earlier than other mathematicians of her generation, she realized that computer science may be a great inspiration for logic. She also paid attention to the need of research on logical foundations of computer science by actively participating in their development. By 1960s she envisioned the significance of logic for the development of theoretical computer science and AI. She was aware of the facts that numerous scientific problems of theoretical computer science may be solved by methods developed in logic, and logical research in computer science may constitute an important source of inspiration for the development of logic. Rasiowa inspired others to conduct intensive, fruitful research on program logics, methods of reasoning with incomplete information and logical calculi for AI systems. As the head of the Section of Mathematical Logic at the Institute of Mathematics (University of Warsaw), she conducted seminars and research projects devoted to these fields.

It is worth recalling that one of the first great scientists to propose the research on relationships between algebraic systems and logical systems was George Boole (who referred to the ideas formulated by, *e.g.*, Leibniz). The works by Boole and his successors led to the development of the concept of Boolean algebra and helped to establish its relationship with the classical predicate calculus. This relationship naturally relies on an algebraic construction introduced by Lindenbaum and Tarski, based on the equivalence classes generated by formulas. The Stone representation theorem applied to the Lindenbaum-Tarski algebra contributed to the development of research on topological properties of models for logic.

The second very important algebraic construction, which defines the relationships between logic and algebra, was initiated by the research of Łukasiewicz and Post. This approach treats formulas as algebraic functions over particular algebras. Key algebraic methods in the research concerning intuitionistic logic and modal logic were developed by Marshall Stone, Alfred Tarski, and John McKinsey. Helena Rasiowa became actively involved in this research area. Together with Roman Sikorski, she developed the first algebraic proof of Gödel's completeness theorem for the classical predicate calculus. Next, she used an algebraic method to prove analogous theorems for the predicate calculus of intuitionistic

logic and modal logics. This enabled her to obtain algebraic proofs of a number of other important theorems in both classical logic and numerous non-classical logics. Since that moment, numerous logicians and mathematicians in the world started to use analogous algebraic methods in their research on logical systems.

The first monograph by Helena Rasiowa, *The Mathematics of Metamathematics*, which she co-authored with Roman Sikorski, was published in 1963 [19].

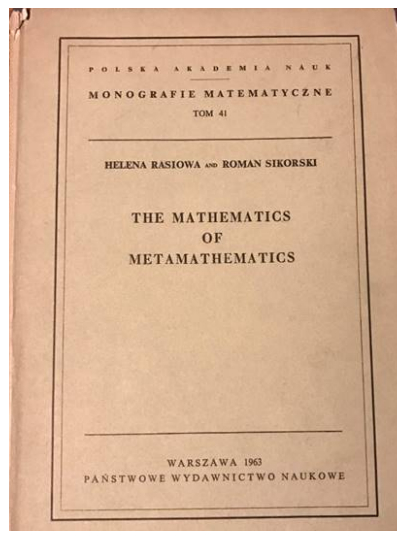

Figure 5: The monograph *The Mathematics of Metamathematics*

It contains a systematic and comprehensive overview of the results related to the algebras of logical calculi (including classical, intuitionistic, modal, and positive logic). The monograph exerted a profound influence on numerous logicians in the world. Let us quote Professor Melvin Fitting [4]:

> [...] *the ideas were of a sort I had never come across before, and I was enchanted. This way of using algebra, producing known results in classical logic, then applying similar techniques to non-classical logics to get new results—it all seemed like magic. Profound results fell out so effortlessly, it seemed. How could one read this book and remain unaffected?*

In the Rasiowa-Sikorski monograph we may find, *e.g.*, a very interesting proof of the Rasiowa-Sikorski lemma, based on a method of

proving existential theorems by means of the Baire category theorem, popular among the representatives of the Polish School of Mathematics. This method was used by such well-known mathematicians as Stefan Banach, Hugo Steinhaus, and Stanisław Mazur. While studying this proof, we become familiar with numerous interesting topological properties of the space of models for the classical predicate calculus. There are versions of the proof of the Rasiowa-Sikorski lemma which do not use the Baire category theorem. However, in this approach, we lose the chance to see interesting relationships between properties of logic and properties of topological spaces associated with logic. Numerous generalizations of the Rasiowa-Sikorski lemma to other algebraic structures (*e.g.*, Post algebras, certain types of distributive lattices in the form of the Rauszer-Sabalski lemma [23]) were created.

In *The Mathematics of Metamathematics*, algebraic models for the predicate calculus, introduced by Rasiowa and Sikorski, also are presented. These include Boolean models for the classical predicate calculus and Heyting models for the intuitionistic predicate calculus. Dana Scott and Robert Solovay used the concept of Boolean models to simplify a well-known Cohen's proof of the independence of the axiom of choice, along with Cantor's continuum hypothesis. In this simplification, the key role is played by both Boolean models and the Rasiowa-Sikorski lemma itself [2]. In 1973, Denis Higgs showed that there are some strong relationships between algebraic semantics of Rasiowa and Sikorski and the semantics based on the topos of sheaves [2]. Later, these relationships were independently developed by Dana Scott and his students. This led to further modifications of Cohen's method and its generalizations in topos theory. The research on relationships of Rasiowa-Sikorski approach and forcing is continued using the Rasiowa-Sikorski sets [3].

Another well-known monograph of Helena Rasiowa, *Algebraic Approach to Non-Classical Logics* [20], presents algebraic theories for a wide class of non-classical logics.

It encompasses positive and classical implicational logics, logics weaker than the positive implicational logic, minimal logic, positive logic with semi-negation, constructive logics with strong negations and Post's logics. The aim of the book was to identify a class of logics that is as broad as possible and for which a general algebraic theory could be formulated. The theory developed consists of tools for proving significant theorems about the logics from this class simultaneously for the entire class, and not - as it was done earlier - separately for each logic.

Helena Rasiowa is an author of about one hundred scientific works

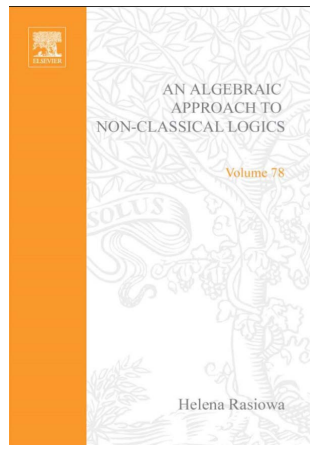

Figure 6: The monograph *Algebraic Approach to Non-Classical Logics*

and the academic textbook, *viz.*, *The Introduction to Contemporary Mathematics*, which gained popularity both in Poland and abroad. Her works and monographs helped to educate whole generations of logicians in Poland and abroad. In different countries, one can meet scientists who after studying the monographs and works of Professor Helena Rasiowa proudly call themselves her students, despite the fact that they have never met her in person. She educated many generations of students and young academic researchers and was an academic supervisor of nearly twenty PhDs, several of whom obtained titles of professors. This includes: Michael Bleicher (1961, Tulane University), Vladimir G. Kirin (1966, University of Zagreb), Andrzej Salwicki (1969), Nguen Cat Ho (1971, Vietnam Academy of Sciences), Cecylia Rauszer (1971), Ewa Orłowska (1971), Grażyna Mirkowska (1972), Maria Semeniuk-Polkowska (1972), Wiktor Bartol (1973), Antoni Kreczmar (1973), Jerzy Tiuryn (1975), Lech Banachowski (1975), Anita Wasilewska (1975), Michał Krynicki (1976), Bolesław Szymański (1976), Dimiter Vakarelov (1977, Sofia University), Bogdan Sabalski (1977), Halina Przymusińska (1979), and Leszek Rudak (1986).

The extremely high position of Helena Rasiowa within the international scientific environment resulted in numerous invitations from the best universities and research centers in Europe and the Americas. She gave lectures, including frequent plenary lectures, during numerous international congresses and conferences. She also chaired many scientific sessions. She had been visiting professor at many universities, ranging from Bahia Blanca in Argentina to Moscow in the Soviet Union, passing through Campinas in Brazil, UNAM in Mexico, Rome in Italy and Ox-

ford University in England. In the USA she was hosted by universities such as Princeton, University of Chicago, University of California at Berkeley and the University of North Carolina at Charlotte. Moreover, she gave invited lectures at 46 universities and research establishments abroad, in some of them more than once.

During her last two years of life, Helena Rasiowa, not succumbing to the aggravating disease, continued working on her new monograph, *Algebraic models of logics*, in which she was the author of 8 chapters [22]. The book was published by University of Warsaw.

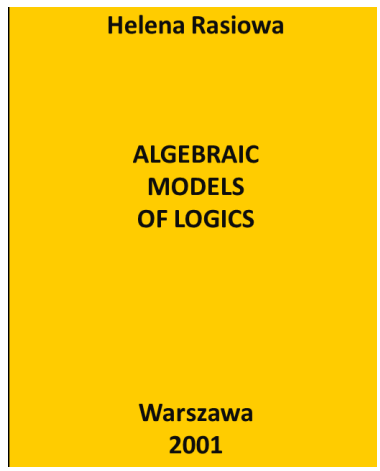

Figure 7: Unfinished book: *Algebraic Models of Logics*

In June 1994, she started the preparation of a special edition of *Studia Logica*, entitled *Reasoning with Incomplete Information*, and, in particular, prepared the list of the topics to cover.

The readers are referred to [1] for additional details on the scientific achievements of Helena Rasiowa, in particular for the full list of her publications.

It should be emphasized that, despite her significant scientific activity, Professor Rasiowa did not refuse taking various roles that were important for the scientific and academic life. The university was her second home. She was a person of great perseverance. In retrospect, it is amazing to realize how she was able to meet all these challenges.

From 1955 to 1958, she was the Director of the Extramural Studies at the Institute of Mathematics (University of Warsaw). From 1964 to 1970, she headed the Section of the Foundations of Mathematics at the University of Warsaw and from 1970 till the end of her life, she was the head of the Section of Mathematical Logic at the same university. For

more than 15 years she was the Dean of the Faculty of Mathematics, Computer Science and Mechanics (1958-1960, 1962-1966, 1968-1978). This was not an easy task. For example, Professor Victor Marek in his letter to participants of the conference dedicated to the 100 Birth Anniversary of Professor Rasiowa wrote:

> *In a difficult situation* [in 1968], *the tact and skill of negotiation that Professor Rasiowa* [as a dean] *showed, without a doubt, allowed the community of Faculty to avoid the 'worst'.*

Prelate Zdzisław Peszkowski, the cousin of Helena Rasiowa, in his talk during the funeral ceremony was asking

> *What did you do to make her often cry at home when she, your dean, was returning from work?*

She also represented the Faculty Council of the Faculty of Mathematics, Computer Science and Mechanics in the Senate of the University of Warsaw. Helena Rasiowa actively participated in the scientific life and performed a number of important functions in academic organizations and associations both in Poland and abroad. From 1961 to 1968, she was a Scientific Secretary of the Institute of Mathematics of Polish Academy of Sciences, and later, its board member. From 1970 to 1972 she was a member of the Committee of Mathematical Assessors at the Central Council of Higher Education and from 1968 to 1972 she was a Chairperson of the Committee of Mathematical Assessors for Teacher's Colleges. Professor Rasiowa was active in the Polish Mathematical Society (PMS). In PMS, she was a member of the board of the Warsaw Chapter, responsible for the popularization of mathematics and training of teachers. She was appointed the President of the Warsaw Chapter of PMS twice (1957-1958, 1963-1964) and she was also the Secretary of the Society (1955-1956) and its Vice-President (1958) as well. In 1987 she received from PMS the title of a honorary member. In the Association for Symbolic Logic, she was a Council member (1958-1960) and a member of the Executive Committee for Foreign Affairs (1972-1974). In 1972, she was an Alternate Assessor (1972-1975) and Assessor (1975-1979) in the Division of Logic, Methodology and Philosophy of Science of the International Union of History and Philosophy of Sciences. For several years, she was the Chairperson of the Scientific Council of Computational Center by the Polish Academy of Sciences and later of the Institute of the Foundations of Computer Science of the Academy, as well.

Thanks to her active participation, efforts aimed at the creation of the *Polish Association for Logic and Philosophy of Science* were undertaken between 1980-1981. This association is the continuation of the Polish Logic Society, founded on April 22, 1936 by Jan Łukasiewicz and Alfred Tarski. The creation of the society, whose aim was to "practice and nurture logic and methodology, along with their history, didactics and possible application," was connected with a great development of logic in the interwar Poland. The Polish Logical Society was the second organization of this type in the world (after the Association for Symbolic Logic in the USA). After the war, the society was not reactivated. The efforts aimed at the creation of a similar society in 1980-1981 became futile as the authorities refused to register it. During the IX International Congress of Logic and Philosophy of Science in Uppsala in 1991, a group of Polish Congress participants met to initiate the establishment of the association. On December 10, 1991, a constituent meeting of the Polish Association for Logic and Philosophy of Science took place.

It is worth mentioning that Helena Rasiowa, despite having in mind all her tragic war experiences caused by the German invasion of Poland, initiated cooperation in the area of Computer Science between University of Warsaw and Humboldt University of Berlin, together with Helmuth Thiele, Professor at Humboldt University,. The workshop initiated is still active after more than 40 years.

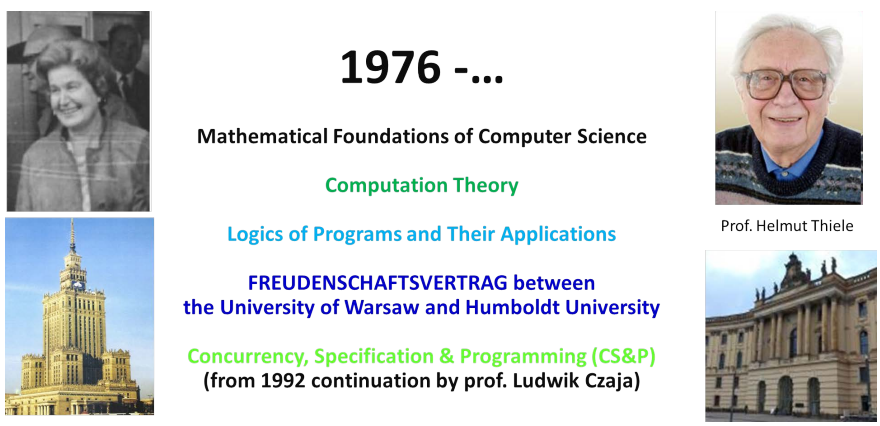

Figure 8: Cooperation between University of Warsaw and Humboldt University

It is possible to identify numerous areas of contemporary research which are directly or indirectly inspired by the works of Helena Rasiowa. These include algebraic methods in logic, deductive systems like tableaux, mathematical foundations of computer science, and artificial

intelligence (including approximate reasoning and interactive granular computations).

Over the years conferences or special sessions dedicated to the memory of Professor Helena Rasiowa have been organized, and volumes of journals and books have been published (e.g., [8, 14, 27], the CS&P 2017 workshop[2], the conference in Rzeszów in 2017 dedicated to the 100 Birth Anniversary of Professor Helena Rasiowa[3] or several exhibitions of paintings of Professor Maria Semeniuk-Polkowska organized together with the special sessions dedicated to the memory of Professor Rasiowa, like the session at IJCRS 2017 in Olsztyn).



Figure 9: Session organized at CS&P 2017 in the memory of Professor Helena Rasiowa on her 100th anniversary of birth

Let us now give room to Professors, the former students, PhD students and/or co-workers of Helena Rasiowa.

Professor Rasiowa strongly supported the school of algorithmic logic created by Professor Andrzej Salwicki [12, 25]. She is the author of more than 15 papers on algorithmic logic. It is worthwhile mentioning that

[2] http://csp2017.mimuw.edu.pl/index.php?id=programme
[3] http://konferencja.ptkwm.org.pl/

the group of Professor Salwicki constructed and implemented LOGLAN, an original programming language [10] based on algorithmic logic. Salwicki, in his presentation during the mentioned conference in Rzeszów celebrating the 100 Birth Anniversary of Professor Rasiowa emphasized:

> [...] *Only the algebraic method proposed by Rasiowa and Sikorski can be used in proving completeness theorem for calculus of program.*

Professor Dimiter Vakarelov (Bulgaria) in his letter to participants of the conference in Rzeszów celebrating the 100th Birth Anniversary of Professor Rasiowa wrote:

> [...] *Soon after my first visit at Warsaw University, I became a Ph.D. student of Professor Rasiowa and had the great chance to work under her guidance. I remember her not only as a great scientist, but also as great woman: she treated her students and young collaborators also as her own children and took care of them as a mother. Those years were unforgettable for me. After defending my thesis, Professor Rasiowa visited our university several times and helped us to create our own Bulgarian school in logic and its applications. At that time our faculty of mathematics (called "Faculty of mathematics and mechanics") was renamed as a "Faculty of mathematics and Informatics" - a suggestion given to us also by Helena Rasiowa.*

Next, in his article [28] he wrote:

> [...] *The impact of Rasiowa's works on non-classical negation is obvious, especially concerning Nelson negation. After her works on this logic, supplying it with a formal semantics and completeness theorems, Nelson logic determines an important and a well established subfield in non-classical logic with various applications.*

On the same occasion as mentioned above, Professor Cat Ho Nguyen (Vietnam) in his letter wrote:

> [...] *Thanks to Professor Helena Rasiowa* [....] *I gained fundamental knowledge in the field of the algebraic logic which was of paramount importance as it built a strong foundation for my career and further research. With such precious*

knowledge, in the late 1980's I and Professor Wolfgang Wechler, from TU-Dresden, Germany, found a novel theory, named the theory of hedge algebras. [...] *This theory has begun to be applied to effectively solve problems of classification, regression, control, image contrast enhancement ... in terms of linguistic fuzzy systems.* [...] *always consider that my researches in the following years have been significantly influenced by the traditional Polish algebraic logic school, of which she was an outstanding scientific representative.*

In [15] Professor Ewa Orłowska has written:

[...] *The origin of dual tableaux goes back to the paper by Helena Rasiowa and Roman Sikorski 'On the Gentzen theorem' published in Fundamenta Mathematicae in 1960. The authors presented a cut free deduction system for the classical first-order logic without identity. Since then the deduction systems in the Rasiowa–Sikorski style have been constructed for a great variety of theories, ranging from well established non-classical logics such as intuitionistic, modal, relevant, and multiple-valued logics, to important applied theories such as, among others, temporal, in particular interval temporal logics, various logics of programs, fuzzy logics, logics of rough sets, theories of spatial reasoning including region connection calculus, theories of order of magnitude reasoning, and formal concept analysis.*

In the field of approximate reasoning it is worth mentioning results of Professor Rasiowa on logics based e.g. on rough sets [16] as well as fuzzy sets [1]. For example, Professor Damian Niwiński in [13] writes:

Łukasiewicz's ideas opened new paths in logic, indicating that notions of uncertainty, vagueness, ambiguity, can be dealt with in a rigorous way. This approach has been particularly rewarding in logic for artificial intelligence. One of the problems there is to induce general rules from large sets of observations (data), which can be incomplete, or even inconsistent. Among various techniques proposed for this problem, the method based on rough sets introduced by Zdzisław Pawlak in Warsaw in the early 1980s [16] was proved quite successful in practice, and received broad recognition from the AI community. The new ideas arose from a fruitful collaboration of Pawlak and numerous logicians in the Warsaw circle

of that time, including Helena Rasiowa, Cecylia Rauszer, Ewa Orłowska, V. Wiktor Marek, Andrzej Skowron, and many others. The survey [8] gives an informative panorama of this development.

Professor Maria Semeniuk-Polkowska wrote in her memories ([26] and personal communication):

In 1965 I was preparing myself to the Master exam during the summer session when I got a call from the Dean office that the Dean wanted me to come. I was mystified as to the reason but when I came I was proposed a post of an assistant. And so I begun the 50 year long stint of work at Warsaw University. I could see how Professor Rasiowa was taking care of us, how She was thinking about our progress and noticed small successes. She was able to discover in each of us the best and exploit our best talents. As I was always interested in languages, I decided to devote my doctoral studies to the field of formal linguistics and Professor Rasiowa warmly supported this decision, her opinion about me was so warm and positive that I felt very strongly motivated. After doctorate which She promoted, She supported my decision to accept a post in the Chair of Formal Linguistics at the Department of Neophilology headed by Professor Olgierd Wojtasiewicz. [...] *We were in touch during last years of Her life, often walking to the park along Frascati street. She remembered her childhood and school years, the Mrs Warecka School, studies at School of Music by the Warsaw Philharmony, and mathematical studies, beautiful lectures by Jan Łukasiewicz, other professors, her Master Thesis with Jan Łukasiewicz and Boleslaw Sobociński, tragic days of Warsaw Uprising. She remembered difficult afterwar years, at Physics Institute by Hoża street, then Astronomic Observatory in Botany Garden by Ujazdowskie, colleagues: Professors Andrzej Mostowski, Roman Sikorski, Stanisław Mazur, Wanda Szmielew, Hanna Szmuszkowicz. Very warmly She spoke of Her students and collaborators: Cecylia Rauszer, Andrzej Skowron, Andrzej Jankowski, Wiktor Bartol, and many others.* [...] *Once, I started talking about 'Flowers of St. Francis' rendered into Polish by Leopold Staff. I learned that St. Francis of Assisi was the most beloved saint of Her. Participation in Saint Masses with Her was a source of deep*

spiritual experience, some of them at Her home, celebrated by Her beloved cousin Prelate Zdzisław Peszkowski, Chaplain of the Katyń Families.

Professor Lech Polkowski in his personal letter reported:

I am the last whom Professor Helena Rasiowa 'took in the palm of her hand' as Irish say and encouraged me to enter the rough set circle with Professors Zdzisław Pawlak and Andrzej Skowron. 25 research articles written together with Andrzej, Professors Pawlak and Paun were every one dedicated in my heart to the memory of Professor Helena Rasiowa who was able to see the first of them in 1994 on introduction of rough mereology. A circle of papers composing the topological theory of rough sets written in 1992-3 was under her and Professor Pawlak's influence when she was in the US.

Helena Rasiowa was an extremely hard-working, friendly and cheerful person, who has been always kind and sensitive to human problems with great intelligence. She was always ready to help, not only as a scientist, but also as a human being in real-life problems. In each, even most difficult situation, she tried to do as much good as possible - this was her life motto as an academic teacher, devoted wholeheartedly to logic and Polish science.

Professor Semeniuk-Polkowska in her memories wrote [26]:

There was so much warmth, care and love in her voice, when she spoke of her children, Zbyszek, Krysia, and granddaughter Magda in the US, and also when she spoke of her "scientific foster-children", Inka, Andrzej, Witek, Anita, Janek, Ela, Halina, Ewa and many, many more. She appreciated people. She said that she rejoiced to see that none of her students had wasted their talents. Some in Poland, others abroad, all of them furthered the growth of science. Andrzej, in whose hands she placed the Chair of Logic, occupied a special place among her former students. She always spoke kindly of him, of his knowledge, responsibility and abilities, of how he had the talent of drawing gifted people to his field, to scientific work. She knew he could be relied on. He was always close, always ready to help, when she needed it.

Professor Cecylia Rauszer, a former PhD student of Professor Rasiowa passed away in 1993. Her research interests and work were concerned with nonclassical logics and she was also very active in the field of the mathematical foundations of computer science, in particular in research on logic for computer science applications In [21], Professor Rasiowa in her memorial letter dedicated to Cecylia Rauszer characterizes her friend and co-worker Cecylia as an outstanding scientist of international renown, distinguished by extremely fine and valuable traits of character. Professor Rasiowa has taught the authors of the article, among other



Figure 10: Helena Rasiowa

things, how to seek answers to the following three questions of great importance in our lives:

- How to support personal, scientific, professional development, and good cooperation among people (especially in very difficult situations)?
- How to construct and develop new AI technologies (and their applications) by constructing appropriate computational models [7, 8]?

- How to apply in practice (especially in complex IT projects) achievements of mathematical logic (especially algebraic methods of logic) and achievements of IT foundations?

Professor Helena Rasiowa was able to combine the love for her children, Krystyna Kijewska and Zbigniew Raś, with the love for mathematics.

She was a tertiary of the Franciscan Order, a fact which, during her life, was known only to some of her loved ones. The faith combined with a passion for mathematics, enabled her to survive the most difficult moments, like the war or the very last stage of her life, when the incurable disease began to destroy her. This was a great lesson for her students about how to behave in the most difficult situations.

Helena Rasiowa, a mathematician and logician, passed away on August 9, 1994.

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References

[1] Bartol W., Orłowska E., Skowron A., (1995). Helena Rasiowa, 1917 - 1994, Reprinted from *Modern Logic. Int. J. for the History of Math. Logic, Set Theory, and Found. of Mathematics*, **5**(3), 231–248. MR 1343900 Banach Center Publ., 46, Logic, algebra, and computer science (Warsaw, 1996), 8–21, Polish Acad. Sci. Inst. Math., Warsaw, 1999. MR 1694745 Cited on pp. 173 and 178.

[2] Bell J.L., (2011). Set Theory Boolean-Valued Models and Independence Proofs. Oxford Logic Guides **47**, Oxford University Press (2011) Cited on p. 171.

[3] Czelakowski J., (2018). Rasiowa-Sikorski sets and forcing, In: Odintsov S. (ed.), Larisa Maksimova on Implication, Interpolation, and Definability, Outstanding Contributions to Logic **15**, Springer, Cham, 117–153. Cited on p. 171.

[4] Fitting M., (1998). A tribute to Professor Helena Rasiowa, In: Orlowska E. (ed.), Logic at Work. Essays Dedicated to the Memory of Helena Rasiowa, Physica-Verlag, Heidelberg, v–viii. Cited on p. 170.

[5] Gieysztor A., (1984). Welcoming remarks on behalf of the Polish Academy of Sciences. Proceedings of the International Congress of Mathematicians (August 16-24, 1983, Warszawa), **1**, PWN, Polish Scientific Publishers, Warsaw, LII–LIII. Cited on p. 166.

[6] Grzegorczyk A., Rasiowa H. (eds.), (1963). Computable analysis, *Rozprawy Matematyczne* **33**, 1–111. Cited on p. 167.

[7] Jankowski A., (2017), Interactive Granular Computations in Networks and Systems Engineering: A Practical Perspective, Lecture Notes in Networks and Systems **17**, Springer, Cham. Cited on p. 181.

[8] Jankowski A., Skowron A., (2008). Logic for Artificial Intelligence: The Rasiowa - Pawlak School Perspective, In: Ehrenfeucht A., Marek V., Srebrny M. (eds.), Andrzej Mostowski and Foundational Studies, IOS Press, Amsterdam, 106–143. Cited on pp. 161, 169, 176, 179, and 181.

[9] Jankowski A., Skowron A., (2018). Helena Rasiowa (1917-1994), In: Garrido A., Wybraniec-Skardowska U. (eds.), Lvov-Warsaw School. Past and Present, Studies in Universal Logic, Birkhaüser Publishing Ltd. Springer, Basel, 703–709. doi: https://doi.org/10.1007/978-3-319-65430-0_48 Cited on pp. 161 and 185.

[10] Kreczmar A., Salwicki A., Warpechowski M., (1990). LOGLAN'88—Report on the Programming Language, Springer, Berlin, Germany. Cited on p. 177.

[11] Leibniz G. W., (1666). Dissertatio de Arte Combinatoria. Leipzig. Cited on p. 161.

[12] Mirkowska-Salwicka G., Salwicki A., (1986). Algorithmic Logic, D. Reidel Publishing Company, Dordrecht and PWN - Polish Scientific Publishers, Warsaw. doi: 10.2307/2274777; Cited on p. 176.

[13] Niwiński D., (2016). Contribution of Warsaw Logicians to Computational Logic, *Axioms*, **5**(2), 16. doi: 10.3390/axioms5020016; Cited on p. 178.

[14] Niwiński D., Zawadowski M. (eds.), (1999). Logic, Algebra and Computer Science: Helena Rasiowa in memoriam, Banach Center Publications **46**, Polish Academy of Sciences, Institute of Mathematics. Cited on p. 176.

[15] Orłowska E., Golińska-Pilarek J., (2011). Dual Tableaux: Foundations, Methodology, Case Studies, Trends in Logic **13**, Springer, Dordrecht. Cited on p. 178.

[16] Pawlak Z., (1982). Rough sets, *International Journal of Computer and Information Sciences* **11**(5), 341–356. Cited on p. 178.

[17] Rasiowa H., (1947). Axiomatisation d'un système partiel de la théorie de la déduction, *Comptes-Rendues de la Soc. de Sci. et de Lettres de Varsovie*, C1 **III**, 22–37. Cited on p. 166.

[18] Rasiowa H., (1947). Sur certaines matrices logiques, *Comptes-Rendues de la Soc. Pol. de Math.*, **20**, 402–403. Cited on p. 166.

[19] Rasiowa H., Sikorski R., (1963). The Mathematics of Metamathematics, Monografie Matematyczne **41**, First Edition, PWN, Warsaw (2nd edition (1968), 3rd edition (1970)). Cited on p. 170.

[20] Rasiowa H., (1974). Algebraic Approach to Non Classical Logics, Studies in Logic and the Foundations of Mathematics **78**, North Holland, Amsterdam. Cited on p. 171.

[21] Rasiowa H., (1994). Cecylia Rauszer, *Studia Logica*, **53**, 467–471. doi: 10.1007/BF01057645; Cited on p. 181.

[22] Rasiowa, H.: Algebraic Models of Logics. Warsaw University, Warsaw (2001). Cited on p. 173.

[23] Rauszer C., Sabalski B., (1975). Notes on the Rasiowa-Sikorski lemma. *Studia Logica*, **3**4, 265–268. doi: 10.1007/BF02125229; Cited on p. 171.

[24] Reflections on the Treatment of Peoples of Alien Races in the East: A Secret Memorandum Handed to Hitler by Himmler on 25 May 1940. Translation of Document No-1880 Prosecution Exhibit 1314. In: Trials of War Criminals Before the Nuernberg Military Tribunals: Volume XIII "The Ministries Case": pp. 147–150. Washington, DC: United States Government Printing Office. https://www.loc.gov/rr/frd/Military_Law/pdf/NT_war-criminals_Vol-XIII.pdf. Accessed on 20 Novmeber 2020. Cited on p. 164.

[25] Salwicki A., (1970). Formalized algorithmic languages, *Bull. Acad. Polon. Sci. Ser. Sci. Math. Astron. Phys.*, **18**, 227–232. Cited on p. 176.

[26] Semeniuk-Polkowska M., (1996). Greatness measured by faith, talent, work and suffering. My memories of Professor Helena Rasiowa, *Bulletin of the Section of Logic* **25**(3-4), 190–202. Cited on pp. 163, 179, and 180.

[27] Skowron A. (ed.), (1996). Logic, algebra and computer science: Helena Rasiowa and Cecylia Rauszer in memoriam (Warsaw, Poland, June 10, 1995), *Bulletin of the Section of Logic*, **25**(3-4), 1–215. Cited on p. 176.

[28] Vakarelov D., (2006) : Non-classical negation in the works of Helena Rasiowa and their impact on the theory of negation, *Studia Logica*, **84**, 105–127. doi: 10.1007/s11225-006-9004-y; Cited on p. 177.

Helena Rasiowa (1917-1994) – życie i osobowość

Andrzej Jankowski and Andrzej Skowron

Streszczenie. Helena Rasiowa (1917-1994) – jedna z czołowych przedstawicielek logików warszawskich. Była nie tylko wielkim naukowcem, ale także wielkim człowiekiem. Profesor Rasiowa wywarła wpływ na wielu badaczy z całego świata, szczególnie swoimi wynikami z logiki algebraicznej, a także wielkim wkładem dla środowiska matematycznego pod każdym względem. Jest także współzałożycielką szkoły sztucznej inteligencji (AI) Pawlaka-Rasiowej. Przygotowując ten artykuł, wykorzystaliśmy kilka cytowanych artykułów poświęconych profesor Rasiowej. W szczególności, artykuł ten jest rozszerzeniem [9]. Dodaliśmy również osobiste komentarze na temat jej osobowości, jaką dostrzegli autorzy tego artykułu i zaczerpnęliśmy z listów i artykułów współpracowników i doktorantów prof. Rasiowej.

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