Harvard Educational Review

Volume 69 Number 4 Winter 1999 ISSN 0017-8055

In His Prime: Dirk Jan Struik Reflects on 103 Years of Mathematical and Politic Activities[1]

ARTHUR B. POWELL
Rutgers University–Newark

abpowell@andromeda.rutgers.edu

MARILYN FRANKENSTEIN
University of Massachusetts Boston, College of Public and Community Service

marilyn.frankenstein@umb.edu

Abstract

In this interview, Arthur B. Powell and Marilyn Frankenstein elicit a perspective on the importance of teacher-student relationships for academic, social, and political learning through the voice of mathematician and Massachusetts Institute of Technology Professor Emeritus Dirk Jan Struik, who was 103 years old at the time of the interview. Through his words, we gain insights into European schooling from the end of the 1800s to the present, and into the intellectual and political life in the early part of this century. We learn about the impact of McCarthyism on intellectual freedom in the United States and about the importance of ethnomathematics from a man who not only lived through these times, but who also became an active political intellectual during this period of history. In this context, Struik discusses his intellectual, academic, and political trajectories, relating stories of his life as a student, teacher, mentor, colleague, professor, political activist, and Marxist intellectual. (p. 416-446)

When we arrived on April 16, 1998, at his two-story home in Belmont, Massachusetts, Dirk Jan Struik was on the telephone with the *Boston Globe*, requesting that the delivery service leave his newspaper closer to his door. This, perhaps, is one of few concessions Dirk makes to his 103 years. On his study table was a recent issue of the progressive weekly, *The Nation*; on a nearby bench was a copy of *Rulers of America: A Study of Finance Capital* (Rochester, 1936); and on a small, cluttered table adjacent to his reading chair, the latest issue of a Dutch mathematics journal lay among other periodicals and books in various languages. In the center of another table, also filled with books and papers, was a spherical crystal bowl etched with the equation M + M + M = 100. On a wall opposite his reading chair, Dirk pointed out to us a portrait of his wife, Ruth Ramler Struik, to whom he was married for seventy years, until her death in 1993 at the age of ninety-nine. Ruth was also a mathematician, as is Rebekka, one of their three daughters.

While the videographer began test shots, Dirk described his daily exercise routine. We remembered that, five years earlier, Mozambican mathematician Paulus Gerdes, after staying overnight at Dirk's home, described to us in amazement how Dirk vigorously exercised each morning. Apparently this attention to his physical health allows him to prepare his daily meals and to negotiate a steep flight of stairs. As we further prepared the interview setting, we found ourselves moving yet another coffee table spilling over with stacks of books and letters in different languages that had been sent to him by people from different corners of the world. We were impressed at the wide range of intellectual issues that he keeps abreast of and imagined that the life of his mind contributes to his longevity.

Dirk is also an experienced interviewee. The same year we interviewed him, a Dutch television crew camped out in his home for a week, interviewing and filming. Yet another film crew, from the Brecht Forum of the Marxist School in New York City, interviewed him for a ten-minute spot concerning his recollections of the trial and execution of Sacco and Vanzetti. A skillful interviewee who recognizes the importance of voicing his worldview, he spoke extensively with us with rather little prompting, filling in details as needed. We hoped not for a linear story, which has been told (Rowe, 1994), but rather one that would unfold in layers, revealing how Dirk himself connects the various strands of his life.

* * * * *

Dirk Jan Struik, Professor Emeritus at the Massachusetts Institute of Technology (MIT), is an internationally acclaimed mathematician and historian of mathematics and science. His doctoral dissertation, completed in 1922, concerned applications of tensor methods to Riemannian manifolds.[2] Translated into more than seventeen languages, his classic book, *A Concise History of Mathematics*, was first published in 1948, with the fourth revision appearing in English in 1987. The book "has probably done more to promote interest in and appreciation for the rich diversity of mathematical ideas and cultures than any other single volume on the history of mathematics" (Rowe, 1994, p. 245).

Some of his other activities are perhaps not as well known. Struik was a founding editor in 1936 of the Marxist-oriented journal, *Science and Society*, and is the editor of two books on Marxism (Struik, 1964a, 1971). He is a scholar-activist whose work exemplifies a commitment to uniting theory and practice in the struggle for justice. Internationally, he has influenced scholars from diverse disciplines — mathematicians, philosophers of mathematics and science, and historians of mathematics and science — and has inspired practical activities.

Struik has had a fascinating career motivated by his pitiless intellectual curiosity. Besides his purely

mathematical preoccupations, he has concerned himself with discovering whether and how social and institutional forces influence mathematical research. As Alberts (1994) notes, Struik asserts "that mathematical conceptions can better be understood in conjunction with larger social and intellectual processes" (p. 280). Philosophically, Struik has used the analytical tools of dialectical and historical materialism to examine and understand the unfolding of mathematical ideas.[3] However, he goes beyond assertions and demonstrates that social context interacts with the production of mathematical knowledge. Unlike historians before him, he believes that an understanding of the operative forces within a social context is indispensable for knowing and doing historical work on mathematics. In this way, Struik has reconciled mathematics and politics in shaping a new sociology of mathematics and science and has made significant contributions to the history of these disciplines (Struik, 1942, 1948c, 1964b, 1984a, 1984b, 1986). As Alberts (1994) states, Struik's "numerous contributions to the history of mathematics were largely undertaken as a complement to his own mathematical production, and were only rarely self-reflexive in the sense of touching on the latter" (p. 290).

The influence of Struik's work has not been confined solely to the academy. His research for his book *Yankee Science in the Making* (1948a) may have helped lead to the restoration of several of the sites he studied, including the old manufacturing section of the city of Lowell and some sections of the Middlesex Canal, both in Massachusetts.[4] During the McCarthy Era, Struik abided by his ethical beliefs, refused to "name names," and lectured widely on freedom of speech.

Of particular interest to us as ethnomathematics[5] and criticalmathematics[6] educators is Struik's role as an intellectual involved in social and political movements. His recent works on ethnomathematics include articles in *Monthly Review*, "Multicultural Mathematics and the History of Mathematics" (1995b), and *Technology Review*, "Everybody Counts: Toward a Broader History of Mathematics" (1995c). In the latter article, he outlines why ethnomathematics "counts" in the history of mathematics. In so doing, he not only makes an important intellectual gesture, but also commits a political act. He validates ethnomathematics, a field that is both an academic and a political program that aims to connect mathematics to its origins in culture (including social and productive contexts) and mathematics education to social justice.

For educators, several interesting points emerge from the interview. Some relate to what seem to have been important factors in Struik's intellectual development:

1. teachers teaching more than just their subject
2. in- and out-of-school learning activities
3. the decisive role teachers can play as mentors
4. students feeling welcome in faculty seminars
5. the intellectual stimulation of a diverse group of students and teachers learning in an informal environment

Moreover, we feel it is significant that, from the perspective of more than one hundred years, the energy and liveliness of his teachers remain more salient for Struik than the details of the content of their lectures.

The interview also reveals Struik's struggle to connect his academic and political passions. Early in his

career, he struggled with the question of whether to be a "professional socialist or a socialist professional."[7] Indeed, many academics and educators today still agonize over similar questions. In Struik's words:

> It was a question all young intellectuals in the movement have to face some time or another. Sometimes a party worker brought it up: I remember Metscher asking me why I want to study all that "bourgeois science." The question was not raised, as it is now, in horror at the degradation of science by the industrial-military establishment, yet the relationship between science, war, and unemployment was already felt in socially conscious circles. But despite all this, it was still easy to see science, especially mathematics, as a noble enterprise of great beauty, and my heart was in it. Moreover, I was convinced that professionals had their own part to play in the struggle for social justice, that Marxism was an enterprise with room for all faculties. An additional factor was that, with all respect for the party leadership, I did not relish the prospect of working permanently under it; it was a little too dictatorial. (quoted in Alberts, 1994, p. 288)

Struik's choice was to attempt to combine his mathematics and his Marxism. The result was to reconcile the two into a new discipline, the sociology of mathematics (Struik, 1942, 1986). Further, his persecution during the McCarthy Era led him to become involved in freedom of speech issues. Finally, having contributed significantly to a number of fields, Struik acts on his vast knowledge of mathematics and its history and sociology to make connections with new disciplines such as ethnomathematics.

At the advanced age of 103, Struik is a living example of the possibilities and importance of lifelong learning. In this interview, he demonstrates a tremendous example of the human side of the life of the mind. Readers can follow 103 years of living history related in Struik's voice and can experience the way his mind recalls and constructs connections among his mathematical and political interests and activities. In editing, we tried to maintain the integrity of Struik's voice and to present his story as he told it. He weaves together nonchronologically the early and late circumstances of his life with his educational, political, and professional experiences. Through his words, you will be drawn into the thought processes of an intellectually lucid centenarian and experience his gentle sense of humor. For teachers, particularly instructors of mathematics, we believe that Struik's personal reflections provide historically fascinating and accessible material that mathematics teachers can use to motivate their students.

* * * * *

Dirk, for us, it is a great honor to be here with you to discuss your life, to discuss your contributions to mathematics and to the historiography of mathematics, and to gather from you some commentary about ideas that you have concerning mathematics education and concerning ethnomathematics. But we think the place for us to begin is to explore a bit of your history in Holland, the early years.

Before 1926, I was in Europe. I was born in Rotterdam in 1894, went to school in Rotterdam — grammar school, high school. Then I ended up at Leiden University [in Leiden, Holland]. However, there was an intermission, since the high school I attended had four languages — Dutch, of course, but also French, English, and German — but not Latin and Greek. And at that time —and I'm speaking all the time of the First World War — the entrance into Dutch universities was only possible if you had some knowledge of Latin and Greek. That was later abolished. So, I had to spend a year taking private lessons in Latin and Greek, which seemed to be useless for somebody who wanted to study natural history and exact sciences. But later, the Latin especially came in very handy and still comes in very handy, since I do some history of science, of course.

I entered Leiden University in 1912, studied mathematics and physics, got my doctoral exam in 1916.[8] Afterward, I was for a while a high school teacher in a town north of Amsterdam, in Alkmaar. Then I became an assistant at the Technical University in Delft for seven years, and became the assistant, especially, to the mathematician [Jan Arnoldus] Schouten, who was one of the founders of tensor analysis. There I sat and learned creative mathematics,[9] which led to my dissertation in 1922 on Riemannian geometry (Struik, 1922).

Then in 1924, I got a Rockefeller fellowship. In 1923, I had married and, with my wife, I went first to Rome to study with [Tullio] Levi-Civita[10] and then to Göttingen [in Germany] to study with [Richard] Courant and [David] Hilbert.[11] These activities occurred within the years 1924 and 1926. Then I ended up in the Netherlands, was unemployed, and did not hang myself! I got a position as a teacher in Amsterdam. In getting it, I had met Norbert Wiener, who was a young assistant professor at MIT. He said, "They are looking for fresh talent. Would you like to come to MIT?" I said, "My future is very uncertain. Perhaps I'll like it."[12]

So the upshot of it was that in September of 1926 I got an invitation from Samuel Stratton, the president of MIT. I was at that time teaching in Amsterdam at a lyceum, and I accepted. In December 1926, I went to the United States. I'm still here. That's the short story of my life.

We would like you to bring us back to some earlier events in Holland. First of all, we're interested in knowing a bit about what brought you to mathematics. How did you become interested in pursuing mathematics?

Papa! My father was a grammar school teacher and was interested in mathematics and history. So, I inherited a love for mathematics and history. He also taught us some mathematics and history. I still remember him telling us some interesting mathematical things, such as how you can count up all the numbers from one to 100, 1 + 2 + 3, and so on. And some other such things he taught us, like how to find out if a number can be divided by three or by five or even by seven. Seven is more complicated, of course. Such kinds of things I learned from my father.

I had good schooling; my teachers as a rule were excellent, both in grammar school and in high school. I have nothing but respect for these persons. By the way, they were all men. I never had a woman teacher, which was good, of course, for masculine chauvinism, which remains to the present time, I'm afraid.

From my high school days, I remember with great respect my teachers in Dutch, French, English, German, natural history, and so on. At that time, I was interested not only in mathematics, but also in plants. With one or two of my friends, we went out on weekends with a botany box collecting plants. As I recall, our interest in botany was purely taxonomic. That means, we wanted to know the names of the plants. So, by and by, I got a pretty good knowledge of the flora of the Netherlands. For a while I asked myself, "Shall I go into botany or into mathematics?" But, mathematics won.

That has an interesting history. My high school mechanics teacher, [G. W.] Ten Dam, came to me one day and said, "I'd like to teach you some calculus." The mathematics at that time in the Netherlands involved a lot of interesting things, geometry, algebra, trigonometry, but not the calculus. That came only after World War II. "If you come to me on Saturday afternoons, I'll teach you some calculus." Why he picked me out and not the other eggheads in that school, I don't know up to the present time. But, he picked me out. And

he went and talked to my father, who said yes.

I went regularly to his beautiful bachelor room in Rotterdam. After we had talked about the secrets of the limit and how to integrate the sine and the cosine functions,[13] we talked about other things. He was a man of great culture. I learned a lot about literature that was not taught in high school. For instance, in French, we got only the very inoffensive French writers, Molière and Corneille. Writers such as Zola and Balzac, with so much sexiness, we were kept innocent of them, as far as possible. It wasn't possible, but it was the theory. So through Ten Dam, I learned a lot, since he had a whole collection of Balzac. It was a time when I did nothing but read Balzac. I recommend him to you. He's the greatest writer who ever lived. And as Engels said, you will learn more about early nineteenth-century history from Balzac than from all the history books.

I read my Balzac and read some Zola, who was of course also taboo. In addition, Ten Dam also mentioned his social ideas. He was a member of a socialist party, not of the official Social Democratic Labor Party [Sociaal Democratische Arbeiderspartij], which had representatives in Congress. He was a member of a small but very radical party, a Marxist party, the Social Democratic Party [Sociaal Democratische Partij]. He acquainted me with some of the leaders of that party in Rotterdam. I'm now speaking of the years around 1910 and 1911, when I got my final high school diploma. And that was the beginning of my interest in socialism.[14]

I already had an interest in politics because my father, who as I said was a grammar school teacher, was also politically interested. He was on what was called the liberal side, which was the side of the big capitalists. At election time, he took my brother and me (I had a brother and sister; I was the oldest) with him, and we did work for the elections of that time, writing envelopes, and all these things. I became acquainted with the candidates and all that kind of stuff, so I was already prepared for this kind of political action.

At that time in Rotterdam, there were only 300,000 inhabitants. It has now more than a million. It was a good time to learn something about society as a whole and about the labor movement in particular because the city had a large labor proletariat. It had socialists on the city council. So I also became acquainted with something of the labor movement in Rotterdam. That was my introduction into the socialist movement.

We are wondering whether, at that time, you found it a disjuncture being introduced to the calculus and also to socialism? Was there some conflict for you?

Not a conflict, but they were entirely different things to me at the time. And they were also entirely different to my friend Ten Dam. But eventually, when I became more acquainted with the Marxist literature, I began to ask, are there relationships between these different fields? That has kept me busy until the present time.

After I got my first taste of radical socialism and of Marxism and became acquainted with some of the leaders of the small Social Democratic Party, which had some very strong intellectuals, I became interested in studying Marxism. I began to read the Marxist classics that were available because friends of mine, like Ten Dam, had these books.

At that time, the leading socialist party was the German one, the German Socialist Party, which contained the great Marxist heroes of the time. Engels had already died in 1895, but his pupils were there, Kautsky and Mehring and Bebel. And their books, I read them. Most of them were in German. Of course, I had learned German in high school. One or two of the leading intellectuals of the Social Democratic Party

became known outside of the Netherlands. There was a great poet, a woman poet, Roland Holst, a wonderful poet, great poet, who became an ardent socialist. And there was the astronomer [Anton] Pannekoek, who became, by the way, famous in the 1960s and 1970s during the student upheaval. I remember, but I don't know if you still remember it — but at the time there were the three M's: Marx, Mao, and Marcuse.

At that time, Pannekoek also became popular among certain of the more radical elements in the student movement. At any rate, I became quite acquainted with Pannekoek since we did some mathematical work together, too. He was much older than I. I learned a good deal of Marxist theory from him and others in the Dutch party. Those theories, of course, have always helped me in getting a pretty strong conviction on these things.

In 1911, Ten Dam, who found that a fellow like myself should not just get lost somewhere, wanted me to enter the university. In the highly stratified Dutch society of that time, this was a tremendous step. The son of a grammar school teacher going to the university — that was something very particular. It happened that I had to learn Latin and Greek. So, for a whole year, I studied Latin and Greek in The Hague.[15] In 1912, I did my exam for the university and had done enough Latin and Greek to be admitted into Leiden University.

I entered the university in 1912 and concentrated on mathematics. But that meant also studying physics, mineralogy, astronomy, and chemistry. In the first years, I traveled up and down from Rotterdam by train with a group of other students. We were called the railroad students. And we went to college. After college, we disappeared again, home.

In 1914 I took my bachelor's exam, and in 1916 took my doctoral [exam] (see footnote 8). There, of course, my whole outlook on the world changed considerably, because I got in touch with modern science. In high school, I learned old-fashioned mathematics, mathematics that *is*. At the university, I became acquainted with mathematics and science that is being *made*. And that was a great revelation.

Now, in taking physics classes, I became acquainted with a most interesting and excellent professor of physics, who is one of the great factors in my life, [Paul] Ehrenfest. He still is well known.[16] Ehrenfest was honored to be the successor of [Hendrik Antoon] Lorentz at Leiden. Lorentz had become emeritus and was curator of the Teylers Museum at Haarlem, but he still visited Leiden every week and gave a lecture. So I'd also been a pupil of Lorentz. But Ehrenfest was the student [of Lorentz], and Ehrenfest was a man of tremendous vivacity. When he gave lectures, he danced in front of his class and began to yell. And there was something beautiful. "No, take off, here is the point where that frog jumps into the water." He always spoke German. He was from Vienna and had married a Russian woman, Tatiana. We learned enormously from Ehrenfest. I was lucky to come to Leiden at the time, between 1912 and 1916, including the time of World War I.

In the mathematical faculty, or the philosophical faculty as it was called, there were a number of exceedingly talented students, all of whom eventually became famous. There was Hans Kramers, who became one of the great men on quantum theory. There was Dirk Coster who, with Hans Kramers, became the pupil of Niels Bohr. Dirk Coster was one of the discoverers of element 72 — hafnium — called after Copenhagen, because that's the Latin name of Copenhagen, Hafniat. Jan Burgers,[17] who became an outstanding man in turbulence, was one of the founders of the present popular theory of chaos; Marcel Minnaert, a Belgian, became a leading astronomer. They were all my friends and comrades. So it was a tremendously stimulating effect, both from the teacher and from the students. I was very lucky in that

respect.

And so I learned from Ehrenfest about what science is. Science is not something which is, but science is something which is growing.[18] It's a process. Ehrenfest was in touch with practically all the leading physicists of that time, with [Philip] Frank and [Walther] Nerst and [Max] Abraham[19] and above all was friendly with Albert Einstein. Einstein came to Leiden repeatedly. At that time, he was a professor in Berlin. I'm thinking of the time 1912–1916. The year 1905 was the publication of the special theory of relativity, and around 1913–1914, Einstein was busy with the general theory of relativity.[20] When he visited Leiden, he was full of information on these new theories. He needed Ehrenfest since, though Ehrenfest was a great physicist himself and did some very good creative physics, Ehrenfest could tell the other fellow, Einstein, what his theory really meant. It sounds paradoxical, but you should have seen that little fellow with his little black beard. Like Norbert Wiener, by the way, Ehrenfest was always up in the air or down in the dumps. As a matter of fact, he ended his life with suicide in a moment of dumps. But that was long after he was my teacher. So, he was one of the greatest teachers that Leiden ever had, and was an enormous influence on those that followed him.

So I got my inauguration into what science really is. Now, Ehrenfest was a physicist, but he was also in mathematics. Though I got my mathematics from my mathematics professor, I learned a lot of what you might call the growing [see footnote 9] mathematics from Ehrenfest. That led to my doctoral exam in 1916. I always remember a good thing we did before the doctoral exam, which I can recommend to all students. What did we do on the day before I had my doctoral exam? We went with my friends, the Kramers, we rented a boat and we went canoeing, and then to visit our professor, Ehrenfest, who treated us to strawberries. Now, this is a much better way of preparing yourself for an exam than sitting down at midnight and studying the last information from your textbooks. I don't know if any one of you still has to do an exam. But [if you do,] rent a canoe and eat strawberries.

We should not forget that, at that time, the university in the Netherlands, like the university here, too, was an elite affair. The whole Leiden University at the time that I was there had no more than perhaps one-thousand or twelve-hundred students. In the philosophical faculty,[21] there were one hundred, distributed over the mathematics and the physics and the astronomy. So I had only a few colleagues in mathematics. As a result, our contact with the professors could be very good. However, it wasn't, because what did most professors do and still do? They run into a class, give the lecture, and disappear. Students had to trap them when they wanted to get something from them.

Ehrenfest was different. We had a student colloquium where we met, and he came there also to talk. He and one or two of the other professors and lecturers came too. This proved that they were interested in us. My mathematics teacher taught magnificent mathematics, real and complex functions. But he appeared suddenly in class, with it always written on the blackboard in a marvelous way. He was a master of the blackboard. As the bell rang, the professor was gone. You had to run to the door to catch him if you wanted to ask him a question. That was my main experience. Apart from that, I did a good deal of work on socialism. But that was another thing.

What brought you to your work in tensor analysis? Were you interested in applications, since you had contact with Einstein and with many other physicists?

That came later. I learned some tensors at Leiden because, especially through the influence of Ehrenfest and Einstein, there was great interest in the theory of relativity. I had taken a class in the theory of relativity at

Leiden, but my real productive interest in tensor theory did not come right away. In 1916, I became a doctorandus as it was called, a man who was ready for a dissertation. I became a [high school] teacher in a small town, Alkmaar. Then I got an invitation which changed my whole career. Professor Schouten at the Technical University in Delft was looking for an assistant. Through Ehrenfest, he was told that this fellow Struik might be the right person. And he was. In 1917, I accepted an assistantship at Delft and became Schouten's assistant for seven years, from 1917 to 1924. There I learned my tensors. Schouten was, as were so many mathematicians at that time, deeply interested in the theory of relativity. I was never so much interested in quantum mechanics as in the theory of relativity, because the Delft is vectors and tensor, and so those things had become very familiar. Schouten was working on his form of what we now call tensor analysis. He called it afinial analysis. By and by, he introduced me to it. Over seven years, I became first, of course, the assistant, but later also the friend and collaborator of Schouten. And we published a good deal.[22] It led to my dissertation of 1922 in Riemannian geometry. I could not get my Ph.D. in Delft because I had my doctoral in Leiden. So I found a professor in Leiden, [William] Van Der Woude, a very wonderful geometer who was interested in all that stuff, and he consented to be my thesis advisor. I got my Ph.D. in a beautiful hall at Leiden. The room where you get your Ph.D. has pictures of all dead professors. The philosophical faculty comes all dressed up in cap, gown, kerchief, and so on. I know about it, because later I had to do the same when I was part of the staff in Utrecht.

By the way, Ehrenfest had a seminar that was quite famous. All kinds of learned chaps and ladies came to the seminar. We were admitted as students, too. We learned a good deal from these people, and made their acquaintance. We met people like [Ernest] Rutherford, for instance. I remember the speech by Rutherford in the seminar. But curious enough, I don't remember what he said. I only remember he had on a bulging white shirt. And there was Einstein, and there was Marie Curie. Madame Curie didn't come for Ehrenfest; she came for Kamerling Onnes, who was also one of the great men there, of the cryogenic laboratory, you know, cold things. He was just at that time discovering the superconductors, around 1912.

At any rate, there was a meeting at that time at Leiden of really great teachers, great scientists. And, it seemed, exceedingly clever students. And I count myself in that. But there's one thing: I'm the only survivor. They're all dead, gone. But remembered — I remember.

During your university days, right before you got your doctorate, did you continue your socialist activities?

Oh yes. In August 1915, I became a member of the Social Democratic Party, which in 1918, after the Russian Revolution, became the Communist Party in the Netherlands. I remember August 1915, because I was at a meeting, an open air meeting in Rotterdam, at the occasion of the first anniversary of the war, because the war started in August 1914. And I remember one thing of the beginning of the war, in addition to the horror, of course. People in the Netherlands thought the worst things were done by people on other continents, but in the "highly civilized" Western Europe, they thought there was no chance for war. The pundits said there couldn't be any war, because there was so much connection, because of the cartels between the French and the Germans on coal and fuel. They wouldn't fight each other. But they did. On the first anniversary of the war, I joined the Social Democratic Party because they had warned of war. They brought to our attention this period of imperialism, of war preparations. The liberals and the Social Democrats denied the possibility of war. But there was war, and so I became convinced that the Marxist analysis was correct. I was a member of the Leiden party and did the usual work, mostly among the younger people of the party. It was a very small party and very sectarian. Oh, boy, it was sectarian. And we knew it, you know. We did, by the way. But we were a little too conscious of it.

This was an important phase of your life. It seems you began to integrate your political and social interests with your university activities. You did politics and mathematics concurrently. What else was going on in your life?

First, I must tell you one thing about Einstein. I still remember, it was in 1922, I became engaged to that lady [pointing to a picture of his wife] at the mathematical congress in Germany. I brought her to Leiden, and there we visited Ehrenfest, because Ehrenfest had been at this congress too, and was one of the persons who brought us together. We were at that physics laboratory in Leiden, talking to Ehrenfest. At the staircase, there was Ruth, there was I, there was Ehrenfest. And down came Einstein on the staircase. "Hello," Albert said. And then Ehrenfest said, "Hello, here is the Struik and the Ramler"; "Bless them," Einstein said. And this, I think, is the reason that I was married for seventy years.

I got married in 1923. We lived in Delft, Ruth and I. Ruth said, "You need to get away from Schouten. You have been too long with his tutorship, go and stand on your own feet." The opportunity came in 1924 when a congress was organized by two Delft professors, one of them my friend Burgers, on applied mechanics. In 1924 we were still in the aftermath of the world war, in which, of course, as you know, the Germans were defeated and were ostracized by the others, especially by the French. So there had been international congresses, but the Germans and the Austrians were excluded. Here these two organizers of the congress, Biezeno and Burgers, invited all parties. Only one Frenchman came. But there came plenty of Germans and people out of Turkey and the United States and Italy. At Delft, they had that beautiful congress on applied mechanics, with a number of famous people, including Courant, Levi-Civita from Rome, and others. Ruth, if I may say so, always stayed very pretty and was a favorite with the middle-aged, learned men. They all looked more at my wife than at me.

During the congress, Ruth took the opportunity of inviting all these learned men to a tea at our house. I was only an assistant. I was really astonished about the nerve that she had. But they came. I'm absolutely in awe that they came. Though I had only published one thing (Schouten & Struik, 1918), they knew that I could do some mathematics. Levi-Civita came to me and said, "What is your future?" I said, "I have no future. I don't know what to do." There were so few places open at the universities at that time. "I cannot stay an assistant all my life." He said, "There is an American fellowship at present, just started at Rockefeller. Perhaps I can get you a fellowship." He and Courant applied for a fellowship for me and my wife. I got a fellowship for two years, first to Rome, to study with Levi-Civita, and later to Göttingen in Germany to study especially with Courant. From 1924 to 1926, I stayed abroad, though I went home for a couple of months.

Levi-Civita suggested that I stop working on tensors for a while. In Italy, I became acquainted for the first time with the history of science. That came about in the following way. I went to Italy in the fall of 1924. We stopped for a while in Bologna, where I visited Professor Ettore Bortolotti, a great historian of mathematics who worked on the mass of manuscripts that is preserved about the great algebraists of the sixteenth century, Scipio del Ferro, Tartaglia, Cardano, and so on. You find these in archives in Bologna. Bortolotti wrote and published about them. He made me so interested in them. There's something about Italy; it is so full of history, and I had already my predilection for history through my father. I was entirely taken in by the history of Italy, and especially so mathematics. That is the beginning, really, of my interest in the history of mathematics, which I then followed further in Rome.

Then I worked as I said for Levi-Civita, and we stayed for nine months in Rome. Then we went to Göttingen. Out of Italy came these papers on hydrodynamics. Out of my Göttingen experience came only some papers on the history of mathematics. There was a difference between mathematical life in Rome and

mathematical life in Göttingen. Mathematical life in Rome was very sedate. Every professor worked by himself, and professors were very polite to each other. It was always the question, if there was a little meeting at the house, a party, who will precede each other when you pass through the door. "After you." "After you, sir." Of course, the lady goes first. Then ancient professors, the senior professors before the junior professors, then the lecturers — that kind of stuff.

Göttingen is a beehive. It was a beehive, still is. At that time, this great mathematician, [Felix] Klein, had just died. But Hilbert was the great man. It was Hilbert and [Gustav] Herglotz and [Felix] Bernstein, the statistician and set theory man, and Emmy Noether, and several others, assistants, an endless number of students passing through or staying there, and not only students but famous mathematicians, going and visiting Göttingen. When in Rome, you had all your historical stuff. In Göttingen, you only could do mathematics. I was there in that beehive of mathematics, especially for Hilbert's classes, which I always remember. He was a very good teacher. He had his own particular, curious idiosyncrasies, of course. For example, he had a famous seminar. When you passed through Göttingen, you were always ultimately invited to give a lecture at Hilbert's seminar. I gave them a lecture on what I did in Rome. Then, after the lecture, Hilbert stood up and gave his judicium, his opinion of it. It could be praising, and it could be devastating. In my case, some of them were praised. Poor Wiener gave a lecture, and he was so nervous. Hilbert was not very friendly and kind to Norbert Wiener. Wiener never forgot that. All lecturers were simply too nervous.

There was a lecture by somebody from Scandinavia. Hilbert listened and said, "Now wait a moment. That theorem you mentioned, that's a beautiful theorem. Indeed, that's a beautiful theorem." He liked to repeat himself. He then continued, "Who has invented that theorem?" The Scandinavian replied, "But Herr Professor, that's your own theorem!" That was Hilbert.

Afterward, I went back to the Netherlands, but I was unemployed and didn't know what to do. For a while, I got a temporary position. In Göttingen I had met Norbert Wiener, who told me that MIT was looking for some new members of its staff in the mathematics department. He asked whether I would like to come. I said, "I have no other plans. There is no room for me in the Netherlands, only as a high school teacher." But I had tasted creative mathematics in Rome and Göttingen, so to become a teacher of mathematics for my life was not particularly attractive. Therefore, I accepted. This was an invitation from the president at MIT, Samuel Stratton, inviting me and asking me how much money I wanted. Wiener told me to ask for $3,000. That was quite a lot of money at the time. My father said, "$3,000, that is much too much. You can't ask for that." But I did, and I got it. I got $3,300. Very soon I became a lecturer. Later I was asked if I would like to stay. I said yes. My wife came over and I became an assistant professor, then an associate, and finally a full professor. In 1960, I became emeritus professor. All at MIT. So, in December 1926 I arrived on these shores and am still here. That's the story.

That's the story of how you came to this point.

How I came into tensors, in differential geometry, and in the history of mathematics, and how I did some work as a communist in the Netherlands, of course. When I was abroad, I had to be more careful. And when I came to the United States, I was a guest first. So I never really joined [the Party]. But I became interested and collaborated with the communists up to the present time.

Earlier in Europe you experienced and described some of the negative aspects of teaching. Could you tell us something about your teaching experiences as a professor at MIT?

What struck me was the high school atmosphere in the undergraduate program at MIT. At Leiden, I had only two exams in four years. You were entirely on your own. You went to college if you wanted to. You didn't go to college if you didn't want to. Here, every two weeks, you had tests, like in high school. I found that very curious, but became acquainted with it.

And then there were professors who took roll calls in class. I found that also curious. I've always refused to take roll calls. If they don't want to listen to me, let them go. But they came to listen to me. Make your lecture so interesting that they come, and not because they want to be on the roll call. Of course, there was also a difference between undergraduate and graduate. In graduate, they are more treated more like an adult. And then, I found colleagues at MIT very pleasant and collegial. There were several who also did work in geometry and tensors.

With whom did you collaborate when you were at MIT?

In the early days, I was considered the messenger of the European fad in tensors and so did a good deal of lecturing on tensors. I also did some work with Wiener in which tensors were involved. There were a few articles I wrote together with Wiener,[23] in which he applied some of my ideas and his ideas on the theory of relativity. Not very important ones, but they exist.

I wrote also one other paper with [Manuel Sandoval] Vallarta, in the physics department. Vallarta was a Mexican who was in the physics department for a couple of years. He was very well acquainted with the literature of physics and was good on cosmic rays. There was a close collaboration between some of us in the mathematics department, Wiener and me and [Philip] Franklin, and people in the physics department, and also in the electron department. MIT was smaller then than now, and we knew each other. So, I wrote one or two papers, small papers, with Vallarta.

Apart from that, I worked by myself at MIT. I still wrote books with Schouten. My two-volume books on the tensor calculus, on differential geometry with Schouten, were published, the first volume in 1935 and the second in 1938.

Was it true that through your acquaintance and collaboration with the Mexican physicist you became interested in helping with the development of the mathematics community in Mexico?

Partly from Vallarta. But that involvement also came through a pupil of mine. In the 1930s, I had a pupil by the name of Alphonso Napoles. He was very good in tensor calculus, and overall. Then he went to Mexico and soon became an outstanding member of the mathematics faculty at the Autonomous University in Mexico City. He became head of the department. Then he invited me to come to Mexico, which I did in 1934, at the time that I had a sabbatical. Included in the invitation was also an invitation by Vallarta, who had returned to Mexico and became a very big shot in the scientific side of the government.

I was in Mexico for six weeks in 1934, which was one of the great experiences of my life. The absolute differences between the Spanish and Indian cultures of Mexico and the Northern European culture of the United States was for me overwhelming. So I never forgot the deep impression I got of Mexico in those days. I was received very friendly. I was one of the very first outside lecturers in Mexico, and my pupils and colleagues showed me around. They showed me the pyramids and all kinds of things, and the colonial monuments and the nature. It was a very grand time. I'll never forget it.

Did you have any reflections on the political climate in Mexico at that time?

Not at that time, because it was just the time that Cardenas became president. Lazaro Cardenas was one of the very few good presidents Mexico had. The Lazaro Cardenas who is now a leader of the Progressive Party is the son of the Cardenas who became president in 1934. He nationalized the oil industry and also had introduced legislation of a social nature. So with him there was a beginning again, a taking up of the progressives and of the revolution of 1912, which had planed down. But there were still plenty of things to remind you of the revolution, burnt haciendas, such kinds of things in the countryside, and people that had participated in the revolution. I always remember going with a friend to a café. There was a group from Italy at the table, the whole section of middle-aged gentlemen with nice Spanish/Mexican beards. They said to me, "Look, there are a group of Caranzistas in the party of Caranza." You know, there were these different factions, Caranza and Maderos and so on. So there were still plenty of memories of the revolution. Cardenas was a highlight, and then it went down again, until the present time. It was never so much down as now. Of course, they have all these lousy presidents, corrupt crooks.

You don't get that same experience if you go there as a tourist, of course. You just go, you buy some silver, and then you undress yourself at the beach at Acapulco. But I had the pleasure of being introduced to Mexico by Mexicans. Napoles was half Indian, half Mestizo. So I was privileged.

One of my most interesting experiences in Mexico had to do with Sergei Eisenstein and a visit I made to a hacienda. Eisenstein was the famous Russian film director. He had come to make a film about the Mexican Revolution. They had brought him to that hacienda out in the country, a hundred miles away from Mexico City. I had a friend who was a journalist and had accompanied Eisenstein in Mexico. My friend took me to the hacienda in Apam where Eisenstein made his film. I remember the curious feeling that I knew what there was in that hacienda because I had seen the film in which Eisenstein had depicted an episode out of the revolution.

But nothing has ever come of that film, because he got in trouble with Upton Sinclair in Hollywood and much of the film was never produced. Out of it, Upton Sinclair made a film, *Sun Over Mexico*, and I've seen that, and the hacienda I went to was in it. But the fight in the film, the Hollywood film, was not about social questions, but a girl, that kind of thing. At any rate, I saw there that hacienda, and that hacienda was typical of some — it was absolutely feudal. I wondered why it still existed after the revolution, because around there they had burned haciendas. I asked the men that they assembled, Why is that hacienda not burned? They said, "This is a hacienda where they cultivate the grape, from which pulche is made, the drink, the pulche. The peons on that hacienda drank too much. They were thus too drunk for the revolution." And so the hacienda was still in existence. At any rate, that's one of my adventures, and I can go on and on. My Mexican adventure, it was unforgettable.

Let's talk more about your teaching experiences at MIT. You also had a relationship with the Samuel Adams School. Could you describe your involvement with that school?

At MIT, I taught a number of courses in calculus and my own special course in tensors. People seemed to like it. There was a time that I also taught probability. It's rather curious, this thing that is so common now — it was not until the 1930s that the interest became strong enough at MIT to have special lectures in it. At any rate, I had some students that were studying with me.

In 1934, I became a nationalized citizen of the United States and with full confidence could participate in the progressive movement here. We had sit-in strikes and a big fight against racism. And racism at that time also included the Jews. There was a great, strong anti-Semitic feeling, especially at the university. I do not

think Harvard had more than three Jews on the staff. One of them was [Harry Austryn] Wolfson, who taught Hebrew. MIT was never very anti-Semitic. We had several Jews on the faculty. Wiener was one of them.

So it was a grand time for radical action. I participated to the best of my extent on the intellectual side of it. We published manifestos and organized organizations to fight racism, to fight Hitlerism, and to work for peace, trying to avoid world war. We were not very successful at that. We fought for social security. If you want peace, we said, then Britain, France, and the United States must collaborate with the Soviet Union. They didn't. Roosevelt was not too bad on that, but the British were absolute reactionaries. Then came the 1940s, the war. I stayed at MIT and taught boys in blue sent to us by the Navy. I have some bitter memories of getting up at six in the winter, because these boys had to be taught at 8 o'clock in the morning. That was a great sacrifice, and it was for the war effort to get up at six.

I did some more for the war effort. From time to time, every two weeks, I'd go to Washington to help on the Dutch desk for a while. The Dutch were involved in the war, of course, which ended up with Germany invading the Netherlands. And they wanted information on the conditions in Holland, and I made reports. I found it was my contribution to the war effort. I stayed overnight on weekends in Washington and learned a little bit about what's going on in Washington. One of my experiences was that many of the great decisions in statesmanship in Washington are made at parties under the heavy influence of liquor. I think it's still the same.

That was during the war. After the war, there came the time of the persecutions. During the war, there was a great collaboration between people from the Left, as I was, and the liberals. That led to the foundation of a number of progressive schools.[24] The example was the Jefferson School in New York; it was under communist leadership and was very popular. They grew and also had a very successful school in San Francisco. There were schools in Chicago and Cleveland. Then we started the Samuel Adams School, which had a very good existence from 1944 to 1948. Around 1945 and 1946, we had an ever-growing audience of people who volunteered their services as teachers on labor laws, international conditions, and so on. Of course, the talks on politics were anti-Cold War. It was a progressive school. I taught in science, some astronomy I think.

After the war the persecutions began and, consequently, the Samuel Adams School lost its support. People refused to pay for it. There were nasty articles in the papers, and we had to give up in 1948, although there were hundreds of students interested in it. However, it has remained a very, very fond memory. That was a magical school.

In 1949, during the time of McCarthy, I was called before one of those Washington committees.[25] I refused to mention names in the only way that you could refuse to mention names and stay out of jail, which was to use the Fifth Amendment. Therefore, we were called Fifth Amendment communists. The Fifth Amendment is the amendment that allows you to refuse to answer because it might incriminate you. The words in the Fifth Amendment are slightly different, but that was what it amounted to. The Supreme Court had refused arguments based on the Fourth and the First Amendments. Some, like my friend Chandler Davis, went to jail for that, because he used the First Amendment, which I also should have used. That was the correct way. They had no business. But I didn't want to go to jail. I had three daughters in college. I liked my job. They certainly would have fired me from MIT. So, I took the Fifth Amendment.

However, in 1951, I was indicted by the Commonwealth of Massachusetts on three charges, all having to do with trying to overthrow the government, not only of Massachusetts, but also of the whole United States.

That lasted until 1955. MIT suspended me, but kept my salary. I never suffered, really, very much, except from the unpleasant idea that I would go to trial. And God knows, in the poisoned atmosphere of that time, I thought that would happen. But [Vito] Marcantonio, who was at that time our great liberal congressman from New York, heard of my story and was convinced that they'd never convict me.

At any rate, in 1955, it came to an end. The Supreme Court decided that state anti-sedition laws were unconstitutional, and I was indicted under a state anti-sedition law. Steve Nelson, a carpenter and trade unionist in the University of Pennsylvania, was similarly indicted. He was terribly treated, thrown in jail, and so on. His advocate suggested that he plead that the state anti-sedition laws were unconstitutional. The Supreme Court, which at that time had become more liberal than a few years before, accepted that. So state anti-sedition laws were declared unconstitutional. I was indicted under an unconstitutional law, and so that indictment was squashed. Afterward, MIT wanted me to appear before a commission of my peers to find out whether I had violated some law or some freedom of teaching or cardinal law. It was a friendly affair, and nothing happened.

When I got indicted, I found out who my friends were. Old friends very politely told me that they found it better not to have any connection with me. There were, of course, people who stayed with me and became stronger friends than ever, until the present time. Many intellectuals, of course, especially university administrators, showed very poor attitudes. Some universities, as soon as you refused to testify before the Committee and used the Fifth Amendment, they fired you. Various intellectuals stood strong and many fell down by the wayside. One of the old-time liberals that stood out was the man who just died at age ninety-four or so, Henry Steele Commager. He stood out as a light, protesting against all this persecution. He, however, was an exception. A most tragic and despicable example is Marvin Ernst. While chief of the American Civil Liberties Union during the McCarthy Era, he collaborated with McCarthy. For example, the Civil Liberties Union expelled Elizabeth Gurley Flynn, who was one of the founders. This is why I never trust the American Civil Liberties Union, though that is perhaps unjustly so. Nevertheless, I can never forget that.

I also appeared before a local witch-hunting committee. That was difficult, because before the federal committees I had used the Fifth Amendment, but in the meantime, MIT had adopted a statute that you had to answer, otherwise you would be fired. I remember I had to talk with the president of MIT at that time, James Killian, who was friendly to me. And he said, "I'm sorry, but if you try before that committee with the Fifth Amendment, I have to fire you. I don't like that." I said, "You know, go ahead. I think that it won't be so bad."

I went to the committee and talked freely, but no names. I got away with it. Why, I don't know. It was a time, 1955, when McCarthy was already dead. At any rate, I got away with it. I resumed my teaching at MIT for five more years, until 1960, when they emerited me. That was the time of my suspension from MIT. They used my textbook on differential geometry (Struik, 1950), but I myself was not allowed to teach it. God knows what I could have put in differential geometry in the way of subverting the loyalty of my students. And at any rate, I've always said that that time was half Nazi Germany, half *Alice in Wonderland*. The craziest things happened.

Another thing — there was an informer here. His name was Herbert Philbrick. He had been in some Party meetings a couple of times and picked up names of men from the committees. He got satisfaction that quite a number of people got into trouble, got fired, and so on. He also did a job on me. But he got a day devoted to him in Massachusetts in 1951, Philbrick Day, on which there were great speeches. He became the hero of a dinner. That was really *Alice in Wonderland*.

By 1955 it was lessened, and in 1960 it was, in a certain sense, over. However, when I tried to get jobs at other universities that had no age limit, as MIT had, I couldn't get hired. The faculties were only too pleased to have me. I talked to faculties in Texas, in Illinois, and in Ohio. They were glad to have me, but the administrations said, "No!" I found out that I had no future any more as a teacher in universities in the United States. I could have gone to Canada, probably, as did others such as Lee Lorch who were on blacklists here. That was 1960. Even Oberlin, where I was held in high esteem by the staff, didn't want me. I suppose the word got out through the FBI, of course, "Be careful of that fellow. He subverts the students." So, after a time, I got all kinds of requests to teach at other places, at a campus in Puerto Rico in 1962, in Mexico several times, in Costa Rica, a whole year in Utrecht, and so on.

Let's shift into a discussion of the history of mathematics. For instance, the influence of your book, A Concise History of Mathematics.

Well, I told you that I got interested in the history of mathematics in Italy. That remained, but more as a hobby, because I did a lot of tensor calculus at that time. My book on that came out in 1937. Besides my other work, I did the history of mathematics, the history of science, and published some related articles in Rome.[26] When I came back to the Netherlands in 1926, I also did some work on the history of mathematics. When I came to this country, I became acquainted with some of the historians of mathematics, especially [Raymond] Archibald at Brown and David Eugene Smith at Columbia. I became more and more interested in historical ideas. However, my real interest in mathematics and the history of mathematics came when I wrote some articles in the 1930s about [Johann] Kepler as a mathematician, later published in a book on Kepler (Struik, 1931). Then I decided in the late 1940s to do a history of science in New England. I had been reading a book, which I can recommend strongly, by a man called Van Wyck Brooks, called *The Flowering of New England* (1936), which is about literary people in New England in the early nineteenth century, Prescott and Emerson and Thoreau. I found it a beautiful book. I asked myself, was such an interesting story possible about the science of that period? I looked into that and found there were some very brilliant scientists, too, in New England. It turned into a full-fledged study of the science of the early republic, which was published in 1948 (Struik, 1948a). That really started my full interest in the history of mathematics, because in the time of my suspension, I got quite out of touch with my mathematical colleagues. Mathematics had been changing so much that I couldn't keep up. I thought as you got older, your work as a creative mathematician stops more or less. I became more and more interested in the history of science, and that is how *Yankee Science in the Making* came into being.

At that time, I got a request from [Willi] Praeger, a mathematics professor at Brown, who was advisor to a new publishing firm, Dover, in New York, who wanted a history of mathematics. They asked whether I would like to write a short history of mathematics. I said yes. I had given some lectures on that and so had many notes. It didn't take me much time, perhaps half a year, to write *A Concise History of Mathematics*. It came out around 1948 and turned out to be a success from the beginning since there was so little on the topic in English. Of course, there was a popular book by Eric Temple Bell, *Men of Mathematics* (1937), but it was not a real history of mathematics from the beginning to the end. And there was Florian Cajori, who is solid but dry as dust. If you have a sleepless night, take Cajori and begin to read. After two pages, you'll fall asleep.

But the story is there. People began to buy it, and then edition after edition came out. Then the Japanese took the initiative and began to translate it. And it ended up in a great number of translations. The book has been a success to the present time, though there are of course much better and much more liberated histories

of mathematics nowadays in English.[27] So I published around that time, 1948–1950, the *Yankee Science* and *History of Mathematics*. That set my pace going and I've been at it ever since.

Did you find interesting connections between the history of mathematics and Marxism?

Oh, yes. From the very beginning, in Holland, when I was interested in mathematics and became interested in Marxism, I asked myself, is there any relationship? I didn't get very far at that time. But I saw the doorways open, and I found that in the history of mathematics, you can study the influence of society on mathematics, a thing which was denied by many old-timers at that time, and is still being denied by some people. [Jean] Dieudonné, for instance, had some nasty words to say about these people that think there is a connection between mathematics and society. "What's the connection between the theory of numbers and the society?" he wrote, "Of course there isn't one." But I wrote about it in my history of mathematics where I put in some of my thoughts.[28]

And that was one of the reasons why that book became well known and popular with the Japanese, who have always had a large section of intellectuals interested in Marxism. They took my book and translated it, and then came the Chinese and soon the Europeans began to translate it, the Russians and Ukrainians translated it. Many countries in which there was a socialist regime or great interest [translated it] just because of the fact that I had done something which neither Cajori nor Bell nor others had done. Namely, I pointed out that there are certain relationships between well-known mathematics and the social structure, a relationship between the mathematics of the Babylonians and the mathematics of the European Renaissance and the socioeconomic conditions of the period. And that's actually kept me busy until the present time. And there are new aspects to that.

How did you first come in contact with Karl Marx's works on the calculus? You wrote a very interesting article for Science and Society*, "Marx and Mathematics," which we've republished in our book,* Ethnomathematics: Challenging Eurocentrism in Mathematics Education *(Powell & Frankenstein, 1997).*

The man who mentioned that there were Marx's mathematical manuscripts was [Ernest] Kolman, a Russian-Czech engineer mathematician, who, by the way, became a good friend of mine. The congress in London in 1931, on the history of science and technology, became famous because of that lecture by [Boris] Hessen (1933) on Newton, which is so often quoted. In it he pointed out to an amazed British audience that Newton's ideas did not come from Heaven, but were rooted in the mercantilist society of his days.[29] That made such a deep impression on some of the younger people that they never stopped talking about it. People like [John Desmond] Bernal, [Joseph] Needham, Hyman Levy, and so on — five or six people got an introduction into the ideas on the relationship of science and society from that Hessen lecture.[30] Now, Kolman gave a lecture and in that lecture mentioned that there were mathematical manuscripts by Karl Marx. That was the way I found out.

Then soon afterwards, the Russians began to publish in Russian, I believe, some of the manuscripts of Marx on calculus. I got hold of them, I forget how. When I was in Moscow in 1935 or 1934, I went to the Marx-Lenin Institute and asked to see these manuscripts of Marx. The upshot of it was that they promised to send me copies of the Marx manuscripts that hadn't been published. They wanted to keep the publishing rights to themselves. So in due time, around 1940 or so, I got these manuscripts. Then, in one of the early publications of *Science and Society*, I wrote my article (Struik, 1948c) on the mathematical manuscripts of Karl Marx, which was, I believe, the first time that something had been written about that in the English language.[31] After all is said, and I say so, it's still very readable, so that the two of you have taken it over

into your book (Powell & Frankenstein, 1997). Then later the Russians published the full manuscripts.

What's interesting in this area is the idea that one's philosophical and political outlook can influence one's view of mathematics; not only one's view of mathematics, but the actual mathematics that you produce. That's what we found fascinating about your writing and the writing that you did on Karl Marx's contributions. Do you know of other examples where one could point to a different mathematics being produced, say different than mainstream Western, as a result of someone's political or philosophical perspectives?

Yes. The ethnomathematicians are discussing that fact, of course. But it is clear that Chinese mathematics shows very clearly the influence of the structure of Chinese society. The same can be said of the character of Egyptian mathematics. Also, we have the relationship between the mathematics of the Italian Renaissance and the early mercantile capitalist society. If you looked at mathematics of sixteenth-century Italy, where you have the beginning of algebra, and all these books on arithmetic, the perspective is developing that there's always a connection with the flowering mercantile civilization of Italy at that time.

From the twelfth century on, you find in big cities, Genoa, Pisa, Florence, Venice, you find schools, usually private schools, and teachers, in which two types of mathematics are being taught, two types of counting are being taught. The counting on the lines, which is using the abacus, and the counting with a new Saracen notation, which is called the Hindu-Arabic notation. There was considerable opposition to the introduction and the use of the Hindu-Arabic system. I think there was a good deal of prejudice, because it came from the infidels, from the Saracens, and so on. But also because you can so easily cheat with our numerical system. Write a check of $50. With just one stroke of the pen, you make it $59. There was a little opposition against it, in Florence especially,[32] and I wrote an article about it, about the rules that were adopted by the guilds to prevent the use of the Hindu-Arabic system in the thirteenth century. But you can count so much better and easier with the Hindu-Arabic system than on the lines and stones and so on that the Hindu-Arabic system has won. And we only use the abacus here on baby pens. Though they still use it in Russia, Japan, and China. But you can't do any work that requires more than the ordinary addition and multiplication. You can't do any work that needs or needed logarithms on the abacus. Now we don't need logarithms either, because we have computers. Actually, the invention of logarithms by [John] Napier is a result of the introduction of the Hindu-Arabic system. If there hadn't been the Hindu-Arabic system, Napier would never have invented the logarithms.

So it was a great triumph of the Hindu-Arabic system, but it has never been able to replace the sexigesimal system of angle measurement by the decimal system. Our angle measurement is perhaps one of the oldest things in our civilization. It comes from the Sumerians; the great degree is divided into sixty minutes, and a minute into sixty seconds. Everybody accepts it. It's all sexigesimal.

We're interested now in your thoughts about ethnomathematics. Perhaps a place to start is if you would describe, from your perspective, what ethnomathematics is, and how you came to ethnomathematics.

Well, I always had an interest in questioning where mathematics came from. Already, in the first edition of my *A Concise History of Mathematics*, there are a few words about early days of counting. Then, of course, I really got interested in the whole situation when [nearly twenty years ago] I got a letter from a man in Mozambique, Paulus Gerdes. Paulus Gerdes, who is a Dutchman, by the way, said, "I have been reading some of your stuff. Can you send me some material on Marx and mathematics?" And so, I sent him some material and that began a correspondence between us and a friendship.[33]

When I saw what he was doing, I got the idea also that it is a way of understanding the way in which mathematics originated. Above all, that hooked my interest, and I began to read his work on the mathematics inherent in the material culture of Mozambique, such as in the making of baskets and fishing nets. Paulus Gerdes writes a book every three months, so we got a lot of stuff from him.[34] So, I remained interested. Then I found out that there are more people interested and discovered a book by Marcia and Robert Ascher, *Code of the Quipu: A Study in Media, Mathematics and Culture* (1981), about the *quipu,* that shows that the Inca civilization, which had no written scripts, developed a very elaborate type of statistics, mathematics.[35] Curiously enough, Ubiratan D'Ambrosio invited Ruth and me to come to Brazil. I forget the year, but some years ago. We talked about all kinds of things, but not about ethnomathematics. Later I found out that D'Ambrosio coined the term "ethnomathematics" and is considered the intellectual originator of the field.

Then, through the literature on ethnomathematics and at special gatherings, I found out, to my great pleasure and surprise, that ethnomathematics had a revolutionary role in this fight against colonialism, the remnants of colonialism.[36] Here, for the first time, I find mathematics really involved in society and it plays a militant role. So the educational, the anticolonial, and the academic sides all appealed to me in ethnomathematics. It appealed to my sense of rebellion and culture.

Conclusion

When we were finishing, after three hours of interview, Dirk told us why the millennium begins not in 2000 but in 2001; he related how he used to lead walks of the Appalachian Mountain Club around Walden Pond; he quoted Thoreau's epigrams, including "circumstantial evidence is sometimes very clear, as when you find a trout in the milk"; and he told us about his fondness for both Thoreau and Marx and his desire to write an article about the two of them. "They are both under different sides of the progressive movement, but they are both progressive. Marx hated nature. He took his children to a park, but I don't think he even told them the names of trees. On the other hand, Thoreau was not a labor leader. However, they were both under the direct influence of the German philosophy. You can make quite a nice story, but I've never written it. Perhaps I still will, Marx and Thoreau." After the videographers had packed up their equipment and we were leaving, Dirk reminded us not to forget to pick him up after his nap so that he could attend a lecture by Martin Bernal, author of *Black Athena: The Afro-Asiatic Roots of Classical Civilization* (1987), who is the son of his friend, J. D. Bernal, the eminent historian of science, whose famous works include *Science in History* (1971).

Dirk Jan Struik is one of our heroes. He has made groundbreaking contributions to the history and sociology of mathematics, and our own work in ethnomathematics has been greatly enriched by those contributions. He is also an active and political intellectual, exploring new ideas and supporting new fields of knowledge. At 103, he still reads and comments on the work of many scholars. He speaks at conferences, writes articles on the history of mathematics, encourages us in our work, and is writing his autobiography. He is one of our heroes because he is a warm, feisty, funny human being whose involvement in many of the significant political events of our time has kept alive his Marxist ideals as well as his belief that humans can create a just world and maintain a balanced ecology.

After the initial interview, we visited Dirk several times to ask follow-up questions. On one visit, we remarked on how sharp his memory is for so many details, down to the spelling of various names in various languages. He then pointed to the crystal bowl we had noted as we were setting up for the video interview. He said it was given to him in Holland at a celebration of his one hundredth birthday and that the equation

symbolized what was responsible for his stamina and continued intellectual acuity: Marriage, Mathematics, and Marxism.

Later, when we visited him for his 104th birthday, he commented, "I am no longer in my prime." He paused. We held our breath, concerned that this meant he was feeling weary, in decline. Then he smiled broadly, adding, "I won't be in my prime again until I am 107."[37]

References

Alberts, G. (1994). On connecting socialism and mathematics: Dirk Struik, Jan Burgers, and Jan Tibergen, *Historia Mathematica, 21,* 280–305.

Ascher, M., & Ascher, R. (1981). *Code of the Quipu: A study in media, mathematics and culture*. Ann Arbor: University of Michigan.

Ascher, M. (1983). The logical-numerical system of Inca Quipus. *Annals of the History of Computing, 5,* 268–278.

Bell, E. T. (1937). *Men of mathematics*. New York: Simon & Schuster.

Bernal, J. D. (1971). *Science in history*. Cambridge, MA: MIT Press.

Bernal, M. (1987). *Black Athena: The Afro-Asiatic roots of classical civilization*. New Brunswick, NJ: Rutgers University.

Brooks, V. W. (1936). *The flowering of New England, 1815–1865*. New York: E. P. Dutton.

Courant, R., & Hilbert, D. (1953). *Methods of mathematical physics*. New York: Interscience.

D'Ambrosio, U. (1985). *Etnomatemática: Arte ou técnica de explicar e conhecer*. São Paulo: Editora Atica.

D'Ambrosio, U. (1990). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 41-48.

Einstein, A. (1961). *Relativity: The special and general theory* (R. W. Lawson, Trans.). New York: Crown. (Original work published 1916)

Frankenstein, M. (1983). Critical mathematics education: An application of Paulo Freire's epistemology. *Journal of Education, 165,* 315-340.

Frankenstein, M. (1988). Reading the world with math: Goals for a criticalmathematical literacy curriculum. In E. Lee, D. Menkart, & M. Okazawa-Rey (Eds.), *Beyond heroes and holidays: A practical guide to K-12 anti-racist, multicultural education and staff development* (pp. 306–313). Washington, DC: Network of Educators on the Americas.

Gardner, M. (1962). *Relativity for the million*. New York: Pocket Books.

Gerdes, P. (1985a). *Marx demystifies calculus*. Minneapolis: MEP (University of Minnesota).

Gerdes, P. (1985b). Conditions and strategies for emancipatory mathematics education in underdeveloped countries. *For the Learning of Mathematics, 5*(3), 15–20.

Gerdes, P. (1988). On culture, geometrical thinking and mathematics education. *Educational Studies in Mathematics, 19,* 137–162.

Gerdes, P. (Ed.). (1994). *Explorations in ethnomathematics and ethnoscience in Mozambique*. Maputo: Universidade Pedagógica.

Gerdes, P. (1997). Survey of current work on ethnomathematics. In A. B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging eurocentrism in mathematics education* (pp. 331–371). New York: State University of New York.

Gerdes, P. (1999). *Geometry from Africa: Mathematical and educational explorations*. Washington, DC: Mathematical Association of America.

Gillings, R. J. (1982). *Mathematics in the times of the pharaohs*. New York: Dover. (Original work published 1972)

Hogben, L. (1936). *Mathematics for the million*. London: Allen & Unwin.

Hogben, L. (1936/1937). Our social heritage. *Science and Society, 1,* 137–151.

Hessen, B. (1933). The social and economic roots of Newton's *Principia*. In *Science at the cross roads: Papers presented at the International Congress of the History of Science and Technology held in London 1931 by the delegates of the U.S.S.R* . (pp. 151–192). London: Kniga.

Joseph, G. G. (1994). *The crest of the peacock: Non-European roots of mathematics*. London: Penguin.

Katz, V. J. (1993). *A history of mathematics: An introduction*. New York: HarperCollins.

Knijnik, G. (1992). An ethnomathematical approach in mathematical education: A matter of political power. *For the Learning of Mathematics, 13*(3), 23–26.

Knijnik, G. (1996). *Educação matemática: Exclusão e tesistência e legitimidade cultural*. Porto Alegre, Brazil: Artes Médicas Sul.

Martin, B. (1988). Mathematics and social interests. *Search, 19,* 209–214.

Powell, A. B. (1986). Marx, mathematics, and Mozambique. *Science and Nature, 7/8,* 119–123.

Powell, A. B. (1995). Criticalmathematics: Observations on its origins and pedagogical purposes. In Y. M. Pothier (Ed.), *Proceeding of 1995 annual meeting of the Canadian Mathematics Education Study Group* (pp. 103–116). Halifax, NS: Mount Saint Vincent University Press.

Powell, A. B., & Frankenstein, M. (Eds.). (1997). *Ethnomathematics: Challenging eurocentrism in mathematics education*. New York: State University of New York Press.

Reich, K. (1994). *Die Entwicklung des Tensorkalküls. Vom absoluten Differentialkalkül zur*

Relativitätstheorie. Berlin: Birkhäuser Verlag.

Rius. (1976). *Marx for beginners*. New York: Pantheon.

Rochester, A. (1936). *Rulers of America: A study of finance capital*. New York: International.

Rowe, D. E. (1989). Interview with Dirk Jan Struik. *Mathematical Intelligencer, 11*(1), 14–26.

Rowe, D. E. (1994). Dirk Jan Struik and his contributions to the history of mathematics. *Historia Mathematica, 21,* 245-273.

Russell, B. (1959). *The ABC of relativity*. New York: New American Library. (Original work published 1925)

Schouten, J. A., & Struik, D. J. (1918). On the connection between geometry and mechanics in static problems. *Proceedings Koninklijke Akademie van Wetenschappen Amsterdam, 27,* 801–809.

Struik, J. D. (1922). *Grundzüge der mehrdimensionalen Differentialgeometrie in direkter Darstellung* (Doctoral Dissertation, University of Leiden). Berlin: Springer-Verlag.

Struik, J. D. (1925). Paolo di Middleburg e il suo posto nella storia delle sciencze esatte. *Periodico di Matematiche*, *4,* 337–347.

Struik, J. D. (1931). Kepler as a mathematician. In *J. Kepler 1571–1630* (Tercentenary Commemoration, History of Science Society) (pp. 39–57). Baltimore: Williams & Wilkins.

Struik, J. D. (1936/1937a). Concerning mathematics. *Science and Society*, 1, 81–101.

Struik, J. D. (1936/1937b). A reply to Professor Hogben. *Science and Society, 1,* 545–550.

Struik, J. D. (1942). On the sociology of mathematics. *Science and Society, 6,* 58–70.

Struik, J. D. (1948a). *Yankee science in the making*. Boston: Little, Brown.

Struik, J. D. (1948b). *A concise history of mathematics*. New York: Dover.

Struik, J. D. (1948c). Marx and mathematics. *Science and Society, 12,* 118–196.

Struik, J. D. (1950). *Lectures on classical differential geometry*. Cambridge, MA: Addison-Wesley.

Struik, J. D. (Ed.). (1964a). *Economic and philosophic manuscript of 1844 by Karl Marx*. New York: International Publishers.

Struik, J. D. (1964b). The influence of mercantilism on colonial science in America. *Organon (Warsaw), 1,* 157–163.

Struik, J. D. (Ed.). (1971). *Birth of the Communist Manifesto*. New York: International Publishers.

Struik, J. D. (1978). J. A. Schouten and the tensor calculus. *Nieuw Archief voor Wishkunde, 3*(26), 96–107.

Struik, J. D. (1984a). Early colonial science in North America and Mexico, *Quipu, 1,* 25–54.

Struik, J. D. (1984b). Early colonial science in North America and Mexico, *Quipu, 2,* 323–325.

Struik, J. D. (1986). The sociology of mathematics revisited. *Science and Society, 50,* 280–299.

Struik, J. D. (1989). Schouten, Levi-Civita, and the emergence of tensor calculus. In D. E. Rowe & J. McCleary (Eds.), *The history of modern mathematics*. Boston: Academic Press.

Struik, J. D. (1995a). Reviews. *Historia Mathematica, 22,* 323–330.

Struik, J. D. (1995b). Multicultural mathematics and the history of mathematics. *Monthly Review, 46*(10), 28–33.

Struik, J. D. (1995c). Everybody counts: Toward a broader history of mathematics. *Technology Review, 98*(5), 36–42, 44.

Wiener, N., & Struik, D. J. (1927). Quantum theory and gravitational relativity. *Nature, 118,* 852–854.

Notes

1. The authors gratefully acknowledge the critical assistance of Lee Lorch, Rebekka Struik, John Manuel Francisco, and Oshon Temple; the financial assistance of the University of Massachusetts Boston and Rutgers University–Newark; the intellectual encouragement of José Segarra; and the time, patience, and humor of Dirk Jan Struik.

2. Struik has done considerable work with the mathematical ideas of tensor calculus — an extension of vector analysis — Riemannian manifolds, differential geometry, and absolute differential calculus. To appreciate these ideas, one needs a background in advanced mathematics. Interested readers might start with Struik's review (1995a) of Karin Reich's (1994) history of tensor calculus or read his own account of the emergence of tensor calculus (1989).

3. Dialectical and historical materialism has a vast and rich literature, which is impossible to describe adequately in the given space. However, in brief, one could consider dialectics as a philosophical view that considers all matters and states of affairs as processes of perpetual change and development as the resolution of contradictory forces. The philosophical ideas of materialism hold matter as primary over consciousness (thought). Marx and Engels formulated the philosophy of dialectical materialism as a vehicle for understanding history by analyzing the tensions among opposing social, economic, and political forces. This was in opposition to an idealist interpretation of history that focuses on nonmaterialist phenomena such as religion (Rius, 1976). These philosophical ideas play a fundamental role in Struik's understanding and interpretation of the historical development of scientific and mathematical ideas (see, for example, Struik, 1948a, 1948b).

4. These sites are important to the history of manufacturing machines and other technological inventions in the United States.

5. Ethnomathematics is a new field of inquiry that lies at the crossroads of mathematics, mathematics education, history, anthropology, cognitive and developmental psychology, feminist studies, and studies of Asia, Africa, and the Americas. The intellectual author of the field is Ubiratan D'Ambrosio, a Brazilian

mathematician and philosopher of mathematics education, who defines ethnomathematics as

> the mathematics which is practiced among identifiable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes, and so on. Its identity depends largely on focuses of interest, on motivation, and on certain codes and jargons which do not belong to the realm of academic mathematics. We may go even further in this concept of ethnomathematics to include, for example, much of the mathematics which is currently practiced by engineers, mainly calculus, which does not respond to the concept of rigor and formalism developed in academic courses of calculus. (D'Ambrosio, 1985, p. 45)

Ethnomathematics challenges the particular ways in which Eurocentrism permeates mathematics education: that the "academic" mathematics taught in schools worldwide was created solely by European males and diffused to the periphery; that mathematical knowledge exists outside of and unaffected by culture; and that only a narrow part of human activity is mathematical and, moreover, worthy of serious contemplation as "legitimate" mathematics. For further elaboration, see D'Ambrosio (1990) and Powell and Frankenstein (1997). For information about the International Study Group on Ethnomathematics and its newsletter, contact Gloria Gilmer, 9155 North 70th Street, Milwaukee, WI 53223.

6. Broadly speaking, criticalmathematics defines a pedagogical perspective that connects education in mathematics with critical analyses of social, economic, cultural, and political issues and with movements for social change. Criticalmathematics educators teach for understanding rather than memorization, start with the mathematical knowledge of students, and engage students to reflect critically on both the substance and process of their learning. In agreement with ethnomathematics, this perspective counters Eurocentric historiography of mathematics and considers the interaction of culture and mathematical knowledge. Moreover, criticalmathematics attends to the dynamics of power in society to understand the effects of racism, sexism, ageism, heterosexism, monopoly capitalism, imperialism, and other alienating, totalitarian institutional structures and attitudes. Finally, criticalmathematics educators attempt to develop a commitment to build more just structures and attitudes and the personal and collective empowerment needed to engage these tasks. For an elaboration on these ideas and the history of the Criticalmathematics Educators Group, see Frankenstein (1983, 1988) and Powell (1995). For information on the group and its newsletter, write to Marilyn Frankenstein, College of Public and Community Service, University of Massachusetts Boston, Boston, MA 02125.

7. For an analysis of how Struik and two other Dutch mathematicians wrestled with connecting socialism and mathematics, see Alberts (1994).

8. At that time, the doctoral process in Leiden involved students in two years of study after their bachelor's degree. Then students took a doctoral examination before writing their thesis.

9. By *creative mathematics*, Struik refers here to a new stage in his mathematics education. Through most of his time at Leiden, there was only one mathematics professor, William Van Der Woude. Consequently, Struik had to learn a good deal of the mathematics on his own. Moreover, he found himself not only studying texts from established fields, but also exploring new and recognizably important fields of mathematics such as tensor calculus. Later in the interview, Struik refers to *creative mathematics* as *growing mathematics*.

10. Tullio Levi-Civita was a theoretical and applied mathematician in the fields of differential geometry and problems of astronomy, such as the three-body problem.

11. Richard Courant (1888–1972), a mathematical physicist, worked mainly in mathematical analysis, whereas David Hilbert (1862–1943) was a pure mathematician interested in the applications of mathematics to physics. According to mathematicians, Hilbert was the last mathematician to understand all subfields of mathematics, from algebraic numbers to the foundations of mathematics. His encyclopedic knowledge of mathematics is no longer typical. Mathematics has become so tremendously vast that nowadays mathematicians are knowledgeable about only a small number of subfields. Together, Courant and Hilbert wrote *Methods of Mathematical Physics* (1953).

12. Struik's difficult decision to come the United States was made "after pondering the possibility of working on a scientific project in the [then] Soviet Union" (Alberts, 1994, p. 290).

13. These are central ideas to differential and integral calculus. Most first-year calculus books address the ideas of limit and the integration of trigonometric functions.

14. Ten Dam's political action and teachings were pivotal for Struik. He, too, became quite an active member of the Sociaal Democratische Partij, the radical left wing of the Dutch socialist movement, and prominent in its youth organization (Alberts, 1994, p. 284). After the Bolshevik Revolution in Russia, the party transformed itself into the Communistische Partij Nederland, for which, under the pseudonym O. Verborg, Struik wrote booklets on historical and dialectical materialism in 1934 (Alberts, 1994, pp. 286–290).

15. Besides Ten Dam, other teachers considered Struik clever and identified him as "university material." However, Ten Dam was financially instrumental; he paid for Struik's year of pre-university study in The Hague. This special school served the upwardly mobile sector of the middle class. It enabled students to take a supplementary examination in Greek and Latin to gain "access to the universities, which we otherwise reserved for Gymnasium pupils" (Alberts, 1994, p. 281). Struik's father later repaid Ten Dam.

16. Paul Ehrenfest (1880–1933), who was born in Vienna and studied in St. Petersburg and Göttingen, was a theoretical physicist. With his wife, Tatiana, he wrote a well-received book on statistical mechanics. In 1912, he became a professor of mathematical physics at Leiden. Known as a great teacher, he was acquainted with all the great physicists of his day. He could tell Einstein what Einstein really meant. Struik's face lit up when he described Ehrenfest as "one of the greatest teachers that I ever had. He made science a living thing. All the science I had learned before was static. Ehrenfest showed me how science is a living and growing field."

17. Jan M. Burgers (1895–1981) also grappled with combining mathematics and politics. According to Alberts (1994), he "stimulated the awareness of social responsibility among scientists" (p. 301).

18. Elsewhere (Rowe, 1989), Struik explains that "the way [Ehrenfest] taught statistical mechanics and electromagnetic theory, you got the feeling of a growing science that emerged out of conflict and debate" (p. 15). Plausibly, Ehrenfest's pedagogy contributed to Struik's early insights in a dialectics of mathematics and science.

19. Max Abraham (1875–1922) and Philip Frank (1884–n.d.) were physicists. Frank was also interested in the philosophy of physics and was a teacher of Struik's wife. Walther Nerst was a recipient of a Nobel Prize in Chemistry.

20. See Einstein (1916/1961) for his popular account of his special and general theory of relativity. For two

popular accounts, see Russell (1925/1959) and Gardner (1962).

21. In many European universities, a faculty is an administrative unit, consisting of disciplinarily related departments, similar to a school or division in U.S. universities, and does not to refer to professors.

22. See Struik (1978, 1989) for two accounts of Schouten's work. Also, see Rowe (1994) for an extensive bibliography of technical papers that Schouten and Struik wrote together.

23. See Wiener and Struik's (1927) article in *Nature*. Also, see Rowe (1994) for citations of their technical papers.

24. In the mid-1940s, Leftist and liberal activists in schools, offices, and factories felt the need to organize centers that could promote progressive and militant citizenship among adult workers. These activists recognized that public schools and colleges did not develop in students an interest in trade unions and left-wing political parties.

25. During this time in the 1950s, other mathematicians were persecuted by the infamous House Un-American Activities Committee, including Chandler Davis and Lee Lorch.

26. See Struik (1925).

27. In a subsequent conversation, Struik indicated some current histories of mathematics that treat the contributions of non-European peoples more extensively. See, for example, Gillings (1972/1982), Katz (1993), and Joseph (1994).

28. For a discussion of the ways in which mathematical knowledge is not neutral, but rather shaped by cultural influences, see Martin (1988).

29. Several sources generated problems posed by the needs of the British mercantile economy of the seventeenth century, including mining, hydrostatics, ballistics, and navigation.

30. J. D. Bernal, J. Needham, Hyman Levy, and other historians of science and mathematics were in the British Social Relations in Science Movement. Struik engaged in a heated exchange of views on "the pertinence of a Hegelian dialectics for a materialist explanation of the cultural history of mathematics" with one member of this movement, Lancelot Hogben, author of the popular book, *Mathematics for the Million* (1936); see also Struik (1936/1937a; 1936/1937b), and Hogben (1936/1937).

31. Struik's 1948 work on Marx's manuscript on the calculus not only introduced it to an English-reading audience, but also, in recent times, helped to inspire a calculus project in Mozambique (see Gerdes, 1985a; Powell, 1986).

32. The opposition was concentrated in Florence since it was the seat of the great banking houses. For Struik's account, see Struik (1948b).

33. Among other important consequences, this correspondence provided information and documents for Gerdes's 1985 book on Marx and the calculus.

34. Gerdes and his team have contributed pathbreaking work to the field of ethnomathematics. See, for instance, Gerdes (1985b, 1988, 1994, 1999). For a comprehensive survey and analysis of research in

ethnomathematics, see Gerdes (1997).

35. The Inca *quipu* is a sophisticated system for recording numbers. It looks like a knotted macramé necklace. As Ascher (1983) describes, "The colors of the cords, the way the cords are connected together, the relative placement of the cords, the spaces between the cords, the knots on the individual cords, and the relative placement of the knots are all part of the logical-numerical recording" (p. 269) of the quipu that can communicate complicated records, such as data in multi-layered matrix charts. Furthermore, the Spanish who wrote about the Incas claimed that the messages encoded on quipus, in addition to numerical data, "were as varied as ballads, peace negotiations, laws, and state history" (p. 269). As Dirk remarked, the Incas had no written script; the quipu challenges the ways in which we think of that form of communication (writing).

The Incas kept track of the vast territory under their control through the messages encoded in the quipu about "details of resources such as items in storehouses that were needed or available, taxes owed or collected, census information, the output of mines, or the composition of work forces" (p. 269). To transport goods and information, the Incas built an extensive road system. Runners used these roads with quipus tied around their waists to deliver data across long distances. The quipu developed in an ideal way for the material needs of Incan civilization. It was portable, compact, clear, and not likely to be destroyed along a strenuous journey.

The Inca civilization of three to five million people existed from about 1400 to 1560 A.D. in what today is Peru and parts of Ecuador, Bolivia, Chile, and Argentina. They built extensive road and irrigation systems; imposed a system of taxation involving agricultural products, labor, and cloths, and other finished products; and built storehouses to hold and redistribute agricultural products, as well as to feed the army as it moved. Today, the quipu is not widely known because of European imperialism: "Within 30 years after the Europeans reached the Andes and discovered the Incas, the Inca culture was destroyed" (p. 269).

36. For an example of the activist role of an ethnomathematical approach, see Knijnik (1992, 1996). Gelsa Knijnik, a Brazilian mathematics educator, uses an ethnomathematical approach in work with *Movimento dos Sem-Terra*, an organized movement of landless rural workers in Brazil, to contribute to a protracted process of social change.

37. Here, Struik refers to the mathematical definition of a prime. A prime number is a positive integer that has only one and itself as divisors. The numbers 103 and 107 are both primes, whereas the ones in between are not.


Online Resources


Back to Table of Contents


Related Articles


Send a Letter to the Editors


Back to HER Home Page