Annotated Bibliography,

Mathematics Concepts and Computer Coding (K-16)

Richard J. Shumway

1988

Annotated Bibliography
Mathematics Concepts and Computer Coding (K–16): Representations, Variable, Limit, & Random 1964–1988

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This bibliography is being developed in the context of investigating the hypothesis that computing technology (computers and graphics calculators most specifically) through graphics, coding, simulations, and computer mathematics systems can have significant impact on the development of the mathematical concepts of representation (symbolic–geometric), variable, limit, and random. Literature from mathematics education, psychology, education, mathematics, statistics, and computer science are examined. Corrections, additions, and comments are welcomed. –RJS

Abelson, H. & diSessa, A. (1980). *Turtle geometry: The computer as a medium for exploring mathematics.* Cambridge, Massachusetts: The MIT Press.
[Extensive exploration of mathematical ideas using Logo.]

Adams, R. (1984). Computers should do things science teachers can't. *Natural History*, December, 70–74.
[Notes *ALGEBRA ARCADE* and *ROCKY'S BOOTS* are potential environments for student learning of mathematics and logic.]

Adda, J. (1982). Difficulties with mathematical symbolism: Synonymy and homonymy. *Visible Language, 16*, 205–214.
[ ]

Adelson, B. (1981). Problem solving and the development of abstract categories in programming languages. *Memory and Cognition, 9*, 422–433.
[Expert programmers recalled more, recalled in larger chunks, used more efficient forms of representation, chunked items and organized hierarchically.]

Adelson, B. (1984). When novices surpass experts: The difficulty of a task may increase with expertise. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*, 483–485.
[Expert programmers formed abstract representations of programs, wheras novices formed concrete representations. (college)]

Ahl, D. (1984). The first decade of personal computing. *Creative Computing, 10(11)*, 30–45.
[History of micro computer development allowing predictions about future development.]

Ahl, D. (1984). Ascent of the personal computer. *Creative Computing, 10*, 80–82.
[Chronology of the personal computer development in U. S. Use to predict future developments.]

Albers, D. (1982). Paul Halmos: Maverick, mathologist. *Two–Year College Mathematics Journal, 13*, 226–242.
["The computer is important, but not to mathematics."]

Albers, D., & Reid, C. (1987). An interview with Lipman Bers. *The College Mathematics Journal, 18(4)*, 267-290.
["What is the strength of mathematics? What makes mathematics possible? It is symbolic reasoning. It is liked "canned thought." You have understood something once. You encode it, and then you go on using it without each time having to think about it. Now there may be people who are totally unable to follow symbolic reasoning--just as I am unable to carry a tune (and yet I do say to myself that I enjoy music). So you must try to explain mathematics without using and symbols. But this may be impossible. Without symbolic reasoning you cannot make a mathematical argument. " (p. 283)]

Albers, D., & Reid, C. (1988). An interview with Mary Ellen Rudin. *The College Mathematics Journal, 19*, 115–135.
[". . . and is especially well known for her ability to construct counterexamples." "I'm a problem solver, primarily a counterexample discoverer. Part of that is a Moore thing, too. That is, he didn't always give us correct theorems, at least half of his statements were false."]

Alexander, D. (1985). A matrix application technique for secondary level mathematics. *The Mathematics Teacher, 78(4)*, 282-285.

[illustrates generalizing matrix approach for linear equations to finding polynomial passing through n+1 points.]

Allardice, B. (1977). The development of written representations for some mathematical concepts. *Journal of Children's Mathematical Behavior, 1*, 4.
[ ]

Alspaugh, C. (1972). Identification of some components of computer programming sptitude. *Journal for Research in Mathematics Education, 3*, 89–98.
[Mathematics background, low impulsive and sociability, and high reflectivity correlated with computer programming aptitude in FORTRAN IV. university level.]

Alspaugh, J. (1971). The relationship of grade placement to programming aptitude and FORTRAN programming achievement. *Journal for Research in Mathematics Education, 2*, 44–48.
[High school students who had twice the hours of instruction learned FORTRAN as well as college students. (11,12, college)]

Althoen, S., & Mclaughlin, R. (1987). Gauss-Jordan reduction: A brief history. *American Mathematical Monthly, 94*, 130-142.
[Illustrates various computational methods for solving linear equations and notes lack of computational devices was primary motivation for such techniques. Computational example given to illustrate Gauss-Jordan method is easily solve by HP-28C using matrices (4x1, 4x4, +, gives 4x1 solution). Perhaps we drop study of these techniques and focus on theorems and concepts needed for modeling issues.]

Anderson, J. and Johnson, W. (1971). Stability and change among three generations of Mexican-Americans: factors affecting achievement. *American Educational Research Journal, 8*, 285–309.
[Self-concept of ability appeared to contribute most to prediction of success in mathematics and English. Parent stress on achievement and on attending college were also factors, and student desire to obtain high grades was significantly related to mathematics achievement. (7-12)]

Anderson, J., Farrell, R. & Sauers, R. (1983). *Learning to program in LISP*. Technical Report. Pittsburgh: Carnegie-Mellon University, Department of Psychology.
[ ]

Apostol, T. (1961). *Calculus*. New York, NY: Blaisdell Publishing.
[Good, elementary development of calculus with careful proofs and suitable motivation. For example, good development of Bolzano's Theorem, needed to claim you can find (most) roots of continuous functions with graphics calculators, see pages 168ff]

Appel, K. & Haken, W. (1981). The nature of proof: Limits and opportunities. *Two Year College Mathematics Journal, 12*, 118–119.
[Notes on the role of theory and computation in mathematics. Computer needs to be thought of as a routine tool for doing mathematics.]

Arganbright, D. (1984). Mathematical applications of an electronic spreadsheet. In V. Hansen & M. Zweng (Eds.) *Computers in Mathematics Education* (pp. 184–193) Reston, VA: National Council of Teachers of Mathematics.
[Illustrate use of spread sheet to do significant mathematics.]

Atwood, M. & Ramsey, H. (1978). *Cognitive structure in the comprehension and memory of computer programs: An investigation of computer programming debugging*. ARI Technical Report TR 78-A210. Science Applications, Englewood, Colorado.
[Chunks or schemata involved in computer programming.]

Ayers, T, Davis, G., Dubinsky, E., & Lewin, P. (1988). Computer experiences in learning composition of functions. *Journal for Research in Mathematics Education, 19*, 249–259.
[Perhaps computer experiences can help students construct mathematical knowledge.]

Barclay, T. (1987, February). A graph is worth how many words? *Classroom Computer Learning*, 46–50.
[ ]

Barker, W. & Ward, J. (1984). *The calculus companion to accompany Calculus 2nd ed. by Howard Anton.* New York: Wiley.
[Example of computer use to accompany calculus.]

Battista, M. (1987). MATHSTUFF Logo procedures: Bridging the gap between Logo and school geometry, *The Arithmetic Teacher, 35(1)*, 7-11.
[Example of procedure writing to help students explore mathematics, symbolic code, and graphic representations.]

Battista, M., & Krockover, G. (1984). The effects of computer use in science and mathematics education upon the computer literacy of preservice elementary teachers. *Journal of Research in Science Teaching, 21*, 39–46.
[Using CAI in science course affected attitudes toward computers, while computer programming in a mathematics education course had little or no effect. (elementary preservice)]

Battista, M., & Steele, K. (1984). The effect of computer assisted and computer programming instruction on the computer literacy of high ability fifth grade students. *School Science and Mathematics, 84*, 649–658.
[Both a drill-and-practice program and programming instruction improved computer literacy in the affective domain, but on the first improved it in the cognitive domain. (grade 5)]

Bayman, P., & Mayer, R. (1983). A diagnosis of beginning programmers' misconceptions of BASIC programming statements. *Communications of the ACM, 26*, 677–679.
[Hands-on experience alone is insufficient to prevent a wide variety of misconceptions regarding BASIC commands and "what the computer is doing." Misconceptions described. College undergraduates.]

Berdonneau, C. (1985). [The construction of sonceptual schemes in 5–12 year old children]. *Enfrance, 2(3)*, 183–190.
[ ]

Bear, G. (1984). Microcomputers and school effectiveness. *Educational Technology, January–84*, 11–15.
["Although worthwhile goals may be achieved in schools that emphasize computer literacy and the learning of computer languages (the most common being BASIC and LOGO), gains, if any, on standardized achievement tests given in such schools will be less impressive and perhaps only found on math tests when higher-level math skills are measured in high school." (p. 13).]

Becker, H. (1986a). *Instructional Uses of Microcomputers: Reports from the 1985 Survey. Issue 1.* Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.
[Describes a quadrupling growth in the number of computers in use between Spring '83 and Spring '85. Programming accounts for 12% of use in K-6 and 49% of use in High School. The average over all grades is 32% for "Drill & Practice," 14% for "Discovery Learning and Problem Solving," 33% for "Programming," and 15% for "Word Processing." The median student-computer ratio is 42-1, with a "best" ratio of 25-1 in Jr-Sr High schools and a "worst" ratio of 60-1 in K-6 Elementary schools.]

Becker, H. (1986b). *Instructional Uses of Microcomputers: Reports from the 1985 Survey. Issue 2.* Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.
[In grades K-6 primary use of computers was for enrichment rather than regular instruction whereas in grades 10-12 primary use was for regular instruction rather than enrichment. Sex differences in use suggest rough parity in most uses. Some patterns of over and under representation did exist, but are difficult to separate from other correlated social patterns. In grades K-3, 42% of computer use was for mathematics, in grades 4-8, 28%, and in grades 9-12, only 9% of computer use was for mathematics, with 48% use for programming or computer literacy courses. Computer use is generally higher for high SES and high ability.]

Becker, H. (1986c). *Instructional Uses of Microcomputers: Reports from the 1985 Survey. Issue 3.* Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.
[Computer using teachers perceptions about the benefits of computer use most frequently focus on increasing student motivation rather than student achievement.]

Becker, H. (1987). *Instructional uses of microcomputers: Reports from the 1985 survey. Issue 4.* Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.
["of all traditional mathematics instruction using computers, 26% occurred at grades K-2; 47% at grades 3-5; 18% at grades 6-8; 5% at grades 9-10; and 3% at grades 11-12." "Math drills formed nearly three-fourths of the mathematics computer activity at the elementary grades and two-thirds of the remedial and general math use of computers in high school." Drill: 72% at K-5; 58% at 6-8; 68% in Math below algebra in high school; and 43% in algebra or more advanced. For the same categories Programming is: 8%; 15%; 0%; and 21%. "Only 13% of the computer-using higher-level math classes reported using computers more than once per week." ". . . from algebra on up, the evidence suggests that the involvement of computers in traditional instructional topics was yet very small."]

Becker, H. (1987). The importance of a methodology that maximizes falsifiability: Its applicability to research about logo. *Educational Researcher, 16(5)*, 11–16.
[Thanks Papert for Logo, but notes that educational uses of Logo must be subject to the same scrutiny as any model for learning]

Beth, E. (1966). *The foundations of mathematics, revised edition.* New York, NY: Harper & Row.
[Beth is mathematician who co-authored a book with Piaget. Cited for history of variable (pp. 52–55), logical development of variable (pp. 179–183), model (pp. 183–184) and counterexample (pp. 184–185).]

Beth, E., & Piaget, J. (1966). Mathematical epistomology and psychology (W. Msays, trans.) Dordrecht, Holland: D. Reidel.
[ ]

Birkhoff, G. (1972). The impact of computers on undergraduate mathematical education in 1984. *American Mathematical Monthly*, *79*, 648–657.
[Calls for calculus with computers, formula manipulation, probability and statistics, pure mathematics, rigor, discrete mathematics (*not* Kemeny-Snell-Thompson type, but *symbol manipulation*), numerical mathematics, individual study, and scientific computing (e.g., applications to other disciplines).]

Blume, G. (1984, April). *A review of research on the effects of computer programming on mathematical problem solving.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.
[Some support that programming has a positive effect on mathematics achievement and problem solving.]

Blume, G. & Schoen, H. (1985). *The effects of learning computer programming on students' performance in mathematical problem solving.* Paper presented at the research presession of the annual meeting of the National Council of Teachers of Mathematics, San Antonio.
[Programming students used systematic trial, equations, and looking back strategies such as checking and correcting errors more frequently than non-programmers. No differences were detected on means of five interview problems or two paper-pencil tests. (Grade 8)]

Blume, G., & Schoen, H. (1988). Mathematical problem–solving performance of eighth–grade programmers and nonprogrammers. *Journal for Research in Mathematics Education*, *19*, 142–156.
[make case from literature that computer programming would influence problem solving behaviors. programmers used more systematic trial and checked for and corrected more errors in their potential solutions. Other expected differences not supported.]

Bodner, G. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education*, *63*, 873–878.
[]

Bolzano, B. (1950). *Paradoxes of the infinite* (Fr. Prihonsky, Trans., ed. by D. Steele). New Haven CN: Yale University Press. (Original work published 1851)
[Steele's historical introduction describes: Bolzano's counterexample of everywhere continuous nowhere differentiable function first printed in 1830, 30 years before private circulation of Weierstrass's; Bolzano's Theorem (allows finding of roots from change of sign of continuous function, the most common strategy to employ with graphics computers); and shows Bolzano gave special attention to the meaning of variable.]

Bonar, J. (1982). *Natural problem solving strategies and programming language constructs*, Proceedings of the Fourth Annual Conference of the Cognitive Science Society, Ann Arbor, MI.
[Prior natural language understanding of programming terms misleads novice programmers.]

Bonar, J., & Soloway, E. (1982, November). *Uncovering principles of novice programming* (Research Report No. 240). New Haven, CT: Yale University, Department of Computer Science.
[]

Booth, L. (1984). *Algebra: Children's strategies and errors.* Berkshire, UK: NFER-NELSON.
[ ]

Bourbaki, N. (1950). The architecture of mathematics. *American Mathematical Monthy*, *57*, 221-32.
[Describes and argues for structures as fundamental building blocks of mathematics.]

Bourne, L., Jr. & Dominowski, R. (1972). Thinking. *Annual Review of Psychology*, *23*, 105–130.
[215 "recent" research studies on human thinking are summarized.]

Bourne, L., Jr., & Guy, D. (1968). Learning conceptual rules II: The role of positive and negative instances. Journal of Experimental Psychology, 77, 488–494.
[Classic results on conceptual rules, their relative difficulty, and the role played by positive and negative instances. Conjunction, disjunction, conditional, and biconditional is order of difficulty and best universe set to use (+ vs -) is smaller and more homogenous one.]

Bourne, L., Jr., Ekstrand, B., Lovallo, W., Kellogg, R., Hiew, C., & Yaroush, R. (1976). Frequency analysis of attribute identification. *Journal of Experimental Psychology: General*, *105*, 294–312.
[Experiments which suggested to us the varying of the frequencies of features of irrelevant attributes as a major factor in the benefits found for negative instances in mathematical concept learning.]

Brabeck, M. (1984). Longitudinal studies of intellectual development during adulthood: Theoretical and research models. *Journal of Research and Development in Education*, *17*, 12–27.
[Extensions of meaning of knowing to stages beyond classical Piagetian stages and models for developmental research. Computer programming may change student perceptions of the nature of knowledge. Stages offer model for investigation.]

Brooks, R. (1980). Studying programmer behavior experimentally: The problems of proper methodology. *Communications of the ACM*, *23*, 207–213.
[Calls for rigorous standards of behavioral research in studies involving computer programming.]

Brown, J. (1982). [Reactions to Mayer, R. (1982). *Contributions of cognitive science and related research in learning to the design of computer literacy curricula*]. In *Computer literacy—cognitive research and solving problems using the computer.* New York, NY: Academic Press, Inc.
[Calls for mental models (or metaphors) and computer systems that allow for the command "undo."]

Bundy, A. (1983). *The computer modelling of mathematical reasoning.* London, UK: Academic Press.
[ ]

Burger, W. & Shaughnessy, J. (1986). Characterizing the van Hiele levels of development in geometry. *Journal for Research in Mathematics Education, 17*, 31-43.
[Suggests van Heile levels can be an effective research tool to identify stages of development of geometric concepts and geometric reasoning. (grades K-15)]

Buriel, R. (1978). Relationship of three field-dependence measures to the reading and mathematics achievement of Anglo American and Mexican American children. *Journal of Educational Psychology, 70*, 167–174.
[Failed to support assumption of cultural difference on field dependence. Grades 1-4.]

Burns, P. (1982). A quantitative synthesis of research findings relative to the pedagogical effectiveness of computer-assisted mathematics instruction in elementary and secondary schools. (The University of Iowa, 1981). *Disseration Abstracts International, 42A*, 2946.
[A meta-analysis of 40 studies indicated that computer-supplimented instruction was significantly more effective in fostering achievement than was traditional instruction. (elementary, secondary)]

Burton, R. & Brown, J. (1978). *An Investigation of Computer Coaching For Informal Learning Activities.* BBN Report No. 3914, ICAI Report No. 12. Cambridge, MS: Bolt, Bernnek, and Newman, Inc.
[ ]

Butler, D. (1985). The M.E.I. schools project: an integrated approach to the teaching of mathematics at senior secondary level. In Commission Internationale de L'Enseignement Mathematique (Eds.), *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 99-113.
[Illustrates micro use in topics: graphs and functions, transformations and matrices, numerical methods, and probability and statistics. (high school)]

Byers, V. & Herscovics, N. (1981). Understanding school mathematics. *Mathematics Teaching, 81*, 24–27.
[Identifies four different kinds of understanding: instrumental, relational, intuitive, and formal. Categories are highly related to and illustrated with variables.]

Calfee, R. (1981). Cognitive psychology and educational practice. *Review of Research in Education, 9*, 3–73.
[Essay-review of research of knowledge about human mind and learning.]

Calmet, J. (1985). Introducing computer algebra to users and students. In Commission Internationale de L'Enseignement Mathematique (Eds.), *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 199-201.
[Available computer algebra systems are not designed as teaching aids. In an environment where they could be designed to be instructional and communicative, they are not. Add multiple methods for same problem, on request, information regarding methods being used, selection of alternative methods, methods for handling correctness, and errors, add theorem proving capability.]

Canning, T., McManus, J., & McCall, C. (1985, April). *Using the computer as a tool in the secondary curriculum—seven case studies.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, Il.
[recommendations relevant to graphics calculators: teacher training, time, and school support. Time, effort, and support needed to promote applications.]

Carpenter, T., Corbitt, M., Kepner, H., Jr., Lindquist, M., & Reys, R. (1980). The current status of computer literacy: NAEP results for secondary teachers. *The Mathematics Teacher, 73*, 669–673.
[Few students had had experience using or programming computers, but they did have beliefs about what computers can do. 1977-78 assessment. (ages 13, 17)]

Carpenter, T., Corbitt, M., Kepner, H., Jr., Lindquist, M., & Reys, R. (1983). Results of the third NAEP mathematics assessment: Secondary school. *The Mathematics Teacher, 76*, 652–659.
[ ]

Carpenter, T. & Moser, J. (1984). The acquisition of addition and subtraction concepts in grades one through three. *Journal for Research in Mathematics Education, 15*, 179-202.
["suggests that the current primary mathematics curriculum fails to capitalize on the rich informal mathematics that children bring to instruction."]

Cashing, D. (1987). Is the distributive property redundant? *College Mathematics Journal, 18*, 402–403.

[illustrate operation satisfying all field properties but distributivity. Can also use computer to test operation tables and explore many other examples of this same type.]

Caviness, B. (1986). Computer algebra: Past and future. *Journal of Symbolic Computing, 2*, 217–236.
[Surveys computer algebra work in computer science from 1966–1986., Discusses MACSYMA, REDUCE, ALDES/SAC–2, and mu–MATH as well as SMP, MAPLE, and SCRATCHPAD. Good bibliography of major results in computer algebras.]

Cheatham, T. , jr. (1974). The unexpected impact of computers on science and mathematics. In *Proceedings of Symposia in Applied Mathematics, American Mathematical Society, 20*, 67-75.
[Makes case for significant role of computer in doing mathematics. Exact algorithms to model world have had a profound impact on scientists understanding. MACSYMA does non-trivial mathematics (1973). Risch's theory for a finite algorithm for integration will have a profound impact on how mathematics is tanght. Educational process must become more oriented to the use of algorithms.]

Chesire, F. (1981). The effect of learning computer programming skills on developing cognitive abilities. *Dissertation Abstracts International, 42*, 645A.
[Several control groups favored on problem solving. H. S. algebra]

Chomsky, N. (1988). *Language and problems of knowledge*. Cambridge, MA: The MIT Press.
[The analysis of the use of variable in language is very similar to FOR–NEXT loops or symbolic logic or mathematical expressions. Do children learn these uses in natural language early? Can they do the same in computer coding? Is it a good model for the use of variable in mathematics? Perhaps. Does its use in language justify early use with childrn in computer coding or mathematics? Maybe.]

Ciborowski, T., & Cole, M. (1972). A cross-culture study of conjunctive and disjunctive concept learning. *Child Development, 43*, 774-789.
[Conjunctive concepts were easierthan disjunctive concepts in a wide variety of measures. The performance of both cultural groups was strikingly similar. (ages 8–24).]

Cipra, B. (1988). Recent innovations in calculus instruction. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 95–103). Washington, DC: Mathematical Association of America.
[Good survey of opinions and ideas about calculus. Suggests large role for graphics calculators and CAS.]

Clark, D. (1971). Teaching concepts in the classroom: A set of teaching prescriptions derived from experimental research. *Journal of Educational Psychology Monograph, 62*, 253–278.
[235 studies on concept learning are used to draw prescriptions for teaching concepts in schools.]

Clark, R. & Leonard, S. (April, 1985). *Computer research confounding*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.
[Analysis of sample of Kulik, et. al. (1980) references. Suggests major advantages of CBI uses in in efficiency and cost, not achievement.]

Clarke, V. (1986). The impact of computers on mathematics abilities and attitudes: A pilot study using logo. *Journal of Computers in Mathematics and Science Teaching, 5*, 32-33.
[ability and attitude scores improved with logo experience, (years 1, 3, 5???)]

Clement, J. (1982). Algebra word problem solutions: Thought processes underlying a common misconception. *Journal for Reaearch in Mathematics Education, 13*, 16–30.
[Intuitive symbolization strategies may over ride instruction. Students have contradictory cognitive schemas for $6E = S$ type problems. May be caused by manipulation without understanding. (Could early experience with symbols facilitate or interfere further? What about an irrelevant attribute analysis of this problem?)]

Clement, J., Lochhead, J., & Monk, G. (1981). Translation difficulties in learning mathematics. *American Mathematical Monthly, 88*, 286–290.
[Documents college students inability to use variables ($6P = S$ problem). (College)]

Clement, J., Lockhead, J., and Soloway, E. (1980). Positive effects of computer programming on students' understanding of variables and equations. *Proceedings of the Annual Conference of the American Society for Computing Machinery*, 467–474.
[Programming enhanced student's ability to use variables. Encourages active, procedural view of equations. (6P = S problem, college)]

Clements, J., Mokros, J., & Schultz. K. (1985, April). *Adolescent's graphing skills: A descriptive analysis.* Paper presented at Annual Meeting of the American Educational Research Association, Chicago, IL.
[ ]

Clements, D. (1984). Implications of media research for instructional application of computers with young children. *Educational Technology, 24*, 7–16.

[Relevant implications: Color, sound, animation elicit attention, but comprehension necessary to *maintain* attention; integrate into curriculum; adults should guide and participate; rich educational environments not found elsewhere. (elementary).]

Clements, D. (1985). *Effects of logo programming on cognition, metacognition skills, and achievement.* A paper presented at the annual meeting of the American Educational Research Association, Chicago, April, 1985.
[CAI vs programming in Logo vs control. Programmers higher on seriation (6 year olds), two metacognition measures, creativity, and describing directions. (6 and 8 year olds)]

Clements, D. (1986). Effects of logo and CAI environments on cognition and creativity. *Journal of Educational Psychology, 78,* 309-318.
[CAI vs programming in Logo vs control. Programmers higher on seriation (6 year olds), two metacognition measures, creativity, and describing directions. (6 and 8 year olds) check this annotation against published article.]

Clements, D. & Gullo, D. (1984). Effects of computer programming on young children's cognition. *Journal of Educational Psychology, 76,* 1051–1058.
[CAI vs programming in Logo. Programmers favored on reflectivity, two measures of divergent thinking, metacognitive ability and ability to describe directions. (First graders)]

Clements, M. (1982). Visual imagery and school mathematics. *For the Learning of Mathematics, 2(3),* 33–38.
[ ]

Cleveland, W., & McGill, R. (1985). Graphical perception and graphical methods for analyzing scientific data. *Science, 229,* 828–833.
[ ]

Cohen, M. (1984). Exemplary computer use in education. *Sirgue Bulletin, Computer Uses in Education, 18(1),* 16-19.
[ ]

Cohen, M. & Carpenter, J. (1980). The effects of non-examples in geometric concept acquisition. *International Journal of Mathematical Education in Science and Technology, 11,* 259–263.
[A sequence of examples and non-examples was favored over a sequence of examples alone. (secondary)]

Cole, D., and Hannafin, M. (1983). An analysis of why students select introductory high school computer coursework. *Educational Technology, 23,* 26–29.
[Inaccurate perceptions of computer courses unduly influence student election of computer coursework. (secondary)]

College Entrance Examination Board. (1982). *Advanced placement examination in computer science.* Princeton, NJ: Author.
[Argues against BASIC and for structured programming. HP–28 programming would be seen as most desirable of graphics calculator languages.]

Collenback, L. (1983). Computer supported problem solving in secondary advanced mathematics. (The University of Texas at Austin, 1982). *Dissertation Abstracts International, 43A,* 2264.
[No evidence was found that students with computer programming experience outperformed those with no such experience. (secondary)]

Collis, B. (1987). Sex differences in the association between secondary school students' attitudes toward mathematics and towards computers. *Journal for Research in Mathematics Education, 18,* 394-402.
[Suggest caution to ensure " . . .more positive attitudes toward mathematics and computers from secondary school females." Correlational results, but author suggests low attitude about mathematics may be transfered to computers by *girls*, nor do providing computer activities in mathematics would improve attitudes toward either mathematics or computers for *girls*. reminder, all data is correlational. grades 8, 12]

Collis, K. (1971). A technique for studying concept formation in mathematics. *Journal for Research in Mathematics Education, 2,* 12–22.
[Card sorting task plausible way to study conceptualization for a math course. (8)]

Comission Internationale de L'Enseignement Mathématique. (1984). The influence of computers and informatics on mathematics and its teaching. *L'Enseignement Mathématique, 30,* 159–172.
[How do computers and informatics influence mathematical ideas, values and the advancement of mathematical science? How can new curricula be designed to meet the needs and possibilities? How can the use of computers help the teaching of mathematics? ages: 16 ->]

Comstock, M. (1985, June). *Analysis of a test to discriminate between sixth, seventh, and eighth grade students in mathematics.* Paper presented for a Research Colloquium of Dr. Arthur L. White, Ohio State University, Columbus, Ohio.
[Developed instrument to measure growth in understanding of variable and used to assess growth in school settings. Data suggests computer programming may have significant effect on sixth-graders' letter usage, as defined by Hart-Kücheman. Comstock recommends follow-up study to study apparent effects.]

Conkwright, N. (1941, 1957). *Introduction the theory theory of equations.* Boston, MS: Ginn and Company.
[The sort of text on theory of equations, some of which may now be important mainstream mathematics for high schools because of graphics calculators. De Moivre, Fundamental Theorem of Algebra, Remainder Theorem, Factor Theorem, Multiple root Theorem, Rational root Theorem, Upper & Lower limits to real roots, Descartes sign test, Rolle's Theorem, Newton's Method, Reciprocal equations, Cardan's formulas (cubic), Ferrari's solution (quartic), Abel's Theorem, Sturm & Budan Theorems, Horner's method, Interpolation, Iteration, Simultaneous equations and matrices, Sylvester's method, Graeffe method. Which of these are now of no use, or vital for students solving equations with graphics calculators and symbol manipulators?]

Corbitt, M. (1985). The impact of computing technology on school mathematics. *The Arithmetic Teacher, 32*, 14–18, 60 and/or *The Mathematics Teacher, 78*, 243–250.
[Set of recommendations from a conference held in March, 1984. Calculators and computers need to play a major role in the study of mathematics.]

Coxford, A. (1985). School algebra: What is still fundamental and what is not? In C. Hirsch & M. Zweng (Eds.), *The secondary school mathematics curriculum* (pp. 53-64). Reston, VA: National Council of Teachers of Mathematics.
[Describes potential impacts of computer and computer algebra systems on school algebra and concludes: "The push to incorporate symbolic mathematical systems in algebra is questionable because we are not sure of the relationships between procedural knowledge and skills and the understanding of algebra." ". . . research must answer before the curriculum should change." (sounds like elementary teachers arguing against the dropping of long division?)]

Crawford, M. (1985). Universities urged to enter the information age. *Science, 229*, 1373.
[blackboards need to be enhanced by computer graphics in mathematics departments]

Crook, C. (1986). *The effects of computer programming on seventh-grade students' use and understanding of variable.* Unpublished doctoral dissertation, Ohio State University, Columbus, Ohio.
[concepts associated with variable learned through programming in BASIC.]

Cull, P. & Eckland, E., Jr. (1985). Towers of hanoi and analysis of algorithms. *American Mathematical Monthly, 92*, 407-420.
["It would be difficult to draw the line and say that this part of analysis of algorithms is mathematics and that part is computer science." Paper demonstrates the role of proof in the construction and analysis of computer algorithms.]

Curcio, F. (1987). Comprehension of mathematical relationships expressed in graphs. *Journal for Research in Mathematics Education, 18*, 382-393.
[no sex differences, results suggests ". . . children should be involved in graphing activities to build and expand relevant schemata needed for comprehension." correlational study, grades 4 and 7.]

Dalbey, J., & Linn, M. (1985). The demands and requirements of computer programming: A literature review. *Journal of Educational Computing, 1*, 253–274.
[ ]

Davenport J. (1985). The University of Bath Syllabuses. In Commission Internationale de L'Enseignement Mathematique (Eds.), *The Influence of Computers and Informatics on Mathematics and Its Teaching,* (Strasbourg, 23-30 Mar 85), 99-113.
[argues for mathematics *and* computing degree. employers are astounded at students' ignorance of computing and astounded at how quickly the students are to learn. author suggests this position is good.]

Davenport, J., & Trager, B. (1985). On the parallel Risch algorithm (II). *ACM Transactions on Mathematical Software, 11*, 356–362.
[illustrates mathematics being used in computer mathematics systems development, in particular, integration.]

Davies, C. (1965). Development of the probability concept in children. *Child Development, 36*, 779–788.
[ ]

Davis, P. (1985). On the role of proof and the promise of microcomputers. In W. Page (Ed.), *American perspectives on the fifth international congress on mathematical education* (pp. 42–45). Washington, DC: Mathematical Association of America.
[Argues excessive computerization will lead to "rotting of the mind," loss of human role models, decreased interaction between scientists and humanists, no research struggle, excessive formalism, and false sense of how mathematics is created.]

Davis, P. & Hersh, R. (1986). *Descartes' dream: The world according to mathematics.* Boston, MA: Houghton Mifflin.
["Intellectual Components of Mathematization. 1. Ability to symbolize, abstract, and generalize the primary experiences of counting and spatial movement. 2. Ability to dichotomize sharply. . . 3. Ability to discern primitive causal chains . . . and reason about such chains. 4. Ability and willingness to extract out of the real an abstract surrogate; correspondingly, the willingness to accept formal manipulation of the abstract surrogate as an adequate representation of the behavior of the real. 5. Ability and desire to manipulate and play woth symbols even in the absence of concrete referents, thus creating an imaginary world which transcends the concrete." (p. 124–125). Computer/calculator work with mathematics would seem to support each of these in various ways.]

Davis, R. (1982). Personal communication to J. M. Oprea.
[Programming valuable to cognitive growth, assimilate to mental models, concept of function is good example, programming increases collection of "models," and programming is good problem solving.]

Davis, R. (1984). *Learning mathematics: The cognitive science approach to mathematics education.* Norwood, NJ: Ablex.
[ ]

Davis, R., Jockusch, E., & McKnight, C. (1978). Cognitive processes in learning algebra. *Journal of Children's Mathematical Behavior, 2,* 10–320.
[]

Damarin, S. (1983). *Development and dissemination of an integrated multi-purpose software package.* NSF proposal, Ohio State University Research Foundation, 12 August 83.
[Example of the development of a graphics tool to help students study mathematics.]

Damarin, S. (1984). TABS—Math: A courseware development project. In V Hansen & M. Zweng (Eds.), *Computers in mathematics education* (pp. 62–71), Reston, VA: National Council of Teachers of Mathematics.
[Description of courseware for geometry, probability, and estimation. Uses simulation and active tutorial.]

Dean, A. & Mollaison, M. (1986). Understanding and solving probability problems: A developmental study. *Journal of Experimental Psychology, 42,* 23-48.
[(ages 5-13)]

DeBlassio, J. and Bell, F. (1981). Attitudes toward computers in high school mathematics courses. *International Journal of Mathematical Education in Science and Technology, 12,* 47–56.
[Positive correlations were found between students' attitudes toward using a computer and attitudes toward mathematics and instructional setting, plus achievement variables. (grades 11, 12)]

DeCorte, E. (1984). *Does learning to program improve children's thinking skills?* Paper presented at the 25th International Congress on Computer-based Education, Columbus, Ohio.
[Review of recent research. Time to undertake well-desigend, longitudinal studies. Good research can build body of knowledge to guide curriculum development.]

Dehn, N. & Schank, R. (1982). Artificial and human intelligence. in R. J. Sternberg (Ed.), *Handbook of human intelligence* (pp. 352–392). Cambridge, MA: Cambridge University Press.
["debugging" central to a ll learning in that detected errors force shifts in attention to that which is important, altering memory organization and affecting all future processing of similar situations.–Clements summary]

Demana, F. & Waits, B. (1987). Enhancing problem solving skills in mathematics through microcomputers. *Collegeiate Microcomputer, 5(1),* 72-75.
[Illustrates grapher and some graphing issues.]

Demana, F. & Waits, B. (1987). Problem solving using microcomputers. *The College Mathematics Journal, 18(3),* 236-241.
[illustrates use of graphics and zoom to do interesting mathematics. Done on micro, but can be done on graphics calculators.]

Demana, F. & Waits, B. (1987). *The Ohio State University Calculator and Computer Project: The mathematics of tomorrow today.* Manuscript submitted for publication.
[Notes only one in six students with four years of high school mathematics is ready for calculus, function is fundamental concept of mathematics, and proposed approach: is a graphic approach using fast computational graphics, interactive, focused on functions, relations, and their graphs, makes generalization possible, and ties together problems, equations, and graphs.]

Demana, F. & Waits, B. (1987, October). *Foreshadowing the study of local maximum and minimum values through computer graphing.* Manuscript submitted for publication.

[Argues graphing prepares for calculus rather than usual calculus for graphing. suggests reexamining whole curriculum in light of these technological developments.]

Demana, F. & Waits, B. (1987, December). *Classical mathematics with a modern twist—the rational root theorem and computer graphing.* Manuscript submitted for publication.
[Suggests combination of graphing, rational root theorem, and synthetic division. I'd do synthetic div. by machine. Why not admit most polynomials do not have rational roots?]

Demana, F. & Waits, B. (1988). Pitfalls in graphical computation, or why a single graph isn't enough. *The College Mathematics Journal, 19*, 177–183.
[Several nice examples of how plots can be deceptive (wrong) for functions such as: $(x^5-x^4+x-1)/(x^2-x-12)$, $x\sin(1/x)$, $x\sin x$, and $\sin 63x$.]

Demana, F. & Waits, B. (1988, in press). Manipulative algebra—the culprit or the scapegoat? *The Mathematics Teacher.*
[Makes case for graphics *and* algebraic manipulations. They say; Let's just do classic mathematics better. I would observe that proof of correctness of programs or graphs provides justification for algebraic representations, not for mindless manipulations, but for mathematical proof.]

Desenfant, G., Dupuis, F., Le Roux, R., Peyrache, M. (1984). Faisons le point. *Bulletin de l'Association des Professeurs de Mathématiques de l'Enseignement Public, 63(342)*, 65-85.
[all the information and opinions available to the authors on computer science teaching at French Schools are compiled (ZDM Oct 84)]

Devitt, J. (1988). *Teaching first year calculus through the use of symbolic algebra: A summary version 0.9.* Saskatoon, Saskatchewan: Department of Mathematics, University of Saskatchewan. (4 Jan 88).
[System used is Maple on Microvax II. CAS is integral part of course. Lectures done in "Maple." Example of text material completely integrating a CAS. Chapters: Intro, Functions & Graphs, Rules for Computing Derivatives, The mean value theorem, Integration.]

Dickson, P. (1985). Thought-provolking software: Juxtaposing symbol systems. *Educational Researcher, 14*, 30–38.
[ ]

Dijkstra, E. (1974). Programming as a discipline of mathematical nature. *American Mathematical Monthly, 81*, 608–612.
[Not only does programming involve: the precision of mathematics, the generalization goal of mathematics, and the need for high level confidence in assertions, but the work on correctness of programs results in formal mathematical proof. Programmers must also be versed in natural and formal languages, be able to invent formalism, develop hierachical structures, and reason and switch from semantic levels with agility. Programmers must invent concepts, invent notation, and engage in organizing thinking.]

Douglas, R. (Ed.). (1986). *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level.* Washington, DC: The Mathematical Association of America.
[Report of conference and papers. Beginning discussions of reform in calculus with national attention.]

Doyle, W. (1986). Using an advance organizer to establish a subsuming function concept for facilitating achievement in remedial college mathematics. *American Educational Research Journal, 23*, 507-516.
[advance organizer facilitated achievement]

Drake, F. (1985). How recent work in mathematical logic relates to the foundations of mathematics. *The Mathematical Intelligencer, 7*, 27-35.
[Partial ordering of consistency strengths, how strong do you have to get to get the mathematics you want? In discussing large cardinals as "never-never land" author suggests 2^(2^16) is probably already there. Stimulates exploration of function 2^(2^x) on calculator (micros don't go far enough).]

Dreyfus, T. & Eisenberg, T. (1982). Intuitive functional concepts: A baseline study on intuitions. *Journal for Research in Mathematics Education, 13*, 360–380.
[Concept analysis of function, abstract and concrete levels, diagram, graphical, and tabular settings. Intuitions independent of setting or level of abstraction. Grades 6–9.]

Dubinsky, E. (1985). Computer experiences as an aid in learning mathematics concepts. In Commission Internationale de L'Enseignement Mathematique (Eds.), *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 61-70.
[developmental data illustrating evolution of mathematical concepts in students in the context of computer experiences. Most sucessful growth with concepts: functions, composition, less so with mathematical induction (three stages indentified), students were more prone to talk in terms of sets and less confused by complicated logical statements. (college level).]

du Boulay, J. (1980). Teaching teachers mathematics through programming. *International Journal of Mathematical Education in Science and Technology, 11*, 347–360.
[Reactions of a small group of students to learning to program in Logo are given. (elem. preservice)]

du Boulay, B. O'Shea, T. & Monk, J. (1981). The black box inside the glass box: Presenting computing concepts to novices. *International Journal Man-Machine Studies, 14*, 237–249.
[Notional machine is idealized, conceptual computer whose properties are implied by constructs in programming language employed. Argues for interactive system, coordination of language and teaching materials, and designing notional machines for high level languages.]

Dudley, U. (1987). *Why math?* By R. P. Driver. Springer-Verlag, New York, 1984. xiv + 233 pp. [Review of *Why math?*]. *American Mathematical Monthly, 95*, 479–483.
[Raises the issue of how inappropriate are most "applications" for teaching mathematics. (On the other hand, we know representations (and/or manipulatives) are most effective for teaching mathematics. Perhaps the conclusion is that the representations or manipulatives need not be practical applications but simply varied representations of the concepts.) The reviewer argues that students do not study mathematics because of applications such as those given by Driver, but maybe because of the challange or because it is fun, or an interesting game. Don't sell mathematics with its applications, the examples are always false and misleading.]

Duggar, C. (1983). A study of the relationships amoung computer programming ability, computer program content, computer programming style, and mathematical achievement in a college level BASIC programming course. (Georgia State University-College of Education, 1983). *Disseration Abstracts International, 44A*, 95.
[N = 9, 6 Hyp. Diff. in programming algebraic vs. geometric pblms, algebraic ability related to programming ability, algorithmic style related to programming and math achievement. (college)]

Dvarskas, D. (1983). The effects of introductory computer programming lessons on the learners ability to analyze mathematical word problems. *Dissertation Abstracts International, 44*, 2665A.
[Programming in either BASIC or Logo improved ability to analyze mathematical word problems. Middle school level.]

Dyck, J. & Mayer, R. (1985). *Basic versus natural language: Is there one underlying comprehensive process.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
[Procedural statements were comprehended the "same" whether described in BASIC or English. College undergraduates.]

Edwards, J., Jr. (1982). The effects of aids, error types and repetitions on the times and strategies utilized in the correction of computer program errors. (The Catholic University of America, 1982). *Disseration Abstracts International, 43A*, 1071.
[No time advantage seemed gained by having beginning programers debug their own programs. (community college)]

Ehrlich, K., Abbott, V., Salter, W., & Soloway, E. (1984). Issues and problems in studying transfer effects of programming. In D. M. Kurland (Ed.), *Developmental studies of computer programming skills* (Tech. Rep. No. 29, pp. 1–16). New York, NY: Bank Street College of Education.
[ ]

Elg, T. (1983). A general cognitive model for teaching problem solving in elementary school using computer simulations. *Dissertation Abstracts International, 44*, 371A.
[Computer simulation improved problem solving ability. Non-math context. Grade 5.]

Ellis, W. (1988). Academic Computing Committee: What's new with computation. *AMATYC News, Spring, 1988*, 3.
[Calls for significant rethinking of mathematics teaching based on computer mathematics systems and graphics calculators. Notes courseware available, use of graphics and computation made in mathematics research, and availability of computer mathematics systems for instruction.]

Er, M. (1984). On the complexity of recursion in problem-solving. *International Journal Man-Machines Studies, 20*, 537–544.
[More research needs to be done to foster the science of recursive programming.]

Erickson, J. & Jones, M. (1978). Thinking. *Annual Review of Psychology, 29*, 61–90.
[218 research studies from 1972-1977 on human thinking are summarized. Problem Solving, Prototype Concepts, two-valued to continuous-valued logic (isomorphic to probability theory), and observation of continuous change in info processing capabilities rather than a Piagetian shift (e.g. Formal reasoning).]

Educational Testing Service (1982). *Advanced placement examination in computer science.* College Entrance Examination Board, ETS.
[Advanced placement course in computer science calls for a language with: IF-THEN-ELSE; WHILE-DO; data typing; independent procedures; procedures should allow paremeters, declaration of local variables, access to global variables; possible to pass parameters by reference and value; recursion; and dynamic allocation of

storage. Pascal only acceptable language, current versions of BASIC specifically named as unacceptable. Exam first offered in May, 1984.]

Falk, R., Falk, R. and Levin, I. (1980). A potential for learning probability in young children. *Educational Studies in Mathematics*, *11*, 181–204.
[At about age 6, children started to select the greater of two probabilities systematically. Spinners, spinning tops, enthusiastic support, carefully reasoned. (ages 4-11)]

Feldman, S. (1972). Children's understanding of negation as a logical operation. *Genetic Psychological Monographs*, *85*, 3–49.
[Among the conclusions from this series of six studies were: understanding of negation as a logical operation develops slowly; negation involves a cognitive operation and is not merely a problem of semantics; and class inclusion did not precede negation. (ages 3–8)]

Feurzeig, W., Horwitz, P., & Nickerson, R. (1981). *Microcomputers in education.* Report No. 4798, prepared for the Department of Health, Education, and Welfare, National Institute of Education and Ministry for the Development of Human Intelligence, Republic of Venezuela. Cambridge, MA: Bolt Beranek & Newman.
[As summarized by Pea & Kurland (1987), "...the teaching of a set of concepts related to programming can be used to provide a natural foundation for the teaching of mathematics, and indeed for the notions and art of logical and rigorous thinking in general." Expected changes in: *rigorous thinking; concepts such as procedure, variable, function, and transformation; heuristics; debugging applicable to problem solving; procedures as building blocks for larger problems; self-consciousness and literacy about processes of solving problems;* and *recognition there is rarely a best way to do something.*]

Fey, J. et. al. (Eds.) (1984). *Computing & mathematics: The impact on secondary school curricula.* Reston, Virginia: National Council of Teachers of Mathematics.
[Discussion and examples of potential impact of computers on the secondary curricula.]

Fey, J. & Heid, M. (1984). Impact of computing on calculus. In J. T. Fey, *et al.*, *Computing & mathematics: The impact on decondary dchool curricula.* Reston, Virginia: National Council of Teachers of Mathematics.
[Points out the potentially dramatic role muMath might play in the study of calculus.]

Fey, J. (1984-1987). *Effects of computer-based curriculum in school algebra.* National Science Foundation project currently in progress.
[ ]

Fey, J. (1986). *Impact of technology on school mathematics curricula.* Paper prepared for Mathematical Sciences Education Board Conference, The School Mathematics Curriculum: Raising National Expectations, 7-8 Nov 86.
["There have been persuasive arguments that the act of writing programs will help students attain deeper understanding of mathematical ideas and that the thinking habits learned in good programming practice will be powerful general problem-solving heuristics." "Elementary and middle schools: " "Computer graphics facilitate early introduction to geometric concepts like congruence, similarity, transformations, vectors, and coordinate graphs; statistical concepts like randomness and simple method of data analysis; and algebraic concepts such as variable and function. "The broad outlines of technology-based change in secondary school mathematics are very attractive. They promise that students will be able to acquire impressive new mathematical skill, understanding, and problem-solving ability. " . . . dramatic change in school mathematics is almost certain to come and those who seize the opportunity will be giving their students a real advantage in the technological world where they will live and work."]

Finlayson, H. (1984). *Mathematical strategies and concepts through turtle geometry.* Paper No. 236, Department of Artificial Intelligence, University of Edinburgh, Scotland.
[Little research support for claims LOGO programming develops problem solving and mathematical skills because research not specific about aims and direction of programming experience. Advocates analysis of children's work to identify mathematical concepts and strategies that may be developed and testing the transfer to school mathematics. (upper elementary)]

Finlayson, H. (1984). *The transfer of mathematical problem solving skills from LOGO experience.* Paper No. 238, Department of Artificial Intelligence, University of Edinburgh, Scotland.
[28 wks of LOGO programming resulted in superiority on concepts of angle and variable, strategies of generalization and abstractions, and identifying relevant attributes in novel problems. Males spent 50% more time programming with no additional gain. (11 year olds).]

Finlayson, H. (1987). The place of *ln x* among the powers of *x*. *American Mathematical Monthly*, 95, 450.
[$\int_1^x t^{k-1}\,dt = (x^k-1)/k$ and $\lim (x^k-1)/k = \ln x$, graph $f_k(x) = (x^k-1)/k$ along with $\ln x$. Good activity for graphics calculator.]

Fischbein, E. (1975). *The intuitive sources of probabilitstic thinking in children.* Dordrecht, Holland: Reidel.
["In the contemporary world, scientific education cannot be profitably reduced to a univocal, deterministic interpretation of events. An efficient scientific culture calls for education in statistical and probabilistic

thinking. Probabilitstic intuitions do not develop spontaneously, except within very narrow limits. . . . it is necessary to train, from early childhood, the complex intuitive base relevant to probabilistic thinking . . ."]

Fischbein E. & Gazit, A. (1984). Does the teaching of probability improve probabilistic intuitions? *Educational Studies in Mathematics*, *15*, 1–24.
[Programme in probability too difficult for fifth grade, but OK for grades 6, 7. Some misconceptions were "corrected."]

Fischbein, E., Pampu, I., and Manzat, I. (1970). Comparison of ratios and the chance concept in children. *Child Development*, *41*, 377–389.
[After brief instruction, 3rd graders were able to make correct decisions, as did 6th graders, through "a comparison of quantitative ratios." (preschool, 3, 6)]

Fischbein, E., Tirosh, D., & Hess, P. (1979). The intuition of infinity. *Educational Studies in Mathematics*, *10(2)*, 3–40.
[ ]

Flanders, J. (1987). How much of the content in mathematics textbooks is new?, *The Arithmetic Teacher*, *35(1)*, 18-23.
[The amount of new material in all texts in grades 4-9 is 49% or less. Suggests causes are achievement tests (do not correlate with content of texts nor current state of technology), and exaggerated definition (and use) of mastery learning model (designed for skill learning, not concept learning or problem solving).]

Flavel, J. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist*, *10*, 909–911.
[ ]

Fletcher, S. (1985). *Cognitive abilities and computer programming.* Paper presented at the Annual Meeting of The American Educational Research Association, Chicago, April, 1985.
[Correlates of aspects of computer programming include Math Reasoning, Form Board, Paper Folding (< 0), Raven's (> 0 & < 0), Hidden Figures, and Gestalt Completion. (College).]

Flores, A. (1984a). A microcomputer and the law of small numbers. *Arithmetic Teacher*, *31(7)*, 60–61.
[Some simple simulations provide counterexamples to the "law of small numbers" or short run regularity.]

Flores Peñafiel, A. (1984b). Pequeños programas, grandes ideas. En *Memoria del Simposio Internacional: La Computación y la Educación Infantil.* Peñafiel, 231-232.
[Examples of short programs involving the learning of significant mathematical concepts.]

Flores Peñafiel, A. (1984c). *Cambios en el curriculum de matemáticas.* Presentado en el seminario organizado por la Universidad Pedagógica Nacional: La enseñanza de las matemáticas en la educación básica, hoy. Cuautla, Mor.
[Discussion of potential changes in the mathematics curriculum.]

Flores Peñafiel, A. (1984d). *La microcomputadora en la enseñanza del cálculo.* Trabajo presentado en el Congreso de la Sociedad Matemática Mexicana. Mérida, Yuc.
[Examples of short programs designed to help teach fundamental concepts of calculus.]

Flores, A. (1985). *Preliminary research on computer programming in calculus.* CIMAT.
[Comparison of programming and using with using programs to study concepts of calculus (grade 11)]

Flores, A. (1985). The joy of geometric patterns a computer activity for the very young.
[Patterns and modular thinking with elementary graphics.]

Flores, A. (1985). They're off!
[A short computer program to simulate and explore fundamental concepts of probability.]

Flores, A. (1986). Effect of computer programming on the learning of calculus concepts. *Dissertation Abstracts International*, *46A*, 3640.
[no differences, but trends suggest further study.]

Flores Peñafiel, A. (1987). El efecto de programar la computadora en el aprendizaje de conceptos de cálculo. *Cuadernos de Investigación*, *2*, 1-75.
[two studies suggest potential effects for computer programming on learning of concepts of calculus.]

Foley, G. (1987, October). *Precalculus applications of the hand-held graphics computer.* Minicourse at the 13th annual convention of AMATYC, Kansas City, MO.
[Collection of short papers discussing and illustrating applications of graphics calculators to the learning of precalculus mathematics. Advantages: speed, generalization, non-contrived problems, solve larger classes of

problems, relieve student of tedious computational graphics, and meaningful examination of calculus concepts such as extrema, monotonicity, asymptotic behavior, continuity, limits, and intermediate value theorem.]

Foley, G. (1987, October). *Using hand-held graphics computers in precalculus mathematics.* A paper presented at the 15th annual mathematics and statistics conference, Miami University, Miami, OH.
[interactive graphics approach encourages abstraction, provides powerful problem solving tool, permits early exposure to numerical analysis, facilitates exploration, and provides foundation for claculus.]

Foley, G. (1987). Reader reflections: Zoom revisited. *The Mathematics Teacher, 80*, 606.
[Documents power of graphics calculator by showing all graphs illustrated by Montaner (1987) can be done on a Casio *fx-7000G* graphics calculator. First published graph from a graphics calculator, 18 months after they became available!]

Foley, G. (1987). Future shock: Hand held computers. *The AMATYC Review, 9(1)*, 53–57.
[Alert to graphics calculator capabilities and implications. First full article showing graph and discussion of educational implications, appearing 2 years after availability (Feb, 88).]

Foley, G. (1988). Timeless and timely issues in the teaching of calculus, *The AMATYC Review*, to appear in Spring, 1988.
[Review of the issues regarding the calculus, discrete mathematics, and computer mathematics systems, the preparation for calculus, the teaching, the testing and grading, and the curricular alternatives. Proposes a strategy that "integrates classical, discrete, and nonstandard methods with computer graphics and symbolic manipulation programs." 32 references and a 26-item bibliography provide excellent set of references.]

Forman, G. (in press). *Constructivism in the computer age.* Hilldale, NJ: Lawrence Erlbaum Associates.
[]

Forsythe, G. (1968). What to do till the computer scientist comes. *American Mathematical Monthly, 75*, 454–462.
(quote: "The most valuable acquisitions in a scientific or technical education are the general-purpose mental tools which remain servicable for a lifetime. I rate natural language and mathematics as the most important of these tools, and computer science as a third.")

Fox, D. (1969). *The research process in education.* New York: Holt, Rinehart and Winston, Inc.
[Describes the types and stages of research in education. The role of clinical, experimental, and evaluation studies in research.]

Francis, G. (1983). Review of Abelson and diSessa (1981), Turtle Geometry: The Computer as a Medium for Exploring Mathematics. *American Mathematical Monthly, 90*, 412–415.
[Logo a lá Abelson & diSessa seen as pedagogical program to exciting ideas of Thurston, et. al. in Geometry using ideas such as curvature, connectivity, and groups of structure-preserving transformations. Notes depth of mathematical thinking and proofs involved in the development. Review is good example of the depth of mathematics that *can be seen* in the Logo environment.]

Fraser, R. (1985). *Roles of mathematics teachers within a curriculum theme of algorithms.* Paper presented at the Research Presession of The Sixty-third Annual Meeting of the National Council of Teachers of Mathematics, San Antonio, Texas.
[Identifies various roles the teacher may play in a computer algorithm context for doing mathematics.]

Frenkel, K. (1986). Complexity and parallel processing: An interview with Richard Karp. *Communications of the ACM, 29*, 112-117.
[levels of problems (problems, general problems, and classes of problems), NP-completeness links levels, probabilistic analysis, parallelism, randomized algorithms and distributed systems, advantage of theory building for generalizability, simulations of cognitive processes must still be precisely formulated, computer scientists today must remember we're a scientific discipline and not just a branch of high technology.]

Friske, M. (1985). Teaching proofs: A lesson from software engineering. *American Mathematical Monthly, 92*, 142–144.
[There is a close analogy between the thought processes used in computer programming and those required for writing proofs; namely, problem specification, logical design (structured, top-down, modular), writing the proof (attention to organization and special language).]

Gagné, R. (1970). *The conditions of learning, 2nd edition.* New York: Holt. Rinehart and Winston.
[Distinguishes between concept learning, principle (rule) learning, and problem solving. Concept learning must be measured with new examples and non-examples.]

Garfield, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for Research in Mathematics Education, 19*, 44–63.
[Reviews research. Best parts deal with misconceptions, thinking. Need to give attention to distribution, average, sample, randomness as well as probabilistic intuitions as "conceptual difficulties abound." misconceptions seem to be deeply rooted, call for cooperative projects at single site. Suggests to me that

conceptual analysis, rôle of nonexamples, logical connectives, etc. could help explore this problem. Certainly must be combination of mathematics education, psychology, and statistics.]

Garofalo, J., & Lester, F., Jr. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education*, *16*, 163–176.
[Provides useful discussions and models for examining mathematical thinking.]

Gersting, J. (1987). *Mathematical structures for computer science, 2nd edition.* San Francisco: W. H. Freeman.
[Abstract algebra concepts seen as critical structures for computer science.]

Givens, W. (1966). Implications of the digital computer for education in the mathematical sciences. *Communications of the ACM*, *9*, 664–666.
[quotes: "The digital computer has profoundly altered the definition of what is interesting in mathematics. The importance of applied logic in human affairs is changed by the existence of the 'logical engine.' ... one should no longer think ... of a single discipline of mathematics but ... a complex of mathematical sciences (Givens actually prefers *applied logic*.)... There is a simple and basic fact about computers which will, in the decades and centuries to come, affect not so much what is known in mathematics as what is thought important in it. This is its finiteness. ... The term *algorithm* must be mentioned in any discussion which deals seriously with the effect of the digital computer on the curricula in the mathematical sciences. ... But what if the very process of drawing the conclusions requires a physical device—the computer—to draw the inferences? No, the real world has always intruded (if only through the biochemistry of the brain) on the elegant environment of the mathematician. ... First, do not expect to learn computer science in a mathematics course any more than you would expect to learn physics there. ... A practical minded engineer will likely prefer to ignore the theory of solution of large systems of linear equations if he cannot solve them anyway. Now that he can, he studies linear algebra. ... mathematically trained students ... should be taught to appreciate the type of algorithmic approach that enables a problem to be handled by a machine.]

Goldberg, S. (1966). Probability judgements of pre–school children: Task conditions and performance. *Child Development*, *37*, 157–168.
[ ]

Gonnet, G. (1988). Examples of Maple applied to problems from the *American Mathmematical Monthly*, *The Maple Newletter*, *No. 2*, 4–9.
[Illustrate CAS, Maple, on problems of some interest. Evidence of potential use by mathematicians and students.]

Gonzalez, E. and Kolers, P. (1982). Mental manipulation of arithmetic symbols. *Journal of Experimental Psychology*, *8*, 308–319.
[Cognitive operations are not independent of the symbols that instigate them. (college)]

Gordon, S. (1979). A discrete approach to computer–oriented calculus. *American Mathematical Monthly*, *86*, 386–391.
[Bibliography includes 19 references to computers in calculus publications. Uses range from graphics tool to programming with applications in calculus. Others add numerical algorithms to standard course. Illustrates a discrete approach using finite differences and finite sums.]

Gorman, H., Jr. and Bourne, L., Jr. (1983). Learning to think by learning Logo: Rule learning in third-grade computer programmers. *Bulletin of the Psychonometric Society*, *21*, 165–167.
[More programming, 1hr/wk vs. 1/2hr/wk favored on conditional rule learning. (3rd grade)]

Greeno, J. (1978). Understanding and procedural knowledge in mathematics instruction. *Educational Psychologist*, *12*, 262–283.
[uses theory of understanding language, problem solving, and algorithmic procedures to look at mathematical skills and relationship between performance and understanding.]

Grossnickle, D., & Laird, B. (1983). Microcomputers: Bitter pills to swallow—Rx for successful implementation efforts. *Technological Horizons in Education Journal*, *10(7)*, 106-108.
[Suggestions for computer implementation include local involvement, evolution rather than revolution, and recognition of the size and scope of the task.]

Grossnickle, D., Laird, B., Cutter, T., and Tefft, J. (1982). Profile of change in education: a high school faculty adopts/rejects microcomputers. *Educational Technology*, *22*, 17–19.
[Case study description of the problems of microcomputer adoption.]

Grossnickle, D., Laird, B., Cutter, T., and Tefft, J. (1983). Profile of change in education: microcomputer adoption status report. *Educational Technology*, *23*, 17–20.
[Case study of school system adoption of microcomputers.]

Grover, S. (1986). A field study of the use of cognitive-developmental principles in microcomputer design for young children. *Journal of Educational Research*, *79*, 325-332.

Hadamard, J. (1945). *An essay on the psychology of invention in the mathematical field.* Princeton, NJ: Princeton University Press.
[Interesting to revisit these essays with computer mathematics systems and graphics calculators in hand. How would the discussions and behaviors change?]

Hadlock, C. (1978). *Field theory and its classical problems.* Washington, DC: The Mathematics Association of America.
[Develops field theory used to solve famous geometric construction problems of antiquity and the problem of solving polynomial equations by radicals. Perhaps suitable development for those who would teach mathematics with a graphics calculators in hand.]

Haecker, V., & Ziehen, T. (1931) Beitrag zur lehre von der vererbung und analyse der zeichnerischen und mathematischen begabung, insbesondere mit bezug auf die korrelation zur musikalischen begabung. Zeitschrift für Psychologie, x, 120–121.
[identifies 3 groups: visual element dominance, abstract element dominant, or visual–abstract balanced.]

Halmos, P. (1944). The foundations of probability. *American Mathematical Monthly, 51*, 493–510.
[measure, independent events, repeated trials, random variables, expectation, variance, and distribution, independent variables, law of large numbers, central limit theorem. Underlying most of these are the concepts of measure and random.]

Halmos, P. (1975). The problem of teaching to teach. *American Mathematical Monthly, 82*, 466–476.
["The best way to learn is to do, to ask, and to do. The best way to teach is to make students ask, and do. Don't preach facts—stimulate acts. The best way to teach teachers is to make them ask and do what they in turn will make their students ask and do."]

Halmos, P. (1980). The heart of mathematics. *American Mathematical Monthly, 87*, 519–524.
[In a nutshell, problems are the heart of mathematics. Examples & discussion for such a view given.]

Hambree, R. & Dessart, D. (1986). Effects of hand-calculators in precollege mathematics education: a meta-analysis. *Journal for Research in Mathematics Education, 17*, 83-99.
[Analysis of 79 studies suggests it is no longer a question of whether calculators should be used, but how. Recommends calculators should be used at all grade levels and for all problem solving instruction and testing above grade 4. Conservative interpretation of research and no results based on graphics calculators.]

Hamming, R. (1980). We would know what they thought when they did it. In N. Metropolis, J Howlett, and G. Rota (Eds.), *History of Computing in the Twentieth Century* (pp. 3–9). New York: Academic Press.
[Tough to pin down exactly when we realized computers could be symbol manipulators as well as number crunchers, i.e., 1947, 1951–1952–1954.]

Hamming, R. (1988). [Review of *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level*]. *The American Mathematical Monthly, 95*, 466–471.
[mathematical maturity—students in calculus must sense generalizations, e.g., variable name used in integral doesn't matter, another critical element of mathematics—abstraction, generalization, and extensions, calculus at local optimum, big changes required to make improvements, doubts mathematicians will respond.]

Hancock, C., Perkins, D., & Simmons, R. (1985). *Children's programming difficulties: An exploratory study* (Tech. Rep.). Cambridge, MA: Educational Technology Center.
[ ]

Hansen, T., Klassen, D., Anderson, R., and Johnson, D. (1981). What teachers think every high school graduate should know about computers. *School Science and Mathematics, 81*, 467–472.
[Teachers supported the idea that every students should have some minimal inderstanding about computers, but the extent of coverage of computer topics was minimal. Computer programming was primary mode of computer use. February, 1978 data. (secondary inservice)]

Hansen, V., & Zweng, M. (Eds.). (1984). *Computers in mathematics education: 1984 Yearbook.* Reston, VA: National Council of Teachers of Mathematics.
[Collection of paper regarding computers in mathematics education by mathematics educators.]

Harper, E. (1980). The boundary between arithmetic and algebra: Conceptual understanding in two language systems. *International Journal of Mathematics Education in Science and Technology, 11*, 237–243.
[Two distinct conceptual understandings of the role played by a letter in relation to geometrical data were found to exist. (grades 1-5)]

Hart, K. (1981). *Children's understanding of mathematics: 11-16.* London: Murray.
[describes extensive work of several projects with British students, use of variable being one of the primary foci.]

Hart, M. (1982). Using computers to understand mathematics, four years on. *Mathematics Teaching, 98*, 52–54.
[Reports initial successes of Nottingham Programming in Mathematics Project on student's use of variables when compared with standard algebra classes and Concepts in Secondary Maths and Science Project (CSMS) norms. (15 year olds).]

Hatfield, L. (1973). *II. Computer-extended problem solving and enquiry.* Columbus, Ohio: ERIC Information Analysis Center for Science, Mathematics and environmental Education.
[Review and suggestions to employ learning theory, conduct considerably more detailed efforts, and calls for cooperative, programmatic research beginning with clinical research to generate hypotheses.]

Hatfield, L. and Kieren, T. (1972). Computer-assisted problem solving in school mathematics. *Journal for Research in Mathematics Education, 3*, 99–112.
[Use of computer programming as a problem-solving tool was found to be especially helpful for average and above-average students in grade 7; in grade 11, it appeared best for average achievers. (grades 7, 11)]

Hatfield, L. (April, 1985). *Theoretical perspectives for algorithmics and student programming in school mathematics.* A paper presented at the research presession of the annual meeting of the National Council of Teachers of Mathematics, San Antonio, Texas.
["...student programming situations must surely be featured...what a student knows, must be found largely in the person's activity of constructing their algorithm...algorithmics is a theme which is integral to constructing knowledge of mathematics." Today, "computer science" courses dominate., occasionally a computer program in a text, very rarely programming is integrated into curriculum but still with little modification of topics taught, and most teachers have had little or no experience learning mathematics with computer programming. Research implications include: study of variable, how computer relates to traditional concepts, role of iteration and recursion, metacognitive demands, how can teachers integrate student programming and algorithmic emphasis into lessons, what allows teachers to modernize curriculum, and how might the curriculum contents be effected? "There continues to be considerable skepticism about the worth of mathematics students writing and using their own computer programs...we must openly construct and study alternative pedagogical and curricular paradigms.]

Hawkins, A., & Kapadia, R. (1984). Children's conceptions of probability—A psychological and pedagogical review. *Educational Studies in Mathematics, 15*, 349–378.
[Garfield & Ahlgren (1988) note questions about merits of retraining, say by simulations or rules from questions raised by Hawkins & Kapadia.]

Hawkins, J. (1987). Computers and girls: Rethinking the issues. In R. Pea & K. Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 242–257). Norwood, NJ: Ablex.
[Consistent sex differences favoring males were found in programming Logo. 8-9, 11-12 year olds. Perhaps as programming was viewed as math–science, then so went the sex differences. Recommended showing multi-roles for computers (is this running from problem?)]

Hawkins, J., & Kurland, D. (1987). Informing the design of software through context–based research. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 258–272). Norwood, NJ: Ablex.
[Provides a useful discussion of preliminary courseware problems. Should be applicable to graphics hand held computers. Strategy One: Study intended use; Strategy Two: Apply basic research to problem of problem development; Phase 1, help students with first encounter (difficulties); Phase 2, writing reusable procedures; Phase 3, mastering flow control and iteration, (and general suggestions that do seem to generalize).]

Hawkins, J., Mawby, R., & Ghitman, J. (1987). Practices of novices and experts in critical inquiry. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 273–297). Norwood, NJ: Ablex.
[Suggests studying experts inquiry behavior to design activities that would encourage expert inquiry like behavior from young children. Give example that can be quite useful in planning a similar strategy.]

Hawkins, J. & Sheingold, K. (1983). Programming in the classroom: Needs and reality. In M. Cole, N. Miyaki, & D. Newman (Eds.), *Procedures (sic) of the Conference on Joint Problem Solving and Microcomputers.* (pp. 17-18). Washington, DC: Office of Naval Research.
[ ]

Heid, M. (1983). Calculus with *muMath:* Implications for curriculum reform. *The Computing Teacher, 11*, 46–49.
[A symbol manipulation system allows for a more conceptually-oriented curriculum and needed curriculum development. first semester college calculus]

Heid, M. (1988). Resequencing skills and concepts in applied calculus using the computer as a tool. *Journal for Research in Mathematics Education, 19*, 3–25.
[Exploratory study of potential impact of computer mathematics system on calculus. Concepts emphasis seems viable.]

Heines, J., Briggs, J. & Ennals, R. (1983). Logic and recursion: The prolog twist. *Creative Computing, 10(11)*, 220-226.
[comparison of recursion in each of the languages, Basic, Pascal, Lisp, and micro-Prolog.]

Henrici, P. (1974). Computational complex analysis. *Proceedings of Symposia in Applied Mathematics, 20*, 79–86.
[Calls for more algorithmic content in curriculum. Invite active participation in experimental computation.]

Herscovics, N., & Kieran, C. (1980). Constructing meaning for the concept of equation. *The Mathematics Teacher, 73*, 8.
[ ]

Hershberger, J. (1983). The effects of a problem solving oriented mathematics program on gifted fifth-grade students. (Purdue University, 1983). *Disseration Abstracts International, 44A*, 1715.
[Extensive computer problem solving enhanced understanding of mathematical topics and aided in developing strategies. (grade 5)]

Herstein, I. (1964). *Topics in algebra.* New York, NY: Blaisdell Publishing Company.
[Field theory approach to theory of equations. Remainder theorem, Existence and isomorphism of splitting fields, Fundamental theorem of Galois theory, Abel's theorem. Do these results need to be available to those using graphics calculators to find roots of polynomials?]

Hoemann, H. and Ross, B. (1971). Children's understanding of probability concepts. *Child Development, 42*, 221–236.
[Successfully choosing the more favorable odds did not necessarily give an index of probability knowledge. (ages 4-13).]

Hoffman, W., Albrecht, R., Atchison, W., Charp, S., & Forsythe, A. (1965). Computers for school mathematics. *The Mathematics Teacher, 58*, 393–401.
[Makes the claim: "students who write computer programs acquire a better understanding of the mathematical concepts involved." and advocates integrated use of computers in all mathematics courses as well as a senior level computer science course. (secondary schools).]

Hofstadter, D. (1979). *Gödel, Escher, Bach: An eternal golden braid.* Basic Books: New York.
[Extended essay on thinking and computers.]

Holtzman, T. & Glaser, R. (1977). Developing computer literacy in children: some observations and suggestions. *Educational Technology, 17*, 5–11.
[Exploratory study with 6 male 6th graders. FOCAL and LOGO used. Children learned either language. (analysis of languages includes BASIC). All languages suitable. Help students plan big programs.]

Hosak, J. (1986). A guide to computer algebra systems. *The College Mathematics Journal, 17*, 434–441.
[ ]

Howe, J. (1983). *Microcomputers in secondary schools–power to the pupil* (Paper No. 252). Edinburgh: Edinburgh University, Department of Artifical Intelligence.
[Most CAI (UK, USA, Canada) asks students questions and checks the *appearance* of student responses. They are not tutorial programs.]

Howe, J. (1983). *Learning mathematics through Logo programming: The transition from laboratory to classroom* (Research paper 118). Edinburgh: Edinburgh University, Department of Artifical Intelligence.
[as described by Noss (1987), suggests sex interaction reflects girls opportunity to close gap between boys and girls that existed at beginning of study.]

Howson, G., Keitel, C., and Kilpatrick, J. (1981). *Curriculum development in mathematics.* Cambridge: Cambridge University Press.
[Draws inferences and suggestions for future curriculum development from the experiences associated with the massive curriculum development efforts of the 60–70's.]

Hoyles, C. (1985). Developing a context for Logo in school mathematics. *Journal of Mathematical Behavior, 4*, 237–256.
[ ]

Jaffe, A. (1984). Appendix C. Ordering the universe: the role of mathematics. In National Research Council. (1984). *Renewing U. S. Mathematics.* Washington, D.C.: National Academy Press. 117–162.
[Makes a case for the strong role of computation in mathematics. Topics: the computer itself, logic and the computer, algorithms and computational complexity, randomness in calculation, randomness in algorithms, computer assisted proofs, and numerical analysis and mathematical modeling.]

Janvier, C. (Ed.). (1986). *Problems of representation in mathematics learning and problem solving*. Hillsdale, NJ: Erlbaum.
[ ]

Johnson, C. & Swoope, K. (1987). Boys' and girls' interest in using computers: Implications for the classroom, *The Arithmetic Teacher, 35(1)*, 14-16.
[Questionnaire (Semantic Diff.) suggested no sex differences in interest in using computers, but sex difference in beliefs that boys will be more interested than girls. Suggests no reinforcement of students' erroneous view of sex difference interests and some attention to sex role nature of some video games.]

Johnson, D. (1966). CAMP (Computer Assisted Mathematics Program). Preliminary report No. 2. University of Minnesota.
[Describes philosophy of students writing programs in BASIC to learn mathematical concepts and problem solving in grades 7–12.]

Johnson, D. et. al. (1968). *CAMP: computer assisted mathematics program*. Glenview, Il.: Scott, Foresman & Co.
[Early examples of integration of computer programming into mathematics curriculum, 7–12.]

Johnson, D. and Harding, R. (1979). University level computing and mathematical problem solving ability. *Journal for Research in Mathematics Education, 10*, 37–55.
[Results on problem-solving test consistently favored groups who had had a computing course. (college)]

Johnson, D. & Tinsley, J. (Eds.). (1978). *Informatics and Mathematics in Secondary Schools: Impacts and Relationships*. Amsterdam: North-Holland.
[Report of IFIP working conference. Set of papers on computers and secondary schools.]

Johnson, D. (1984). Informatics: Implications of calculators and computers for primary–school mathematics. In R. Morris (Ed.), *Studies in mathematics education: The mathematical education of primary–school teachers* (pp. 89–106). Paris, France: Unesco.
[tool or tutor? Chooses tool, and gives several examples for primary–school concepts and problem solving.]

Johnson, J. (April, 1985). *Algorithmics and the mathematics curriculum*. A paper presented at the research presession of the annual meeting of the National Council of Teachers of Mathematics, San Antonio, Texas.
[Algorithms play an integral role in problem solving and are excellent tools which can improve teaching, learning, understanding, and doing of mathematics. Illustrates *elimination of content, extension of content, and addition of new content* in secondary curriculum. Generalization, consolidation, and abstraction play role as evolutionary forces in the progress of mathematics and mathematics education. Computing technology allows algorithmics to embody these forces today. "Today's mathematicians and mathematics educators are responsible for directing the growing process so that it proceeds in a purposeful manner...it is just as easy to teach poorly and rotely with an algoritmic approach as without it. The key is not the presense of algorithms, but rather how students use them to learn, understand, and do mathematics."]

Kahneman, D. & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, 80, 237-251.
[Claim prediction by representativeness underlies behavior correct or incorrect. Examine with respect to role of nonexamples.]

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgement under uncertainty: Heuristics and biases*. Cambridge, UK: Cambridge University Press.
[according to Garfield & Ahlgren (1988), clear theme of this book is that "innappropriate reasoning is (a) widespread and persistent, (b) similar at all age levels, (c) found even among experienced researchers, and (d) quite difficult to change."]

Kaput, J. (1985). Review of Davis, R. B. (1984). "Learning mathematics: The cognitive science approach to mathematics education." *College Mathematics Journal, 16*, 319–322.
[claims Davis confronts directly most foundational questions of mathematics education. Data are task–based intervews.]

Kaput, J. (1986). *Information technology and mathematics: Opening new representational windows*. Cambridge, MS: Educational Technology Center, Harvard Graduate School of Education. (to appear in *Journal of Mathematical Behavior*.)
[Graphical representations of mathematical manipulations and ideas. Good ideas for graphics calculators. Also discusses geometry suppposer, etc. "radical enrichment in the kinds of rational activities associated with learning and doing mathematics." ". . . student as active agent . . ."]

Kaput, J. (1987). Representational systems and mathematics. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 19–26). Hillsdale, NJ: Lawrence Erlbaum Associates.
[". . . more direct and systematic attention needs to be paid to the ways we use symbols . . . in mathematical representations. . ."(p. 20). Cites "good" examples of representations in mathematics (morphisms, generic algebraic constructions, canonical building–block (internal & external), approximation, feature/property isolation, logic models) and claims the essential character of mathematics is representations.]

Kaput, J. (1987). Toward a theory of symbol use in mathematics. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 159–195). Hillsdale, NJ: Lawrence Erlbaum Associates.
[Rather philosophical "treatment," but some value in the later sections as he comes to grips with specific problems, e.g., symbols as tools of thought, equivalence (semantic & syntatic), pictures do not always enhance performance (6P = S problem, for example), computers can communicate variability in variables represented geometrically, Recommends "that study of the differences between geometric and algebraic symbol systems would be especially fruitful as would the study more generally of the fundamental cognitive processing differences between and interactions among natural and synthetic symbol systems." (p. 192).]

Karp, R. (1986). Combinatorics, complexity, and randomness. *Communications of the ACM*, *29*, 98-111.
[Shows fundamental relationships between computers, mathematics, foundations, random, NP-problems, through classic problems and results. Excellent, readable overview.]

Karplus, R. (1979). Continuous functions: Students' viewpoints. *European Journal of Science Education*, *1*, 397–415.
[ ]

Kasilus, M. (1983). A study on group instruction vs. directed study techniques for teaching computer programming to gifted secondary mathematics students. (Georgia State University-College of Education, 1983). *Disseration Abstracts International*, *44A*, 658.
[Both types of instruction were effective. Neither changed attitudes toward computer science. (secondary)]

Keislar, E. and Stern, C. (1970). Differentiated instruction in problem solving for children of different mental ability levels. *Journal of Educational Psychology*, *61*, 445–450.
[Children in the high MA group who were taught a complex strategy ("hypothesis testing") were surerior to those taught a simple strategy ("gambler's"); the reverse was true with the low MA group. (2, 3)]

Kemeny, J. (1966). The role of computers and their applications in the teaching of mathematics. In Howard F. Fehr (Ed.), *Needed research in mathematics education*. New York: Teachers College Press.
[Important mathematics learned from writing computer programs.]

Kemeny, J. (1983). Finite mathematics–then and now. In T. Ralston & G. Young (Eds.), *The future of college mathematics* (pp. 201-208), New York, NY: Springer-Verlag.
[Consider $\int^{13} e^x\,dx$. Clearly the answer is $e^{13}-1$, but what is the answer to one significant digit and how do the two answers compare? The problem is not *the answer*, but which answer do you need.]

Kenney, M. & Bezuska, S. (1987). *Tessellations using Logo*. Palo Alto, CA: Dale Seymour Publications.
[Illustration of linking between symbolic code and geometric representations.]

Kidder, J. (1981). *The Soul of a New Machine*. Boston: Little, Brown and Company.
[Reveals inner workings of computer design in layperson style text.]

Kieren, T. (1973). *Research On Computers in Mathematics Education*. Columbus, Ohio: ERIC Information Analysis Center for Science, Mathematics and environmental Education.
[Evidence is strongest for drill & practice and computer augmented problem solving.]

Kieren, T. (1978). Informatics and the secondary school mathematics curriculum. In D. Johnson and J. Tinsley (Eds.), *Informatics and mathematics in secondary schools: impacts and relationships*. Amersterdam: North-Holland Publishing, 77-83.
[Topics proposed for computer use: Number, Functions & Operators, Calculus, Symbolic Control, Probability, Applied Mathematics.]

Kieren, T. (1984). *LOGO in education: what, how, where, why and consequences*. University of Alberta.
[Cited research implications: Logo use needs investigation, styles of logo use and intellectual communication, focus on what goals and objectives of Logo use are appropriate and how these can be achieved, a wide variety of uses needs to be studied with a number of small projects. Bibliography of over 150 citations.]

Kimberling, C. (1985). Graph many functions, part 2. *The Mathematics Teacher*, *78(4)*, 278-280.
[illustrates how families of graphs (e.g., Knuth functions) can be used to investigate mathematics.]

Kingma, J. (1984). A comparison of four methods of scaling for the acquisition of early number concept. *Journal of General Psychology*, *110*, 23–45.
[Scaling strategies for constructing a developmental scale. Mokken scale analysis most suitable for number comparisons task. grades: K, 1]

Kliman, M. (1985). *A new approach to infant and early primary mathematics*. Paper No. 241, Department of Artificial Intelligence, University of Edinburgh, Scotland.

[Programming icons (simplified version of LOGO) using only a joystick provides motivating context for mathematical work.]

Knerr, C. (1982). Ther enhancement of traditional instruction and learing analytic Geometry via computer support. (Lehigh University, 1981). *Disseration Abstracts International, 42A*, 3483.
[The computer-augmented approach was more effective than traditional instruction alone, especially for diverse or complex concepts. (grade 12)]

Knuth, D. (1968, 1969, 1973, 1974(2nd ed., vol. 1)). *The Art of Computer Programming, Vols. 1, 2, 3.* Reading, Mass: Addison-Wesley.
[Landmark books illustrating computer science as study of algorithms.]

Knuth, D. (1974). Computer science and its relation to mathematics. *American Mathematical Monthly, 81*, 323–343.
[Illustrates interplay of mathematics and computer science as well as programming mathematics teaching mathematics.]

Knuth, D. (1985). Algorithmic thinking and mathematical thinking. *American Mathematical Monthly, 92*, 170–181.
[Examines "mathematical thinking" with an eye to its algorithmic nature. Many similarities are noted: formula manipulation; representations of reality (models); reduction to simpler problems; abstract reasoning; information structures; and algorithms. Differences: mathematicians use infinity and computer scientists use economy of operation and assignment operations.]

Kolata, G. (1982). How can computers get common sense? *Science, 217*, 1237–1238.
[Describes Minsky's frames and McCarthy's circumscription. Draws distinction between mathematics and artificial intelligence.]

Kolata, G. (1984). Graph theory result proved. *Science, 224*, 480–481.
[Paul Seymour: "I wouldn't even know how to use a computers for this work."]

Koler, P., & Smythe, W. (1979). Images, symbols, and skills. *Canadian Journal of Psychology, 33*, 158–184.
[]

Krutetskii, V. (1976). *The psychology of mathematical abilities in school children.* J. Kilpatrick & I Wirsup (Eds.), Chicago: University of Chicago Press.
[Suggestions for interview strategies and measurement strategies for variables, etc. Excellent source of strategies for research on variable. Also examines 3 types, analytic, geometric, and harmonic, noting differences but not claiming related to giftedness, except to classify type.]

Küchemann, D. (1981). Algebra. In Hart, K. M. (Ed.) *Children's understanding of mathematics: 11–16.* London: John Marry, 102–120.
[Describes a taxonomy for various ways letters (variables) are used by children, 10–16 in age.]

Kulik, J., Kulik, Chen-Lin C., and Cohen, P. (1980). Effectiveness of computer-based college teaching: a meta-analysis of findings. *Review of Educational Research, 50*, 525–544.
[1967-1978, 5/59 involved programming, all dissertations, dated 70,74,78,69,70; college level]

Kurland, D., Clement, C., Mawby, R., & Pea, R. (1987). Mapping the cognitive demands of learning to program. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 103–127). Norwood, NJ: Ablex.
[spaghetti like programming observed in some Logo classrooms, to develop modular programming, students need means–ends procedural reasoning and decentering (being able to perform as computer performs versus as one intends the computer to perform). In experiment (8th–11th grade girls) was difficult to uncover cognitive demands of programming. Students seem to use unsophisiticated strategies.]

Kurland, D. & Pea, R. (1983). *Children's mental models of recursive Logo programs.* Technical Report No. 10. New York: Center for Children and Technology, Bank Street College of Education.
[Recursion is not naturally discovered by children using Logo, iteration understanding aids recursion understanding, natural language constructs interfere. N = 7, 11-12 year olds.]

Kurland, D., Pea, R., Clement, C., & Mawby, R. (in press). A study of the development of programming ability and thinking skills in high school students. *Journal of Educational Computing Research.*
[ ]

Lagarias, J. (1985). The *3x+1* problem and its generalizations. *American Mathematical Monthly, 92(1)*, 3–23.
[Extensive discussion of Collatz problem. Good problem to explore with computers and kids. Unsolved.]

Lakatos, I. (1976). *Proofs and refutations: The logic of mathematical discovery.* Cambridge, UK: Cambridge University Press.

[Illustrates through dialogues and history the role of counterexamples in proofs and doing mathematics. The changing standards for proof and errors of mathematicians paint a very different picture of creative mathematics than that of simply theorems and proofs, theorems and proofs. Examples used: Euler's formula, convergence of continuous functions (Cauchy), concept of bounded variation, and Carathéodory definition of measurable set. Contrasts heuristic approach to "deductivist" approach. "One can easily give more examples, where stating the primitive conjecture, showing the proof, the counterexamples, and following the heuristic order up to the theorem and to the proof–generated definition would dispel the authoritarian mysticism of abstract mathematics, and act as a break on degeneration." (p. 154).]

Langford, P. (1974). Development of concepts of infinity and limit in mathematics. *Archives of Psychology, 42*, 311–322.
[ ]

Lane, K. (1985). Symbolic manipulators and the teaching of college mathematics: some possible consequences and opportunities. In Commission Internationale de L'Enseignement Mathematique, *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 179-184.
[digital computing power ignore. same with symbolic computing power? Describes Colby College program (Sloan). Noting that "Students often feel that the real meat of the course is the computational derivatives, integrals, power series, or any of the other manipulative activities. Attempts to get students to focus on analysis and synthesis often end in failure." To address such difficulties, fundamental processes of calculus (somewhat arbitrarily identified as: approximation, transformation, and comparison) were emphasized, MACSYMA and MAPLE used, single and multivariable topics done concurrently. Examples given include: graphing $f(x) = (x^2-4)/(x^2-1)$; using Taylor's theorem to estimate *sqrt(7)*. [I would observe that now, with graphics calculator you can find, say, the degree 15 Taylor's series for sin and graph both sin and Taylor's series on same graph for comparison.] Lane observes symbolic manipulators in freshman calculus has been the single most effective weapon he has found for combating misconceptions that concepts, ideas, and statements are not part of mathematics and that doing mathematics is to compute. Also, mathematics has often not been used because computations were difficult. At first, computers were also not used. Now, both computers and computational mathematics can be used by more people ["anyone"?]. What about hand-computational facility lost? ". . . mathematics and what is important in mathematics is changing rapidly." "The ability to use mathematics to describe the world is a skill requiring more of our instructional time." "It seems clear to me you can't just give each student a symbolic manipulator and go on teaching the course like you have always taught it."]

Larkin, J. and Rainard, B. (1984). A research methodology for studying how people think. *Journal of Research in Science Teaching*, 21, 235–254.
[Practical suggestions for clinical, information processing strategy for identifying thinking processes.]

Lawler, R. (1985). *Computer experience and cognitive development.* Chichester, England: Ellis Horwood.
[Longitudinal study of author's 6–year–old daughter's interactions with Logo over a 6–month period.]

Lax, P., Burstein, S., Lax, A. (1976). *Calculus with applications and computing, Volume 1.* New York: Springer Verlag.
[Example of computing in mathematics teaching.]

Lee, J. (1986). The effects of past computer experience on computerized aptitude test performance. *Educational and Psychological Measurement, 46*, 727-733.
[past computer experience correlated with arithmetic reasoning (college)]

Lemonick, M. (1987). Pictures worth a million bytes. *Time, 129(20)*, 64-65.
[Gives several examples of mathematical and scientific discoveries made from computer graphics displays of data or relationships. Argument is that human brain and eyes can detect important, subtle relationships from graphics displays. Mathematics: "creation of a complete embedded minimal surface with finite topology," astronomy, biology, chemistry, etc. Need "rises from sheer the number crunching power of computers."]

Lempers, J., Flavell, E., & Flavel, J. (1977). The development in very young children of tacit knowledge concerning visual perception. *Genetic Psychology Monographs, 95*, 3–53.
[ ]

Leonard, B., & Shultz, H. (1987). The role of the computer in mathematical reasoning. *The AMATYC Review, 9(1)*, 8–11.
[illustrates computer use for unattainable proof, test conjectures to motivate proof, or indicate numerical result that can be proved analytically later, and finally a BASIC program that proves a result for 4 digits combined with analytic arguments that show any number reduces to four–digit case already proved by computer. Does not illustrate or discuss learning benefits of coding.]

Leron, U. (1985). Logo today: Vision and reality. *The Computing Teacher, 12*, 26–32.
[Must distinguish between mathematics observed by "experts" and mathematics actually learned by child.]

Lesgold, A. & Reif, F. (1983). *Computers in education: Realizing the potential.* Chairman's report of a research conference, 20-24 Nov 82, Pittsburgh, PA. Washington, D.C.: U.S. Gov. Printing Office.

[Recommends: prototype research, cognitive issues including expert-novice thinking, knowledge structures, and mental models. A coherent and sustained research investment is needed. Research should be integrated into coherent combinations of basic, prototype, and field research. Team approach involving mathematics, computer science, cognitive science, mathematics education, and research design.]

Lesh, R. (1987). The evolution of problem representations in the presence of powerful conceptual amplifiers. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 197–206). Hillsdale, NJ: Lawrence Erlbaum Associates.
["The procedures needed to compute a given derivative or integral bear virtually no resemblence to the network of relations that define the underlying ideas and that constitute meaning." (p. 202). Experimental Study: Compard two groups of ninth graders, one using computer symbol manipulator–grapher. Confirms Palmiter result with younger age and different topic in stronger manner in that no computation group excelled on both concepts and computations.]

Lester, F. (1975). Developmental aspects of children's ability to understand mathematical proof. *Journal for Research in Mathematics Education, 6*, 14–25.
[Significant differences in mean performance on problem-solving tasks were found among groups on both time and non-time variables. Certain aspects of mathematical proof can be understood by children at age nine or younger. (grades 1-12, ages 6-18)]

Lester, F. & Shumway, R. (1970). *tscore*. Columbus, Ohio: Ohio State University computer assisted instruction course.
[Tutorial course using Coursewriter II, version 3 to teach the purpose and value of standard scores for assigning grades.]

Liao, T. & Piel, E. (1984). The yellow-light problem: Computer-based applied mathematics. In V. Hansen & M. Zweng (Eds.), *Computers in Mathematics Education* (pp. 97–106). Reston, VA: National Council of Teachers of Mathematics.
[Illustrates a simulation to teach mathematics.]

Lichtman, D. (1979). Survey of educator's attitudes towards computers. *Creative Computing, 5*, 48–50.
[Teachers view computers as much more dehumanizing and isolating than others, are insecure about computers, and few see improvement in the quality of life through the use of computers. Administrators are more positive. Concern: Many computers purchased (by administrators), but few used with students. 1975-1976 data]

Link, B. (1982). *Computer programming for mathematical concept learning*, Master's Project, Mathematics Education, Ohio State University.
[For the concepts, LCM & GCF, writing computer programs "taught" concepts to programmers. (Grade 5)]

Lippert, R. (1987). Teaching problem solving in mathematics and science with expert systems. *School Science and Mathematics, 87*, 477–493.
[Raises issue, in my mind, of "real" expert systems in mathematics that link and allow explorations of mathematical relationships. Graphics, hand–held computers are just the beginning of such notions, but a beginning.]

Lochhead, J. & Clement, J. (Eds.). (1979). *Cognitive process instruction: Research on teaching thinking skills*. Philadelphia: Franklin Institute Press.
[Programming environment holds promise of teaching how to think rather than what to think?]

Lockwood, R. (1984). The genealogy of BASIC. *Creative Computing, 10*, X–X.
[Traces various versions of BASIC and their interrelationship in chronological chart form.]

Lovelock, D., & Newell, A. (1988). A claculus curriculum for the nineties. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 162–168). Washington, DC: Mathematical Association of America.
[". . . teach students to think logically. . . 'little' things make a big difference. . . family of curves, such as $x^2 + c/x^2$ . . .problems with no solution. . . by introducing cis(x) in the context of a little complex arithmetic . . . many of the techniques of integration can be bypassed, and many of the trigonometric identities can safely be forgotten . . . (on the use of computers) . . . this is not a negotiable item—it is essential.]

Luehrmann, A. (1981). Should the computer teach the students or vica versa? In R. Taylor (Ed.), *The computer in the school: tutor, tool, tutee*. New York: Teachers College Press, 129–135.
[Alegorical tale about reading and writing which argues for student directed use of computers in all disciplines.]

Luehrman, A. (1984). Structured programming in BASIC, Parts 1–5. Creative Computing, May–October, 1985, xx–xx.
[argues effectively for structured programming in the context of various forms of BASIC.]

Maddux, C. & Johnson, D. (1984). LOGO: Putting the child in charge. *Academic Therapy, 20*, 93–99.

["Logo designed to overcome attention problems, permit self correction, and provide practice in spatial relationships and perceptual skills." children.]

Markovits, H. (1986). The curious effect of using drawings in conditional reasoning problems. *Educational Studies in Mathematics, 17*, 81-87.
[conditional reasoning performance lower on problems with drawings, but the "mathematical relevance" of drawings seems questionable. (college)]

Markovits, Z., Eylon, B. & Bruckheimer, M. (1986). Functions today and yesterday. *For the Learning of Mathematics, 6*,18-24,28.
[common function concepts causing difficulty (grade 9)]

Markovits, Z., Eylon, B., & Bruckheimer, M. (1988). Difficulties students have with the function concept. In A. Coxford (Ed.), *The ideas of algebra, K–12* (pp. 43-60), Washington, DC: National Council of Teachers of Mathematics.
[". . . easier to manage functions given in graphical form than in algebraic form."]

Mason, J. (1987). What do symbols represent? In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 73–81). Hillsdale, NJ: Lawrence Erlbaum Associates.
[Cute example: For all $\delta > 0$ there exists and $x > 0$ such that $|F(x+\varepsilon) - F(\varepsilon)| < \delta$ versus usual. Role of "traditions" is clear advantage for "knowing." (See irrelevant attributes used as relevant cues and the difficulty of concept for newcomer becomres more apparent)]

Mathematical Association of America. (1984). *Preliminary report: Panel on discrete mathematics in the first two years.* Washington, DC: Mathematical Association of America.
[Outlines discrete mathematics course and reports on experimental projects related to discrete mathematics in the first two years of college.]

Matz, M. (1981). Towards a process model of high school algebra errors. In D. Sleeman & J. Brown (Eds.), *Intelligent tutoring systems.* London, UK: Academic Press.
[ ]

Mauer, S. (1984). Two meanings of algorithmic mathematics. *Mathematics Teacher, 77*, 430–435.
[Many confuse learning to perform algorithms with the design and study of algorithms, the second being the focus of algorithmic mathematics.]

May, K. (1959). *Elements of modern mathematics.* Reading, MA: Addison–Wesley.
[See pages 7–17 and 113–121 for discussion of variable in mathematics for beginning mathematics students.]

Mayer, R. (1975). Information processing variables in learning to solve problems. *Review of Educational Research, 45(4)*, 525–541.
[data confirms three–stage model. Mayer argues for meaningful instruction and basic conceptual underpinnings before computational algorithms.]

Mayer, R. (1975). Different problem-solving competencies established in learning computer programming with and without meaningful models. *Journal of Educational Psychology, 67*, 725–734.
[FORTRAN, diagram model of computer helped with program interpretation and looping. non-diagram favored on generalization. (College introductory Psy students)]

Mayer, R. (1976). Some conditions of meaningful learning for computer programming: Advance organizers and subject control of frame order. *Journal of Educational Psychology, 68*, 143–150.
["Prior exposure to a meaningful model, especially a concrete model that can be related to new unfamiliar information, is a powerful aid in learning." (College)]

Mayer, R. (1979). A psychology of learning BASIC. *Communications of the ACM, 22*, 589–593.
[Analysis, research evidence, and recommendations for teaching BASIC which include: transactions, prestatements, mandatory chunks, ask for transactions for given code, emphasize subroutines and structured programming. (College)]

Mayer, R. (1981). The psychology of how novices learn computer programming. *Computing Surveys, 13*, 121–141.
[Concrete models and putting commands in own words were effective for improving problem solving with programming. Suggested goals: meaning of individual statements and schemata that give statements a higher level meaning. (College)]

Mayer, R. (1982). Contributions of cognitive science and related research in learning to the design of computer literacy curricula. In *Computer Literacy–Cognitive Research and Solving Problems Using the Computer.* Academic Press, Inc.
[Five recommendations: concrete model, own words, build on existing intuitions, methods for chunking, analyze statements into smaller, meaningful parts. Research provides some support for first two, and research is needed for latter three. (College)]

Mayer, R., Dyck, J., & Vilberg, W. (1985, April). *A three-minute test that predicts success in learning BASIC*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, Ill.
[Translating word problems test correlates (r = 0.54) with programming in BASIC. (College)]

McAllister, A. (in press). Problems solving at the threshold of computer programming. *Student Services Project Bulletin*, Toronto Board of Education.
[three student strategies identified involving extended series or subunits for unit building, found correlation between Tower of Hanoi and Logo programming, and suggests techniques for further study. (grades 2 & 3.)]

McKean, K. (1987). The orderly pursuit of pure disorder. *Discover, 8(1)*, 72-81.
[Popular press article documenting value and importance of random in today's society and widespread misconceptions among laypersons about concept of random.]

McKeithen, K., Reitman, J., Rueter, H., & Hirtle, S. (1981). Knowledge organization and skill differences in computer programmers. *Cognitive Psychology, 13*, 307–325.
[ALGOL W language. Novices, intermediates, and experts compared. Classic differences of program recall of regular and scrambled programs replicated. Recall organization of 21 reserved words showed experts recalled by structure and novices by a variety of natiral language strategies. Intermediates used a mixture of novice and expert strategies. (College & Adults)]

McKenna, J. (1972). Computers and experimentation in mathematics. *American Mathematical Monthly, 79*, 294–295.
[Calls for computer programming in mathematics courses to learn mathematics more effectively.]

McKnight, C., Crosswhite, F., Dossey, J., Kifer, E., Swafford, J., Travers, K., & Cooney, T. (1987). *The underachieving curriculum: assessing U. S. school mathematics from an international perspective.* Champaign, IL: Stipes Publishing Co.
[Data from 1981-82. Confirms low level use of calculators in mathematics classes (less than 30% at grade eight). In addition, 30% did not use or banned their use at both eighth and twelfth grades. ". . . it seems clear that the use of calculators was not responsible for the low levels of achievement in U.S. classrooms since calculators were notably absent . . ." nor were calculators " . . . being used in those curricular areas where such use would be appropriate." Also documents lack of substance and new material at each level of curriculum.]

Metropolis, N., Howlett, J., and Rota, G. (Editors). (1980). *A History of Computing in the Twentieth Century*. New York: Academic Press.
[General history. Documents role of computing on mathematics.]

Menis, J. (1984). Improvement in student attitudes and development of scientific curiosity by means of computer studies. *Educational Techonology, 24*, 31–32.
[BASIC programming increases curiosity. n = 65. (age 14)]

Menis, Y. Snyder, M., and Ben-Kohav, E. (1980). Improving achievement in algebra by means of the computer. *Educational Technology, 20*, 19–22.
[Computer as homework drill aid raised self-confidence of weaker students. (grade 10)]

Meil, G. (1980). Calculator calculus and rondoff errors. *Americal Mathematical Monthly, 87*, 243–252.
[illustrates failure of computer/calculator computations to follow field properties, *e.g.*, identity not unique, distributivity fails, and then goes on to examine difficulties when considering limits. Early warning to mathematicians regarding computer arithmetic and how it differs from "expected" behaviors.]

Meissner, H. (1984). Draft summary report, Working Group 1.1/1.2, *Calculators for Developing Countries and for Developed Countries*, Proceedings of The Fifth International Congress on Mathematical Education, Adelaide, Australia, August, 1984.
[Research and curriculum materials offer ample support for calculator yet more than 80% of school curricula "ignore" calculators.]

Messick, S. & Solley, C. (1957). Probability learning in children: Some exploratory studies. *Journal of Genetic Psychology, 90*, 23–32.
[ ]

Microsoft Corporation. (1984). *Microsoft BASIC Interpreter for Apple Macintosh.* Microsoft Coorporation.
[Suggests this version of BASIC contains most of capabilities required for ETS advanced placement test.]

Miller, L. (1974). Programming by non-programmers. *International Journal of Man-Machines Studies, 6*, 237–260.
[Programming research extends problem solving research into new areas while involving all classic activities presently classified as problem solving. Procedure specification influenced by problem and 'natural' procedure specification behavior. Transfer-of-control structure important to efficiency and correctness. (naïve college undergraduates)]

Miller, L. (1981). Natural language programming: Styles, strategies, and contrasts. *IBM Systems Journal, 20*, 183–215.
[Unconstrained programming-language interface seems inappropriate, but some changes can be made to improve the natural ease of computer systems. (naïve college undergraduates)]

Miller, G., Emihovich, C., Clare, V., & Froning, D. (1985, April). The effects of interactive programming on preschool shildren's self–monitoring. A paper presented at the annual meeting of the Americal Educational Research Association, Chicago, Il.
[Logo programming vs CAI control. ability to detect embedded errors improved significantly for Logo treatment. 14 Pre–schoolers, 5.4 yrs, range from 4.8–6.3]

Milojkovic, J. (1984). Children learning computer programming: Cognitive and motivational consequences. (Stanford University, 1984). *Dissertation Abstracts International, 45*, DA8408330.
[BASIC vs. Logo vs. CAL but failed to support expected differences. (grade 5)]

Minsky, M. (1986). *The society of mind.* New York, NY: Simon and Schuster.
[Wealth of ideas for models of thinking and potential machine–mind interactions.]

Molnar, A. (1973). *I. Computer innovations in education.* Columbus, Ohio: ERIC Information Analysis Center for Science, Mathematics and environmental Education.
[Survey of use and status of computer uses for 1973.]

Montaner, F. (1987). Use of the zoom in the analysis of a curve. *The Mathematics Teacher, 80*, 19–28.
[Show power of graphics for exploring mathematics. One should note that all figures of Montaner can be done on a graphics calculator as well as using a microcomputer and programs in BASIC.]

Moon, F. (1985). Quoted in: Cornell will use MACSYMA and muMath. *SIAM News, 18(4)*, 2.
["The impact of computer algebra in mathematical and theoretical work in engineering and science is bound to have as much effect as the original introduction of the computer. . . . This new software technology has the potential for reintroducing mathematical analysis alongside the now popular CAD and other numerical methods of analysis."]

Moore, L., & Smith, D. (1987). [Review of *Toward a lean and lively calculus*]. *College Mathematics Journal, 18*, 439–442.
["*Lean and Lively* brings into sharp relief a fundamental paradox: On the one hand, there is a widespread consensus on the content of the 'standard' calculus course—topics, syllabus, textbooks. On the other hand, there is no consensus at all on the purposes and goals of the course in any intellectually defensible sense. We talk about calculus as one of the outstanding intellectual achievements of all time, but we don't teach it that way. We talk about teaching students to think, but we are really training them to parrot algorithms for solutions of already–solved problems. We talk about beauty in mathematics, but we teach and test a lot of ugliness." (p. 442)]

Moore, M., & Burger, W. (1983). *Elementary teacher education: Including Logo in teaching informal geometry*. Corvalis, OR: Oregon State University.
[Illustrates value of symbolic–geometric representation, but also raises concerns regarding misrepresentations that can occur, for example, in Logo, a 360–sided regular polygon (via the coding) is called a circle.]

Morier, D., & Borgida, E. (1984). The conjunction fallacy: A task specific phenomenon? *Personality and Social Psychology Bulletin, 10*, 243–252.
[ ]

Morris, D. (April, 1985). *Some aggregate characteristics of the faculties of elementary schools offering programming instruction on microcomputers.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.
[Survey of 173 schools confirms computers are not equitably distributed and that afluent schools tend to teach programming, while non-afluent schools use computers for remedial exercises. Use of computers for programming is one of many correlates of achievement. Elementary school faculties do not seem to cause increases in achievement, but rather act as "intermediaries in a chain of events wherby external socioeconomic forces shape outcomes of the educational system."]

Morris, J. (1983). Microcomputers in a sixth-grade classroom. *Arithmetic Teacher, 31*, 22–24.
[Achievement gain was higher for the class using a microcomputer for three geometry strategy games than for the class without computer. (grade 6)]

Murakami, H. & Hata, M. (1985). The progress of change and mathematics education in Japan. In Commission Internationale de L'Enseignement Mathematique, *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 81-91.
[predicts computer algebra systems on hand-held computer. Argues for basic course without computers followed by extensions using computers. Draws analogy that as students in elementary school should learn addition, subtraction, multiplication, division, etc. without using calculators, students should also learn

differentiation without CAS. Use CAS for applications, problem solving/ CAS can " . . . shift the focal point of mathematical education to more essential point, such as more emphasis on problem understanding, elaborating basic strategies and mathematical formaulations and verification of obtained results. Accordingly, a greater amount of more essential materials must be included in the mathematical curriculum." Revision of the curriculum is necessary. Computer assist in helping man think for himself.]

Murphy, J. (1988). Mathematics on capital hill. *Focus, The Newsletter of the Mathematical Association of America, 8(2)*, xxxii.
["What do these people think of mathematics and mathematicians? Mathematics is seen as an arcane and irrelevant exercise that has something to do with strange numbers and bizarre spaces and that it is practiced by people who are antisocial and can't speak english. Legislators hope that very soon computers will make mathematics unnecessary." Interesting perception about mathematics and the use of computers.]

National Council of Teachers of Mathematics. (1980). *An agenda for action: Recommendations for school mathematics of the 1980s.* Reston, VA: National Council of Teachers of Mathematics.
[Recommends use of calculators and computers at all grade levels.]

National Council of Teachers of Mathematics. (1987). *Guidelines for the post-baccalaureate preparation of teachers of mathematics.* Draft report prepared for NCTM.
[ability to use and teach with computing devices, use of variables, probability, and modeling are integral part of new recommendations.]

National Council of Teachers of Mathematics. (1987). The use of computers in the learning and teaching of mathematics. *NCTM News Bulletin, 24(2)*, p. 3
[course content must be modified, computers are tools to do mathematics, ". . . schools should be equipped with computers, peripherals, and courseware in sufficient quantity and quality for them to be used consistently in the teaching and learning of mathematics. . . For example, teachers should be able to identify topics for which expressing an algorithm as a computer program will deepen student insight . . ."]

National Council of Teachers of Mathematics. (1987). *Curriculum and evaluation standanrds for school mathematics* (working draft, Oct, 1987). Reston, VA: Author.
[calls for use of examples and counterexamples, various representation systems (including computers and calculators), and probability and statistics, K–12, among many others.]

National Research Council. (1984). *Renewing U. S. mathematics.* Washington, DC: National Academy Press.
[Shows growing role computers play in doing mathematics.]

Nesher, P. (1986). Learning mathematics: A cognitive perspective. *American Psychologist, 41*, 1114–1122.
[ ]

Nesher, P., & Schwartz, J. (1952). *Early quantification.* Unpublished manuscript. Cambridge, MA: Massachusetts Institute of Technology.
[ ]

Newell, A., & Simon, H. (1972). *Human problem solving.* Engelwoodcliffs, NJ: Prentice–Hall.
[ ]

Nievergelt, Y. (1987). The chip with the college education: The HP–28C. *American Mathematical Monthly, 94*, 895–902.
[First journal article after Tucker note to illustrate graphics calculator capabilities. Not too oriented to implications for teaching.]

Nickerson, R. (1982). Computer programming as a vehicle for teaching thinking skills. *Thinking: The Journal of Philosophy for Children, 4*, 42–48.
[ ]

Nisbett, R., Krantz, D., Jepson, C., & Kunda, Z. (1983). The use of statistical thinking in everyday inductive reasoning. *Psychological Review, 90*, 339–363.
[ ]

Noss, R. (April, 1985). *Creating a mathematical environment through Logo.* A paper presented at the research presession of the annual meeting of the National Council of Teachers of Mathematics, San Antonio, Texas.
[Report of first year of 18 month Chiltern Logo Project (UK). Summarized prior research by observing: programming difficult to learn, programming as adjunct can impose heavy demands on children, transfer to mathematics concepts requires explicit linkages, and effects on children's mathematical concepts take time to emerge. Argues Logo offers, at present, most accessible, powerful language for novice programmers. Mathematical thinking includes: particularization, generalization, conjecture, and verification. Proposes model: *make sense of new idea, explore, solve problems,* and *need for more power.* Reports anecdotal information regarding students work, for example, students' reluctance to move to more powerful techniques.

Recommends emphasis remain on the process of algorithm design and modification–on programming, and make more explicit relationship to mathematics. (118 children, ages 8–11).]

Noss, R. (1986). Constructing a conceptual framework for elementary algebra through Logo programming. *Educational Studies in Mathematics, 17*, 335-357.
[Logo may provide a framework for further learning about variable (ages 10-11)]

Noss, R. (1987). Children's learning of geometrical concepts through Logo. *Journal for Research in Mathematics Education, 18*, 343-362.
[Trends favored Logo and suggested a possible sex interaction, but no significant differences were found. suggests ". . . conscious and careful intervention strategy." Supports notion that small, tight, theory-building research is needed. grades 3-5.]

O'Brien, D. and Overton, W. (1980). Conditional reasoning following contradictory evidence: A developmental analysis. *Journal of Experimental Child Psychology, 30* 44–61.
[College students improved and transferred performance on conditional reasoning tasks. Seventh graders demonstrated confusion, while third graders were not affected by training. (grades 3, 7, college)]

Oprea, J. (1985). The effects of computer programming on a student's mathematical generalization and understanding of variables (Doctoral Dissertation, Ohio State University, 1984). *Dissertation Abstracts International, 46A*, 369.
[Sixth grade students can learn to program, learning computer programming enhances understanding of variable, and perhaps generalization ability. (grade 6)]

Orey, D. (1984). Logo goes Guatemalan–an ethnographic study. *The Computing Teacher*, 46–47. (August/Sept 84)
[Compared children from New Mexico, and, Bananera, and Patzan, Chimaltenango, both in Guatemala. Differences were few.]

Orton, A. (1970). *A cross sectional study of the development of the mathematical concept of function is secondary school children of average and above average ability*. Unpublished master's thesis, University of Leeds, UK.
[]

Orton, R. (1988). Using subjective probability to introduce probability concepts. *School Science and Mathematics, 88*, 105–112.
[Argues for using subjective probability to introduce probability. Defines four types: axiomatic, classical, frequency, and subjective. Model useful for talking about notions of probability.]

Palmiter, J. (1986). The Impact of A Computer Algebra System on College Calculus (Doctoral dissertation, Ohio State University, 1986). *Dissertation Abstracts International, 47A*, 1640.
[MACSYMA reduced time for integral calculus by 50%, allowed for improved concept learning, increased computational power of students, and did not debilitate later required learning of traditional algorithms. (grade 13)]

Palmiter, J. (1987, January). *Using a computer algebra system to reduce time spent in teaching integral calculus*. Paper presented at the annual meeting of the Mathematical Association of America, San Antonio, TX.
[Many of criticisms of calculus can be relieved by use of computer algebra system. Computer algebra systems should be used throughout college mathematics courses. Focus on concepts instead of computations.]

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books, Inc.
[Makes case for logo learning environment.]

Papert, S. (1987). Computer criticism vs. technocentric thinking. *Educational Researcher, 16(1)*, 22 -30.
[Attacks Pea & Kurland, compliments Clement & Gullo, cricicizes ExperLogo, emphasizes working culture aspect of computer environment, computer as carrier of mathematical learning, research must not be variable controlling experimental if that means the whole computer environment is not present. However, very bad piece of scientific writing because of the failure to document references, etc.]

Pea, R. (1983). *Logo programming and problem solving*. (Technical Report No. 12). New York: Center for Children and Technology, Bank Street College of Education.
[Rather than anecdotes, systematic developmental research documenting what children are learning as they learn to program is necessary. Pemature to discard programming or Logo, but doubts raised from empirical studies "that the Logo ideal is attainable with its discovery-learning pedagogy." 8-9, and 11-12 year olds]

Pea, R. (1985). Beyond amplification: Using computers to reorganize mental functioning. *Educational Psychologist, 20*, 167–182.
[ ]

Pea, R. (1987). Cognitive technologies for mathematics education. In A. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 89-122). Hillsdale, NJ: Lawrence Erlbaum Associates.
[Makes case for importance of symbolic tools, "doors to mathematical thinking are opened," (p. 96), computer can serve as mediational tool for promoting dialogue, routinization, mathematical context, multiple representations, learning to learn, problem solving, dramatic tools now available for doing mathematics.]

Pea, R. (1987). The aims of software criticism: Reply to professor Papert. *Educational Researcher, 16(5)*, 4–8.
[Critque of Papert's paper by one who had suggested caution as Papert's ideas did not seem to be very easy to implemented in the classroom. Bottom line is that Pea appropriately criticizes Papert for suggesting educational activism and experimental research are radically incompatible and his apparent bias for research with outcomes to his liking. Pea had attempted, in a fairly ideal research situation, to document the results Papert had suggested would occur, but was unsucessful.]

Pea, R. & Kurland, M. (1987). On the cognitive effects of learning computer programming. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 147–177). Norwood, NJ: Ablex.
[Reviews psychological and general education research (not mathematics education research), and calls for longitudinal research to study the role of computer progamming and transfer to other knowledge. "How can we organize learning experiences so that in the course of learning to program students are confronted with new ideas and have opportunities to build them into their own understanding of the computer system and computational concepts." (p. 151).. (I would have made mathematical ideas the focus). Suggests direct guidance needed for transfer, programming may provide one excellent domain for highly developed thinking processes. Need empirical studies to refine characterizations of levels of programming proficiency, transfer, etc. studies of learning and development process by which individual students become programmers and cognitive consequences of different levels of programming would be far better than standard correlational studies.]

Pea, R. & Kurland, M. (1983). *On the cognitive prerequisites of learning computer programming.* (Technical Report No. 18). New York: Center for Children and Technology, Bank Street College of Education.
[Domain-specific knowledge very important, 8-12 year olds capable of substantial debugging, no evidence about the educational superiority of different programming languages, factors frequently mentioned as prequisites to programming are: mathematical ability, momory capacity, analogical reasoning, conditional reasoning, procedual thinking, and temporal reasoning, but constraints on learning to program are unknown, no substantial studies to support claim to teach mathematical rigor, mathematical exploration, or general mathematical concepts, calls for *developmental study of programming, research with children,* not adults, *identifying purpose of programming, team approach,* and notes little known on the limits of instructability of programming.]

Pea, R., Kurland, M., & Hawkins, J. (1987). Logo and development of thinking skills. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 178–197). Norwood, NJ: Ablex.
[Two–year period, private school, one 3/4 grade and one 5/6 grade. Intensive training for teachers, etc., but, students did not differ at end of study, "Logo instructional environment that Papert (1980) currently offers to educators is devoid of curriculum, and lacks an account of how technology can be used as a tool to stimulate students' thinking about such powerful ideas as planning and problem decomposition. Teachers are told not to teach, but are not told what to substitute for teaching." (Apparently tried to duplicate Papert environment and failed to find evidence of change).]

Pea, R., Soloway, E., & Spohrer, J. (1987). The buggy path to the development of programming expertise. *Focus on Learning Problems in Mathematics, 9*, 5–30.
[ ]

Pekelis, V. (1974). X, Y, Z–Calculation Mathematics. In *Cybernetics A to Z.* Moscow: Mir Publishers, 301-310.
[Argues for importance of computation in doing mathematics.]

Pennington, N. (1982). *Cognitive components of expertise in computer programming: A review of the literature* (Technical Report N. 46). Ann Arbor: University of Michigan Center for Cognitive Science.
[Identifies potential programming knowledge schemas or chunks used by experts.]

Pepper, J. (1981). Following students' suggestions for rewriting a computer progamming textbook. *American Educational Research Journal, 18*, 259–269. (college) [Delete?]

Perkins, D. (1981). *The mind's best work.* Cambridge, MA: Harvard University Press.
[studying the thinking of novices and experts.]

Petty, O., & Jansson, L. (1987). Sequencing examples and nonexamples to facilitate concept attainment. *Journal for Research in Mathematics Education, 18*, 112–125.
[Confirmation of rational set in mathematics task of concept of parallelogram. Literature review old.]

Phillips, G. & Grodsky, M. (1985, April) *Testing Piaget's theory of probability concept development: A Bayesian approach using the theory of signal detection.* A paper presented at the Annual Convention of the American Educational Research Association, Chicago, Il.
[Suggests " . . .that children as early as 4 to 5 years of age solve probabilistic tasks as well as do adults." Reviews literature and proposes research strategy for investigating further that has promise. (5, 11, and 18 year-olds)]

Piaget, J. & Inhelder, B. (1975). *The origins of the idea of chance in children* (L. Leake, Jr., P. Burrell, & H. Fishbein, Trans.). New York, NY: W. W. Norton. (Original work published in 1951)
[Early study of probability concepts in children. Suggests probability as formal construct develops only during the formal operational stage.]

Piaget, J., & Inhelder, B. (1956). *The child's conception of space.* London, UK: Routledge and Keegan Paul.
[ ]

Piele, D. (1983, March). Beyond turtle graphics. *Creative Computing*, 180-185.
[Prefers BASIC to Logo for non-graphics uses.]

Pollatsek, A., Konold, C., Wells, A., & Lima, S. (1984). Beliefs underlying random sampling. *Memory and Cognition*, *12*, 394–401.
[Garfield & Ahlgren quote "Since students' actual heuristic, representativeness, is so different in form from the appropriate mechanistic belief, it may not be easy to effect any lasting change in students's beleifs about random samples."]]

Pollak, H. (1982). *The mathematical sciences curriculum K-12: What is still fundamental and what is not.* Report to the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. Washington, D.C.: National Science Foundation, iv+ 15 pp (1 December, 1982).
[Makes case fundamental changes in curriculum need to be considered given new computing technology. Calculators & computers at earliest possible grade, more emphasis on mental arithmetic, estimation, and approximation and substantially less on paper–pencil algorithms, collection and analysis of data, discrete mathematics, statistics, probability, and computer science, streamline traditional secondary curriculum to make room for new topics. Symbol manipulation and computer graphics must have major impact on curriculum. (Excellent prediction for now available (Jan 87) graphics calculators!). Needed: research, equal access, better qualified teachers.]

Pollak, H. (1986). Summary of Conference. Prepared for distribution to participants of the conference, *The School Mathematics Curriculum: Raising National Expectations,* sponsored by The Mathematical Sciences Education Board and the Center for Academic Interinstitutional Programs 7-8 Nov 86, UCLA.
[discrete mathematics, " . . . computers are one of the most visible forces for educational change, in that they undermine the reasons for the traditional dreariness of much of our mathematics." 'zero-based' curriculum? (C, F, or K?), "teaching understanding," Algebra is a system of representations, ". . . it's important motivation, particularly when you connect it with the computer, and it's a link between the very concrete arithmetic and the rather abstract higher mathematics that some of the students will meet." "The meeting also emphasized the importance of research for the process of change."]

Pollak, H. (1987). Cognitive science and mathematics education: A mathematician's perspective. In A. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 89-122). Hillsdale, NJ: Lawrence Erlbaum Associates.
["I would like to have students try some other combinations of variables to see that they don't lead anywhere. How else will they appreciate the cleverness of the actual solution?" (p. 254). School problems are all solvable problems, real problems are not. N is big and ε is small. Try the reverse, it'll drive you crazy.]

Ponte, J. (1984). Functional reasoning and the interpretation of Cartesian graphs (Doctoral dissertation, University of Georgia, 1984). *Dissertation Abstracts International*, *45A*, 1675.
[]

Popham, W. (1980). Two decades of educational technology: personal observations. *Educational Technology*, 19–21.
[No triumphs in two decades to gain public support. Public support needed for quality development.]

Prékopa, A. (Ed.) (1979). *Survey of Mathematical Programming*, (Vols. 1, 2, 3). Amsterdam: North Holland Publishing Co.
[Proceedings of 9th International Mathematical Programming Symposium (Budapest, 23-27 August 1976) and gives evidence of active role of computer in mathematics.]

Presmeg, N. (1986). Visualization and mathematical giftedness. *Educational Studies in Mathematics*, *17*, 297-311.
[Suggests high visualization preference may not be attribute of "talented" mathematics students. visualizers underrepresented among high achievers in mathematics. Argues ability to shift from one to other is key. Data contrary to this thesis may be caused by testing and teaching procedures that favor nonvisualizers. (secondary)]

Pritchard, M. (April, 1985). *Student programming as a context for developing mathematical concepts.* A paper presented at the research presession of the annual meeting of the National Council of Teachers of Mathematics, San Antonio, Texas.
[Case study. 4 students solving interation problems with computer programming. "The use of computer programming as a context for exploring mathematics nurtured their developing knowledge of iteration in a way that may not have been possible apart from the computer." (9-10 grade).]

Ralston, A. & Shaw, M. (1980). (1980). Curriculum '78–is computer science really that unmathematical? *Communications of the ACM, 23,* 67-70.
["Mathematical reasoning does play an essential role in all areas of computer science which have developed or are developing from an art to a science. ... for any science or any engineering discipline, the fundamental pronciples and theories can only be understood through the medium of mathematics."]

Ralston, A. (1980). *Computer Science, Mathematics, and the Undergraduate Curriculum in Both.* (Technical Report Number 161). Buffalo, New York: Department of Computer Science, State University of New York at Buffalo.
[83 pages. "... the importance of mathematics in computer science is and should be growing rapidly. ... the growth of computer science should be having–but has not had–a profound effect on undergraduate education." Rigorous thinking and abstraction are common to both mathematics and computer science. ...mathematics and computer science courses need to be interrelated right from the beginning. Extended argument for discrete mathematics.]

Ralston, A. (1981). Computer science, mathematics, and the undergraduate curriculum in both. *American Mathematical Monthly, 89,* 472–484.
[Analysis of mathematical needs for computer science and call for discrete mathematics including algorithms, logic, probability, and abstract algebra.]

Ralston, A. (1985). The really new college mathematics and its impact on the high school curriculum. In C. R. Hirsch (Ed.), *The Secondary School Mathematics Curriculum* (pp. 29-42). Reston, VA: The National Council of Teachers of Mathematics.
[Discusses discrete mathematics and computers and their impact on secondary school mathematics. Major points: calculators with MACSYMA, discrete mattematics, substantial reduction in hand symbol manipulation, algorithmic approach "brings a clarity and precision to mathematics teaching greater than what is normally present." (uses quadratic equation as an example), "teachers need to learn to live with–and maybe love–the hardware, the software, and the ideas of computer science."]

Ralston, A. (1986). Draft Report of the Task Force on Curriculum Frameworks for K-12 Mathematics. Preliminary draft prepared for distribution to participants of the conference, *The School Mathematics Curriculum: Raising National Expectations,* sponsored by The Mathematical Sciences Education Board and the Center for Academic Interinstitutional Programs, 7-8 Nov 86, UCLA.
[". . . calculators, computers, and computer science offer totally new approaches to doing, teaching and learning mathematics; . . ." badly needed are: probability, exploratory data analysis, statistics, model building, optomization problems, algorithmic thinking. We must focus in the future on mathematical power. ". . . diminution in the skill development of the curriculum will allow more focus on the understanding of mathematics and on the mathematical processes and reasoning which lie at the heart of mathematical problem solving."]

Ralston, A. (1987). Let them use calculators. *Technology Review, 90(6),* 30–31.
[ ]

Rambally, G. (1983). Interactive computer graphics in mathematics education. (University of Oregon, 1982). *Disseration Abstracts International, 44A,* 2915.
[A graphics system was developed and methods outlined for its use with a variety of mathematical topics. (secondary)]

Rampy, L. (1984, April). *The problem solving style of fifth graders using Logo.* Paper presenbted at the meeting of the American Educational Research Association, New Orleans, LA.
[ ]

Rea, R. and Reys, R. (1970). Mathematical competencies of entering kindergarteners. *The Arithmetic Teacher, 17,* 65–74.
[Counting: > 20, 37%; >14, 50%; >10, 75%. Considerable variability, age, sex, previous education, father's education, mother's education, and father's occupation were all significant factors. (K)]

Research Advisory Committee, National Council of Teachers of Mathematics. (1985). *Research Agenda Project.* Proposal submitted to the National Science Foundation.
[Five areas were chosen for working groups, including number concepts, algebra, problem solving, effective teaching, and technology.]

Reding, A. (1982). The effects of computer programming on problem solving abilities of fifth grade students. (University of Wyoming, 1981). *Disseration Abstracts International*, *42A*, 3484-3485.
[Students with no access to computers achieved a higher mean gain than did students using computer programming. (grade 5)]

Redish, E. (1988). The coming revolution in physics instruction. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 106–112). Washington, DC: Mathematical Association of America.
[Agrues for: practical numerical methods, qualitative behaviors, approximation theory, discrete systems, and pathological functions. Seems most resonant with graphics approaches, but with real interest in say, the Cantor set. "rigor and structure of mathematical thought" most critical.]

Renz, P. (1988). Calculus for a new century: MAA/NRC symposium sets agenda. *Focus, The Newsletter of the Mathematical Association of America*, *8(1)*, 1, 4.
[Summarizes by noting Calculus must become more conceptual, but really fails to note role of machines in calculus. Very different than Steen view that machines may be carriers of today's mathematics.]

Resnick, L. & Ford, S. (1980). *The Psychology of Mathematics Learning*. Erlbaum, Hillsdale, N. J.
[Reviews psychology related to learning mathematics. Mostly associated with computation (pencil-papaer type).]

Resnick, L. (1983). Mathematics and science learning: A new conception. *Science*, *220*, 477-478.
[Findings in cognitive science suggest: learners construct understanding; to understand is to know relationships; learning depends on prior knowledge; it is never too soon to start; focus on qualitative aspects of mathematics; confront naïve theories of students; support vigorous programs of cognitive research in mathematics learning.]

Resnick, L. (1987). *Education and learning to think*. Washington, DC: National Academy Press.
[Report by Committee on Mathematics, Science, and Technology Education, Commission on Behavioral and Social Sciences and Education, National Research Council. "children . . . solve arithmetic problems by manipulating symbols while ignoring their meaning . . . most students learn mathematics as a routine skill; they do not develop higher order capacities for organizing and interpreting information. It seems likely that a less routinized approach to mathematics could produce substantial improvements in learning." limited evidence " . . . suggests that sucessful math learners engage in more metacognitive behaviors . . . are less likely to practice symbol manipulation rules without reference to the meaning of the symbols . . ." and " . . . engage in more task analysis. (p. 14–15) " " . . . a more promising route may be to teach thinking skills within specific disciplines . . . (p. 18)" , e.g., within, say, mathematics. ". . . Mathematics poses special problems, derived from its heavy dependence on formal notations. . . (p. 39). Resnick calls for research to understand how students " . . . come to seek the connections between formal notations and their justifying concepts (p. 39)." "Basic mathematics will not be effectively learned if children only try to memorize rules for manipulating written numerical symbols (p. 45)." Makes a case for connections between notation and meaning and rejects symbol manipulating without meaning.]

Resnick, L., Cauzinilla–Marmeche, E. & Mathieu, J. (1987). Understanding algebra. In J. Sloboda & D. Rodgers (Eds.), *Cognitive processes in mathematics* (pp. 169–203). New York, NY: Oxford University Press.
[ ]

Revlin, R., Leirer, H., Yopp, H., & Yopp, R. (1980). The belief–bias effect in formal reasoning: The influence of knowledge on logic. *Memory & Cognition*, *8*, 584–592.
[Rather than reason incorrectly when conflict between logic and beliefs occurs, subjects opt for no conclusion.]

Risch, R. (1969). The problem of integration in finite terms. *Transactions of the American Mathematical Society*, *139*, 167-189.
[Uses: functions of complex variables to limit functions to exponentiation, logs, and algebraic operations; differential fields; strengthened Liouville theorem; mathematical logic; abstract algebra; and complex analysis to give an algorithm for determining elementary integrability. Referred to as Risch's algorithm and is a basis for some of integration algorithms of computer algebra systems.]

Risch, R. (1970). The solution of the problem of integration in finite terms. *Bulletin of the American Mathematical Society*, *76*, 605–608.
[Brief report announcing Risch's algorithm and outlining its proofs. 1969 paper shows more detail of mathematics used in this work.]

Robitaille, D., Sherrill, J., and Kaufman, D. (1977). The effect of computer utilization on the achievement and attitudes of ninth-grade mathematics students. *Journal for Research in Mathematics Education*, *8*,26–32.
[In each of the two schools studied, the computer group had lower achievement scores (programming) (grade 9)]

Rose, N. (1984). The effects of learning computer programming on the general problem solving abilities of fifth grade students. *Dissertation Abstracts International*. *44*, 2355A.

[Programming instruction (20+6 hrs.) produced gain on Cornell Critical Thinking Test (general logical skills). Replicate, introduce computer programming into curriculum, and develop more refined measures of problem solving. (grade 5)]

Rosenbaum, R. (1981). A study to determine the effect on achievement and course attitude when community college students write and execute computer programs for selected topics in elementary statistics. *Dissertation Abstracts International, 41*, 5013A.
[No evidence, or some evidence favoring the control group. (community college)]

Rouchier, A. (1984). L place de l'informatique dans l'enseignement secondaire français. *Zentralblatt für Didaktik der Mathematik*, 16(1), 12–15.
[

Rudd, D. (1985). A closer look at an advanced placement calculus problem. *The Mathematics Teacher, 78(4)*, 288-291.
[shows how graphs of functions such as $x^2\cos(1/x)$ can be used to explore fundamental mathematics.]

Sagan, H. (1984). *Calculus accompanied on the Apple.* Reston: Reston.
[Example of a computer based calculus course.]

Salomon, G. (May, 1985). *Information technologies: What you see is not (always) what you get.* Tel Aviv University, Israel.
[Opportunity for deeper learning (but may not be taken), strong reciprocal relations between mind and culturally evolved technologies, prior knowledge structures, modelling, short-circuting, flexible and continuous adaptation, short-term effects are a matter of high road, mindful learning. Long-term effects on thought processes are a matter of decades or centuries.]

Samurçay, R. (198x). Signification et fonctionnement du concept de variable informatique chez des eleves debutants. *xxxxxxxxxx, xxx*, 143–161.
[cognitive problems associated with concept of variable in programming (Pascal) for 15–16 year olds. Use of variables within programs permitted testing of student's concepts of variable.]

Samurçay, R. (1985). Learning programming: An analysis of looping strategies used by beginning students. *For the Learning of Mathematics, 5(1)*, 37–43.
[ ]

Sarason, D. & Gillman, L. (Eds.). (1983). *P. R. Halmos, Selecta: Expository writing.* New York, NY: Springer–Verlag.
[Book of readings of Halmos's expository writings.]

Sandefur, J., Jr. (1985). Discrete mathematics: A unified approach. In C. Hirsch & M. Zweng (Eds.), *The secondary school mathematics curriculum* (pp. 90-106). Reston, VA: National Council of Teachers of Mathematics.
[Recommends recursion, first-order difference equations, probability, higher-order equations, linear algebra, and systems of equations for discrete mathematics in high school. I would note that mathematics-speaking calculators make these recommendations even more viable and appropriate.]

Saunders, J. and Bell, F. (1980). Computer-enhanced algebra resources: Their effects on achievement and attitudes. *International Journal of Mathematical Education in Science and Technology, 11*, 465-473.
[Using the computer-enhanced materials had no significant effect on achievement or attitudes toward mathematics or the instructional setting, but did have a significant effect on attitude toward computers. (secondary)]

Schauble, L. (April, 1985). *Computer contexts for learning and development.* A paper presented at the annual meeting of the American Educational Research Association, Chicago.
[Describes issues related to research carried out at Children's Television Workshop. Although primarily a software development, observations include preschooler's had difficulty remembering sequences of instructions, keep screen uncluttered, interactive "real-world" testing critical, role of supporting contexts critical, need to wean support from the user. Examples of supportive environments are: novice-apprentice learning, mother-child problem solving, and conversations between older and younger children.]

Schoenfeld, A. (1980). Heuristics in the classroom. In S. Krulik & R. Reys (Eds.), *Problem solving in school mathematics* (pp. 9–22). Reston, VA: The National Council of Teachers of Mathematics.
[Drawing pictures and special cases play important role in problem solving. Graphics calculators would seem to be powerful tools for just those activities, providing both drawings and useful counterexamples or examples.]

Schoenfeld, A. (1982). Problem perception and knowledge structure in expert and novice mathematical problem solvers. *Journal of Experimental Pschology, x*, xx–xx.
[ ]

Schoenfeld, A. (1983). The wild, wild, wild, wild, wild world of problem solving. *For the Learning of Mathematics*, *3*, 40–47.
[Calls for the cooperative efforts of mathematicians, psychologists, and mathematics educators.]

Schoenfeld, A. (1985). *Mathematical problem solving*. New York, NY: Academic Press.
[ ]

Schoenfeld, A. (1987). Pólya, problem solving, and education. *Mathematics Magazine*, *60*, 283–291.
[Gives anecdote showing the importance of choosing the appropriate strategy vs being able to carry–out strategies.]

Schoenfeld, A. (1986). Notes on teaching calculus: Report of the methods workshop. In R. Douglas (Ed.), *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level* (pp. xv–xxi). Washington, DC: Mathematical Association of America.
[ ]

Schroeder, M. (1978). Piagetian, mathematical and spatial reasoning as predictors of success in computer programming. (University of Northern Colorado, 1978). *Dissertation Abstracts International*, *39A*, 4850.
[Correlates of programming ability were mathematical reasoning and Piagetian formal reasoning, but no evidence of spatial reasoning ability as a correlate. (College)]

Schroeder, T. (1983). An assessment of elementary school students' development and application of probability concepts while playing and discussing two strategy games on the microcomputer. (Indiana University, 1983). *Disseration Abstracts International*, *44A*, 1365.
[Some students had little difficulty applying probability concepts and explaining their strategies, while others could not relate moves to probability. (grades 4-6)]

Schulz, C. (1984). A survey of colleges and universities regarding entrance requirements in computer-related areas. *Mathematics Teacher*, *77*, 519–524.
[Typing skill and knowledge of a programming language were most frequently desired for incoming freshman. (college freshman)]

Schwartz, J. & Yerushalmy, M. (1987). The geometric supposer: An intellectual prosthesis for making conjectures. *The College Mathematics Journal*, *18*, 58-65.
[Illustrates conjecturing and discovering mathematics with the graphics and computational support of the software, the geometric supposer.]

Schwartzenberger, R., & Tall, D. (1978). Conflict in the learning of real numbers and limits. *Mathematics Teaching*, *82*, 44–49.
[ ]

Schubert, J. (1986). Gender equity in computer learning. *Theory Into Practice*, *15*, 267–275.
[Evidence of inequity for sexes. Suggests strategies to overcome. (Graphics calculator could aid as every student can have one (no competition) and the activities to do mathematics are no more sex biased than mathematics itself.)]

Shapiro, B. and O'Brien, T. (1970). Logical thinking in children- ages six through thirteen. *Child Development*, *41*, 823-829.
[Ability to recognize logical necessity was significantly easier than the ability to test for it, at all age levels. Recognition "leveled off" high at 6-8 years, while testing continued to increase over the eight years, with no "leveling off" evident. (Age 6-13)]

Shaughnessy, J. (1981). Misconceptions of probability: From systematic errors to systematic experiments and decisions. In A. P. Shulte & J. R. Smart (Eds.) *Teaching statistics and probability* (pp. 90-100). Reston, VA: National Council of Teachers of Mathematics.
[discusses common misconceptions, questions for detecting such misconceptions, suggests some activities, and also identifies misuses of statistics. can help document need for school attention.]

Shaughnessy, J. & Burger, W. (1985). Spadework prior to deduction in geometry. *Mathematics Teacher*, *78*, 419-428.
[Describes the van Hiele levels, strategies for measuring, reports discouraging status of U. S. students, and proposes early, continuous, geometric experiences in schools paralleling students' experiences with number concepts.]

Shavelson, R. and Stanton, G. (1975). Construct validation: Methodology and applications to three measures of cognitive structure. *Journal of Educational Measurement*, *12*, 67–85.
[That word association, card sorting, and graph building methods converge and reflect underlying mathematical structure was confirmed by two studies.]

Shavelson, R. (1981). Teaching mathematics: Contributions of cognitive research. *Educational Psychologist, 16*, 23–44.
[Argues for comparing cognitive structures of students, before and after instruction, with comparable structures of teachers, other students, or experts to detect treatment effects.]

Sheil, B. (1981). The psychological study of programming. *Computing Surveys, 13*, 101–120.
[Reviews psychological research on programming, notes ineffectiveness, and calls for more sophisticated experimental techniques and a deeper view of programming.]

Sheingold, K. (1987). The microcomputer as a symbolic medium. In R. Pea & K Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educational computing* (pp. 198–208). Norwood, NJ: Ablex.
[Raises issue of symbolic thought, when it develops (maybe early (age 5)) and how a computer is a symbolic medium. Notes however: "Programming languages are, it turns out, very complex symbol systems, the mastery of which takes much time and intensive effort (Kurland, Mawby, & Cahir, 1984; Pea & Kurland, 1984b). So, while I think it worthwhile to introduce young children to ideas about programmability, it is equally important for educators to look carefully at what is actually learned and understood." (p. 203).]

Shneiderman, B. (1976). Exploratory experiments in programming behavior. *International Journal of Computer Information Science, 5*, 123-143.
[Programmers remember executable programs better than scrambled, while non-programers show no difference. Second experiment with conditional branching. Infer "chunking" going on. Experienced programmers recode into internal structure. (college & adults)]

Shneiderman, B. (1977). Measuring computer program quality and comprehension. *International Journal of Man-Machine Studies, 9*, 465–478.
[Measure of program quality, programmer comprehension of programs have been difficult to measure. Syntactic/semantic model and experiments suggest memorization/recall tasks as potentially appropriate measures for quality of program, comprehension of program, programming ability, and understanding of subject content of program.]

Shneiderman, B. (1980). *Software psychology: Human factors in computers and information systems.* Winthrop, New York.
(quote: experienced programmers chunk to aid memory of programs.)

Shuell, T. (1986). Cognitive conceptions of learning. *Review of Educational Research, 56*, 411-436.
[Calls for a sensible combination of current concerns for cognitive learning (active, constructive, cumulative, and goal oriented learning) with traditional concerns of learning research.]

Shumway, R. (1974). Negative instances in mathematical concept acquisition: Transfer effects between the concepts of commutativity and associativity. *Journal for Research in Mathematics Education, 5*, 197-211.
[Tutorial and data collection use of computers. Illustrates complexity and difficulty of even naïve tutorial programming. Nonexamples play significant role in concept learning. (grade 9)]

Shumway, R. (1977). Positive versus positive and negative instances and the acquisition of the concepts of distributivity and homomorphism. *Journal of Structural Learning, 4*, 331-348.
[Same as Shumway (1974), but different concepts and different age. (college)]

Shumway, R. (Ed.). (1980). *Research in mathematics education.* Reston, Virginia: National Council of Teachers of Mathematics.
[Professional reference review of research in mathematics education.]

Shumway, R. (1982). Problem-solving research: A concept learning perspective. In F. Lester & J. Garafalo (Eds.), *Mathematical Problem Solving: Issues in Research* (pp. 131-139), Philadelphia, PA: The Franklin Institute Press.
[Suggests role concept learning and psychological research might play in problem solving.]

Shumway, R. (1983a). Let kids write programs. *The Arithmetic Teacher, 31(6)*, 2, 56.
[Makes case for student computer programming (short programs) to do and learn mathematics.]

Shumway, R. (1983b). Try this. *The Arithmetic Teacher*, September, *31(1)*, 52-53.
[Simple counting and addition programs in BASIC that introduce the use of variables.]

Shumway, R. (1983c). What machine? *The Arithmetic Teacher, 31(2)*, 54-55.
[Discusses capabilities of variously priced machines to do mathematics.]

Shumway, R. (1983d). Simulation. *The Arithmetic Teacher, 31(3)*, 52-53.
[Illustrates elementary probability simulations suitable for young children.]

Shumway, R. (1983e). Growing numbers. *The Arithmetic Teacher, 31(4)*, 38-39.
[simulates exponential growth with a simple, iterative addition program.]

Shumway, R. (1984a). Young children, programming, and mathematical thinking. In V. Hansen and M. Zweng (Eds.) *Computers in mathematics education.* (pp. 127-134). Reston, VA: National Council of Teachers of Mathematics.
[Illustrates programming tasks claimed to be suitable for first-graders, relates experiences with such children, and hypothesizes potential benefits in *computer literacy*, *specific mathematics* such as Cartesian coordinates, counting, place value, exponential growth, and scientific notation, and *general mathematics concepts* such as variable, sequences, number names, and recursion, *mathematical thinking*, *problem solving*, and *logical reasoning*.]

Shumway, R. (1984b). Graphing. *The Arithmetic Teacher, 31(5)*, 38-39.
[introduction to graphing in BASIC. K-5]

Shumway, R. (1984c). Try this: Computer counting. *The Arithmetic Teacher, 31(6)*, 57-58.
[demonstrates simple computer programs to help develop number sense. K-3]

Shumway, R. (1985). Why logo? *The Arithmetic Teacher, 32(9)*, 18-19.
[Suggests logo as another language (in addition to BASIC) to use with children because of its ease of learning, vector graphics, procedures, and structural programming support.]

Shumway, R. (1986). Applications of calculators and computers in science and mathematics education. In D. Layton (Ed.), *Innovation in Science and Technology Education.* (pp. 117-136). Paris, France: UNESCO.
[Calculator & Computer research, nature of learning mathematics, impact of technology, computation, theory building, modelling, thinking, curriculum, language and machines, and the future. Builds case for coding and the subsequent executions of code as potentially powerful contributors to learning mathematics.]

Shumway, R. (1987). *101 ways to learn mathematics using BASIC.* Englewood Cliffs, NJ: Prentice-Hall.
[Illustrates programming ideas that support, facilitate, or stimulate the learning of mathematics. (grades K-8).]

Shumway, R. (1988). Calculators and computers. In T. Post (Ed.) *Teaching mathematics in grades K-8: Research based methods.* (pp. 334-383). Boston, MA: Allyn and Bacon, Inc.
[Summarizes research, provides examples of computer and calculator use for computations, concept learning, and problem solving, and suggests some needed curriculum reform.]

Shumway, R. (1988). Programming finite group structures to learn algebraic concepts. In A. Coxford (Ed.), *The ideas of algebra, K-12* (pp. 152–154). Reston, VA: National Council of Teachers of Mathematics.
[Example of computer programming activity to learn abstract mathematical concepts and see some roles for proof in computer programming. (grades 11-15)]

Shumway, R. (1987, October). *The new calculators: Illuminating some dark corners in the college mathematics curriculum.* A paper presented at the 15th annual mathematics and statistics conference, Miami University, Miami, OH.
[Illustrates graphics calculator capabilities, gives implications for public schools, presents data on mathematical understandings of prospective teachers, and draws implications for college mathematics calling for: graphic representations as standard tools for doing mathematics, matrix representations of fundamental mathematical ideas, Galois theory, Taylor's theorem, Weierstaauss approximation, complex variables, hypothesis testing, symbolic logic, computer arithmetic, and computer programming of mathematical concepts, treatment of fundamental concepts such as definition, variable, random, completeness, differentiation, measure and integration, representations, counting, functions, finite systems, modeling, and proof, and significant deemphasis on numeric and symbolic computation.]

Siegel, S. & Andrews, J. (1962). Magnitude of reinforcement and choice behavior in children. *Journal of Experimental Psychology, 63*, 337–341.
[ ]

Sims, C. (1984). *Abstract algebra–a computational appraoch.* New York, NY: J Wiley & Sons.
[ ]

Skemp, R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching, 77*, 20-26.
[relational understanding—what to do and why; instrumental understanding—knowing rule and being able to do it. We have two games in town and often there is a mismatch between students and teachers, or teachers and teachers, at all levels. Advantages of instrumental: easier, rewards immediate, right answers more quickly and accurately. Advantages of relational: adaptable to new tasks, easier to remember, relational knowlege motivating, students seek more relational understandings. Short-term vs long-term learning? Causes of instrumental approach: exams, packed syllabi, measurement problems, difficulty for teachers to change. Analogical examples: music instruction, learning new town. "What constitutes mathematics is not the subject matter, but a particular kind of knowledge about it."]

Skemp, R. (1982). Symbolic understanding. *Mathematics Teaching, 99*, 59-61.
[*symbolic understanding*—connect mathematical symbolism with relevant mathematical ideas, or more carefully, provisionally—"symbolic understanding is a mutual assimilation between a symbol system and an

appropriate conceptual structure." Like Descartes connecting geometry and algebra. Some interesting examples: 23 vs 2^3; 572 vs 5,7,2; (2, 3) as rational, point in plane, vector, . . . We have limited choices so how do children build up a variety of meanings for the same symbols? We need "(i) conceptual structure as stronger attractor than symbol system; (ii) symbol system —> conceptual structure must be strong and easy. New material must be assimilated conceptually, first conceptual structure, then symbolic representation, talking is ok, students invent own symbols as transitional representations. "Symbolic understanding is a mutual assimilation between a symbol system and a conceptual structure, dominated by the conceptual structure." Symbols are magnificent servants, but bad masters, because by themselves, they do not understand what they are doing." Student use of computers can fit these last quotes nicely.]

Skemp. R. (1987). The psychology of learning mathematics (Expanded American Edition). Hillsdale, NJ: Lawrence Erlbaum Associates.
[Collection of Skemp's writings including reprints of above as well as 1971 book of same title. Provides more models for discussion of issues such as symbols, visual–symbolic representations, nature of knowledge. Graphics calculators may assist in symbol development, visual–symbolic interaction, and constructing one's own knowledge.]

Sloane, N. (1986). My friend MACSYMA. *Notices of American Mathematical Society*, *33*, 40–43.
[Illustrates how MACSYMA can help professional mathematicians.]

Small, D. (1987). Report of the CUPM panel on calculus articulation: Problems in the transition from high school calculus to college calculus, *American Mathematical Monthly*, *18*, 776-785.
[In 1982, 55% of students attended high school where calculus was taught. Of 32,000 taking AP exam, 12,000 received scores of 4 or 5, scores needed for successful continuation in college. This is 6% of all students taking calculus. H. S. calculus needs to be taught by teacher having had a rigorous junior-senior level real analysis course and the course must be restricted enrollment, full-year, use college text, have AP as major goal, and use AP as evaluation. "...should not be a watered-down treatmnet of calculus that does not deal in depth with the concepts, covers no proofs, or rigorous derivations, and mostly stresses mechanics."]

Small, D., Hosack, J., & Lane, K. (1986). Computer algebra systems in undergraduate instruction. *The College Mathematics Journal*, *17*, 423–433.
[ ]

Small, D., & Hosack, J. (1986). Computer algebra systems, tools for reforming calculus instruction. In R. Douglas (Ed.), *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level* (pp. 143–155). Washington, DC: The Mathematical Association of America.
[Conceptual understanding: PS appraoches, more varied examples, graphs to analyze functions, changing students' perceptions of what is important in mathematics.]

Soloway, E., Bonar, J., & Ehrlich, K. (1983). Cognitive strategies and looping constructs: An empirical study. *Communications of the ACM*, *26*, 853–860.
[]

Soloway, E., Lochhead, J., & Clement, J. (1982). Positive effects of computer programming on the student's understanding of variables and equations.(or Does computer programming enhance problem solving ability? Some positive evidence on algebra word problems.) In R. J. Seidel, R. E. Anderson, & B. Hunter. (Eds.). *Computer literacy: issues and directions for 1985*. New York: Academic Press. 171-185.
[See Clement, J. et. al. (1982). Programming enhanced student's ability to use variables. Encourages active, procedural view of equations. ($6P = S$ problem, college)]

Stasz, C. & Winkler, J. (April, 1985). *District and school incentives for teacher's instructional uses of microcomputers*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.
[The most important incentives for teachers using computers are the technological support of hardware and courseware.]

Steen, L. (1981a). Computers in the classroom. In L. A. Steen & D. J. Albers (Eds.), *Teaching Teachers, Teaching Students* (pp. 112–119). Boston: Birkhäuser.
[Reviews ICME–IV talks regarding computers. quote: "Whether computers will be viewed as an 'instrument of the devil' or as a 'carrier of mathematical culture' is one of the major challanges facing mathematics teachers in the last two decades of this century."]

Steen, L. (1981b). Computer calculus. *Science News*, *119*, 250–251.
[Layperson description of power of symbolic computer algebra and role of Risch's algorithm.]

Steen, L. (1985). Living with a new mathematical species. In Commission Internationale de L'Enseignement Mathematique, *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 23-34.
[changes in mathematics because of computers: computer-assisted proofs not just in graph theory, but even in functional analysis; as with physics, because of computer science, mathematics became more efficacious by

becoming more abstract; "abstract theories of finite state machines and deterministic automata are reflections in the mirror of computer science of well established mathematical structures from abstract algebra and mathematical logic"; "Computers are mathematics machines, as calculators are arithmetic machines. Just as the introduction of calculators upset the comfortable paradigm of primary school arithmetic, so the spread of sophisticated computers will upset the centuries old tradition of college and university mathematics."; "Good teachers, however, should respond to the computer as a blessing in disguise--as a *deus ex machine* to rescue teaching from the morass of rules and templates that generations of texts and tests have produced."; "Is it really worth spending one month of every year teaching half of a country's 18 year old students how to imitate a computer?"; "discussion will readily elicit counterexamples, and some informal proofs. With the aid of the mathematics-speaking computer, students can for the first time learn college mathematics by discovery."; and the computer has speeded up the evolutionary nature of mathematics, so must we speed up the change in curriculum and pedagogy."]

Steen, L. (1986). Twenty questions for calculus reformers. In R. Douglas (Ed.), *Toward a lean and lively calculus: Report of the conference/workshop to develop curriculum and teaching methods for calculus at the college level.* Washington, DC: The Mathematical Association of America.
[Reports that on GRE (largely advanced calculus), ". . . foreign-educated students average one standard deviation higher than U. S. educated students." Should calculus books be put on a diet?]

Steen, L. (1986, November). Forces for change in the mathematics curriculum. Text of an address given at the conference, *The School mathematics curriculum: Raising national expectations*, sponsored by the Mathematical Sciences Education Board and the Center for Academic Interinstitutional Programs, 7 Nov 86, UCLA.
["mathematics-speaking calculators offer a marvelous opportunity for stimulating pedagogy." " . . . their presence in our culture will change forever the rationale, the dynamics, and the incentive for traditional high school and college mathematics." Forces: *people*, *machines*, *applications*, *nature*, and *role* of mathematics. We must steer course consistent with these forces.]

Steen, L. (1987). Smokestack classrooms. *Focus, The Newsletter of the Mathematical Association of America*, *7*, 1, 4.
["Mathematics is changing, and so must mathematics education. The pervasive nature of computing is changing the role of mathematics, requiring corresponding changes in school curricula. Computers now compute, so students must learn to think." "Indeed, solving complex problems, rather than rote learning alone, is becoming the new international standard of success in school mathematics."]

Steen, L. (Ed.). (1988). *Calculus for a new century: A pump, not a filter.* Washington, DC: The Mathematical Association of America.
[Report on National Colloquium, 28–29 Oct 87. Excellent set of readings.]

Steen, L. (1988). Who still does math with paper and pencil? In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 231–232). Washington, DC: Mathematical Association of America. (Reprinted from *The Chronicle of Higher Education*, 1987, October 14, A48.)
[Mathematicws-capable calculators, paper and pencil algorithms are out. Suggests some potential changes with such calculators. "Undergraduate mathematics will become more like real mathematics, both in the industrial work place and in academic research. By using machines to expidite calculations, students can experience mathematics as it really is—as a tentative, exploratory discipline in which risks and failures yield clues to success." (p. 232). Reminds one of Lakatos lament.]

Steen, L. (1988). Celebrating mathematics. *The American Mathematical Monthly*, *95*, 414–427.
[Paints contrasting pictures of research mathematics and mathematics of classroom]

Stenberg, W., Walker, R., et. al. (1968). *Calculus, a computer oriented presentation*, Project CRICISAM, Florida State University, Tallahassee, Florida.
[Early calculus materials using computers. (college).]

Stevenson, H. & Weir, M. (1959). Variables affecting children's performance in a probability learning task. *Journal of Experimental Psychology*, *57*, 403–412.
[ ]

Stevenson, H. & Zigler, E. (1958). Probability learning in children. *Journal of Experimental Psychology*, *56*, 185–192.
[ ]

Stewart, I., & Tall, D. (1987). *Complex analysis (the hitchhiker's guide to the plane).* Cambridge, UK: Cambridge University Press. $19.95.
[Excellent introduction to complex variables for those who've seen it, but want to see again for teaching ideas. Geometric representations key element.]

Stout, D. (1982). The effects of negative instances and focusing strategies on conjunctive concept learning (Doctoral dissertation, Ohio State University, 1982). *Dissertation Abstracts International*, *43A*, 2584–2585.
[negative instances powerful benefit with many irrelevant attribute demensions.]

Stoutemyer, D. (1985). Using computer symbolic math for learning by discovery. In Commission Internationale de L'Enseignement Mathematique, *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 185-190.
[". . . computer symbolic math systems now permit such rapid and flawless processing of nontrivial examples that is is easy to search for patterns which suggest conjectures and generalizations, then search for counterexamples or machine-aided proofs."]

Streibel, M. (April, 1985). *A critical analysis of computer-based approaches to education: drill-and-practice, tutorials, and programming/simulations.* A paper presented at the annual meeting of the American Educational Research Association. Chicago.
[Among other criticisms for drill-and-practice and tutorials, comments that programming delegitimizes non-technologicla ways of learning and thinking about problems.]

Suppes, P. and Feldman, S. (1971). Young children's comprehension of logical connectives. *Journal of Experimental Child Psychology, 12*, 304–317.
[Age and SES affected pupil's responses to conjunction, disjunction, and negation commands. Conjunction was easiest, followed closely by "exclusive-or"; disjunction was most difficult. Negation substantially increased the difficulty of commands. (nursery school, kindergarten)]

Suydam, M. (1973). *III. The use of computers in mathematics education: Bibliography.* Colunbus, Ohio: ERIC Information Analysis Center for Science, Mathematics and Environmental Education.
[Annotated bibliography of early work on computers in mathematics education. X–1972.]

Suydam, M. (1984). Microcomputers in mathematics instruction. *The Arithmetic Teacher, 32(2)*, 35.
[Most educational software is for mathematics and involves drill and practice. Few programs are designed to teach concepts or develop problem solving techniques. Drill and practice programs are effective. The evidence on other ways of using the computer in mathematics instruction is scarce.]

Suydam, M. (1986). *Review of research: Computers in mathematics education, K-12.* Columbus, OH: Ohio State University.
[July, '86 review.]

Suydam, M. (1986). *Evaluation in mathematics* (Information Bulletin No. 2, 1986), ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, OH: Ohio State University.
[Notes inadequacies of standardized tests and need to develop specific tests for specific goals. Several problem solving tests are cited.]

Suydam, M. (1986). *An overview of research: Computers in mathematics education, K-12.* Mathematics Education Digest No. 1, 1986, ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, OH: Ohio State University.
[Programming skills can be taught at the elementary level and extended (dramatically, for those students with time and interest) at the secondary level, much software is not sensational, but improving, many students cannot be considered computer literate, programming sometimes improves mathematical achievement, generally no sex differences, programming requires same problem solving skills as mathematical problem solving, instruction in programming in BASIC or Logo improves ability to analyze problems, some studies report success using Logo to teach geometric concepts, problem solving, and spatial skills, calls for integration of computers in ongoing curriculum.]

Swift, J. (1984). Exploring data with a microcomputer. In V. Hansen & M. Zweng (Eds.), *Computers in mathematics education* (pp. 107–117), Reston, VA: National Council of Teachers of Mathematics.
[Illustrates the tool use of the computer to explore a data bank of statistics.]

Taback, S. (1975). The child's concept of limit. In M. Rosskopf (Ed.), *Children's mathematical concepts* (pp. 111–144). New York, NY: Teachers College Press.
[rule of correspondence, convergence (divergence), neighborhood, and limit point were examined with 8, 10, and 12 year–olds. Tasks in non–mathematical contexts, concrete and abstract. Age differences found (10 & 12 much more successful than 8), but generally subjects less successful than Piagetian counterpart experiment on repeated subdivisions. Tabeck suggests context (irrevelent attributes?) may be significant factor in confusing subjects.]

Tagatz, G., Layman, J., and Needham, J. (1970). Information processing of third and fourth grade children. *Contemporary Education, 42*, 31- 34.
[In the processing of positive versus negative information on a cardmatching task, a significant difference was found for grade level, but not sex, SES, or point of presenting information. (3,4)]

Tall, D. (1980). Looking at graphs through infinitesimal microscopes, windows and telescopes. *The Mathematical Gazette, 64*, 22-49.
[approach to non-standard analysis using superreals. Ideas interact well with graphics calculator and suggest some interesting, graphical approaches to fundamental ideas of calculus.]

Tall, D. (1985). Understanding the calculus. *Mathematics Teaching, 110*, 49-53.

[Points out the important conceptual and mathematical role graphs play in the development of fundamental concepts of calculus. For example, perhaps magnifying a curve and seeing it get "straighter" and "straighter" so that the derivative is really the slope of the "curve," rather than studying limits of secant lines first has cognitive and mathematical advantages.]

Tall, D. (1985). The gradiant of a graph. *Mathematics Teaching, 111*, 48-52.
[Graphing gradiant function for small values of h gives good intuitions about derivative with problem of limit discussions.]

Tall, D. (1985). Tagents and the Leibniz notation. *Mathematics Teaching, 113*, 48-51.
[Looking at tangents graphically from the perspective of dy/dx, where dy, dx are small. Continuation of Tall series on calculus.]

Tall, D. (1986). A graphical approach to integration. *Mathematics Teaching, 114*, 48-51.
[Graphic approach to integral by computing areas and plotting function. Role of continuity in fundamental theorem become important. Idea can be generalized to discontinuous functions.]

Tall, D. (1986). Lies, damn lies . . . and differential equations. *Mathematics Teaching, 115*, 54-57.
[illustrates the cognitive and mathematical value of sketching solution curves for differential equations.]

Tall, D. (1986). Whither calculus?. *Mathematics Teaching, 118*, 50-54.
[note, need page 54. Discusses numeric, graphical, and symbolic implications for computer in calculus.]

Tall, D. & Schwarzenberger, R. (1978). Conflicts in the learning of real numbers and limits. *Mathematics Teaching, 82*, 44–49.
[ ]

Tall, D. & Vinner, S. (1981). Concept image and concept definition in mathematics, with particular reference to limits and continuity. *Educational Studies in Mathematics, 12*, 151-169.
[ ]

Taylor, R. (Ed.). (1980). *The computer in the school: Tutor, tool, tutee.* New York: Teachers College Press.
[Tutor role: computer teaches student (creative CAI, Bork, Suppes); Tool: computer does work for learner; Tutee: student teaches computer (Dwyer, Luehrmann, & Papert). Emphasis is on students controlling computer rather than computer controlling students.]

Taylor, V. , Smith, D., & Riley, M. (1984). A pre-math computer program for children: validation of its effecxtivemess. *Computers in the Schools, 1*, 49–59.
[A microcomputer pre-math program used for varying lengths of time produced no clear learning attributable to the use of the program. (ages 4-5)]

Tennyson, R. & Park, O. (1980). The teaching of concepts: A review of instructional design research literature. *Review of Educational Research, 50*, 55–70.
[Four step process for concept teaching recommended. Taxonomical structure identified, concept defined in terms of critical attributes, rational set of examples, arranged by divergency and difficultly.]

Tenneyson, R. & Cocchiarella, M. (1986). An empirically based instructional design theory for teaching concepts. *Review of Educational Research, 56*, 40-71.
[provides a potential model for concept learning and instructional strategies based on some 20-years of empirical research. This model can be applied to mathematical concepts and should be helpful in a research effort involving mathematical concepts and computer use in the learning of such concepts.]

Teske, S. (1987). U. S. math curriculum doesn't add up, researchers say. *Education Daily, 20(11)*, 1-2.
["the use of calculators and computers . . . should be expanded . . . more complex subjects should be introduced to students earlier. . . elementary students should take courses in subjects such as statistics and probability."]

Tesler, L. (1984). Programming languages. *Scientific American, 251*, 70-78.
[Illustrates many of the popular programming languages and their characteristics. Bottom line is to chose language appropriate to problem. All are useful and valuable.]

Thomas, H. L. (1975). The child's concept of function. In M. Rosskopf (Ed.), *Children's mathematical concepts* (pp. 145–172). New York, NY: Teachers College Press.
[High ability 7th and 8th graders, five stages wrt function proposed and "documented." Observed 1–1 vs well-defined problem still present in our juniors and seniors, role and importance of representations, underlying concepts and relationships with variable and quantification seen as important next steps.]

Thompson, P. (1985). A Piagetian approach to transformation geometry via microworlds. *Mathematics Teacher, 78*, 465–471.
[Describes *Motions* as an environment for students to use the operations of transformational geometry to explore, experiment, and experience transformations and the mathematical structures involved.]

Torres, O. & Martínez, P. (1985). Dos Estrategias para la enseñanza de BASIC. *Cero Uno Cero, 3*, 72–79.
[Supports adaptation of Mayer (1979) strategies for children. (5th grade)]

Tucker, T. (1987). Calculators with a college education? *Focus, The Newsletter of the Mathematical Association of America, 7(1)*, 1,5.
[Briefly describes Casio fx7000G (early '86) and HP-28C (January, '87), their capabilities (graphics, differentiation (e.g., $(1+x^2)^{sin(x)}$), matrix manipulation, numerical integration, Taylor polynomials), predicts 2-10 hours for student proficiency, notes mathematicians are traditionally slow at coming to grips with technology, and asks when our curriculum will recognize their existence. First (?) documentation in mathematics education literature of existence of Casio *fx-7000G*, one year after release. Perhaps this suggests implications for instruction will be very slow in realization (10 years?).]

Tucker, T. (1988). Calculus tomorrow. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 14–17). Washington, DC: Mathematical Association of America.
[calculators are tools that raise as many questions as they answer and that is good. We may have machines who think and students who think as well because mindless button pushing makes no sense.]

Ulam, S. (1980). Von Neumann: The interaction of mathematics and computing. In N. Metropolis, J Howlett, and G. C. Rota (Eds.), *History of Computing in the Twentieth Century* (pp. 93–99). New York: Academic Press.
[Computers play an important role in doing mathematics.]

United States Department of Education. (1983). *Computers in education: realizing the potential.* Washington, D. C.: U. S. Government Printing Office.
[Call for essential basic and prototype research activities to realize the potential for the computer in education.]

Usiskin, Z. (1985). We need another revolution in secondary school mathematics. In C. R. Hirsch (Ed.), *The Secondary School Mathematics Curriculum* (pp. 1-21). Reston, VA: The National Council of Teachers of Mathematics.
[Reviews recent public policy statements and draws inference we need a massive curriculum revision. Computers play a major role in the revisions.]

Valverde, L. (1984). Underachievement and underrepresentation of Hispanics in mathematics and mathematics-related careers. *Journal for Research in Mathematics Education, 15*, 123–133.

Vinner, S. (1987). Continuous functions—images and reasoning in college students. In J. Bergeron, N. Herscovics, & C. Kieran (Eds.), Proceedings of the 11th International Conference on the Psychology of Mathematics Education (pp. 177–183). Montreal, Canada: PME.
[ ]

Vobejda, B. (1987, October 29). Dreaded but indespensable: Calculus in crisis. *Washington Post*, p. A3.
[Mathematical Sciences Education Board conference " . . . called for 'deep structural change' in calculus courses, revisions that would tap the potential for computer technology, focus more on real-life problems and the concepts behind calculus and move away from drill and routine exercises.']

Vygotsky, L. (1978). *Mind in Society*. Cambridge, MA: Harvard University Press.
[Language and symbol development at root of learning and development. Study learning potential through two stumuli, the environment or problem, and a human "helper." Cultivate learning don't impose. Observation: computer programming may offer opportunity for language and symbol development in a natural rather than imposed way and offer no upper limits on learning.]

Wagner, S. (1981). Conservation of equation and function under transformation of variables. *Journal for Research in Mathematics Education, 12*, 107–118.
[Ability to conserve equation or function varies, less than half of sample conserved on any of four tasks. Implications for student ability to use and understand variable. 10-15 year olds.]

Wagner, S. (1983). What are these things called variables? *Mathematics Teacher, 76*, 474–479.
[Discussion of differences and common misconceptions about the use of variable in school mathematics. Some guidance for potential measure of understanding of variable.]

Wainer, H., & Thissen, D. (1981). Graphical data analysis. *Annual Review of Psychology, 32*, 192–241.
[ ]

Waits, B. & Demana, F. (1986). *A vehicle to apply mathematics—writing a computer graphing program.* Columbus, OH: Ohio State University.
[Development of a graphing program of some 50 lines in BASIC and illustrating mathematical use.]

Waits, B. & Demana, F. (1987). Solving problems graphically using microcomputers. *The UMAP Journal, 8(1)*, 1–7.
[3 examples of problems and micro–graphic approaches to solving. Shows interplay between symbolic and geometric representations. limber stick, bond yield rate, $(1\text{-}cosx^{12})/x^{24}$.]

Waits, B. & Demana, F. (1987, April). *A computer graphing based approach to solving inequalities.* Columbus, OH: Ohio State University.
[illustrates graphical solutions to inequalities. Observes need for continuity and intermediate value theorem (actually Bolzano's theorem). Avoids artificial problems & is a more generalizable technique.]

Waits, B. & Demana, F. (1987, December). *An application of programming and mathematics: Writing a computer graphing program.* Columbus, OH: Ohio State University.
[Notes on problems and transformations used in mathematizing Apple & IBM screens for plotting functions. Graphics calculators make these discussions historical but still practical for micro-users.]

Waits, B. & Demana, F. (1988, in press). Microcomputer graphing: A microscope for the mathematics student. *School Science and Mathematics.*
[Gives graphics program for Apple II family, and explores $(x^3\text{-}10x^2+x+50)/(x\text{-}2)$ including "limiting behaviors", for example, with very large viewing rectangle, looks like x^2, with very small rectangle the roots are easily found. Powerful tool for mathematics. Symbolic and graphic representations.]

Waits, B., & Demana, F. (1988, February). *Computers and the rational–root theorem, another view.* Columbus, OH: Ohio State University.
[illustrates root finding techniques appropriate for a world of graphics calculators.]

Walker, D. (1987). Logo needs research: A response to Papert's paper. *Educational Researcher, 16(5)*, 9–11.
[Notes we need more, careful research using a variety of modes to gain scientific evidence. Dismisses Papert's view that research is inappropriate (perhaps because it doesn't agree with Papert?!). All research has limitations, including Papert's anecdotal "evidence." We need replications and a variety of studies with a variety of paridgms.]

Wells, G. (1981). The relationship between the processes involved in problem solving and the processes involved in computer programming. (University of Cincinnati, 1981). *Dissertation Abstracts International, 42*, 8123791.
[Initial evidence computer programming is an effective way to invoke problem solving processes. (high school)]

Wenger, R. (1987). Cognitive science and algebra learning. In A. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 217–251). Hillsdale, NJ: Lawrence Erlbaum Associates.
[A great deal of discussion of overgeneralization or lack of concept learning in equation manipulation with no recognition of nonexample research directly related to these issues. Author also notes these skills may not be appropriate for today (Why make this error of extensive analysis of an outmoded algorithm?) Suggests move to algebraic–graphic modes as appropriate. I agree with Kaput criticism (p. 244-245) referring to self-contaqined nature of buggy research and fact that these skills may now be moot. Researchers must be willing to throw away the old stuff when it is no longer appropriate.]

Wertheimer, M. (1959). *Productive thinking, enlarged edition.* New York, NY: Harper & Row.
[ ]

Wheeler, M. (1987) Children's understanding of zero and infinity. *The Arithmetic Teacher, 35(3)*, 42–44.
[Certainly the concepts of zero and infinity are critical to the concept of limit and geometric interpretations of mathematical symbols. Wheeler reviews research and raises some important issues about potential difficulties with geometric representations, decimal representations, *etc.* Wheeler observes that " . . .children show considerable inderstanding about infinity—a topic not in the mainstream of the elementary school mathematics curriculum. They also show considerable misunderstanding about zero—a topic that is in the mainstream . . ." and calls for needed growth in children's understandings of zero and infinity.]

Wickelgren, W. (1974). *How to solve problems*. San Francisco, CA: Freeman.
[ ]

Wileman, S., Stephens, Larry, and Konvalina, J. (1982). The relationship between mathematical competencies and computer science aptitude and achievement. *Journal of Computers in Mathematics and Science Teaching*, 2, 20–21.
[A strong relationship was found between mathematical competencies and probable success in beginning computer science courses. (college)]

Wilf, H. (1982). The disk with a college education. *The American Mathematical Monthly*, *89*, 4-8.
[Raises issue of role of muMath in college mathematics.]

Wilson, J., & Albers, D. (1988). Calculus for physical sciences. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 59–62). Washington, DC: Mathematical Association of America.

[all participants except high school teachers supported elimination of ε–δ proofs, reduce derivative computations, concept building fundamental, graphics calculators significantly change what should be taught. (I'd challange removal of proofs because of machines. Machines make proofs more important, not less.)]

Wilson, P. (1984). The role of computer programming in the development of mathematical concepts. Proceedings of the Sixth Annual Meeting of PME-NA (Ed. Moser, J). Madison, Wisconsin: PME.
[Explored varaible and iteration with Logo in grades 4-6. Mathematics correlated, partial understanding of variable, good understanding of iteration.]

Wilson, P. (1985). *Continued research in geometric concept learning*. Ohio State University.
[Computer allows dynamic visual images, interaction, and numerous and diverse examples. Assists concrete-abstract transition. Observations: rich learning environment is not enough, visual impact is important, quality of interaction with computer is critical.]

Wilson, P. (1986). Feature frequency and the use of negative instances in a geometric task. *Journal for Research in Mathematics Education, 17*, 130-139.
[Frequency of irrelevant features and nonexamples are important variables in mathematical concept learning.]

Wilson, R. (1979). *Much ado about calculus*. New York: Springer Verlag.
[Preface discusses role of computers in the study of mathematics and suggests roles.]

Winkler, J., Stasz, C. & Shavelson, R. (1986). *Administrative policies for increasing the use of microcomputers in instruction* (Report R-3409-NIE, Prepared for the National Institute of Education). Santa Monica, CA: Rand Corporation.
[Survey identifying correlates of microcomputer use suggest: schools should continue to acquire computers and software, provide centralized, routine assistance in integrating computers into instruction, provide district inservice training, and compensate computer-using teachers.]

Winter, M. (1985). Using computers with undergraduate mathematics students in college algebra, elementary calculus, and teacher-training courses. In Commission Internationale de L'Enseignement Mathematique, *The Influence of Computers and Informatics on Mathematics and Its Teaching*, (Strasbourg, 23-30 Mar 85), 127-128.
[graphics and programming to support concept learning.]

Wittrock, M. (1974). Generative model of mathematics learning. *Journal for Research in Mathematics Education, 5*, 181–196.
[Requiring reorganization of randomly generated conceptual maps seems to teach significant mathematics.]

Wittrock, M. (April, 1985). *Cognitive processes in the learning and teaching of science*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, Il.
[Cognitive processes of attention, motivation, and comprehension or knowledge acquisition are important for learning science, mathematics, and reading. Study teachers' and learners' models of comprehension and knowledge acquisition. "Teaching involves knowing the learners' *models, strategies*, and *zeitgeists* and leading students to revise them and to *generate an understanding* of science that more closely represents scientific *reality* [emphasis added.]."]

Wolfram, S. (1984). Computer software in science and mathematics. *Scientific American, 251*, 188-203.
[Illustrates many of the tool uses of the computer in mathematics and science.]

Wos, L. (1985). Automated reasoning. *The American Mathematical Monthly, 92*, 85–92.
[Automated reasoning programs can be a powerful tool for mathematicians doing mathematics.]

Yost, P., Siegel, A. & Andrews, J. (1962). Non–verbal probability judgements by young children. *Child Development, 33*, 769–780.
[ ]

Young, G. (1988). Present problems and future prospects. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 172–175). Washington, DC: Mathematical Association of America.
["I am one of the people who believe that the computer will revolutionize our subject as greatly as did Arabic numerals, the invention of algebra, and the invention of calculus itself." (p. 173).]

Young, R. (1981). The machine inside the machine: Users' models of pocket calculators. *International Journal of Man–Machine Studies, 15*, 51–85.
[ ]

Zammarelli, J. and Bolton, N. (1977). The effects of play on mathematical concept formation. *British Journal of Educational Psychology, 47*, 155–161.
[The pay group made significantly higher scores than a group observing the play group or a control group. (ages 10-12)]

Zbyszynski, H. (1983). Abstract thought as a component of computer programming. (Boston University School of Education, 1983). *Disseration Abstracts International, 44A*, 1366.
[Found correlation between heuristics and programming. (college)]

Zielke, D. (1983). Solving linear equations on a microcomputer: Thought processes, errors, and guidance. (The University of Texas at Austin, 1982). *Disseration Abstracts International, 44A*, 3835.
[Different ability levels, use of different methods, and instruction with different levels of guidance resulted in use of different thought processes, different errors, and different requirements for guidance. (college)]

Zimmerman, B. and Rosenthal, T. (1972). Observation, repetition, and ethnic background in concept attainment and generalization. *Child Development, 43*, 605–613.
[Both "modeling" (rule giving) and repetition improved performance on a form-selection task in which mathematical terms were (incidentally) used. Anglo-American children outperformed Mexican-American children. (grade 5]

Zorn, P., & Viktora, S. (1988). Computer algebra systems: Second discussion session. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 79–81). Washington, DC: Mathematical Association of America.
["Surprisingly large number" use computers in calculus. Main themes: define goals of calculus, CAS interaction with calculus (how will drive or be driven?), need new materials, calculus must become more conceptual.]

Zorn, P. (1988). Computing in undergraduate mathematics. In L. Steen (Ed.), *Calculus for a new century: A pump, not a filter* (pp. 233–239). Washington, DC: Mathematical Association of America.
[Zorn's list of benefits and opportunities: "1. To make undergraduate mathematics more like "real" mathematics. 2. To illustrate mathematical ideas. 3. To help students work examples. 4. To study, not just perform, algorithms. 5. To support more varied, realistic, and illuminating applications. 6. To exploit and improve geometric intuition. 7. To encourage mathematical experiments. 8. To facilitate statistical analysis and enrich probabilistic intuition. 9. To teach approximation. 10. To prepare students to computer effectively—but skeptically—in careers. 11. To show the mathematical significance of the computer revolution. 12. To make higher-level mathematics accessible to students." (pp. 235–237). Questions posed: "2. How should analytic and numerical viewpoints be balanced? 3. How does computing change what students should know? 9. Will computing help students learn mathematical ideas more deeply, more easily, and more quickly?"]