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In Memoriam Henk Bos (1940–2024)

Henk Bos in memoriam: with notes from his Nachlass

Historian of mathematics Henk Bos (17 July 1940 Enschede – 12 February 2024 Amsterdam) spent his career at Utrecht University, where he started as an undergraduate student in 1961, obtained his PhD in 1973, and retired as professor in 2005. The International Commission on the History of Mathematics awarded Henk the highest prize in the field — the Kenneth O. May Medal — in 2005. In this article, Viktor Blåsjö, one of the descendants of the research group Henk founded, reflects on Henk's scholarly legacy.

Henk Bos was an expert on 17th-century mathematics. But his influence as a historian went far beyond the particular topics he worked on. His way of doing history was not only technically excellent but also inspirational. What the poets call "to see a world in a grain of sand, and a heaven in a wild flower" captures Henk's ability to make every humble historical case study seem like a perfect distillation of the mathematician's soul. He was a master at uncovering rich layers of conceptual and philosophical depth hidden beneath the surface of concrete mathematical practice. More than accounts of the past, Henk's works are eye-opening meditations on the life and evolution of mathematical ideas.

"Recognition and wonder" was the title Henk chose for his 1987 inaugural address upon being appointed professor at Utrecht University (Figure 1). The slogan is deceptively simple and encapsulates a complex historiographical picture. "Recognition" connotes that history of mathematics is written for mathematicians: we recognise historical mathematicians as our brethren and leverage recognised parallels between past and present mathematics to approach history with momentum and purpose. But good history does not stop with self-affirming stories. The sense of wonder—which Henk could evoke like no other historian—snaps us out of our complacent credence in the familiar and sparks a burning curiosity in questions we did not know existed."

Many a budding mathematician, the present author included, have found themselves, to their surprise and against what they thought were their better judgement, being passionate about history and philosophy after reading Henk Bos.

Henk implored us to be "open to the working of wonder and mindful not to be side-tracked by expectations based on superficial recognition" (E1989a, 9). By his steadfast use of this principle, Henk again and again uncovered remarkably rich and lively subplots in the history of mathematics that had been entirely neglected by generations of historians who lacked Henk's gift to make the unfamiliar seem eminently reasonable. One example is the Huygens manuscript that is reproduced on the title page of Henk's inaugural address (Figure 1) where Huygens expresses the quadrature of a hyperbola in terms of the tractional motion of a small boat in a tub of syrup. "The editors of Huygens' Oeuvres Complètes did not quite know what to do with [these manuscripts]. They decided not to publish them in full" (E1989a, 10). It would be easy indeed to gloss past the sheer weirdness of these manuscripts, and to convince oneself that they could hardly be crucial to the history of mathematics. But, in his masterful study (E1988), Henk makes us see how these seemingly weird investigations are a completely natural culmination of a compelling research program with a sound mathematical and philosophical rationale.

Henk's magnum opus (E2001)—"a brilliant book" [11]—is another case in point. Descartes pioneered analytic geometry, but the interesting question is not who was the first to combine algebra and geometry but what circumstances made such a thing possible at all. "The hindsight of successful algebraic geometry [has led to] a historiography that commonly treats the emergence of analytic geometry in the seventeenth century as merely laudable, rather than as enigmatic. Viewed from the perspective of the late sixteenth century, it was not at all obvious that algebra should be of use as a tool for geometrical analysis." (E2001, 134) Indeed, although analytic geometry was to become the long-term legacy of Descartes's *Géométrie*, the work itself "...can only be understood if it is recognized that the book's primary aim was to provide a general method for geometrical problem solving

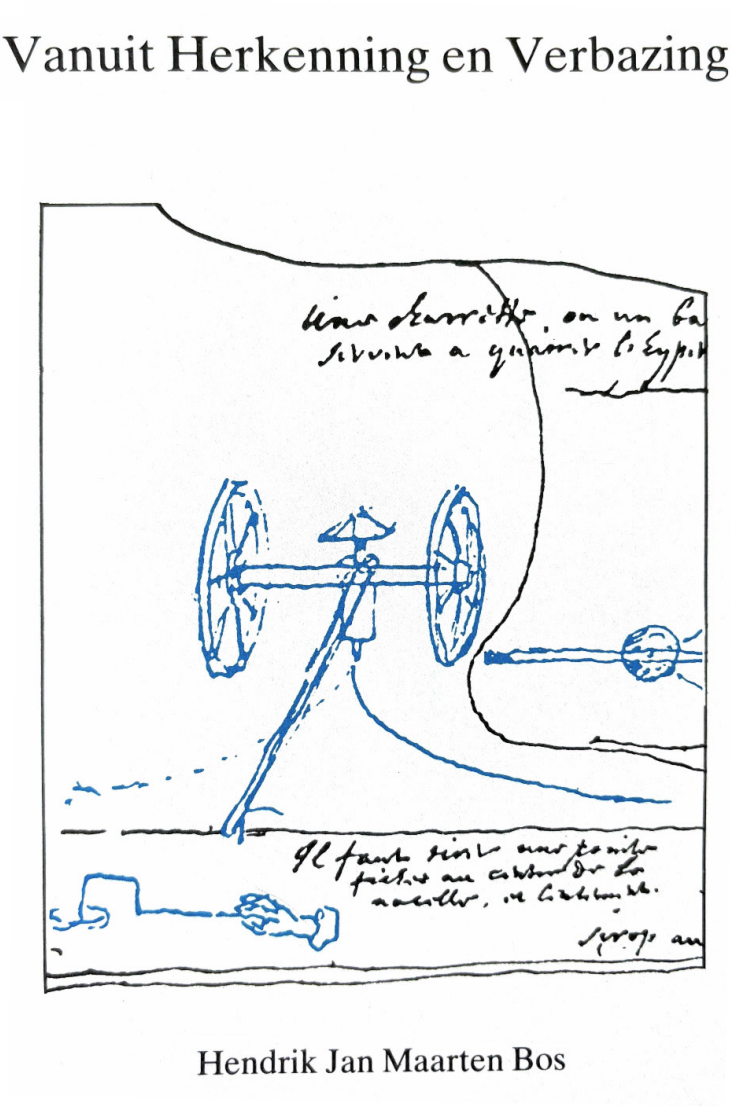

Figure 1 Henk's 1987 inaugural address

and not to establish a technique for studying curves" (E2001, 228).

After Henk's illuminating treatment, readers can only find it "strange that historians of mathematics have never wondered why Descartes, in his Géométrie, keeps to kinematic criteria [for constructing curves], delaying, in this way, the algebraization of geometry" [7]. Indeed, in retrospect it is clear that this should have been a key question, but it took Henk's penetrating eye to make it one.

Figure 2 summarises the leitmotif of Henk's contrarian insights on these matters. (Henk left many unpublished papers and correspondence that are now kept by the Utrecht University Library [12]. I have gone through these documents and I shall include a number of excerpts from them in this article. Otherwise unattributed quotations and images are taken from this collection.)

Henk unveiled the centrality of constructive practices in early modern mathematics, but he was reluctant to synthesise his findings into a grand philosophical narrative. He declared himself "a consumer rather than as a producer of philosophies of mathematics" (E2004b, 64), and professed to merely "touch upon philosophical issues related to construction" in a manner "far from exhaustive" (E2001, 14). Figure 3 hints at one of the philosophical motivations of constructivism, but, like a Rembrandt of math history, Henk skilfully left just enough unsaid to stimulate the reader's own thought.

At least one reviewer wished that "Bos had interspersed the book a little more with generalisations, as first approximations of the complex historical reality" [10, 172]. Henk's reluctance to do so can perhaps be understood in terms of his reflections on the historical work of Hans Freudenthal (who was Henk's PhD advisor, although "I had relatively little contact with him; I was too bashful and he let me find my own way" (E1992c, 107)). Henk found Freudenthal's work "truly historical" in that it went beyond "chronological reports and explanations of mathematical achievements" in favour of highlighting "contemporary context, written with distance and nuance" (E1993c, 54). Nevertheless,

> [Freudenthal] . . . "was not afraid to judge the achievements of earlier mathematicians. . . . This approach certainly brings liveliness and personality to the study of the past, but I feel also that something is missing. For can it really be that the interest in thinking and writing about the past lies primarily in deciding who was the cleverer mathematician and who was more quick to jump on the progressive band wagon? It is not possible to go beyond judgement to explanations or questions?" (E1993c, 55)

Questions rather than judgements is the way of the wonderer. Eschewing judgement may preclude grand syntheses and

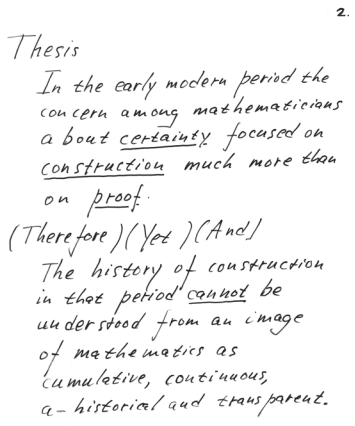

Figure 2 A lecture slide where Henk summarises a key point in his work. From the conference "QED: Demonstration in Historical and Cross-Cultural Context," Max Planck Institute for the History of Science, May 1998. Playing on the title of the conference, Henk provocatively titled his talk "QEF: The primacy of construction over proof in early modern mathematics." This little in-joke encapsulates a major theme of Henk's work: the foundational centrality of constructions, which concern making or doing (quod erat faciendum) rather than proving (demonstrandum).

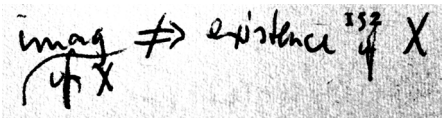

Figure 3 Henk's marginal note on page 152 of his copy of Descartes, Discourse on Method and The Meditations, Penguin Classics, 1968, where Descartes discusses the imagination: "imag[ination] of $x \Rightarrow$ existence of x." Believing oneself able to imagine certain objects is not a sufficient basis for taking them as given in mathematical discourse. For example, Euclid carefully shows how to construct a square in Elements I.46 rather than taking the existence of squares as intuitively evident. This rigorously uncovers the precise assumptions on which the existence of squares rests, including in particular the parallel postulate (indeed, the nonexistence of squares in hyperbolic or spherical geometry speaks to the subtlety of the issue).

argumentative positions, but it invites the reader to a more active role in co-interpreting the curiosities of the past. Surely this is how Henk's work could be so stimulating to so many, and so universally appreciated by historians, mathematicians, and philosophers of all stripes.

Henk's deep explorations of the constructive practices of Descartes and Huygens are examples of his unparalleled mastery of wonder. They also show his creative independence of the prejudices of settled wisdom that can make many steeped in modern science fail to appreciate the richness and marvel of the past. But let's not forget the other half of his slogan: recognition and wonder. Henk spent his entire career in a mathematics department. Henk's wonderful recoveries of forgotten historical thought-worlds were always grounded in recognisable mathematics. As one review put it, Bos (E2001) is "a history of mathematics book that takes both mathematics and history with deep seriousness" [5]—a balance that Henk himself was always keen to preserve. At a history of mathematics summer school in Palermo in 1996, Henk observed in the opening lecture that many historians of mathematics nowadays seem to take "little interest in mathematics," adding: "fine, but I am addicted."

Integrating history and mathematics is advantageous to both fields. In a 1994 Dibner Institute lecture, Henk characterised the contributions of historians, or the "professional rememberers," to the mathematical community in therapeutic terms: "You might say that I happen to specialize in the mathematicians' communal memory; I serve the remembrance of their 'temps perdu'. . . . Suppressing one's past is dangerous."

Conversely, mathematical rigour is essential for quality scholarship in the history of mathematics. In a December 1982 internal university memorandum, Henk presented "Arguments for maintaining history of mathematics as a specialty within the mathematics department." He writes (I translate from Dutch):

> The international mathematical community has good and established channels for publishing historical research .... For historians of mathematics it is of the utmost importance to use these channels; thereby ... one writes for an international, critically interested audience. This situation is a very important precondition

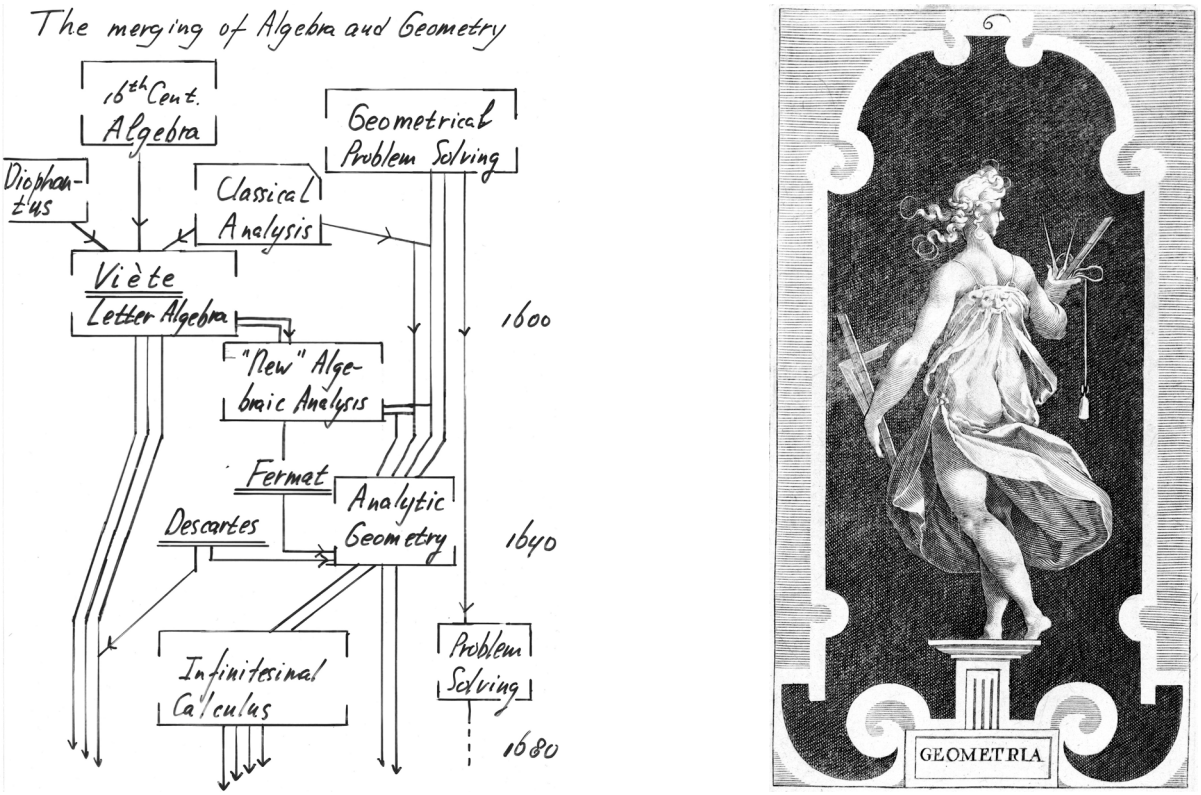

Figure 4 Left: Henk's flowchart of some of the main historical developments that he worked on (lecture slide from a 1991 lecture in Milan). Right: From Lucas Kilian, *Septem Artium Liberalium Icones* (1606). Henk used this image in an unpublished ˚Arhus lecture where he gave a poetic description of these developments: "Here is the Lady Geometry, evidently of high and noble family, because she has an emblem. She is strict in rules (which you don't recognize immediately) and she is beautiful (as you see), as a phoenix rejuvenated by the fire of Renaissance scholars. Then there is the Squire Algebra, a somewhat shady figure of doubtful parentage, a Robin Hood type (or maybe even the Thief of Baghdad) helping merchants and craftsmen with tricks like calling the unknown number x. He has no emblem. The lovers—maybe they did not know yet—were meant for each other but there were many obstacles. The families were of different class and styles. And there were various interfering uncles. Viète was not very supportive: he basically told them that their marriage should be made in heaven, the heaven of abstract quantities above numbers and geometrical figures. In that heaven each would lose his or her identity; not an appealing suggestion for people in love. Nor was uncle Kepler very supportive. He flatly told them that they were so different that a union was impossible. Algebra produces merely tricks and approximations, he said, whereas geometry was about true knowledge. Using algebra was therefore 'base and degraded in geometry'. Finally there was Descartes. He was in favor of the match and became one of the godfathers of the child that at the end of the opera came of the union of algebra and geometry, namely analytic geometry."

for sustaining a tradition of solid historical research.

The critical scrutiny of mathematicians as a quality control on historical scholarship is also reflected in another striking episode in Henk's correspondence. In letters to his mentor Jerry Ravetz from around 1970, Henk complains about a colleague in the field who had written about Dedekind's definition of real numbers without realising or appreciating (as Henk discovered through discussion) that the Cauchy sequence definition of real numbers generalises naturally to any metric space, unlike Dedekind cuts. This was an example, as Henk saw it, of the mathematical weaknesses of historians that threatened, he worried, to "become a danger to the field of history of math."

Another letter in Henk's correspondence that illuminates his relationship with mathematicians is a 1989 referee report that Henk wrote for an article by leading mathematician Vladimir Arnold. The article, titled "The topological proof of the transcendence of Abelian integrals in Newton's Principia," was submitted to *Historia Mathematica*. It was not to appear in this journal; instead Arnold subsequently incorporated this material in his book [1]. Arnold's approach is notoriously anachronistic. As the title of his article indicates, he helps himself to ample amounts of modern mathematics to interpret mathematical developments that predate the formal development of those ideas by hundreds of years. Many historians would balk categorically at such an approach. Typical of this attitude is a review of Arnold's subsequent book lamenting that "unfortunately other mathematicians tend to learn their 'history' from books such as this" [3]. Henk's referee report recognised those issues but also found strengths in the work and recommended revision rather than rejection:

> I got upset about his attitude: typically the famous mathematician who dives in historical study, disregards all earlier literature, ...claims to understand Newton better than Newton himself (and all the experts), and sees modern mathematics everywhere. On the other hand, he did clear up a point about which I've been wondering for a long time (namely: in what way is Newton's statement about ovals near a correct statement — I always distrusted the counterexamples as missing Newton's point) and which apparently was too difficult for mortal historians of mathematics —so we need the immortal mathematicians, bless them.

His criticisms notwithstanding, this still shows Henk being closer and more sympathetic to the mathematicians than many of his fellow historians of mathematics. Another example from Henk's letters is him inviting André Weil to a history of mathematics initiative connected to the 1986 ICM in Berkeley. (In a 1984 letter, Weil declined the invitation, writing that "while I have always been deeply interested in the history of mathematics, . . . at my age, I prefer (egoistically, perhaps) to go on doing my own work in my own way.")

Henk's mathematical orientation can be felt in his works. Henk's PhD dissertation, published as E1974a, is recognised as an "excellent study" by historians [8]. But its organising principle is mathematical-conceptual, not chronological or textual. Indeed, Henk spends a significant part of the work clarifying subtle issues regarding higher-order differentials which, as he shows, the historical actors themselves were confused about.

The late 17th century is where Henk started his historical work, and it remained his natural home. His book on Descartes opens with a conundrum from a 1694 letter by Leibniz—almost half a century after Descartes's death—which Henk explains was his own path to Descartes (E2001, v). What started out as clearing up some preliminaries turned out to be richer than expected. By contrast, Henk's attempts to trace the same issues in the other direction, into the 18th century (E1984a; E1989b), arguably proved rather more barren. With a mathematician's intuition one might have expected the analytic geometry of a philosopher to have been of limited depth and offered few possibilities for novel content-based insights, whereas increasing technical level in the 18th century might be expected to lead to rich developments.

Instead, Descartes's geometry proved profound both mathematically and conceptually, whereas the 18th century tail of the constructivist research program unceremoniously ground to a halt in a dead end. I imagine that Henk had hoped for more mathematical rewards in the 18th-century sources. As an indication of one direction of his interests, in Henk's Nachlass there are detailed notes (written in collaboration with his Utrecht mathematics colleague Gunther Cornelissen) using modern Galois theory to analyse some of Descartes's elusive and sometimes erroneous claims about the behaviour of algebraic equations. But if for example Henk's study E1984a did not pay off along such lines, it nevertheless became something

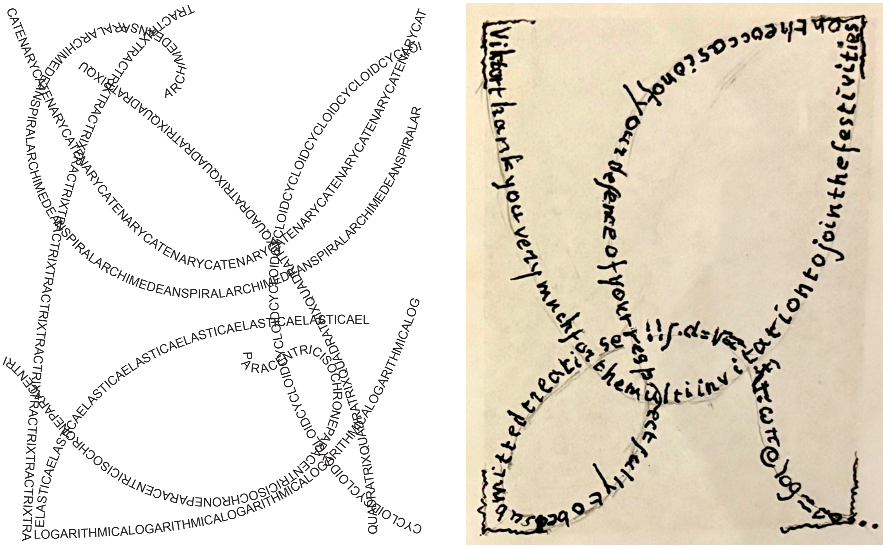

Figure 5 Left is the cover illustration of my dissertation, showing curves that played a key role in the second half of the 17th century, all of which Henk published about. Right is Henk's playful reply to the invitation to my PhD defence.

of a cult classic in the field as a methodological model for how to study a dying and forgotten research program.

In (E1978b, 60), Henk observes "a tension in the relation between Leibniz and Huygens": "Huygens is a cautious man, setting high and strict standards of clarity and relevance for his scientific work, wary of grand schemes" — the latter being Leibniz's stock-in-trade. In terms of this dichotomy of personalities, Henk was surely a Huygens rather than a Leibniz. It is therefore ironic that Henk ended up being best known as an expert on Descartes — another grand schemer. But indeed Henk became a Descartes scholar rather unintentionally. In letters from 1989-90, he laments: "I had a difficult fight with Descartes (my eternal adversary)." "Descartes remains an irritatingly elusive mathematician." At this time Henk realised that he had to devote a full book to Descartes, which had not been his plan: "I've decided to publish separately what first looked as the first part of a book (now to be volume 1)." Sadly, Henk did not have the opportunity to finish his projected "volume 2" — which, if anything, was perhaps the part he was more interested in.

A decade earlier, in a 1980 letter to Ravetz, we find Henk outlining his relation to Descartes in more optimistic terms:

> I think that although he wrote very cryptically, and took pleasure in that, basically Descartes likes it to be understood. That pleasure he has not often had, not from his followers nor from his historians. So I decidedly had the feeling that Descartes began to like me more while I was writing it [E1981a]. And so together we joked about my colleagues who had written on the Géométrie and sometimes got angry about them. They, especially the French ones, are useless. Basically, I have found, because they do not write about what Descartes had in mind, but about the significance of it. And that significance of course exists also if Descartes himself did not see it that way. And so his work becomes primarily great and secondarily a completely ununderstandable mixture of quotations, interpretations, personal philosophies of the historian, statements of the significance and the sort of philosophical sing-song to which the authors take refuge when they do not understand their texts.

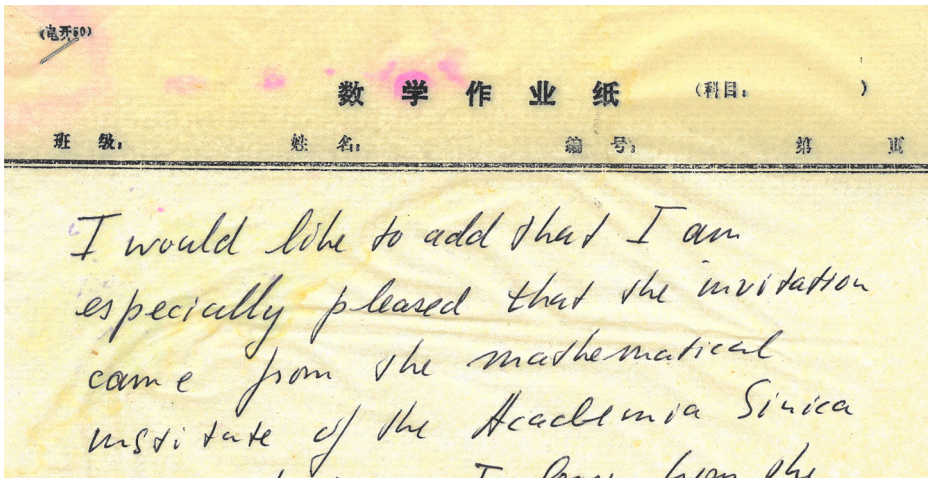

Figure 6 Henk Bos visited China in 1993.

Henk's candor here about the state of the secondary literature is far from the tone of his published writings.

But it is clear to any reader how little use Henk made of secondary sources despite writing on one of the most studied figures in the history of mathematics and philosophy. "Some authors will wonder why Bos did not use or cite their historical inquiries," one reviewer observed [9]. In light of his private remarks, Henk's silence was perhaps best for all parties.

In conclusion, Henk's "interpretations of Cartesian analytic geometry and Leibnizian calculus have provided the starting point for all those who have tried to understand the conceptual developments of mathematics in the crucial period between the Renaissance and the Enlightenment" [6]. But more than that, his way of doing history will be an inspiration and an example for generations to come. In the words of a review of "one of the most interesting and important papers to be published on the history of modern mathematics for some time": "The author [Henk Bos] has brought to light a rich network of mathematical debate. . . . By refusing to view the story through the modern spectacles of algebra and geometry, the author has exposed a fascinating case of mathematicians at work. It is to be hoped others will now go and do likewise." [4]

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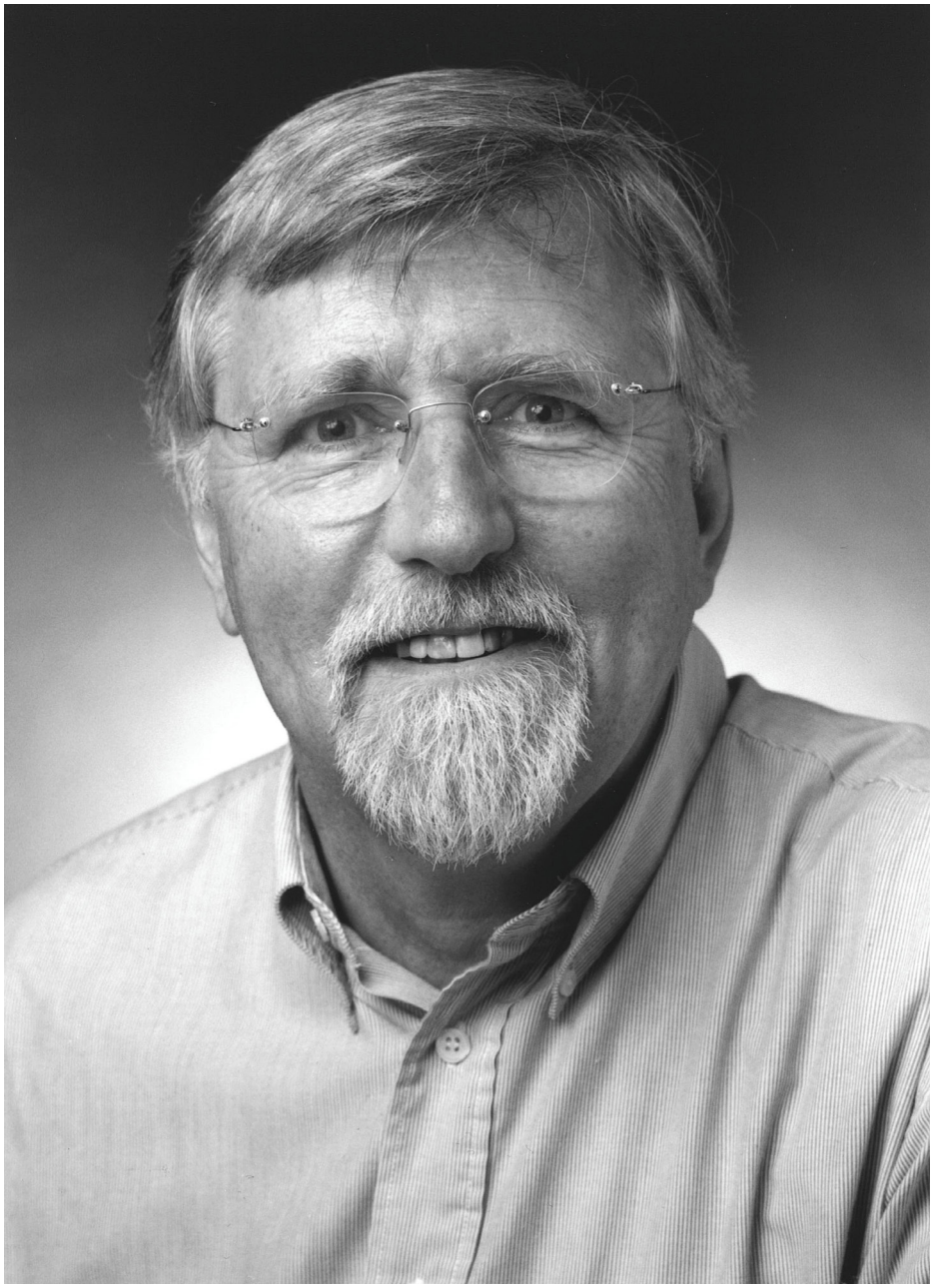

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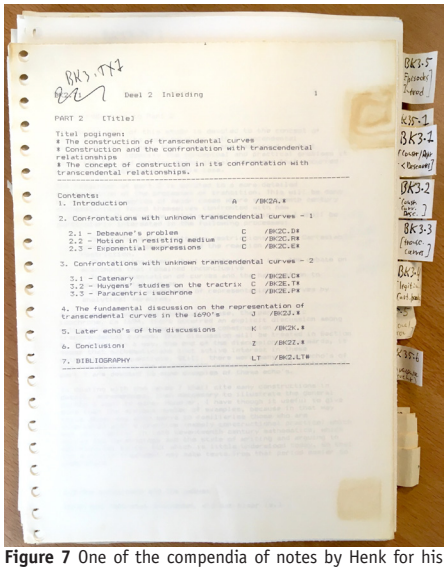

Figure 7 One of the compendia of notes by Henk for his projected but unfinished book that was to extend the issues of his Descartes book E2001 into the second half of the 17th century..

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