3. COURNOT. EXPOSITION DE LA THÉORIE DES CHANCES ET DES PROBABILITÉS (1843).

Le hasard : **la rencontre de deux séries causales indépendantes**

4. POINCARÉ. SCIENCE ET MÉTHODE, CH. IV : LE HASARD, 1908.

"Petites causes, grands effets . . . "

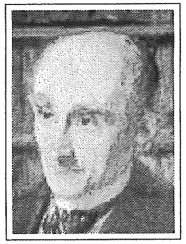
Où l'on peut reparler sans contradiction des "**lois du hasard**" :

Vers la séparation déterminisme—prédictibilité, et le chaos comme paradigme.

5. BERGSON, L'ÉVOLUTION CRÉATRICE. 1907.

Désordre & hasard : un ordre auquel nous ne nous attendions pas ?

La tuile et le passant : "... je trouve un mécanisme là où j'aurais cherché, là où j'aurais dû rencontrer, semble-t-il, une intention; c'est ce que j'exprime en parlant de *hasard*."



The Mathematical School in Catania at the beginning of the 20th Century and its Influence on Didactics

MAMMANA Carmelo, TAZZIOLI Rossana
Università di Catania (Italy)

Abstract

At the beginning of this century, S. CATANIA, M. DE FRANCHIS, M. CIPOLLA, G. MARLETTA and other mathematicians taught at the University of Catania and published textbooks of mathematics at the same time. S. CATANIA wrote textbooks for secondary school, which followed PEANO's formalism in mathematics. His main work "Aritmetica razionale" (1905) simplified a lot PEANO's treatise "Aritmetica generale ed algebra elementare" (1902), which was very difficult to understand. PEANO, PIERI, and BURALI-FORTI appreciated a lot CATANIA's book, but other mathematicians -for example SCORZA and CASTELNUOVO- did not agree on Peanian approach to didactics of mathematics; there was a hard polemic on the subject. CIPOLLA published textbooks on algebra written in a traditional, but rigorous way. Textbooks on geometry were published by DE FRANCHIS and MARLETTA. In his "Geometria elementare" (1901) DE FRANCHIS considered the concepts of point and segment as fundamental, as PEANO had done in his "Principii di geometria logicamente esposti". DE FRANCHIS applied to them the idea of motion and deduced the most important properties of figures. His results were proved by using methods of the theory of transformation groups, developed by Klein and Lie. As DE FRANCHIS did, in his "Trattato di geometria elementare" (1912) MARLETTA posed points and segments at the basis of his theory and then followed VERONESE's approach to geometry.

The content of these textbooks is connected with the researches on foundations of mathematics and on geometry, which were developed in Italy at that time.

1. At the beginning of the twentieth century, the following mathematicians taught at the University of Catania: Giuseppe Zurria, Giuseppe Chizzoni, Vincenzo Mollame, Giovanni Pennacchietti, Giuseppe Lauricella, Mario PIERI and Sebastiano CATANIA. The last-mentioned wrote many textbooks of mathematics for secondary school inspired by the ideas of the Peanian school, which PIERI also belonged to what was the Peanian school, and, what was its impact on didactics?

Giuseppe PEANO (1858-1932), the founder of the so-called Peanian school, studied and taught at the University of Turin; he made fundamental contributions to mathematical logic and in 1891 founded the journal *Rivista di Matematica*, devoted to logic and the foundations of mathematics. In his *Arithmetices principia* (1889a) he stated three primitive concepts (zero, number, and successive of a number) and a group of nine axioms : four axioms describing the symbols N (natural numbers), = (equality) and $a + 1$ (the successor of a number), and five further axioms, collectively known as the *Peanian axioms*.

From around 1892, PEANO embarked on a new and extremely ambitious project, namely the *Formulario Mathematico*. In his words :

> It would be of the greatest usefulness to collect and publish all the theorems now known that refer to given branches of mathematical sciences [. . .] Such a collection, which would be long and difficult in ordinary language, is made significantly easier by using the notation of mathematical logic.

This great project involved his whole group : as many as 45 mathematicians who belonged to the Peanian school collaborated on such a program in order to stimulate research in and promote the use of the axiomatic method; among them, we may mention Giovanni Vailati, Giulio Vivanti, Cesare BURALI-FORTI, Alessandro PADOA, Giovanni Vacca and Mario PIERI. According to PEANO :

> Each professor will be able to adopt this *Formulario* as a textbook, for it ought to contain all theorems and all methods. His teaching will be reduced to showing how to read the formulas, and to indicate to the students the theorems that he wishes to explain in his course.

In the foundations of geometry, he published *Principii di geometria logicamente esposti* (1889b). He did not define "point", "plane", and so on in the usual way. Instead he wrote : "The sign 1 must be read as *point*", and so on. PEANO did not prove the independence of his axioms, and coherence was an unimportant question for him. He followed Pasch's ideas in geometry and considered two primitive concepts : "point" and "segment". He proposed to deduce all the principal statements of geometry of position from such primitive concepts and some axioms inspired by Pasch's axioms. In his paper "Sui fondamenti della geometria" (1894), PEANO developed his previous ideas on geometry by introducing the notion of "congruence", which is connected with the concept of motion (two figures are congruent if a motion exists which changes one into the other). Such a concept is considered as a special affinity, characterized by suitable axioms. A relevant role is played by the concept of "flag" (a point being the origin of a half-straight line, which bounds a half-plane); a "motion" is defined by a transformation carrying flags into flags.

The Peanian school was active in didactics, and textbooks of mathematics were published by BURALI-FORTI and PEANO himself. In the pamphlet *Sulla questione III proposta dalla Mathesis* (1898) BURALI-FORTI remarked that Italian textbooks often express themselves wrongly, criticizing some recent books of practical arithmetic and elementary algebra for mathematically

unrigorous definitions such as :
"*Quantity* is everything which can be increased or decreased";
"*Unity* is each *object*, concrete or abstract, considered as isolated";
"*Number*, in general, is both the unity (number *one*) and the aggregate of unities";
"Numbers can be distinguished in *concrete* (*three horses*. . .) and in abstract (*two, three,*. . .)".

Polemics also arose between the Peanian school and other authors. For example, Pacchiani strongly criticized the textbooks published by BURALI-FORTI and Ramorino (see references). In these books, indeed, numbers are symbols, while the concept of number is introduced by means of the Peanian axioms and is not deduced from the definition of geometrical quantity. Pacchiani, in his review in *Periodico di matematica* (anno XIII, 1898, p. 201) argued for the following procedure in didactics: "to proceed from concrete to abstract"; therefore he could not agree with the point of view of BURALI-FORTI. BURALI-FORTI's answer was immediate: by a well-known logical principle "*number = abstract number*" and the science of logic has, as a consequence, that "*concrete numbers do not exist*", that is to say: "*concrete number = nothing*" (see *Periodico di matematica*, anno XIII, 1898, p. 230).

In 1903 PEANO himself published a textbook for secondary school, *Aritmetica generale ed algebra elementare*, where he used mathematical logic as an instrument for elementary arithmetic and algebra. According to him, symbols summarize language and are clearer than language; in fact, his textbook is written in a style that is quite incomprehensible for pupils. In PEANO's opinion, *Formulario* should serve as a treatise for University and his *Aritmetica generale* is the analogous handbook for secondary schools.

During the period 1890-1910, the impact of the Peanian movement on school education was weak; the books by PEANO and BURALI-FORTI were really difficult to follow for pupils and teachers, and their diffusion was low.

Sebastiano CATANIA, as we shall see, tried to make PEANO's ideas simpler and more understandable; indeed, his textbooks had many editions were relatively successful. It is remarkable that the attitude of the Peanian school to didactics changed a lot, and in the 1920s some authors belonging to PEANO's group published textbooks where intuition and experiments play a role, even if rigour is not abandoned. For example, in his *Matematica intuitiva* (1924-26) PADOA developpes a concrete, experimental method, far from logic. PEANO shows the same attitude in his textbook for primary school *Giochi di aritmetica e problemi interessanti* (1925), where exercises are interesting, stimulating, intuitive and inspired by every-day life.

Mario PIERI (1860-1913), who taught in Catania from 1900 to 1908, made remarkable contributions to axiomatics, in line with PEANO's ideas. In 1899 PIERI constructed an axiomatic system for Euclidean and Lobacevskij-Bolyai geometry based on two terms: point and motion. In 1904 he presented the first axiomatic system for complex projective geometry based on three primitive concepts: complex projective point, complex line (union of two distinct complex points) and chain (concatenation of three collinear and distinct complex points). In his 1907 paper "Sopra gli assiomi aritmetici", published in *Bollettino dell'Accademia Gioenia*, PIERI simplified PEANO's theory by reducing the number of primitive concepts to two and the number of postulates to four. Such works deeply influenced CATANIA's textbooks on algebra.

2. Sebastiano CATANIA (1853-1946) qualified for university teaching of descriptive geometry in 1883 at the University of Catania and in 1888 became professor of mathematics at the Istituto

Nautico. He started publishing textbooks in 1904, and was possibly influenced by PIERI's ideas on formalism and axiomatics.

In that period there were two main lines in didactics of mathematics: the synthetic or axiomatic method, followed by the Peanian school and by S. CATANIA, according to which rigour is the most important thing and formalism is its expression; and the analytic or intuitive method, according to which mathematics should be taught as intuitively as possible, and geometry should help in understanding arithmetic.

In 1904 CATANIA published his textbook for secondary school *Aritmetica razionale* which, in CATANIA's words, is a translation in simple language of PEANO's *Aritmetica generale ed Algebra elementare*. The reaction was not unanimous: from one side, PEANO and his group supported CATANIA's ideas; from the other, there were mathematicians such as SCORZA and VERONESE who criticized his axiomatic approach to didactics. BURALI-FORTI (*Bollettino di bibliografia* ... **7**, 1904) wrote that CATANIA's textbook is rigorous, neither trivial nor arid, but "very satisfactory"; Natucci (*Il Bollettino di Matematica* **4**, 1905) remarked that CATANIA simplified PEANO's work and published "a book corresponding to the modern didactical requirements better than many other books"; MARLETTA wrote: "Congratulations to CATANIA" in his review (*Periodico di Matematica* (3) **5**, 1907) and PIERI noticed that CATANIA's textbook shows the didactical advantages of Peanian symbolism.

However, a hard polemic arose between CATANIA and SCORZA. Gaetano SCORZA (1876-1939) graduated at the University of Pisa in 1899 and from 1902 to 1912 taught in secondary schools. From 1916 to 1921, he was professor of geometry at the University of Catania. SCORZA was one of the founders of the theory of algebras and wrote on the subject a very good and famous treatise (*Corpi numerici e algebre*, 1921). In *Nuovi Doveri* (fasc. 15 giugno 1908), SCORZA reviewed CATANIA's textbook (1906b) in a very unfavourable way, arguing that CATANIA's book was inapt for any didactical aim and, moreover, full of conceptual and grammatical mistakes and inaccuracies. "It would be necessary to raise objections about not only single proofs, but entire theories", SCORZA wrote. In his answer (1908), CATANIA mantained his argument by quoting some good reviews of his books, and some letters which he received from Michele CIPOLLA, PEANO, Francesco Gerbaldi and others.

Gerbaldi, who was professor at the University of Genoa, wrote in his letter to CATANIA : "I am very glad to see that you took advantage of PEANO's ideas, by popularizing them". And he concluded that teachers could find in CATANIA's book a good source for a rigorous teaching of Arithmetic in secondary schools.

And CIPOLLA wrote :

> I will use your Arithmetics during the scholastic year 1905-1906, since I think that it is till now the only one which meets the School's requirements and needs.

In his letter, PEANO remarked about CATANIA's attempt to draft a textbook based on his textbook *Aritmetica generale*... :

> My Arithmetic [PEANO 1903] purposed to show that it is *possible* to do symbolic Arithmetic at school. Therefore, I support your proposal, that is to say to publish a book more suitable for school...

And in other letters to CATANIA, PEANO wrote : "Your book is a work of art; therefore I can say little about its usefulness...", and:

> I am very pleased to read the new edition of your Arithmetic and Algebra and I am really amazed to see your skill to reduce many theories [...] to a form which is simple and understandable to the public.

In his answer to SCORZA, CATANIA added: "I knew very well that with my work I could strike against secular prejudices" and Professor PIERI, "who is an authority on this subject", remarked that many difficulties could arise for the circulation of his books despite their being judged in a very positive way. Such books are "fruit of many years' of conscientious work on PEANO's writings, beginning with *Arithmetices principia, nova methodo exposita*, Torino, 1889". Anyway, the old editions of CATANIA's books were sold out, and around 1910 his textbooks were a success.

3. Another polemic broke out between Natucci and CATANIA, arising from a very particular arithmetical question; but the discussion very soon involved the different points of view on didactics of mathematics. Was it better to teach rational arithmetic or intuitive arithmetic?

During the meeting of *Mathesis* (April 13th, 1913; see *Bollettino della Mathesis* **5**, 1913, p. 49-51), Ricaldone said, among other things, that CATANIA's textbook has many good qualities, "but they are too elevated for the average intelligence of the young people for whom they are intended". He recommended Palatini's book for secondary schools, which is also rigorous but clearer than CATANIA's handbook. CATANIA (1913a) reports the remark by Ricaldone and points out : "mathematical logic sometimes has a good effect [...] but R. is opposed to adopt textbooks for secondary school which are written in conformity with it"; he adds in a footnote : "It is impossible to discuss a statement of this kind; I can just notice that *Mathesis* has no reason to exist if it reports such remarks".

The president of *Mathesis*, Guido CASTELNUOVO answered to CATANIA (1913a, b) that his journal published what authors sent in. And anyway, as a person and not as the president of *Mathesis*, CASTELNUOVO wrote that he was against CATANIA's didactical method. CATANIA's treatises are very rigorous, of course -CASTELNUOVO goes on- but they do not leave any place for experience and intuition. Mathematical logic has an important role in the development of science, but, he concluded, "I would be blind if I did not see that science would not be born by means of logic alone".

In his answer (1913b), CATANIA remarked that in his experience as a teacher pupils' minds start from primitive objects and then build the arithmetic or geometric conceptions by means of a logical process. Some proofs in his treatises can also be neglected; but how is it possible to build a mathematical theory just by using intuition? Giuseppe VERONESE made some considerations about the polemic of CATANIA-CASTELNUOVO (1914); his point of view was a compromise : "rational teaching of geometry must be based on a practical and experimental teaching". An equilibrium between rigour and intuition should be looked for.

It is evident that sometimes the real object of the polemic was not CATANIA, but PEANO. The discussion concerned the formalistic approach of the Peanian school to didactics in comparison with the intuitive method, and also involved a different way of making research in mathematics : the intuitive school of CASTELNUOVO, Federigo ENRIQUES, Francesco Severi in opposition to the axiomatic method supported by PEANO and his group.

4. Between 1905 and 1923 many important mathematicians happened to become professors at the University of Catania. After teaching some years in Catania, they often moved to other Universities. In that period we find at the University of Catania, Giuseppe Lauricella (mathematical physics), Carlo Severini and Guido Fubini (analysis), PIERI, SCORZA, CIPOLLA, and DE FRANCHIS (algebra and geometry). Some years later : Giuseppe MARLETTA (geometry) and Vincenzo Amato (analysis), both graduated at the University of Catania, Mauro Picone (from 1919 to 1924) and Pia Nalli (from 1926 on), two great analysts.

Among them, DE FRANCHIS, CIPOLLA, MARLETTA and Amato published textbooks for secondary school.

Michele CIPOLLA (1880-1947) graduated at the University of Palermo, after studying for one year at the Scuola Normale Superiore in Pisa. He taught several years in a secondary school before being appointed a professor. He was professor of analysis at the University of Catania from 1911 to 1923, and then moved to the University of Palermo. CIPOLLA made fundamental contributions to number theory and to the theory of finite groups as well as to the foundations of mathematics. On the latter subject, CIPOLLA published an interesting treatise (1927) collecting his lectures, which is in line with the well-known *Questioni riguardanti le matematiche elementari* (1912-14) written by ENRIQUES. CIPOLLA wrote some of his textbooks for secondary school with Vincenzo Amato (1878-1963), who graduated at the University of Catania in 1901 and became assistant of algebra and then of analytic geometry from 1901 to 1904. After teaching about thirty years at secondary school, he became professor of analysis only in 1936. At the very beginning of his career, Amato was interested in mechanics and then in the theory of groups, influenced by CIPOLLA's ideas.

We shall analyse the following textbooks by CIPOLLA and Amato, both published about 1920-25 : *Algebra elementare per il ginnasio superiore, per l'Istituto magistrale inferiore e per l'Istituto tecnico inferiore* and *Aritmetica razionale ad uso del corso superiore degl'instituti magistrali*. Here, natural numbers are introduced in a very intuitive way: How many books? How many objects?

"If the set is *single* (or *unitary*, that is to say it is constitutes by a *single* object), we answer : *one*. [...] [We answer] *two* if we exclude *one* object, then *one* object will remain" and so on. "Each of such words expresses a **natural number**, according to a meaning which is denominated **cardinal**". Then CIPOLLA and Amato define "equality" of two sets by means of classes of equivalence (two sets are "equivalent" if a bijective map between them exists; such a relation is symmetric, reflexive and transitive) and give an intuitive idea of "successor of a number", of "series of numbers", of "ordinal numbers", addition and the other operations. Fractions are introduced by employing "geometrical quantities" and by considering "homogeneous" quantities which can be added; for example n times $A, A + A + A + \dots$, is nA. Operations with rational numbers, monomials, polynomials and so on are given in the usual way.

The geometrical approach to rational numbers and the employment of classes of equivalence were adopted also by Michele DE FRANCHIS (1875-1946). He graduated at the University of Palermo, where he became assistant of F. Gerbaldi, and was professor of analytic and projective geometry at the University of Cagliari during the academic year 1905/6. Then he moved to the Universities of Parma (1906-9), Catania (1909-14) and finally Palermo (from 1914). DE FRANCHIS made research in algebraic geometry; his most important work, written together with Bagnera, concerning classification of hyperelliptic surfaces, earned the Bordin prize of 1909 from the Academy of Sciences of Paris.

DE FRANCHIS wrote an interesting textbook of geometry for secondary school published in 1909, but drafted in 1901, in which he developed a logical-deductive approach. In it, teachers have a large freedom; indeed, they can choose between fusionism and separatism and can also free pupils from the weight of certain proofs. One reads in the preface to this book:

> It must be pointed out that, in this book, plane geometry and solid geometry are united together, but it is easy to divide them: the book is indeed drafted in such a way that it is possible to treat the planimetry apart.

The book starts from two primitive elements : *point* and *segment*, in line with PEANO's ideas. From point and segment DE FRANCHIS defines all the fundamental concepts of geometry, and the definition of a plane is given by using the notion of *shadow*, as PEANO did :

> Let H and K be two figures. We call the shadow of K with respect to H the figure made by the prolongations of the segments connecting H's points with K's points; such prolongations of the segments must be considered from the side of K's points.

Then :

> A half-plane is the shadow of a straight line with respect to a point outside it.

The problem of "equality between figures" was one of the most important in didactics of mathematics of that period. Euclid considered equality as both congruence (or superposition) and equivalence (or equiextension). In order to define the congruence between figures, Euclid used the concept of rigid motion; such an approach was much criticized, even if it is postulated in the textbooks of Sannia and d'Ovidio, Faifofer, and others. Regarding the equality of figures, there were two main approaches : the *congruence* according to Hilbertian axiomatics, based on the primitive concept of the *congruence between segments and angles*, and the notion of *equality*, based on the theory of groups of transformations developed by Klein in his Erlangen program.

DE FRANCHIS chose the latter approach. He considered what we call today the group of direct isometries of space and developed geometry starting from such a group. DE FRANCHIS introduced "motion" as an element of the group of "rigid" transformations; thus a motion cannot transform an element into a proper part of it (for example a segment into a part of that segment, an angle into a part of that angle, and so on), and a motion exists which maps a segment AB onto a half straight line a, in such a way that A (or B) coincides with the origin of a and B (or A) lies on a. If a triangle has a side which lies on the origin of a half-plane, then a motion exists which leaves such a side unchanged and maps the triangle onto the half-plane. If three points of a figure -not belonging to the same straight line- are unchanged under a motion, then such a motion is the identity.

DE FRANCHIS's approach is very modern, in particular in defining equality between figures by using the theory of transformation groups.

In his *Complementi di geometria ad uso degli istituti tecnici*, written during his professorship at the University of Catania, there is an original treatment of figures in space; all figures, according to DE FRANCHIS, belong to space. He introduces the group of equality, which is nowadays called the group of direct isometries, and proves the following relevant theorem : Inverse isometries can be reduced to the composition of a symmetry with direct isometries. Since similarities -direct and inverse- are bijections of space on itself, DE FRANCHIS characterizes them as follows : Inverse similarities are the composition of a symmetry with respect to a point by direct similarities; inverse plane similarities are the composition of a symmetry with respect to an axis and direct similarities.

Interesting textbooks were also published by Giuseppe MARLETTA (1878-1944), who graduated at the University of Catania in 1901 and became professor of projective and descriptive geometry in 1926, after teaching about twenty years in secondary schools. He devoted himself to projective geometry in spaces of n dimensions; some of his results on algebraic geometry are nowadays revalued and very well considered. MARLETTA was much influenced by PIERI, whom he considered as his teacher.

In his textbooks, MARLETTA tried to write rigorously, but "in a really simple way for young pupils". His most relevant textbook is *Trattato di geometria* for secondary schools, whose first edition was published in 1911. Many editions of it were published, some of them after MARLETTA's death. In his treatise, MARLETTA considers fundamental concepts (such as points, straight lines and planes), which are already well-known by pupils in an intuitive way, that is to say as a result of very simple observations. He organizes such concepts in order to constitute the so-called "rational geometry", and posits many postulates which are not independent one of the other, since some of them are theorems. MARLETTA indeed aims to make his treatment as simple as possible, and assumes some theorems as postulates if their proofs are too difficult for pupils.

In his axiomatics, MARLETTA was influenced by Euclid on one hand and Hilbert on the other. For example, the axiom "Distinct points exist" is followed by the remark "a very little object, such as a grain of sand or the point of a needle, gives us a rough idea of what a point is".

Very original is the definition of parallel lines :

> Two straight lines are parallel if a half-plane exists which has one of them as origin and contains all points of the other one.

Such a definition allows him to develop the theory of parallels in a very simple way. As regards to equality, MARLETTA uses bijections (two figures are equal if a suitable bijection between their points exists), but he also gives the intuitive idea of equality as the overlapping of figures.

5. Around 1900-1910 several important mathematicians worked at the University of Catania and contributed to create great interest in mathematics; as a result, in 1921 a group of mathematicians founded the Circolo Matematico of Catania. Picone, SCORZA, and CIPOLLA had the most important roles in the foundation of the Circolo, and many young mathematicians, such as Niccolò Spampinato, Giorgio Aprile and Giuseppe Fichera, helped much in the organization. Unfortunately, some years after the foundation of Circolo, SCORZA moved to Naples, Picone to Pise, CIPOLLA to Palermo and the Circolo broke up.

The Circolo Matematico of Catania was devoted more to didactics than to pure mathematics; in addition, CIPOLLA and DE FRANCHIS, and later MARLETTA and Amato, had taught for many years at secondary school, before being appointed professors at the University. Therefore, didactics of mathematics was considered an interesting field at the University of Catania, where many professors of mathematics published textbooks for secondary school.

But what about the relevance of their textbooks in Italy? Sebastiano CATANIA's textbooks were adopted in schools till about 1920; then the formalistic approach was abandoned. The textbooks

published by CIPOLLA, AMATO and MARLETTA had many editions; MARLETTA's *Trattato di geometria* was published again in 1946, edited by Aprile. DE FRANCHIS's books -written just before Gentile's reform of 1923- had little circulation after the reform; DE FRANCHIS did not devote himself to making new editions of his textbooks, which became obsolete very soon with respect to scholastic programmes.

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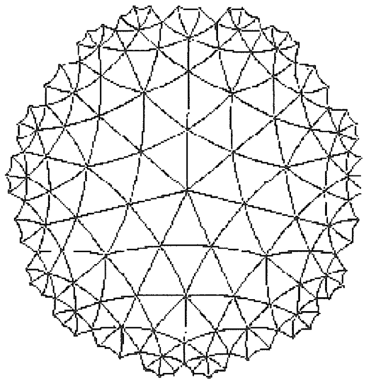

La Géométrie d'Oronce à l'attaque

METIN, Frédéric
IREM Dijon (France)

Abstract

Imaginez que vous soyez privé de tableau, craies et salle de classe; ce serait peut-être une catastrophe ! Les professeurs de Mathématiques ont peu le souci de la pratique (nos exercices d'application n'en sont pas) et, bien que "le grand livre de la nature etc.", ils seraient démunis en dehors de leur salle de cours. Ce n'est pas le cas à la Renaissance : de nombreux livres de géométrie sont divisés en "théorie" et "pratique", comme celui d'Oronce Fine (traduit en 1570). Les problèmes abordés sont ceux de la mesure d'objets distants ou inaccessibles; il est presque exclusivement fait usage du théorème "de Thalès", à l'aide d'instruments de mesure des angles.

L'usage du "baston pour mesurer" m'a permis, pour une fois, d'emmener les élèves à l'extérieur de l'école, pour mettre en pratique des connaissances jusque là assez abstraites.