A Conference Honoring Arnold Ross on His Ninetieth Birthday

Daniel B. Shapiro

Professor Arnold E. Ross has been a positive influence in the lives of several generations of bright young students. On the occasion of his ninetieth birthday, a celebration in honor of Professor Ross was held in August 1996 on the campus of the Ohio State University. This three-day gathering involved a mathematics conference[1] with six invited speakers giving hour lectures, and twelve other scientists discussing their work in half-hour talks. The celebration also served as a reunion for many alumni of the Ross Summer Program. The Ross Program is an intensive eight-week session in mathematics for talented high school students. Professor Ross started the program in 1957 and has directed it every summer since then, teaching the basic number theory class every morning during the program. In those thirty-nine years nearly 2,000 young students have participated in his program.

Arnold Ephraim Ross was born in Chicago on August 24, 1906, the son of Jewish emigrants from Ukraine. In 1909 he traveled with his mother to visit relatives in Odessa. They remained in Odessa for several years, unable to return to the U.S. during the turbulent times of the First World War and the Russian revolution. In his teenage years Ross was a talented mathematics student who benefited greatly from association with the charismatic teacher S. O. Shatunovsky. As Ross writes in [9]: "Material privation of the year of famine was made easier to bear through the excitement of our mathematical adventure."

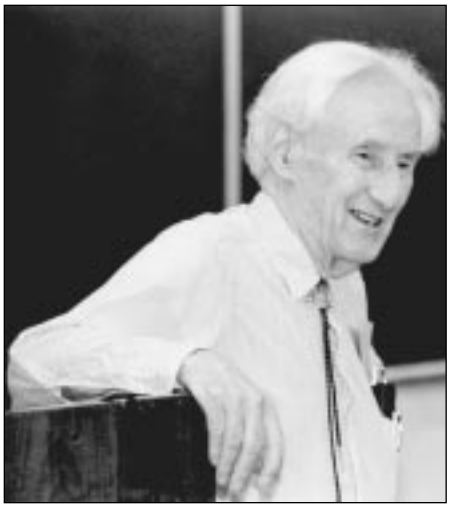
In 1921, after many efforts, Ross obtained permission to leave the USSR. He returned to Chicago, studied English, and entered the University of Chicago. It was here that Ross developed his successful teaching style, greatly inspired by his advisor, Professor E. H. Moore, the American progenitor of "the discovery method" of teaching.[2] Ross was drawn toward number theory, and after graduation he continued his studies as a research assistant to Professor L. E. Dickson, a prominent number theorist. Ross completed his Ph.D. under Dickson in 1931 and married Bea Halley Horicker in the same year. Academic jobs were scarce. After a postdoc at Caltech in 1931–33 working with E. T. Bell, Ross returned to Chicago and helped organize Peoples Junior College, an experimental cooperative venture. In 1935 he became an assistant professor at St. Louis University and remained there for nearly eleven years. During the war years Ross worked for the U.S. Navy as a research mathematician. In 1946 Ross was hired as the head of the mathematics department at the University of Notre Dame, where he remained until moving to the Ohio State University in 1963. Ross continued as the chairman of the Ohio State Department of Mathematics until his mandatory retirement in 1976. During his thirty years of

Daniel B. Shapiro is in the Department of Mathematics at the Ohio State University, Columbus. His e-mail address is shapiro@math.ohio-state.edu.

[1] *Sponsored by the Department of Mathematics and by the Mathematics Research Institute at the Ohio State University.*

[2] *Some background on E. H. Moore appears in [3].*

chairmanship Ross was instrumental in improving the mathematics departments at Notre Dame and at OSU. He also assisted numerous talented Eastern European mathematicians in obtaining visas to work in the United States. Ross has received many honors over the years, including the 1985 MAA Award for Distinguished Service [2] and his election as an AAAS Fellow in 1988. We were saddened by the passing of Bea Ross in 1984. Many thought that the Ross Summer Program would soon end, but his marriage to Madeleine revitalized Arnold and his program.



For many years Ross has been interested in working with very young students (see [9, 10]). He created various honors programs for undergraduates, designed summer programs to stimulate in-service math teachers, set up a "Sunday School" for children, and designed and directed outreach programs for inner-city adults and children in Columbus ([5, 6, and 11]). Of all his efforts, though, the one that has had the most influence over the years is the Ross Summer Program for gifted high school students. Ross started this program in 1957 as an outgrowth of a teacher training program at Notre Dame [4]. His Summer Program grew in size and scope and evolved in many ways in those early years, enriched by the contributions of numerous distinguished mathematicians, including R. P. Bambah, Max Dehn, Kurt Mahler, Thoralf Skolem, Ivo Thomas, Hans Zassenhaus, and many others. The Ross Program moved to Ohio State in the summer of 1964 and has continued there, except for four summers (1975–78) when it moved to the University of Chicago at the invitation of Felix Browder. Around the time of his retirement from OSU in 1976, Ross helped to start similar programs in India, Australia, and West Germany [7]. More recently various alumni of the Ross Program have started summer programs in the same spirit at several institutions, including Boston University, Southwest Texas State University, and the Université du Québec á Montréal. What has made Ross's effort so successful?

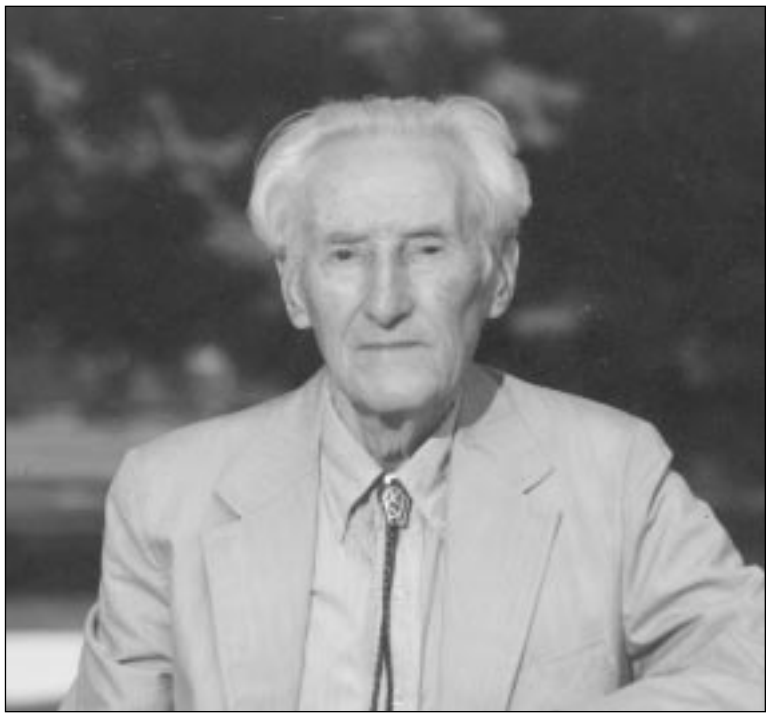
The Ross Program has survived and thrived for nearly forty years for several reasons: (1) the recruitment of excellent students, (2) the design of the courses, (3) the encouragement of students to return and then to serve as counselors. I will discuss these points briefly. Further information about the history and design of this program appears in [4, 7, 8, 9, and 10].

First, a stimulating and exciting summer course depends on the abilities and efforts of the students. Students are admitted to the Ross Program if they exhibit some mathematical maturity by doing well on the set of mathematics problems included with the application to the program or by otherwise showing a great eagerness to learn. The program is not widely advertised, with recruitment depending mainly on word of mouth and on personal contacts.

Second, the emphasis in the program is to open opportunities for gifted precollege students while avoiding a narrowing of their outlook. Ross made an ideal choice of subject matter for this purpose: elementary number theory. This topic has interesting problems which are close to the surface but which lead to deeper insights. The eight weeks of the program provide enough time to start from zero knowledge and still get to some interesting topics, including continued fractions, Gaussian integers, and quadratic reciprocity. The goal of the program is not just to teach number theory, or even mathematics, but to provide a stimulating intellectual experience, an "adventure of the mind", stressing the value of abstraction. Participants learn processes that are central to all scientific

thought: they experiment with ideas and make their own conjectures. The aims of the Ross Program are summed up in the often-repeated motto "Think deeply of simple things."

All first-year students take the basic course in number theory. They meet every weekday morning for lectures and three afternoons a week in smaller groups for problem seminars. Daily problem sets stimulate beginning students toward numerical exploration and personal discovery and promote techniques of writing convincing mathematical proofs. These ideas are typified by the problems starting with: "Prove or disprove and salvage if possible." Problem sets are graded every day by the counselors, who live in the dorm with the younger students. Discussions of the problem sets appear in [8] and [9].



The third key feature of the Ross Program is the practice of encouraging successful participants to return for subsequent summers as students and later as counselors. Second-year students usually retake the basic number theory course, solidifying their mastery of the ideas and working with the less-experienced students. Some of the best students return for several summers, becoming the counselors who grade homework papers and exams. Typically, there are 40 to 50 first-year students, 15 more advanced students, and 15 counselors. Various advanced courses are offered for returning students and counselors [9]. For example, this summer three courses were offered: Combinatorics, General Topology, and Representations of Finite Groups. At their own initiative, the counselors also arranged a minicourse on quantum theory. The courses offered in recent years have been Algebraic Number Theory, Knot Theory, Fractal Geometry, Convex Set Theory, and Real and p-Adic Analysis.

Funding for the Ross Program has always been problematic. In the 1960s the National Science Foundation (NSF) funded many summer programs in science education, but their policy was to support students only once, no returning students. Since returning students are a central part of the Ross Program, extra funds had to be found to support them. The NSF funding has vanished and reappeared several times over the years, and we often heard the phrase "This is the last year of the program." Even so, Ross has been able to obtain funding to keep the program alive using various means of support, including gifts from friends of the program, small scholarship grants from industry, a grant from the National Security Agency, and continued support from the Ohio State University and the Department of Mathematics.

The Arnold Ross Conference held in August was a genuine tribute to his outstanding efforts on behalf of mathematics and science education and to his lasting positive influence on many generations of scientists. All the lecturers are alumni of the Ross Program or have a close personal connection with Ross. David Harbater and Jeff Kahn were the main lecturers on the first day of the conference (August 9). Harbater (University of Pennsylvania) spoke on "Symmetries of fields and covers". He described analogies between covering spaces in topology and Galois extensions in field theory, focusing on the question of which groups can be realized as such symmetry groups. Kahn (Rutgers University) lectured on "Theory of finite sets, some linear algebra and a geometric application". He discussed the problem of Borsuk on whether a subset of R^d with diameter 1 can be expressed as a union of $d+1$ subsets each of diameter less than 1.

Thomas Banchoff (Brown University) and Charles Fefferman (Princeton University) delivered the two "Arnold Ross Lectures" on the second day. These are part of the series of Arnold Ross Lectures sponsored by the AMS, as described in [12]. Banchoff began his talk with a

tribute describing how Ross has been a tremendous positive influence in Banchoff's life.[3] He noted that one of Ross's great talents is to recognize what various people are good at and to encourage their development in that direction. Banchoff then presented a multimedia lecture on "Higher dimensional geometry and the Internet", describing strides in computer graphics in recent decades. He emphasized the point that computers can help people to visualize what they already know but that the machinery cannot substitute for live teachers. Fefferman began his talk by remarking on the importance of Ross's accomplishments with his program. Fefferman then lectured on "Turbulence", with such a clear discussion of the Navier-Stokes equation and the Euler equation that most of the high school students in the audience gained some understanding of what is going on in that subject.

The final day of the conference began with lectures by Karl Rubin[4] and Alice Silverberg, both at the Ohio State University. Rubin spoke on "The arithmetic of elliptic curves", describing the group structure on the curve E and how it can be used to find rational points and how the rank of the group $E(Q)$ has a conjectural connection to the order of vanishing of a certain L-function $L(E, s)$ at $s = 1$. Silverberg lectured on "Points of finite order on abelian varieties", describing an abelian variety as a higher-dimensional analog of an elliptic curve. She defined when an abelian variety A is semistable and when it is modular and described several results relating these ideas to properties of the points of finite order in A.

In addition to the six invited lectures, conference activities included twelve half-hour lectures and a banquet. One striking aspect of all the lectures is how accessible they were. Inspired by Professor Ross, the lecturers were aware of the composition of the audience and strove to explain their ideas in a way that bright high school students could understand. Other nonexperts in the audience also appreciated these efforts. The Ninetieth Birthday Conference closed with a renewed appreciation by attendees that a huge amount of mathematics and science can be accomplished by "thinking deeply of simple things" in the style of Arnold Ross.

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[3] *See Banchoff's anecdote about Ross in [1].*

[4] *Rubin has constructed the Ross Program home page. Visit* `http://www.math.ohio-state.edu/~rubin/rossprogram/`.