

Elements of Cartography: Tracing Fifty Years of Academic Cartography

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When Arthur Robinson published the first edition of *Elements of Cartography* in 1953, it marked a major change in academic cartography. Erwin Raisz's *General Cartography*, first published in 1938 and revised in 1948, had been the standard text. Robinson's book represented the metamorphosis in cartography after WWII and set the standard for the second half of the twentieth century. A review of the book's contents through its 6 editions reveals the prevalent thinking in cartography during a dynamic period in the history of cartography. Through it we can trace changes from hand-drawn maps to the rise of GIS and remote sensing. Although *Elements* is no longer the major textbook, its impact was enormous. This paper traces the history of late twentieth century cartography through the pages of *Elements of Cartography*. A content analysis of all six editions of *Elements of Cartography* was done to determine the emphasis on various aspects of cartography. An analysis of Erwin Raisz's two editions of *General Cartography* was also included in order to note the changes in content and philosophy from pre-war to post-war cartography.

Keywords: cartography, textbooks, *Elements of Cartography*, Erwin Raisz

INTRODUCTION

Anyone who took a course on cartography, or who taught cartography in the last half of the 20th century, learned and taught the "gospel according to Robinson", and the gospel was *Elements of Cartography*. Amen. The impact of this textbook during a nearly fifty-year period was enormous; it both reflected changes in the field, and influenced them. The first edition of *Elements* was published in 1953, and now a half-century later, we take many of its innovations for granted. However, when it was first published, it was revolutionary.

"... the gospel was *Elements of Cartography*."

John Wolter noted that textbooks have historical value in tracing the trends of a science. He examined the contents of the first three editions of *Elements* (Wolter, 1975). Although one can trace the history of any field by looking at any series of textbooks, *Elements* is unusual because of its extremely long run of 6 editions under the same primary authorship, spanning 1953 to 1995—a period that encompasses major changes in cartography.

In this article, I will look at changes in the book, rather than relate to the reader the history of cartography in the last half of the 20th century—many readers of *Cartographic Perspectives* have lived the history, some even making history. In order to understand the impact of *Elements of Cartography*, it is necessary to understand the cartographic culture of the period when it was introduced.

Pre World War II

Erwin Raisz's *General Cartography* was the standard text in the years immediately preceding and following WWII. The first edition was published in 1938, and the second edition in 1948. John Wolter considered the first edition of *General Cartography* a landmark textbook, in that it emphasized the "definitive nature of cartography" (Wolter, 1975). The 1938 edition provided a picture of what cartography was like 65 years ago. At that time there were few geography departments that offered courses in cartography, more often than not they were offered in civil engineering departments, and certainly the technical aspects were not considered a suitable research subject. Other than "history of cartography", or the creation of new projections, there was little in the literature on cartography. Cartographers made maps, they didn't write about them or concern themselves with whether symbols were effective and understood by readers. Cartography was a craft and a body of skills, not what we today would consider a science.

In the introduction to the 1938 edition, Raisz posed the question, "What should be included in a cartography course?" (see Figure 1) Raisz believed cartography should qualify the student to give clear and *correct* [emphasis mine] graphic expression to his/her ideas. He felt that in order to do this well, the student must adhere to certain cartographic principles and traditions, which could best be learned by an historical approach. In other words, the right way to make a map was the way maps had always been made. He felt the student should know commonly used projections and be able to construct them, but he said, "The mathematics of projections will be of little practical value to [the student]...". The course should teach the student to select symbols intelligently, with special regard to the modern methods of representing relief. Symbols here were primarily qualitative symbols, such as would be found on a topographic map, or on other general maps. And finally the course should teach good composition, handling of tools, lettering (particularly hand lettering), and fine drawing (Raisz, 1938). Preparation of special (thematic) maps, globes, field sketching and 3-D models was the subject of advanced study. One must remem-

"Cartographers made maps, they didn't write about them or concern themselves with whether symbols were effective and understood by readers."

1938 Goals of a Cartography Course

The purpose of such a course is to qualify the student to give clear and correct graphic expression to his ideas. To do this well he must adhere to certain cartographic principles and traditions, which can best be learned by a historical course.

The student should know the commonly used projections and be able to construct them. The mathematics of projection, however, will be of little practical value for him.

The course should enable him to select his symbols intelligently, with special regard to modern methods of representing relief.

Laboratory exercises should teach him good composition, handling of tools, lettering and fine drawing.

Figure 1. Raisz, Erwin. *General Cartography*, New York: McGraw-Hill, 1938.

“References listed in the bibliography were primarily to history of cartography, to projections, and to map drafting.”

“Raisz’s textbooks emphasized practical aspects.”

ber that in 1938, technical pens, mylar, rub-on lettering, and pre-printed patterns, all tools we now consider *old fashioned* had not yet been invented.

The book included a fifteen-page chapter on *distribution maps* in which isarithms, choropleth, and proportional symbols were discussed. A twenty-three page section described economic maps, geographic maps, and maps of other sciences. There was no discussion of how to make such maps, or where to obtain data. Nor was the term “generalization” found in the book. The term *Statistical maps* was used as a synonym for distribution maps, but there was no content on even basic statistical analysis. References listed in the bibliography were primarily to history of cartography, to projections, and to map drafting.

World War II brought large changes in technology, especially for the speedier production of maps. One would expect that the 1948 edition of *General Cartography* would reflect those advances in the field that were brought about by the war. However, except for a chapter on wartime cartography (in which Raisz described mapping agencies and the kinds of maps they made) and the addition of two chapters on air photos, there were few revisions. The bibliography in the second edition was divided into categories, and included many works on air photos and air photo reading, plus a section on surveying. The basic thrust of the second edition remained the same as the first.

Raisz’s textbooks emphasized practical aspects. He stated in the 1938 edition “In the beginning of [a course in cartography], while lectures are on the history of maps, the laboratory hours are best utilized teaching lettering and the use of drawing instruments.” A list of drafting equipment, and a series of lab exercises was included (Figure 2). Many of the early exercises were specifically drafting exercises, with later exercises telling students to “make a population map of...”, with little or no instruction on how to obtain data, let alone how to process the data. There were several field surveying exercises that took students outdoors with a plane table and compass. These examples, plus sections on field sketching, were indicators of the different ways cartographers and their activities were viewed in the first half of the 20th century.

All the foregoing instruments should be part of the geographic drafting room of every university. For individual students of cartography, who do not want to go into map making professionally, the following equipment is sufficient for a regular year’s course;

1 HB pencil	----
1 2H pencil	
Gillett pens, Nos. 290, 303, and 404	
3 penholders	
1 instrument set, consisting of a compass, a divider, and a ruling pen	
1 kneading eraser	
1 soft eraser	
1 celluloid triangle 8 inches long	
1 wooden T square	
1 bottle of India ink	
1 No. 4 sable brush	
2 sheets of one-ply Strathmore board, smooth finish, large size	
2 sheets of two-ply Strathmore board, smooth finish, large size	
1 set of colored inks	} for every six students
1 block of transparent tracing paper	
1 bottle of reproduction white	
1 sheet of cross-section paper	
1 set of colored crayons	

Figure 2.

Impact of WWII

In the fall of 1941, Arthur Robinson, then twenty-six years old, interrupted his graduate studies to go to Washington D.C. to work as a cartographer in what became the Office of Strategic Services (OSS). Eventually he became the director of the mapping division. While there, he and other geographers in the organization needed to make maps quickly, and therefore new techniques, map types, and technologies were developed. After the war, Robinson returned to Ohio State to work on his Ph.D.

In 1952, 1953 and 1954, Robinson published three pieces that set forth what he saw as the goals and research agenda for cartography. The first of these was *The Look of Maps*, the second was the first edition of *Elements of Cartography*, and the third was the section on cartography for the mid-century survey of geography titled *American Geography: Inventory and Prospect*.

Robinson's dissertation was published in 1952 as *The Look of Maps*, which many consider to be THE impetus for the enormous changes in cartography for the next 50 years. Barbara Petchenik said

if we examine the characteristics of recent decades of research in cartography we can find stated explicitly in this book all of the fundamental assumptions that shaped that research as well as the major goals the research has been organized to achieve. (1983, 38)

Ironically, *The Look of Maps* contained no maps, but instead was a collection of essays on various aspects of map design. In fact, Norman Thrower recalls that Erwin Raisz, on first seeing the book, fanned through the pages and said, "*The Look of Maps*—no maps to look at!" (Thrower, 2003, personal communication)

The third piece (chronologically), the section in *Inventory and Prospect* written by Robinson, affords not only an overview of the field of cartography, but Robinson's vision of the field. Although he had input from O.M. Miller and Erwin Raisz, clearly the primary view was Robinson's.

By the early 1950s, geographers, who like Robinson had been engaged in wartime cartography, returned from military service to teach. The number of geography departments that offered cartography and air photo interpretation subsequently increased. *Geographic cartography* as an academic discipline was emerging, and owing to research by Robinson, Jenks, and Sherman, cartographers were beginning to examine their work, and to ask questions about the effectiveness of maps, validity of data, and how to symbolize geographic information (Robinson, 1954; Wolter, 1975). The textbook *Elements of Cartography* provided the tools for academic cartographers.

Elements of Cartography

What was so revolutionary, so innovative about *Elements*? A cover blurb on the first edition of *Elements* says "One of the important innovations in *Elements of Cartography* is the inclusion of a chapter on map design, a phase rarely covered in other books" (Figure 3). Another cover blurb said "Presents cartography as an intellectual art and science rather than as a sterile system of drafting and drawing procedures" (Robinson, 1953). Today these topics are such an integral part of any cartography text or course that they would not be mentioned. Prior to 1950, though, cartography was more of a craft than a science, as we have seen from Raisz's books.

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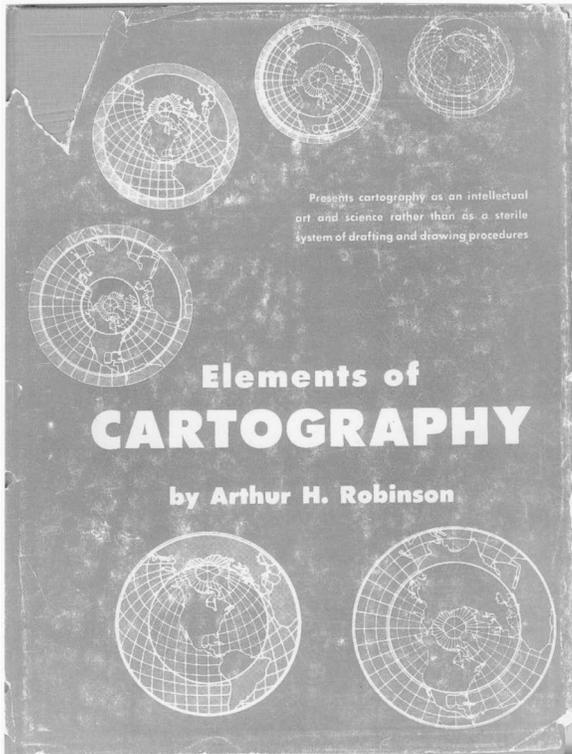


Figure 3. First edition of *Elements of Cartography* (see page 77 for color version)

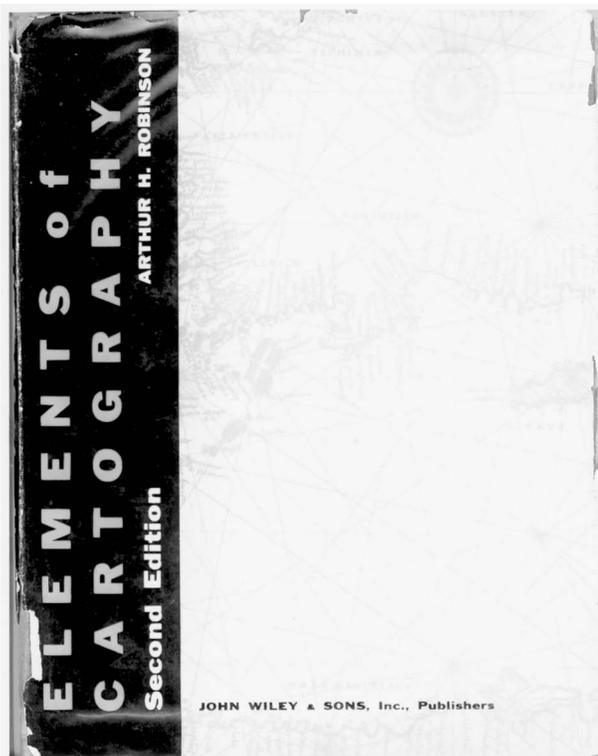


Figure 4. Second edition of *Elements of Cartography* (see page 77 for color version)

The first edition of *Elements* was only 218 pages of text, plus eight appendices. The first chapter, “The Art and Science of Cartography”, set out Robinson’s philosophy of the field. It included a discussion of Map Data, Principles of Cartography, Art in Cartography and the Science of Cartography. None of these had been described in Raisz’s works. Two chapters were devoted to projections. The first discussed the employment of projections, an analysis of deformations including Tissot’s indicatrix, and ways of classifying and describing projections. A second chapter focused on the construction of eighteen specific projections. An appendix of projection tables was included. One must remember that, in 1953, projections were drawn by hand. As a result, many introductory classes focused on projection use and construction.

Although there is only a twenty-one-page chapter on “Design”, this aspect is woven throughout the book. This is especially apparent in the material on map lettering. While Raisz focused primarily on hand lettering, and told how to make a lettering guide, Robinson discussed the importance of lettering, planning for lettering, styles of type, and interaction of lettering and background. In other words, cartographic typography.

One of the lengthier chapters was on symbolization and distribution maps. Here we find another innovation—a section on processing data (the quantitative revolution in geography was beginning), and a discussion of specific symbols and symbology. Other texts prior to *Elements* (and even some post-*Elements*) addressed specific map types by geographic phenomenon, such as climatic maps, geologic maps, topographic maps, and population maps. If one wanted to learn about isarithms in general, it was necessary to look up each map type by geographic phenomenon that might use isarithms.

Though Robinson stated “The act of drafting a map is no more cartography than typing is authorship”, (Robinson, 1953, 10) he recognized that ultimately maps had to be drafted and reproduced, thus a twenty-five-page chapter was devoted to drafting and reproduction. [Today we might say that knowing mapping software is no more cartography than knowing word processing is authorship, and we teach the use of various software packages.]

The second edition of *Elements* appeared in 1960, (Figure 4) and included no major changes, although research of the previous seven years was incorporated, and some sections were expanded. Projections increased from two chapters and two appendices to three chapters and two appendices. Symbolization, which Robinson had seen as the weakest chapter, was increased to three chapters and fifty-nine pages up from twenty-six pages. In this edition, Robinson responded to some criticisms expressed in reviews, and the book was, as are many second editions, a refinement of the earlier edition. In the preface to the second edition, Robinson stated,

Perhaps the most significant [change] has been a continuation of the recent expansion of interest in cartography and in area analysis in all fields. The persistent growth of population pressures and the strengthening of regional ties throughout the world have multiplied many times over the need for both the smaller-scale map and the topographic map. Cartography has, therefore, continued to develop rapidly, both as a research technique as well as a tool of presentation. (Robinson, 1960, v)

Especially reflective of changes in geography was a section on elementary statistical concepts. Although only slightly over seven pages, and dealing primarily with measures of central tendency and the standard deviation, this section was a departure from previous works.

By the time of the third edition in 1969, (Figure 5) the quantitative revolution was in full force in Geography, and computers were increasingly being used. Randall Sale, who had been involved in earlier editions of the text, was listed as a second author. The book was expanded to a total of 343 pages. In the preface the authors stated,

The study of spatial distributions is increasingly significant, both in the number of disciplines concerned and in the technical support provided by modern data gathering, machine processing, and new analytical methods. As a consequence, the demands upon cartography to map and display spatial variations and relationships also has increased. It is not just a matter of more maps being wanted by greater numbers of people: the complexity and quality of the maps needed have increased at the same time. (Robinson and Sale, 1969, v)

For the first time in a cartography textbook, changes in the field were described as a revolution.. Robinson stated, cartography is in the midst of a revolution, and few aspects of this complex field have escaped the forces of change.... (Robinson and Sale, 1969, v)

In this edition, the chapter on construction of projections was relegated to an appendix reflecting the increasing use of computers for this task. The number of pages devoted to processing data and symbolization was increased from a single twenty-six page chapter in the first edition, to three chapters totaling seventy-four pages by the third edition. A major change was the addition of a twenty-nine-page chapter on "Compilation from Air Photographs", which was a mini-course on photo interpretation and photogrammetry. For the first time there were references to automation in cartography in the index.

The fourth edition in 1978 (figure 6) marked several changes. The book had expanded to 448 pages, twice the size of the first edition. A third author, Joel Morrison, at that time with USGS, was added. A chapter detailing color theory and employment was included as well as a color signature, reflecting increased interest in color

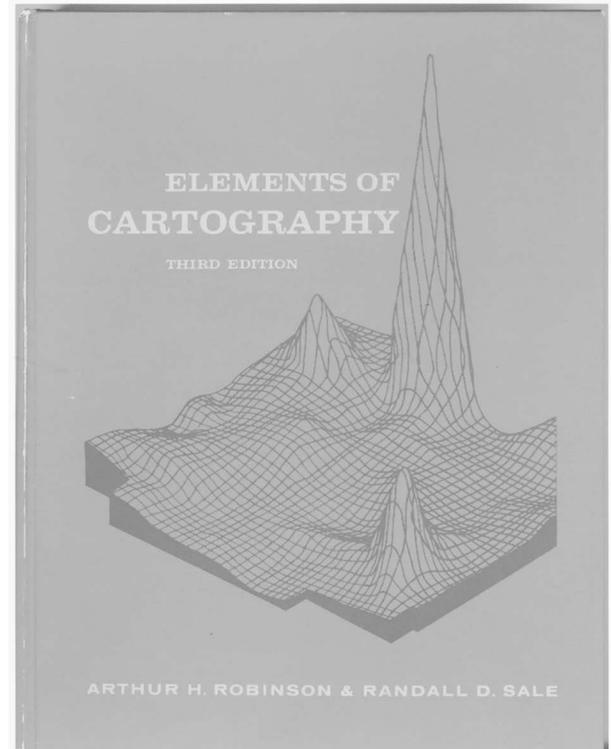


Figure 5. Third edition of Elements of Cartography (see page 77 for color version)

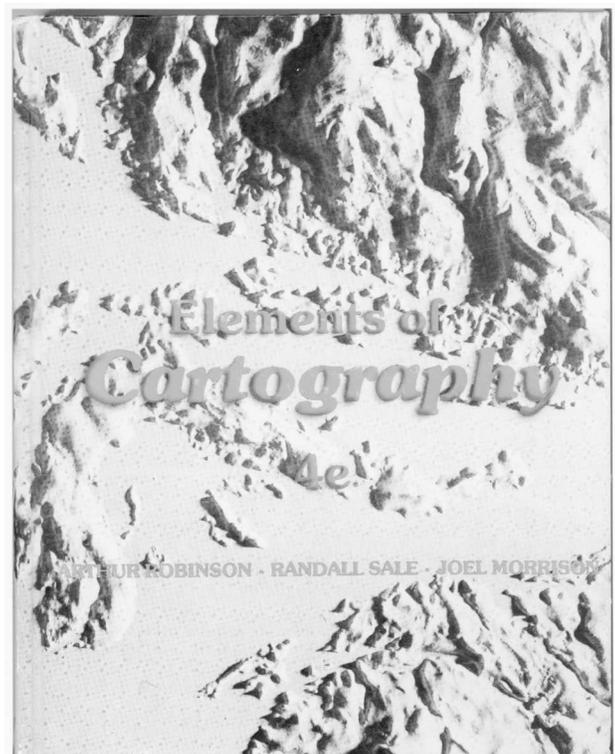


Figure 6. Fourth edition of Elements of Cartography (see page 77 for color version)

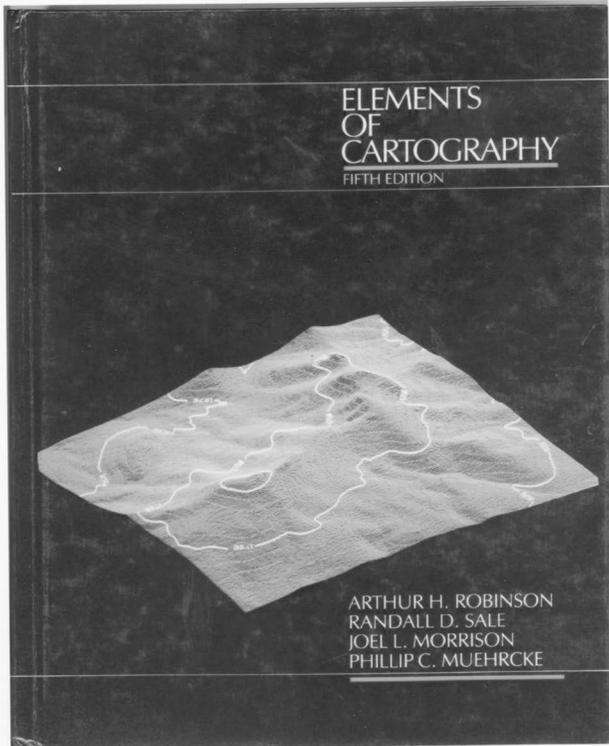


Figure 7. Fifth edition of *Elements of Cartography* (see page 78 for color version)

research. All illustrations were in two colors. Generalization was given its own chapter, and symbolism was enlarged “to reflect the basic significance of this communicative aspect of cartography” (Robinson *et al.*, 1978, v). A significant change in the 4th edition, marking the impact of the technological revolution, was the inclusion of material on computers. References to computer assistance were made throughout the book, and a separate twenty-page chapter “Computer-Assisted Cartography” was added. The subject was still new enough that a two and one-half page glossary was included in the chapter. The material on air photography was expanded to include remote sensing.

By the fifth edition in 1985, (Figure 7) the cartographic “revolution” was in full swing, and *Elements* reflected this. Phillip Muehrcke had come on as fourth author, and the book had grown to 544 pages. The authors recognized that the revolution in the field was more than technological, but included changes in the basic concepts.

Cartography is in transition. Where the changes will lead is uncertain, but change in the discipline is pervasive, and the rate of change seems to be accelerating. Many of the changes are the result of very rapid and substantial development in the technology available to cartography. But, equally important, a conceptual maturation of the discipline itself has evolved. (Robinson *et al.*, 1985, v)

They noted that many practitioners must also adopt a new awareness of why cartography exists and develop an appreciation for its growing usefulness.

...as cartography has matured to an independent field, its basic principles have received increasing attention with the result that the field of cartography has developed to the stage where it is possible to talk with some confidence about basic theoretical principles that guide the mapping process. (Robinson *et al.*, 1985, v)

“They noted that many practitioners must also adopt a new awareness of why cartography exists and develop an appreciation for its growing usefulness.”

Cartography texts could no longer be “recipe books” or “how to” books.

The authors also pointed out that the cartographic curriculum at universities was lagging behind advances in the field. In 1984 desktop computers were becoming more common, but mapping software was not readily available and much of it was crude. Departments were adding computer labs and “computer-assisted cartography” courses, but in many cases were hampered by administrators who saw geography as a “chalk and blackboard” discipline. This was especially true for small departments. *Elements of Cartography* probably served as ammunition in the fight for departmental computer labs at some universities.

In the fifth edition, a sixteen-page chapter on “The Nature of Cartography” was introduced, which included a discussion of the four different foci of Cartography (geometric, technologic, presentation, and artistic). Another chapter (thirteen pages) was devoted to the “Technology of Cartography”. Remote sensing was given its own chapter. The book was divided into 4 sections: Introduction to Cartography; Theoretical Principles of Cartography; The Practice of Cartography: Data Manipulation and Generalization; and The Practice of Cartography: Production and Reproduction.

There were only three appendices in the fifth edition compared to the eight in the fourth edition. Gone were the trigonometric and logarithmic tables, reflecting the ubiquity of calculators and increasing availability of computers, but a glossary of technical terms from other disciplines was added.

By the sixth edition in 1995, (Figure 8) Arthur Robinson, then eighty years old and retired, had assumed an advisory and editorial position, Randall Sale had passed away, and Jon Kimmerling and Stephen Guptill were added as junior authors. Many changes had occurred in the field in the eleven years between the fifth and sixth editions. A major factor in these was the increase in desktop computers.

The current technological revolution goes a step further, permitting everyone to be a mapmaker. This means that diverse map users are no longer forced to make do with identical copies of a printed map. They can construct or tailor maps to fit individual needs. (Robinson *et al.*, 1995, v)

And those users were not necessarily familiar with cartographic principles.

This was the largest and most encyclopedic edition with 674 pages, more than three times the size of the first edition with fifty-four pages of appendices and an eleven page, three column, six-point-type index. There were thirty-one chapters grouped into seven sections. The impact of GIS was responsible for most of the changes in this edition. The authors stated:

In response to information-age demands, mapping increasingly is conducted within the context of geographical information systems (GIS) technology. Therefore, we have explicitly linked GIS and cartography throughout the book. Since integration and flexibility lie at the heart of GIS technology, we have had to expand the scope of the sixth edition. (Robinson *et al.*, 1995, v)

The authors noted that cartography now provided two products: databases and visualizations. This was the first time that the term visualization had been used in the text. These two products guided what was included. Unlike previous editions, which stressed the design and production of small-scale thematic maps, the sixth edition gave some emphasis to reference mapping and considered mapping throughout the possible range of scales. There was increasing emphasis on database questions. Three chapters (a total of forty-eight pages) dealt with data formats, structuring, accuracy and exchange standards, but these subjects were also scattered throughout the text. A section of three chapters dealt with sources of data including ground surveying and positioning, which had not been included in previous texts, and a chapter on census data. Remote sensing had been increased to two chapters, and GIS was given its own chapter. Two new chapters, "Multivariate Mapping and Modeling" (eight pages) and "Dynamic/Interactive Mapping" (ten pages) signaled the new map types cartographers were called upon to create.

Because there was still some call for manual methods, these were included, but were relegated to an appendix. Some technical subjects were

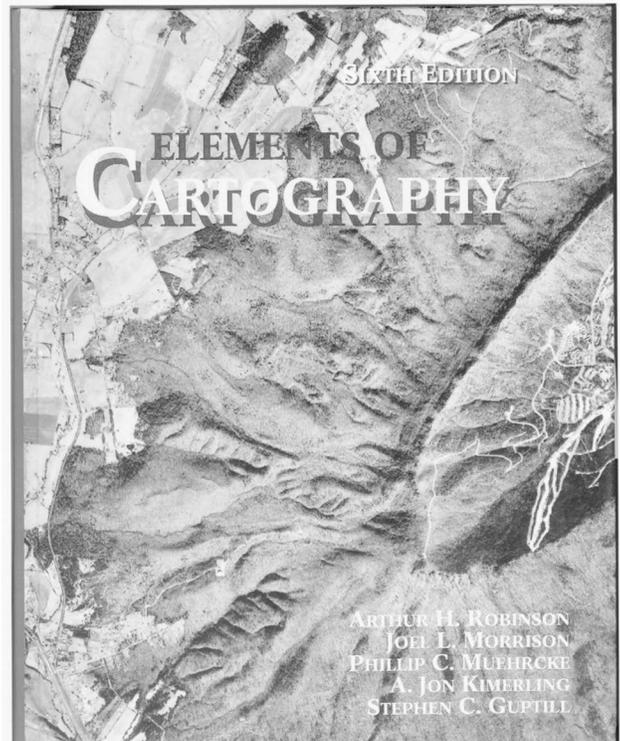


Figure 8. Sixth edition of Elements of Cartography (see page 78 for color version)

"The authors noted that cartography now provided two products: databases and visualizations."

“The frequency of editions of cartography textbooks is indicative of how fast the field is changing.”

placed in boxes or sidebars. One sidebar was the discussion of Tissot’s *Indicatrix*, which was included in each edition, but migrated from chapter subheading, to appendix, to finally a “box” in the sixth edition. References to the most recent research in the field has been a constant in all editions of *Elements*, and in more recent editions, these were included at the end of each chapter.

Until about 1985, *Elements* dominated the field in the United States. Erwin Raisz published *Principles of Cartography* in 1962, but it was really a reworking of the older *General Cartography*, and could not topple *Elements*. The major competition came from British publications, notably Monkhouse and Wilkinson’s *Maps and Diagrams* first published in 1952, but these had a definite British slant. Not until the publication of Borden Dent’s *Thematic Cartography* in 1985 was Robinson’s hold on the American market weakened. Several other American textbooks were written in the next few years, but only Dent managed to challenge *Elements*.¹

The frequency of editions of cartography textbooks is indicative of how fast the field is changing. Raisz’s two editions of *General Cartography* were published ten years apart; his second book, *Principles of Cartography*, was published a leisurely fourteen years later. New editions of *Elements* were published at roughly eight and one-half year intervals, but Borden Dent’s textbook (under various names) has gone through five editions from 1985 to 1999 or roughly a new edition every three and one-half years. In part this reflects publishers’ desires to sell books, but it also reflects the rapid changes in cartography and users’ demands for the latest techniques.

CONCLUSIONS

What have I learned from poring through more than sixty years of cartography texts? First, I was struck anew by the richness of the field and the remarkable changes that have taken place in the last half of the twentieth century. *Elements* not only shows the changes in basic mapping operations, but also the changes in philosophy of the field, the technology, the kinds of data cartographers use, new types of maps, and new uses of maps. Whereas, fifty years ago one could be simply “a cartographer”, now we have specialists in sub-fields—one can focus on map design, or thematic mapping, or communication, or visualization.

Sadly, the sixth edition marks the end of an era; there will probably be no seventh edition of *Elements of Cartography*, at least not in its current form. Of the original authors Arthur Robinson and Randall Sale have both passed away, and Philip Muehrcke has retired. New cartography texts have been written, and more will be written, but it is doubtful that any will be able to last for nearly fifty years and have such a tremendous impact.

NOTES

¹ Other American texts were Campbell, John. (1984) *Introductory Cartography*, New Jersey: Prentice-Hall, and Tyner, Judith (1992), *Introduction to Thematic Cartography*, New Jersey: Prentice-Hall.

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