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ABSTRACT

Focusing on how expert writers in various disciplines convey complex ideas, this paper shows how the techniques used by the mathematician, Clark Kimberling, in various writings can (1) be transferred to other disciplines, (2) show learning taking place, and (3) provide models for students to re-enact learning in all subject areas. The paper defines the process of discovery and describes Kimberling's four stylistic devices tc create a form reproducing this activity of discovery: (1) first-person references to the teacher/writer's experience in the classroom and second-person references to the audience (other teachers); (2) language and syntax depicting the excitement of learning; (3) idealized dialogue ("language somewhere between the way students usually talk and the actual language of mathematics,") and (4) insertion of bits of mathematics history into the discussion to establish continuity between present and past discoveries. The paper then discusses the use of the articles to stimulate students' writing about the process of one of their own discoveries and mentions some of the varied topics on which students have written. The paper includes a discussion of the benefits of using these articles in composition assignments. A four-page bibliography lists articles and other writings by Kimberling. (EL)

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Writing for Mathematics Discovery-Learning: A Model for Composition Courses

Laura H. Weaver

Presented in THE WRITING PROCESS OF PRACTICING PROFESSIONALS

Conference on College Composition and Communication

Minneapolis, March 22, 1985

In my teaching of composition, I have been searching for methods that expert writers in other disciplines use to introduce readers to complex ideas. As part of that search I began examining the writing done by my University of Evansville colleagues outside the English Department. Of the publications I examined, the best (in range and in quality) are those by Dr. Clark Kimberling (Professor of Mathematics). I have studied his writings as a whole (see bibliography on handout [pp. 20-24]): they range from articles in scholarly mathematics journals such as _Fibonacci Quarterly_ and _American Mathematics Monthly_ and a 60-page biographical study of Emmy Noether (a woman mathematician) in _Emmy Noether: A Tribute to Her Life and Work_ (the first chapter in a book having other chapters written by leading twentieth-century mathematicians in Germany, the Soviet Union, and the U.S.) to the "Microcomputer-assisted Discoveries" section[1] he initiated for _The Mathematics Teacher_ (published by the National Council of Teachers of Mathematics and designed for junior college and high school mathematics teachers). (A report of my study of his adaptation to differing audiences would be another paper in itself.) Here, however, I am concentrating on the "Microcomputer-assisted Discoveries" articles: published,

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accepted but not yet published, and submitted. (See bibliography.)

NOTE: I wish to emphasize that while I myself cannot analyze and judge the mathematics content, I have obtained assessments by those who can. Other mathematicians' respect for Dr. Kimberling is indicated by this statement by Dr. Harry B. Tunis, Managing Editor of The Mathematics Teacher:

In recent years there has been a trend in professional journals to include articles on the effective uses of technology in the classroom, in particular, using microcomputers for instruction. This theme has been explored extensively in the section, "Microcomputer-assisted Discoveries," in the Mathematics Teacher, a refereed publication of the National Council of Teachers of Mathematics. The most prolific contributor of this section has been Clark Kimberling. His writing has offered novel tips on how to use computing power to teach mathematics better. His writings have been very well received by the readers of the journal (letter).

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In addition, the Mathdisks accompanying these "Microcomputer-assisted Discoveries" articles have been favorably reviewed. (See *The Mathematics Teacher*, November, 1984 [pp. 641-642] and February, 1985 [pp. 148-149].)

Finally, attesting to Kimberling's reputation is an entry in *A Dictionary of Mathematics*: "Kimberling point" ("isoperimetric point" named for Dr. Clark Kimberling) (105).

In this presentation I shall report the findings of my study to discover what techniques Kimberling uses to convey complex material and whether those devices are transferrable to other disciplines and, consequently, teachable in composition courses. I have concluded that he does employ creative strategies applicable to any field. Further, I have found that he not only conveys complex material in a clear and lively fashion but also depicts learning actually taking place; his descriptions of the process of discovery (the achievement of insight) provide models for students' re-enacting the learning that takes place in all subject

(cont.)

areas.[2] After describing what I have found in Kimberling's articles, I shall report on my use of them in my composition courses.

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Even before writing the "Microcomputer-assisted Discoveries" articles, Kimberling was interested in the process of discovery. In "Mathematics for Creative Students" (1979) he wrote of the "curious student's need to ask questions, and the wandering, divergent, and inductive thinking which attend an active curiosity" and the teacher's need to provide an atmosphere allowing for "freedom, curiosity, deep involvement and incubation which characterize creative mathematical thinking. . . ." (4). Now he has found ways to demonstrate, in the structure and vocabulary of these articles, the process of discovery. In the classroom milieu of his articles occurs a dramatization of Henri Poincaré and Jacques Hadamard's theory of the stages of preparation, incubation, illumination, and verification (stages used in composition theory by Young, Becker and Pike--among others) and the elements of insight outlined by Bernard Lonergan in <u>Insight: A Study of Human Understanding</u>. According to Lonergan, insight "comes as a release to the tension of inquiry, comes suddenly and unexpectedly, is a function not of outer circumstances but inner conditions, pivots between the concrete and the abstract, and passes into the habitual texture of one's mind." Such insight, Lonergan suggests, "depends upon a habitual orientation, upon a perpetual alertness ever asking the little question, 'Why?'" (3-5).

While insight may not be dependent on outer circumstances, the teacher can help it occur. In Kimberling's articles the teacher's role in creating a situation conducive to discovery is that of the "enabler" described by Janice Lauer in "Writing as Inquiry: Some Questions for Teachers": "maintaining a delicate balance between abandoning them [students] to the 'mystery' of discovery and forcing them into a completely linear, mechanical series of operations" (92).

Just as important as philosophy and composition theory in providing a framework for my study is the term "discovery-learning" as used in mathematics education and by Kimberling himself. What I am calling the process of discovery covers the following two meanings of discovery-learning. In mathematics education this term means, according to Kimberling, "learning that proceeds by the learner's following a path that leads toward an objective. When the objective is 'close enough' to be visible, the learner 'sees' it, i.e., discovers it" (conversation, Feb. 1985).[3] However, Kimberling also uses the term to mean "learning in which the learner feels that he controls and owns and 'guides' the content being learned; learning that patterns itself after the nature of the learner's own curiosity and other innate urges and interests." Something Kimberling wrote in "Roots: Half-Interval Search" (an article in this series) helps one's understanding of these articles as a whole: "Discovery learning does not exclusively belong to individuals working alone, and even when it is 'private,' certain stages can be prompted and exemplified by a teacher. These stages are gradations of awareness of what is known, together with a convergence of mental powers on the particular problem to be solved. It is less helpful for the teacher (and students) to ponder how discovery occurs than it is to see and feel it occur. . . . Examples of discovery teaching and discovery learning are more productive than analyses" (120).

To create a form reproducing this activity of discovery, Kimberling uses a number of stylistic devices. For this paper, I have isolated four: (1) first person references (much like a first-person narrator) to the teacher/writer's experience in the classroom and second-person references to his audience (other teachers); (2) language and syntax depicting the excitement of learning; (3) "idealized dialogue" (draft of "Roots:. Half" 2) (also called "hypothetical dialogue" ["Roots: Half" 120])--Kimberling's term for "a new form that suits mathematics discourse," language somewhere between "the way students usually talk and the actual language of mathematics"; and (4) the insertion of bits of mathematics history into the discussion to establish continuity between present and past discoveries.

By using first and second person, Kimberling sets up a concrete situation consisting of human beings engaged in the learning process. In this created classroom, the teacher/writer is deeply involved with the students and with his audience (other teachers). Teacher/writer/narrator Kimberling, who often uses phrases like "my students" ("Primes" 434) and "asked me after class" ("Integrals" 5), is sometimes a leader, an enabler; sometimes a listener ("I have found it entertaining to listen" ["Generate" 118]), but always a participant. This involvement in the learning process is communicated to his audience of other teachers, whom he addresses in second person: ". . . I would like to read about mathematical discoveries your students have made with the assistance of microcomputers" ("Number Bases" 601).

The excitement of discovery, the dominant feature of the learning process as described by Kimberling, is conveyed by carefully-chosen language and syntax: affective words, figures of speech, question words, and syntax (representing tentativeness, speculation, pauses, sudden bursts of insight, recognition of mistakes, and additional insights). First, Kimberling fuses cerebral and affective elements of discovery. Although he deals with complicated material (polynomials, standard deviation, conics), he consistently uses "feeling" words for both teacher's and students' reactions: "I am amazed" ("Lines" 454), "enjoyed" ("Circles" 46), "fun to use" ("Generate" 118), and "students surprised and pleased" ("From Simple" 5). See also the following example:

> After completing experiments 4 and 5, one of my students exclaimed, "I sure didn't know a computer could do mathematics like this!" When I asked her what she meant, she said that the inventors of computers must have been mathematicians and that doing mathematics must have been the original purpose of computers.
>
> I asked her for something specific, and she said, "Oh, it's that line 107 [in experiment 4]: <u>I still can't believe the computer can do that</u>!" ("Graph, Part 1" 7)

Equally far removed from abstract discussion of mathematics is Kimberling's frequent use of figurative language. For example, "alchemy" occurs in discovery-learning ("Euclidean" 512), and students can "be led to the doorstep of Dirichlet's theorem"

("Primes" 436). Further, student-discoverers are excited by a "sense of ownership"; "the study of . . . number bases . . . provides fertile ground for . . . discoveries"; and, finally, in this sustained metaphor Kimberling offers "three more territories involving number bases for further exploration by students" ("Number Bases" 599, 601). Two other sustained uses of figurative language are particularly engaging. In his description of a student's winning program in an Applesoft Basic Programming Contest, Kimberling writes that the random numbers graphics "remind one of colored balloons, suddenly freed and rising into the sky." The term "balloon" is then used not only for the title of the student's program ("Will's Balloon Race") but also for the questions Kimberling poses for students, for example, "What is the expected number of random numbers before there is a winning balloon?" ("Random Numbers" 681, 683). The second example is Kimberling's description of the mean and standard deviation of a set of numbers: "Suppose . . . the computer starts printing a row of asterisks (let's call them stars), and the student presses a key to stop printing the stars as close as possible at the end of one row, before they spill onto the next row." Kimberling entitles the program, "Stop the Stars," and refers to "perfect forty-star rows," "the actual count of stars," and "star counts" ("Mean" 633).

Another feature of Kimberling's language is its emphasis on the question, on the unsolved (reminding one of Rilke's advice in Letters to a Young Poet: ". . . .Love the questions themselves . . ." [35]). Pervading the articles are phrases and sentences like "grapple with" ("Graph, Part 3" 3), "enjoy experimenting with" ("Random Numbers" 683), "The debate leads to a desire to examine" ("Generate" 118), ". . . contributing their own 'What ifs' can be an effective means of learning and discovery" ("Primes" 435); and students' musings: "Let me think about it some more. . . . I don't know how to say it just right" ("Roots: Half" 121) and "Until yesterday, I thought. . . . I was surprised to learn" ("Normal Curve, Part 2" 2).

Not only language but also syntax communicates the excitement of discovery, especially the fluctuations between uncertainty and certainty. Specific devices employed by Kimberling's hypothetical students are beginnings like "I have a feeling" ("Normal Curve, Part 2" 3), "I guess" ("Normal Curve, Part 1" 5), "Did they" ("Normal Curve, Part 1" 5); exclamations like "Wait a minute. I see how to do that!" ("Roots: Newton's" 2), and "Oh, I see" ("Roots: Newton's" 3); and elliptical constructions ("I mean, keep taking their midpoints or something" ("Roots: Half" 121). An especially effective example of tentativeness sustained throughout a sentence is the following: Student: "So, maybe we could find the X-intercept of the tangent line and say it's close to the X-intercept of the curve... but it wouldn't always have to be very close, so I don't know if we're on the right track" ("Roots: Newton's" 2).

The third main device is Kimberling's "idealized dialogue" or "hypothetical dialogue" (also "idealized classroom discussion" [in a few articles in manuscript]) to portray a classroom situation that dramatizes the process of discovery. In one article Kimberling prefaces the dialogue with a brief discussion of its function: "One way to write down ideas about teaching mathematics is to quote a hypothetical classroom discussion. With this technique, the writer can cover lots of ground in a few sentences. The technique also provides for close-ups of mathematical motivation and problem-solving" ("Using a Microcomputer, Part 3" 1-2). More frequently, however, Kimberling uses headings ("Using a Microcomputer, Part 1" 1; "Part 2" 3) and lead-in sentences, such as "Following is an idealized dialogue between teacher and students" ("Roots: Newton's" 2) and (in the first published use of the dialogue) "Accordingly, let us imagine a teacher and class, setting out to discover, collectively, how to make a computer find roots. Here is a hypothetical dialogue" ("Roots: Half" 120). The latter preface illustrates accurately the discovery-learning atmosphere created by the dialogue not only in that particular article but also in these articles as a whole.

The characters in the dialogue are sometimes labeled Teacher and Student(s) and at other times Teacher and several students named George, Sam, Lorene, and Jonette. In the dialogue containing the named students, Kimberling (like a writer of fiction) differentiates among the characters. While he does not, he says, intend for them to be consistent from article to article, Jonette does appear to be "the most insightful"; Kimberling usually gives her "the role of honor student." Sam, on the other hand, is the "talented rebel." What the characters (both teacher and students) say is not intended to reproduce what specific people have said at any particular time or place. Whether the conversation is factually true is "irrelevant"; intended "to get people to read" the material, the idealized dialogue or "rigged conversation" is, Kimberling says, "as accurate a way to reflect reality as is mythology."

In the dialogue Kimberling assigns mathematical content to both teacner and students. While the teacher is clearly the leader, the students also sometimes take the initiative in presenting ideas. (See, on the handouts, excerpts from "Roots: Half-Interval Search," "The Normal Curve, Part 2," and "Using a Microcomputer Instead of Probability Tables, Part 2.") The articulateness of these students has led a few referees of Kimberling's articles to misunderstand the intent of the dialogue. (This is only one exception, however, to the very favorable responses his articles have elicited.) For example, one referee wrote, "In the 'real' world, the probability of a group of students talking in the way that 'George' and 'Sam' do is very close to 0." In response to that lack of understanding, Kimberling (clearly in control of his material) explains: ". . . All four [students] say exactly what a mathematician-writer wants them to say, in order to communicate about mathematics and the learning of mathematics. The four students do not say what real students at their level say (except maybe at Harvard)."

While the students are quite knowledgeable, the dialogue is not pompous but lifelike; and, further, Kimberling distinguishes between the teacher's and their language. The teacher says, "Let's pretend" ("Roots: Half" 120), "Let's imagine" ("Roots: Newton's" 2), and "Suppose you toss 20 coins" ("Using a Microcomputer, Part 1" 1). Explaining integral, the teacher calls it "one of the toughest definitions in any calculus textbook" and, in the same discussion, speaks of a "stumbling block" ("Integrals" 1). In a discussion of root searching, a student says a "trialand-error method . . . might work okay" and comments on their 'luck[ing] . . . onto" something (draft of "Roots: Half" 3).[4] A discovery during a discussion of Newton's Method for approximating roots of functions leads a student to comment, "pretty slick" and "No wonder they made Newton a knight" ("Roots: Newton's" 3). On other occasions, students say, "Oh, that's like so many problems in the book" ("Using a Microcomputer, Part 1" 1) and "Wait a minute" ("Roots: Newton's" 2).

The fourth technique I shall discuss here is Kimberling's inclusion of mathematics history at appropriate places in his articles. Before citing examples of this device, I should like to explain his reason for doing this: he is responding, he says (in a letter in the ISGHPM Newsletter) to the lack of knowledge of mathematics among developers of mathematics-instruction computer software and the resultant teaching of "more and more 'applications' to students who know less and less what they are expected to 'apply.'" Kimberling hopes "to combat this fragmentation and noncommitted sense of purpose among students" by means of mathematics history: "not only mathematics history courses and seminars . . . but rather, such far-reaching measures as a historical paragraph or two during runs of high-school level mathematical microcomputer programs." As an example, Kimberling mentions (in that letter) the difference between "a program that illustrates successive cases of Goldbach's Conjecture without any mention of 'Goldbox' (that's what students think you're saying) and the same program with a remark that 'in 1742, Christian Goldbach wrote . . . and to this day, no one knows the answer!" (Letter, ISGHPM Newsletter 7; see also his letter in The Mathematics Teacher 328).

To create such awareness, Kimberling uses both general and specific references to the history of mathematics. One technique is his presenting the reader with "a big outline of mathematics" ("a look at the totality of mathematics") (which he compares to one's "looking at a continent from a spaceship"). For example, in "Complex Roots: the Bairstow-Hitchcock Method" he refers to the "eminence" that the FTA (Fundamental Theorem of Mathematics) "holds in the history and structure of mathematics." Then he suggests that "the teacher may set the scene for the FTA with a brief outline of five successive number systems--successive not only mathematically, but also historically and pedagogically" (1).

More frequently, Kimberling creates awareness of mathematics history by strategically placing references to specific items--sometimes briefly (one or two sentences) and sometimes in one- or two-page explanations. Always, these sections are woven naturally into the text. And always they pique curiosity and establish a relationship between an individual's questions and answers and past questioners/discoverers. Examples of brief references are the following: "before 1780, Euler discovered, without a microcomputer, that" ("Primes" 436); "This remarkable fact was first proved by Niels Abel (pronounced Ah'bl) in 1824, when he was twenty-two years old" ("Roots: Half" 120); "a discussion-development of the famous algorithm that Sir Isaac Newton first wrote in a manuscript dated 1671" ("Roots: Newton's" 2); "The Fibonacci numbers . . . are named after Leonardo Fibonacci (1170?-1250?)" ("Roots: Newton's" 5); "J. L. Lagrange (1736-1813), one of the greatest mathematicians of all time, pondered the 'N-point problem' . . ." ("Lagrange" 1); "If no one offers a solution, I tell the class that long ago a man named John Napier was asking himself the same question. Finally, he realized that there was no word for x in this case, and so he made one up: logarithm, and he wrote x = LOG(y)" (followed by Kimberling's mentioning a book on Napier and the origin of logarithms) ("From Simple" 4-5).

Some bits of mathematics history are specifically placed in a context of praise for students' curiosity, which is linked to curiosity displayed in the past: "That's a good kind of curiosity, George, the kind that led to one of the most important parts of statistics and probability theory, called the normal curve" ("The Normal Curve, Part 1" 5); "What you have discovered was first developed by two twentieth-century Russian mathematicians Kolmogorov and Smirnov" ("The Normal Curve, Part 3" 2-3). Kimberling also sometimes raises philosophical questions about the term "discovery;" for example, "Lagrange invented (or discovered--which was it?--a good question for student philosophers) these polynomials while trying to interpolate between known values of the functions" ("Lagrange" 4).

In addition to one- and two-sentence references to the history of mathematics, Kimberling includes some extended discussions, for example, of Donald Knuth ("Graph, Part 2" 1) and of Sir Leonard Bairstow and Frank L. Hitchcock ("Complex Roots: the Bairstow-Hitchcock Method" 2-3). (See handouts.) The latter article reproduces Kimberling's own search for information and includes photographs of these two men.

Finally, having used mathematics history to create awareness of the past and having linked students' curiosity to that in the past, Kimberling also employs another novel technique to encourage discovery. He credits students with classroom discoveries, for example, "Jennifer's Constant" ("Euclidean" 512), "Ric's Variation" ("Mean" 633), "Sam's Sums" and "George's Six-Liner" ("Using a Microcomputer, Part 1" 3). This continuum of past and present discoveries is a fitting culmination for the various discovery-learning stylistic strategies Kimberling has used in these articles.

After examining Kimberling's "Microcomputer-assisted Discoveries" articles, I used them to stimulate students' writing about the process of one of their own discoveries. Immediately preceding this process-of-discovery assignment, my students had written a paper on a conventional process. In that essay they paid attention, of course, to person (first or third for informative processes and second for instructional ones), major and minor steps, clear signals of time and place, etc. Then I asked them to write about a less-ordered process--a discovery they experienced in learning something new in their major field or in another one.

To prepare for their writing, we looked at a summary of Henri Poincaré and Jacques Hadamard's theory of the stages in creative thinking. (See handout.) Second, I distributed a copy of Kimberling's article, "Roots: Half-Interval Search," and excerpts from other articles, including "The Normal Curve: Part 1: Darts." (See handouts.) Emphasizing that we would study not the mathematics content but the devices that Kimberling uses to convey material, I presented some of the findings of my study of his articles. Then we examined, in the handout articles, the dialogue structure, language and syntax, and insertions of mathematics history. That discussion led to students' brainstorming about their own discoveries. After class discussions and the students' work on their own outside of class, in individual conferences they and I looked at their jottings, and we talked about topics for their papers. In later conferences, students brought in rough drafts of their essays. Usually I duplicated some papers (in either rough draft or final form), and we discussed them in class.

Now I would like to mention some of the topics on which my students have written. Originally when I assigned a process-of-discovery paper based on Kimberling's articles, I intended that the subject matter would be a discovery in an academic field. However, since I did not definitely limit the subject matter, some students wrote on non-academic discoveries. (I am now, in my assignment during this Spring Quarter, limiting it to academic areas and will be eager to see the results.)

Among the academic topics chosen by my students are the following:

- triangle median program
- the heart (in a biology lab)
- an electrical engineering design project
- correcting syntax errors
- playing with vibrato on a bassoon
- reading of Tolkien and then other fantasies and science fiction
- genealogical research
- reading of Hagopian's Regimes, Movements, and Ideologies and Anthony Lewis' Gideon's Trumpet (in a political science course)

Non-academic topics included the following:

- conducting (chairing) meetings
- coordinating a flag corps' routine with steps of a marching band
- developing a process for changing the chasers in a pipe threading machine
- driving a car
- riding a bike
- lifesaving

In their essays, students used narrative, description, and exposition. A dialogue form was used in some essays, for example, on the triangle median program, conducting meetings, and coordinating a flag corps routine. While sometimes mechanical, the dialogue did manage to convey the fumblings, speculations, and discoveries involved in learning.

(I am now analyzing the students' essays further. I plan to assign this paper several more times and use other Kimberling articles. Later, I plan to use his articles in additional ways: for example, to study the functions of different sections of the text or to compare/contrast these articles with others [by Kimberling or other writers] conveying complex ideas.)

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My use of Kimberling's articles in composition assignments has had several benefits: it allows students to choose the material; and, allied with process rather than product, it provides occasions for students not merely to report on content in a given subject area or, indeed, to analyze discovery, but to describe (in Kimberling's words) their "see[ing] and feel[ing] . . . [discovery] occur" ("Roots: Half" 120). And, finally, although initially I was looking at strategies for handling complicated material, I eventually found that Kimberling's articles provided more than an answer to that question; his dramatizations of the workings of the mind have helped to cultivate students' excitement about learning. For students in a composition course or in any course containing a writing component, Kimberling's discovery-learning articles constitute a paradigm of a liberal arts education and, simultaneously, integrate the liberal arts and technology.

Notes

[1] This section is now (as of January 1985) entitled "Microcomputer-assisted Mathematics."

[2] To see the distinctiveness of the strategies used in the articles being examined here, note some of Kimberling's other articles, no less effective artistically but different (for example, an attached excerpt from "Triangle Centers and Their Multiplication").

[3] All subsequent Kimberling quotations for which no source is indicated are from conversations during 1983-1985.

[4] In the published version Kimberling used, instead, the following: "might work at first" and "we had a" ("Roots: Half" 121).

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WRITING FOR MATHEMATICS DISCOVERY-LEARNING: A MODEL FOR COMPOSITION COURSES

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Professor of Mathematics
University of Evansville

(the subject of this presentation)

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NOTE: My present paper, "Writing for Mathematics Discovery-Learning: A Model for Composition Courses," is based on a study of the following "Microcomputer-assisted Discoveries"* articles (#3-#30) (L.H.W.):

3. "Primes." The Mathematics Teacher 76 (1983): 434-37.

4. "Euclidean Algorithm and Continued Fractions." The Mathematics Teacher 76 (1983): 510-12, 548.

5. "Number Bases." The Mathematics Teacher 76 (1983): 599-601.

6. "Random Numbers." The Mathematics Teacher 76 (1983): 681-84, 666.

7. "Probability Machine." The Mathematics Teacher 77 (1984): 42-47.

8. "Generate Your Own Random Numbers." The Mathematics Teacher 77 (1984): 118-23.

9. "Conics." The Mathematics Teacher 77 (1984): 363-68.

10. "Lines." The Mathematics Teacher 77 (1984): 452-54, 435.

11. "Mean, Standard Deviation, and Stopping the Stars." The Mathematics Teacher 77 (1984): 633-36.

12. "Circles and Star Polygons." The Mathematics Teacher 78 (1985): 46-51, 54.

13. "Roots: Half-Interval Search." The Mathematics Teacher 78 (1985): 120-23.

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14. "Graph Many Functions, Part 1."

15. "Graph Many Functions, Part 2."

*Now (beginning January 1985) entitled "Microcomputer-assisted Mathematics"

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16. "Graph Many Functions, Part 3."
17. "Integrals, with Applications."
18. "Powers of Complex Numbers."
19. "Roots: Newton's Method."
20. "Permutations and Combinations."
21. "Factoring and Unfactoring."
22. "Quadratic."
23. "Complex Roots: the Bairstow-Hitchcock Method."
24. "Lagrange Polynomials."
25. "From Simple Interest to e."

Submitted

26. "The Normal Curve (Part 1: Darts)."
27. "The Normal Curve (Part 2: Is This Random Variable Normal?")
28. "Using a Microcomputer Instead of Probability Tables: Part 1: The Binomial Distribution."
29. "Using a Microcomputer Instead of Probability Tables: Part 2: The Poisson Distribution."
30. "Using a Microcomputer Instead of Probability Tables: Part 3: The Normal Distribution."

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