IN SEARCH OF MEANING

David Henderson (1939-2018)

David Henderson was born February 23, 1939, in Walla Walla, WA. His parents Rev. William H. Henderson (1910-1991) and Kathleen Wilson Henderson (1913-2007) had met in New Haven, CT in 1935, where William studied in Yale Divinity School, and Kathleen was a graduate student at Yale Nursing School.

William Henderson came from a family of steel workers and was the first in the family to receive higher education. He had a long and varied career serving as United Service Organization (USO) director and as a pastor to students at Presbyterian university centers. Kathleen came from a long line of academics dating back to 1600's. Her maternal grandfather John Paterson-Smyth (1852-1932) left a professorship at Trinity College, Dublin because the university did not support his writings to common people. Her father H. A. Wilson (1874-1964) was the first Chair of the Physics Department at Rice University where he worked for 40 years. [1] After completing her undergraduate studies at Rice University as a physics major with high honors, Kathleen pursued her wish to become a nurse so that she could be more helpful to people than being a scientist.

When David was growing up the Henderson family moved frequently due to their father's career. For the first three years of David's life they lived in Milton-Freewater, OR, where William and Kathleen Henderson had three sons David, Bill, and Stephen, in quick succession, then moved to Blacksburg, VA. David's sister Marjorie was born in 1945. David started first grade in Key West, FL, where the family was living on an Army and Navy base at the end of World War II. With parents both busy at work, David, being the oldest, was responsible for taking care of his siblings. An encounter with soldiers at the base left David with a deep childhood trauma that affected him throughout his life. After the war the family moved to Morgantown, WV, where one of David's regular chores was to every Saturday clean the front porch from a thick layer of coal dust. The family next moved to Ann Arbor, MI where William Henderson was a pastor to Presbyterian students at the University of Michigan. David's mother continued her nursing career in various hospitals and schools, but her real passions were Civil Rights and the Peace Movement.

David is ready for school

David used to say that he never learned to write in proper cursive because after every family move there was a different school and different teacher's requirements. David's brother Bill remembered attending 3 different first grades, so for David that had to be 3 different second grades. These frequent changes of schools and places where he lived also made it impossible for him to have long-term friends.

Finally, in Ames, IO, David had a period of 6 years in the same locality. He graduated from Ames High school in 1957. David's sister Marjorie Ogilvie remembers: "David joined Boy Scouts, becoming an Eagle Scout and receiving top honors at Explorer Scouts. He played tuba and sousaphone in the school band and was also a member of the football team. He later ran long distances, well before running became fashionable. He loved music and made beautiful block prints." David's family remembers that he also loved to sing from a top of his lungs, unfortunately off key… "I remember David as being one of the smarter boys, if not the smartest, in our class," David's classmate from Ames, Robert Callahan, wrote "but when I looked in 1957 annual, I realized how many activities he was in during the three years of high school - Band, Boys' Glee Cub, Choir, Cubs' Club (junior reporters for the student newspaper), Football, Hi-Y (a boys organization), Intramural Council, Jr. Red Cross, Rifle Club, Science Club, tTack, and Homeroom Activity Director. I dare say that he was in more different activities than anyone else in our class, but he did it without any fanfare and was very quietly in the background."

David age 18

Later in life David learned to play piano quite well, his favorites were Chopin and Shostakovich. He even composed a piece for piano, “Spring”, with complicated chords.

Since an early age David loved to explore shapes, to think about how we visualize our experience, and how to represent those images. He wrote:

> *I did not like mathematics in school, because it seemed very dead to me—just memorizing techniques for computing things and I was not very good at memorizing. I especially did not like my high-school geometry course, with its two column formal proofs.* [2]

David explored shapes, forms, spatial relationships through drawing, sculpture, wood-working, photography, and then, in high school, in understanding ideas in physics and chemistry, not realizing that it was all geometry.

In college, mathematics for David became a little more interesting with some challenging problems but

> *…mathematics had little meaning for me. I was interested in understanding reality, mathematics was merely a very precise and technical language, very useful for me in physics, but the meaning seemed to me to be in physics, not in the mathematics. I switched into mathematics and became a mathematician when I experienced that in doing mathematics, I was making contact with real meaning of my universe.* [3]

Student at Swarthmore College

Initially David was a joint physics/philosophy major at Swarthmore College. In his last year in college some of David’s professors pointed out that his passion is geometry, which is a part of mathematics.

> *From my experiences in mathematics courses (there was no geometry course offered at that time) I still didn’t buy it and put more energy into philosophy. My break with philosophy happened in connection with an honor’s paper “What is truth?” that I poured much energy into arguing that “truth” is relative to a community. Both examiners gave me an A+ and said that it is well-written, well-structured and had a good logical structure. But they didn’t care about the meanings of the structures. So, I switched to mathematics where at least the structures were more explicit and where there was “geometry” which I began to see as a home for my passions*. [4]

David's first original mathematical result

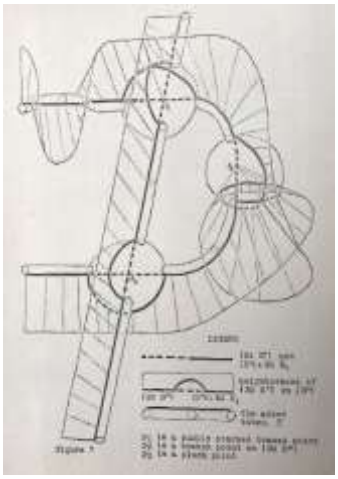
David's first mathematics research paper on the geometry of Venn diagrams with more than four classes evolved from a college course on the philosophy of logic when he was a senior at Swarthmore college. [5]

David married his Swarthmore classmate Beverly Burt in December 1960 and received his bachelor's in mathematics, physics and philosophy with High Honors from Swarthmore College in 1961. During the summer of 1961 he held his first professional position as a mathematician at Sun Shipbuilding and Dry Dock Co., which was the major shipbuilding company in Chester, PA, 15 miles south of Philadelphia. David's task there was to calculate optimum negative curvature on the front of the ship. Whenever we happened to see ships in dry dock, David always pointed out the place where the ship has a negative curvature, which is never visible when the ship is in the water.

> I enrolled as a graduate student at the University of Wisconsin in the Department of Mathematics. I studied "Foundations of Mathematics" with Kleene and "Geometric Topology" with Bing. I gave up on Foundations of mathematics when I experienced again an emphasis on structure and not on meaning. However, I flourished under Bing. When I first arrived in graduate school, I was intimidated by my fellow graduate students who knew all the fancy formal terminology – as a physics/philosophy major I did not know much of that. Bing was a student of R.L. Moore. I remember clearly Bing writing "It is impossible to understand the formal definition of continuity until after you have experienced its meaning." Ahh! This is what I was looking for. Bing was on the alive meaning side and because I found him, I stayed in mathematics. [6]

David Henderson earned his Ph.D. in geometric topology in 1964 for his thesis "Extensions of Dehn's Lemma and the loop theorem" [7]. By then his family had grown to four – son Keith was born in 1961, daughter Rebecca in 1964.

"Henderson's thesis was closely related to his discovery of an error in a "proof" of the Poincare Conjecture then being publicized widely by the Romanian topologist Valentin Poénaru. So, even as a graduate student David had acquired something of a reputation," remembers Prof. Ross Geoghegan, who became the first Henderson's PhD advisee, now chair of the Department of Mathematical Sciences at Binghamton University.



Picture from Henderson's PhD thesis

After completing graduate studies David Henderson spent two years as a postdoctoral researcher at the Institute for Advanced Study in Princeton, NJ. While at the Institute David produced a notable example in dimension theory - an infinite-dimensional compact metrizable space with the property that every proper closed subset has dimension zero or infinity. [8]; [9] Later, others produced even better examples of this pathology, where the word "closed" was removed, but David's example made his name well known among topologists. Among other things it led to his Alfred P. Sloan fellowship (1968), which stimulates fundamental research by early career scientists and scholars of outstanding promise. The problem David had solved in 1965 was a famous problem known in the Soviet Union as "Problema Tumarkina" (1925) and in Poland as Problem Mazurkiewicza (Stefan Mazurkiewicz (1888-1945) independently posed it 1933 [10]). David had constructed an example of an infinite-dimensional continuum (compact connected metric space) with no finite-dimensional sub-continua (or sub-compacta). That first example was very difficult. "Simpler examples of such spaces were given by Bing in 1966, Henderson himself in 1967, and Zarulea in 1972. In 1979 Rubin, Schori and Walsh gave a still simpler example that significantly clarified the matter. Pol in 1986 gave a relatively simple example as a finale of long series of achievements." [11] A quite recent and unexpected application of the "Henderson compactum" was used by J. Zapletal to solve a natural problem about forcing that stood open for a long time. [12]

ПРАВДА

Орган Центрального Комитета Коммунистической партии Советского Союза

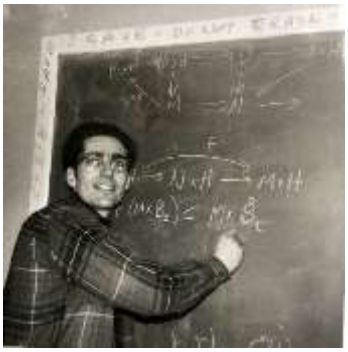
СОЗИДАНИЕ ЧЕРЕЗ ОТРИЦАНИЕ

At the ICM 1966 in Moscow and Pravda mentioning David Henderson

Henderson's brilliant result led him to be asked to present it at the International Congress of Mathematicians held in Moscow in 1966. There was a special session set up to present the solution of the long-standing problem, with Prof. Lev Abramovich Tumarkin (1901-1974) in attendance himself. This talk was documented in the article published by the leading Soviet newspaper *Pravda* [13] quoting Tumarkin saying that he was very happy to see the problem he had posed as a senior in Moscow State University be solved by another young mathematician. As a follow-up of this first visit in Moscow, from January to May 1970, David Henderson was an exchange scientist at the Steklov Institute, Soviet Academy of Sciences, and gave lectures on geometric topology (in Russian!) at the Faculty of Mathematics and Mechanics, Moscow State University; the following month, in June 1970, he was an exchange scientist at the Institute of Mathematics, Polish Academy of Science, Warsaw. In Moscow David worked with several prominent Soviet mathematicians, but he also learned how mathematics was taught in schools: mathematics was one of the most prestigious subjects and math teachers had a lot of support from prominent mathematicians. From his visit in Moscow David remembered with an admiration his meetings with Pavel Sergeyevitch Aleksandrov (1896-1982), who was the leading Soviet topologist and a legendary mathematician. (Tumarkin was one of his students.). During his time in Moscow David was a regular attendee of Lyudmila Keldish's topology seminar [14].

Karol Borsuk and David Henderson in Poland, 1970

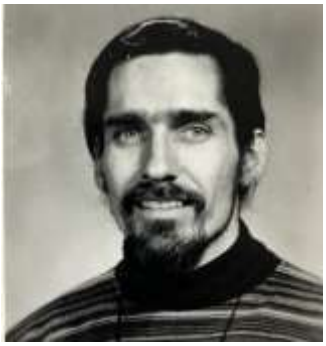
In fall of 1966 David Henderson joined the Department of Mathematics, Cornell University. Here he met James Eells (1926-2007), who at that time was a full-time professor there and became interested in infinite-dimensional topology as it relates to analysis. At Cornell, Henderson shifted his focus to infinite-dimensional vector spaces and the manifolds modeled on them. R. D. Anderson had just shown [15] that all separable, infinite-dimensional, Fréchet spaces are homeomorphic to Hilbert space, and Henderson produced a series of papers culminating in a proof [16] that all separable topological manifolds modeled on one of these spaces were homeomorphic to open subsets of the model. Combined with the above theorem of Anderson and work of Eells, Elworthy, and Burghelea (cf. [17], [18]) this established that all such manifolds have C^∞ structures, are homeomorphic if they are homotopy equivalent, and that homotopy equivalences between them are homotopic to homeomorphisms.



David started teaching in 1966

Prof. Geoghegan remembers: "Dave arrived at Cornell in 1966 and taught a Moore-style topology class for first year graduate students that Fall. No Moore-style course had ever been taught at Cornell. I was one of the thirty students, and the course, particularly the method of instruction, made a huge impact on me. I asked Dave to be my advisor. I owe a lot to him. While I shone in that course, I failed an exam I should have aced, and were it not for Dave's intervention to have the rules bent, I'd have been placed in the category of "not quite PhD material". Subsequently, when I had some success in my PhD thesis, it was Dave's incredibly generous letter of recommendation (which someone showed me) that got me off to a good start at the Institute of Advanced Study in Princeton. Dave had enormous talent in the geometrical parts of mathematics. I do wish he had kept on in that direction." Between 1965 and 1975 Henderson published 30 research papers in geometric topology.

David was deep in his geometric universe, finding new paths and connections in infinite dimensions. The stormy events of the sixties were on the outskirts of this mathematical world he was immersed in. Then came an event that forever shook him and changed his life. By 1969—with the war raging in Vietnam and the battle for civil rights in full tilt—campus unrest was hardly new to American universities, Cornell included. It was April 18, 1969 when members of the Afro-American Society (AAS) occupied Willard Straight Hall to protest racism and the judicial system at Cornell University. One of the AAS leaders Tom Jones, who famously announced on the radio "Cornell has three hours to live" was David's student. David's perception of academia got shaken. More than any single event before or after, this takeover polarized Cornellians, particularly among the faculty. Some faculty decided to leave Cornell, some buried themselves even more into their research, but some stood up for students and suggested changes in the traditional academic education system. David Henderson was one of them. In 1970 David Henderson became a member of the Graduate Field of Education at Cornell and directed the teacher education program for secondary school mathematics teachers.



David in late 1970's

In fall of 1971 David Henderson (with the help of Leonard Silver) started experimental teaching of the main Calculus sequence by *Exam-Tutorials*. Each course was divided in modules. Students were provided with a detailed description of each module and they had variety of resources for learning the material. When students felt that they had mastered the material, they came to the exam-tutor center and took an exam. When a student had finished, the tutor went over the exam with the student together. An exam counted as "passed" if the student showed sufficient mastery of the material (80% plus some understanding of every important topic) at which point the student could move on to the next topic. Otherwise the tutor would help the student to decide what s/he must study more, and when s/he felt ready, they could return to take a different but equivalent version of the exam. "Henderson said he conceived his new teaching system because he has aversion to the standard lecture-exam system which tends to be impersonal in super-big courses. With 517 students enrolled Math 111 qualifies as one of the giants." [19]

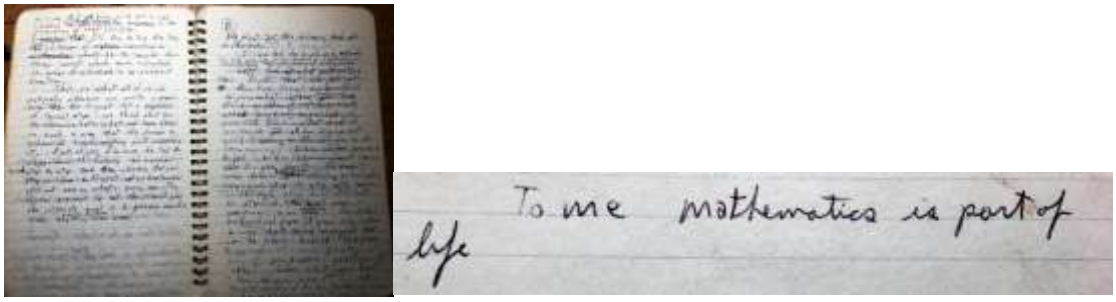
This experiment was not long-lived. However, the result of it was the creation of a Math Support Center in the Department of Mathematics -- a drop-in tutoring center, staffed with undergraduate tutors that have a broad range of mathematical experience and knowledge, which continues to exist to this day.

The stormy 1970's had taken a toll on David's personal life – he and Beverly separated but both stayed as colleagues in Cornell's Math Department.

Henderson felt that his training in mathematics has been very formal.

> *In the early 1970's I quit mathematics. I got angry with mathematics for what mathematics had done to me.* [20]

David's philosophical doubts about the value of research mathematics took over. He was again returning to his search for meaning. He reduced his teaching load to part time and for a while even took a leave from the university. For three years while living in a cabin he built in the woods, the only course he taught was geometry for prospective teachers which was not considered a *real* mathematics course. His personal notes in journals from that time reveal different directions of his thoughts which at the end again converged to what is the meaning in mathematics and his love of geometry.



Thoughts about mathematics in personal journals from late 1970's

> *What a person thinks is mathematics, how they react to or feel about mathematics and what they think is the "right" answer about mathematics are 3 entirely different things*. [21]

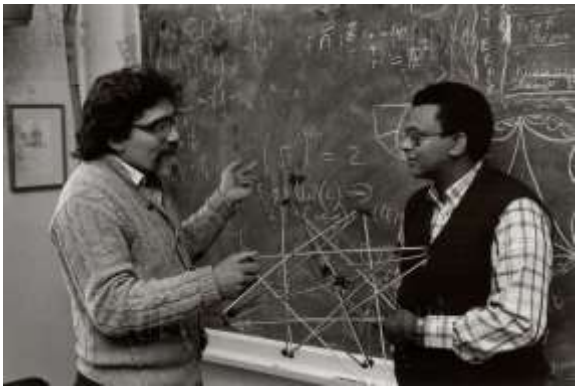
> *The majority of people today are scared of mathematics (and mathematicians) and feel powerless in the presence of mathematical ideas. Many people learn and view mathematics in rigid, rote ways that lock those person's into conditioned responses that limit their creative participation in their universe. This has been systematically reinforced by our culture which views mathematics as only accessible to a talented few. These views and attitudes have become part of what separates and holds down many oppressed groups, including women, working class,*

> *and racial minorities. The situation is not, however, hopeless. We can affect changes that will move mathematics towards a positive position in each person's life.* [22]

As David himself described the maturity of his ideas

> *I had a vision that all my academic ancestors picked me up the same way a mother-cat picks up her babies and put me back in the center of the university.* [23]

David also had a long family history of strong able women and men who were socially active: advocating for Voting Rights, Civil Rights, the end of predatory lending, etc. David's parents, through their own example, taught their four children that they all must do their part [in society] to be more inclusive. For David this social activism meant to improve mathematics education. Professor Henderson returned to full time teaching.



David Henderson and John Volmink in 1985

> *By "experience" I mean more than physical experience. We experience ideas and images. We experience "seeing" the whole ball with its center all at once. We experience ourselves growing (changing). All I can physically sense is some aspects of myself at a given instant in time. Yet I have an image of (sense of) my life as a whole changing from one point in time to another. It's very similar to imagining the ball as a whole.* [24]

In 1986 Henderson co-founded a new teacher education program (in conjunction with Cornell's Department of Education) for secondary mathematics and science teachers. The same year he also founded and directed a program in the Department of Mathematics for in-service workshops and courses for current mathematics teachers. From 1996 to 2001 he organized and led week-long *Undergraduate Faculty Enhancement* workshops for college/university faculty who were teaching geometry to future teachers.

Teaching Math 451- Euclidean and Non-Euclidean Geometry

David Henderson's deep thinking about meaningful mathematics culminated in his book *Experiencing Geometry* [25].

> *Formalism contains the power of the meaning but not the meaning. It is necessary to bring the power back to the meaning. A formal proof as we normally conceive it is not the goal of mathematics – it is a tool – a means to an end. The goal is understanding. Without understanding we will never be satisfied – with it we want to expand that understanding and to communicate it to others. This book is based on a view of proof as a convincing communication that answers – Why?* [26]

This book grew out of his own experience with geometry through art, music, carpentry; his geometry teaching experience to first and second graders, math majors, future high school math teachers, and at workshops for teachers.

David and Daina returned to Etna in 2005

On October 1, 1995 David Henderson gave a closing plenary address *Alive* Geometry at the ICMI Study Conference "Teaching Geometry for the 21st Century" Catania, Sicily. After his talk, Daina Taimina walked up to him to say a few comments about teaching geometry. This was the beginning of their collaboration for the rest of David's life. They had intense e-mail exchanges over next 9 months while David was preparing for another invited plenary address in June 1996 for the annual conference of the Canadian Mathematics Education Study Group. This address *Alive Mathematical Reasoning* [20] is David's manifesto.

For the next 22 years David gave numerous invited talks and lead many workshops sharing his deep love of mathematics and how to find meaning in teaching and learning mathematics through personal experience. He had a significant supervisory role in 40 graduate theses in the Field of Education and he was the chair of 4 PhD theses and 14 M.S. theses in mathematics education, almost all of these theses (as a condition of his supervision) had a strong mathematics component. In 1998 David published *Differential Geometry: A Geometric Introduction* [26]. Then followed two more editions of *Experiencing Geometry* with Daina Taimina as the co-author. [27] In 2018, David and Daina had started preparing the 4th edition of the book. David enjoyed typesetting his own books and he also typeset both editions of Daina's book *Crocheting Adventures with the Hyperbolic Planes.* [28] There are numerous publications which they both wrote together.

In 2012 David retired after 46 years of teaching at Cornell University; partially because he was diagnosed with Parkinson's disease which affected the quality of his teaching. He also believed that tenured professors should know when it is time for them to give way to the new generation who would fill students' minds with fresh ideas. However, David did not quit working in mathematics education.

In 2005 he had already accepted an invitation to join the core curriculum development team of the Algebra Project led by Robert Moses, a National Science Foundation-supported initiative that helps ensure that all students learn the mathematics they need to enter college and not need remedial courses. In 2011 Henderson joined Richard Lehrer on a project to develop and research

coherent curricula for K-5 mathematics and science. David wrote geometry curriculum for this project. Since 2016 Henderson has been part of a research project called "Function Learning Progressions," funded by a four-year National Science Foundation Discovery Research K-12 grant to both the Algebra Project and the nonprofit Educational Testing Service.

In Palestine 2015

David Henderson followed his parents' example of being socially engaged. He was building bridges between mathematical communities and learning mathematics from his students wherever he went to teach his understanding of mathematics. To mention just a few of his international activities in mathematics education: In 1980 he was a Visiting Professor at Birzeit University, Palestine, he also visited Hebrew University in Jerusalem and organized joint seminars for Jewish and Palestinian mathematicians. In 1995 he gave workshops and had interactions with local mathematicians and educators in Johannesburg, Qwa Qwa, Durban, and Cape Town, South Africa. In 2000 he was a Fulbright Scholar in the University of Latvia in Riga, Latvia, and visited Tartu University, Estonia. In 2015 he and Daina spent a semester in Palestinian Technical University Kadoori, Tulkarem, West Bank.

David was looking forward to working on the new edition of *Experiencing Geometry,* and he was also planning to write a book on calculus from a geometric viewpoint. These plans were brutally destroyed by a driver who didn't yield to David on pedestrian crosswalk December 19, 2018. David passed away from his injuries the next day.

Many thanks to Beverly and James West, Henryk Torunczyk, Marjorie Ogilvie, Bill Henderson, and Lelde Taimina-Tzou for comments and help.

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