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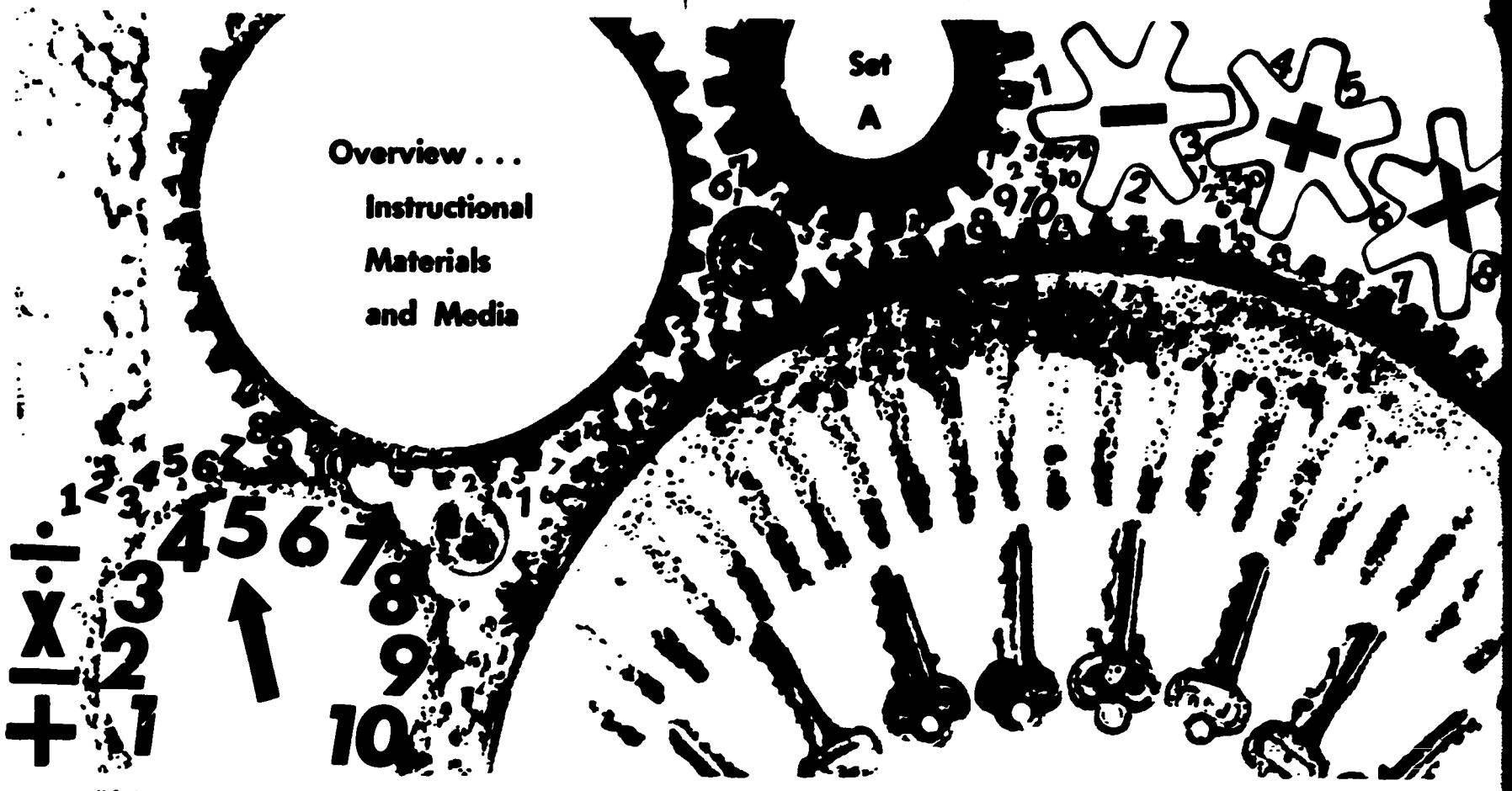
ABSTRACT

This bulletin provides a review of research studies which relate to the uses of instructional materials and media in elementary school mathematics. The studies cited pertain to the following questions: (1) What may we learn from analyses of mathematics textbooks? (2) Does programmed instruction facilitate achievement? (3) What other factors have been investigated with programmed instruction? (4) What types of manipulative materials have been found to be effective? (5) How should materials be used? (6) Is teaching by television effective? (7) How are computers aiding in the instructional process? (FL)






Using Research: A Key to Elementary School Mathematics



## INSTRUCTIONAL MATERIALS AND MEDIA

**What may we learn from analyses of mathematics textbooks?**

Textbooks have been analyzed from several points of view. Some analyses provide historical perspectives. Others present information on content included in many texts for children and for teachers. Manuals for teachers have also been analyzed in terms of content, objectives, and uses.

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**Does programmed instruction facilitate achievement?**

Research on programmed instruction has shown that it can be used in upper grades to present many topics usually taught at a grade level, as well as topics which are commonly presented at a later grade level. Achievement is usually at least as good as that attained with conventional instruction, but less time is generally required, on the average, when programmed instruction is used. Programmed materials appear to be an effective supplement to the work of the teacher.

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**What other factors have been investigated with programmed instruction?**

Among the other factors which have been investigated with programmed instruction are the effect of various methods of teaching and learning, the effect of materials on pupils with different characteristics, and the amount of time which a teacher spends with individuals when using programmed instruction. When it was used to control the method of presentation, some form of a "guided discovery" approach generally resulted in higher achievement than did teaching by presenting rules. Programmed instruction appeared to be effective for some learners "ordinarily considered less well-adjusted." It has also been found that you may spend a

much greater proportion of your time giving individuals help than you can with convention .l instruction; use of programmed materials apparently both frees the time and encourages use of it for individual instruction.

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**What types of manipulative materials have been found to be effective?**

While many types of materials have been studied and found to be effective, it appears that: (1) the learning of mathematics depends more on the teacher than on the materials used, and (2) expensive materials are no better than inexpensive ones developed or provided by the teacher. Use of a variety of materials has not been found to be more effective than use of only one.

Much research has focused on the use of the Cuisenaire materials and program. Especially at the primary level, pupils apparently learn traditional subject matter at least as well as in a conventional program. They also learn some additional concepts and skills. By third grade, however, the effect of earlier teaching of some concepts is less apparent.

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**How should materials be used?**

Strangely, manipulation appears to be less important than we commonly believe. Having pupils manipulate materials themselves has not been found to be more effective than having pupils merely watch the teacher handle them.

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**Is teaching by television effective?**

Television can be used to present key lessons in mathematics, with the teacher using it as an integral part of the program.

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**How are computers aiding in the instructional process?**

Computer-assisted instruction is being explored. Both tutorial programs, in which the computer presents a lesson, and drill-and-practice programs are being used, with promising achievement results.

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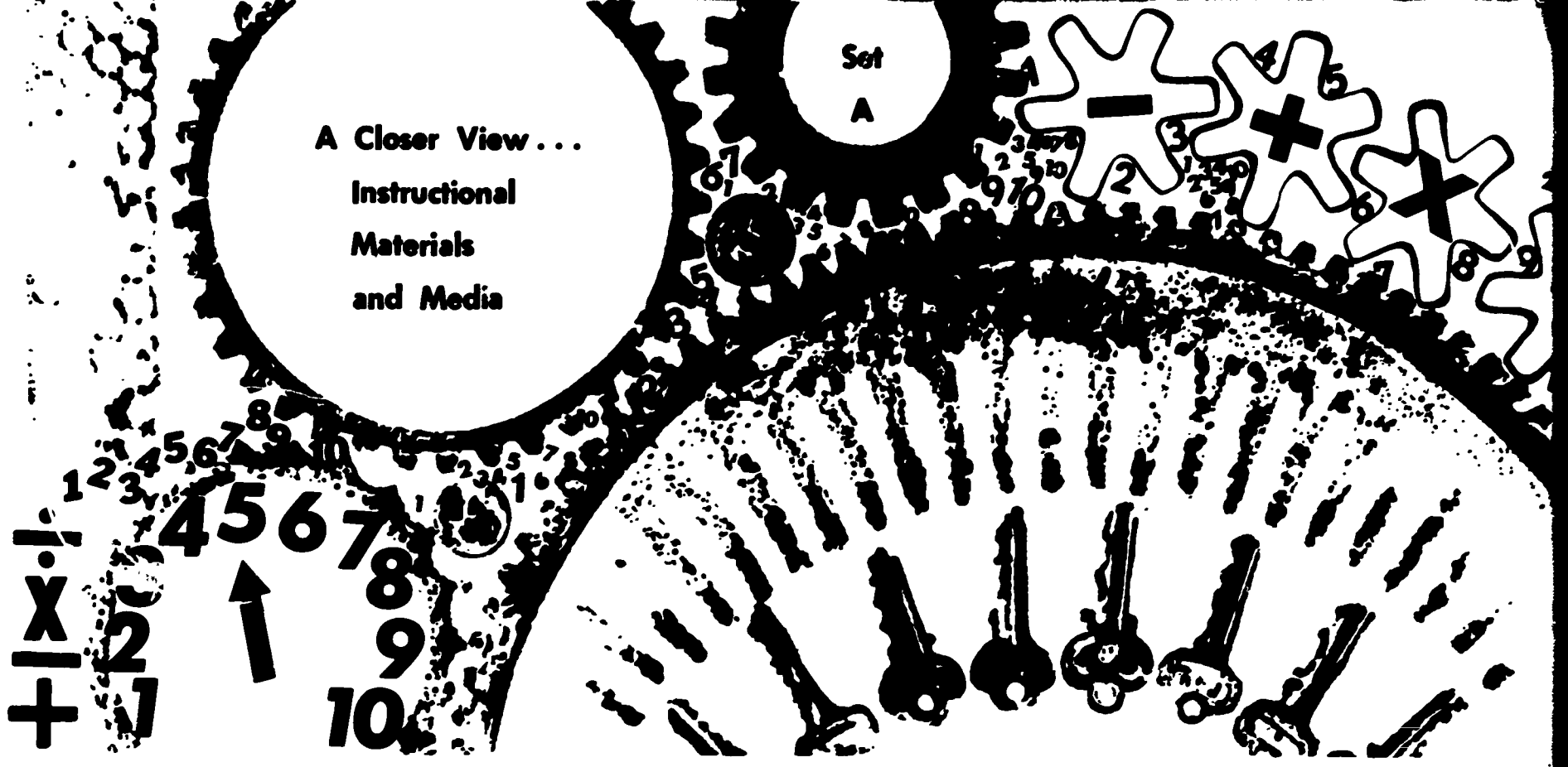
If you would like more information about the research whose findings are cited above, contact MARILYN N. SUYDAM, Project Director, at The Pennsylvania State University, University Park, Pennsylvania, 16802.






## INSTRUCTIONAL MATERIALS AND MEDIA

**What may we learn from analyses of mathematics textbooks?**

Elementary mathematics textbooks have been analyzed for different purposes and from different bases. One of the most comprehensive analyses is that by Smith and Eaton (1942-43), which includes approximately 200 books used in this country between 1790 and 1940. Their purpose was to study "the basic characteristics and trends of textbooks of the past." Analysis was in terms of the social and economic life of the period, relative emphasis on various aspects of content, the psychological approach, purpose, and scope.

Dooley (1960) studied 153 series of elementary school mathematics textbooks published in the U.S. between 1900 and 1957, attempting to ascertain the effect of research on the content and methods suggested in textbooks. She found that when recommendations were "clear, concise and exact," they were incorporated into many textbooks within five years.

Burns (1960) analyzed ten textbook series and accompanying workbooks and teacher's manuals. He presented specific information

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The bulletin was prepared by MARILYN N. SUYDAM, The Pennsylvania State University, Project Director, and J. FRED WEAVER, The University of Wisconsin-Madison, Project Consultant. Art by Ed Saffell.

It should be noted that research is variable with respect to its quality; hence, the same degree of confidence cannot be placed in all findings. An attempt has been made to take this fact into consideration in preparing this bulletin.

on the similar content included at each grade level, physical features, and points of emphasis. Folsom (1960) concentrated on manuals, using observations of classroom practice to determine how consistently teachers used suggestions about procedures, enrichment activities, and materials.

Hicks (1968) compared 16 textbooks for teacher education with texts for children, to ascertain the similarities and differences in inclusion of content topics. Marksberry, McCarter, and Noyce (1969) compared cognitive objectives in textbooks with those from research committees and with questions and activities suggested in teacher's manuals.

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**Does programmed instruction facilitate achievement?**

Programmed instruction materials allow each pupil to progress at his own rate. Some studies ascertained the feasibility of using programmed instruction to teach specific content. For instance, Kalin (1962) compared pupils in grades 4, 5, and 6 having IQ's greater than 115 using a programmed text or taught by regular teaching procedures for a two-week unit in equations and inequalities. Differences in achievement were not significant, but 20% less time was spent by those using the program. The idea that the use of programmed materials may result in a decrease in the time which most students must spend on a topic was substantiated in many other studies.

Fincher and Fillmer (1965) reported that fifth graders who used programmed materials on addition and subtraction with fractions achieved significantly greater gains on achievement posttests than pupils using a conventional classroom approach, while retention scores were not significantly different.

In a comparison of a year's program, Banghart and others (1963) found that fourth graders using programmed materials scored significantly higher on comprehension but not on problem solving sections of a standardized test than those receiving regular instruction. They noted that "programmed materials are most effective when used to supplement the classroom teacher."

**What other factors have been investigated with programmed instruction?**

Neuhouser (1965) found that for eighth graders, programmed materials on exponents were more effective on measures of understanding, ability to transfer, and retention when there was no verbalization of rules, while the program in which pupils were guided to state rules after discovery took longer. The program in which rules were stated for pupils was poorest.

It was reported by Traweek (1964) that fourth graders with poorer personality adjustment scores achieved beyond their expected performance on programmed units on fractions. There were no significant differences in the IQ's of successful and unsuccessful learners.

Teachers using programmed instruction materials devoted 68% of their time to work with individuals, while teachers of conventional classes devoted only 3% of their time to individuals (Goebel, 1966).

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What types of manipulative materials have been found to be effective?

Lerch and Mangrum (1965) compiled a list of instructional aids most frequently recommended by the teachers' manuals of nine fourth grade textbooks. Items to be counted, grouped, or described; pocket charts; and number lines were among the aids mentioned most frequently.

Earhart (1964) used an abacus to teach first, second, and third graders whose teachers received in-service help, while other groups received instruction without use of an abacus. On tests of reasoning there were no significant differences, while on tests of fundamentals the group using the abacus performed significantly better. It is difficult to tell whether the abacus or the in-service help was the basis for this difference, however.

Lucas (1967) studied the use of attribute blocks (which are varied in shape, color, and size) in first grade. He found that children trained for 2,000 minutes showed greater ability (1) to conserve cardinally and (2) to conceptualize addition-subtraction relations, than those taught more conventionally in a "modern" program.

Harshman, Wells, and Payne (1962) reported on a study of first graders who were taught for one year by programs with varying content based on either (1) a collection of inexpensive, commercial materials, (2) a commercial set of expensive materials, or (3) materials provided by the teacher. Teachers in the first two instances received in-service training. When significant differences in achievement were observed, they were always in favor of the third program. It was concluded that (1) high expenditure for manipulative materials does not seem justified, and (2) perhaps different materials should be used with different IQ groups.

Much research has been focused on the use of the Cuisenaire materials and program, in attempts to answer the question, "How effective is it?" Crowder (1966) reported that a group of first graders using the Cuisenaire program (1) learned more conventional subject matter and more mathematical concepts and skills than pupils taught by a conventional program; (2) average and above average pupils profited most from the Cuisenaire program; and (3) sex was not a significant factor in relation to achievement, while socioeconomic status was.

Working with first and second graders, Hollis (1965) compared the use of a Cuisenaire program with a conventional approach. He concluded that (1) children learned traditional subject matter with the Cuisenaire program as well as they did with the conventional method, and (2) pupils taught by the Cuisenaire program acquired additional concepts and skills beyond the ones taught in the conventional program.

Brownell (1968) used tests and extensive interviews in an analysis of the effect on underlying thought processes of three mathematics programs, with British children who had studied those programs for three years. He concluded that (1) in Scotland, the Cuisenaire program was in general much more

effective than the conventional program in developing meaningful mathematical abstractions; and (2) in England, the conventional program had the highest over-all ranking for effectiveness in promoting conceptual maturity, with the Dienes and the Cuisenaire programs ranked about equal to each other. Brownell inferred that the quality of teaching was decisive in determining the relative effectiveness of the programs.

Other studies have been concerned with the effect of use of the Cuisenaire program on a particular topic, for shorter periods of time. Lucow (1964) and Haynes (1964) studied use of the program to teach multiplication and division concepts for six weeks in third grade. Lucow attempted to control the effect of prior work in grades 1 and 2. He concluded that the Cuisenaire method was as effective as regular instruction in general, and seemed to operate better in a rural setting, especially with high and middle IQ levels, than in an urban setting. Haynes used pupils who were unfamiliar with the materials; no significant differences in achievement were found between pupils who used the Cuisenaire program and those who did not.

Prior background, length of time, and the specific topic may account for differences in the success of the Cuisenaire program. It has been suggested that it might be more effective in grades 1 and 2, with its effectiveness dissipating during third grade. No body of reported research is available about its effects beyond the third grade level.

Sole (1957) concluded that (1) use of a variety of materials did not "produce better results" than use of only one material, and (2) the learning of mathematics depends more on the teacher than on the materials used.

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**How should manipulative materials be used?**

It may be that having pupils manipulate materials themselves may not be more effective than merely watching the teacher or having no material aid. Jamison (1964) compared instruction in counting in other numeration systems using (1) a large variable-base abacus, (2) a large abacus plus a small abacus for each pupil, and (3) only the chalkboard. There were no significant differences between mean gains.

Toney (1968) also found that a fourth grade group using individually manipulated materials for half a year was not significantly different in achievement from one seeing only a teacher demonstration. And Trueblood (1968) reported no achievement advantage for fourth graders who manipulated materials themselves during a unit on exponents and non-decimal bases.

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**Is teaching by television effective?**

Jacobs and Bollenbacher (1960) reported that after a year of instruction in grade 7 by television or by conventional instruction, significant interaction effects were noted between levels of pupil ability and methods of instruction. Conventional instruction appeared better for those of high ability, the

television method was better at the average ability level, and no significant difference occurred at the below average ability level.

"Patterns in Arithmetic" is a program for grades 1 through 6 which incorporates television instruction. Weaver (1965) summarized a report by Hartung and Suchy on the project at an early stage of its development, noting that there were no significant differences on standardized tests between groups taught by the PIA program or by conventional instruction at the end of the sixth grade after three years of instruction.

Van Engen and Parr (1969) reported that an evaluation of the program in grades 1 and 3 showed that, on both standardized computational and concepts tests, performance of the PIA group "compared favorably" with the norm groups. Attitude of both teachers and pupils toward PIA was also favorable; this has been substantiated by other studies.

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**How are computers aiding in the instructional process?**

Computer-assisted instruction is presently being used in some elementary school mathematics classes. Suppes (1969) has reported extensively on the use of both tutorial and drill-and-practice programs. He found that the drill-and-practice materials result in at least equivalent achievement in less time than it would take the classroom teacher using only conventional methods. The computer also readily collects data on how children are responding, thus facilitating diagnosis of their difficulties as well as increasing our knowledge of how they learn.

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## List of Selected References


Banghart, Frank W.; McLaulin, John C.; Wesson, James B.; and Pikaart, Leonard. An Experimental Study of Programmed Versus Traditional Elementary School Mathematics. Arithmetic Teacher 10: 199-204; April 1963.

Brownell, William A. Conceptual Maturity in Arithmetic Under Differing Systems of Instruction. Elementary School Journal 69: 151-163; December 1968.

Burns, Paul C. Arithmetic Books for Elementary Schools. Arithmetic Teacher 7: 147-149; March 1960.

Crowder, Alex Belcher, Jr. A Comparative Study of Two Methods of Teaching Arithmetic in the First Grade. (North Texas State University, 1965.) Dissertation Abstracts 26: 3778; January 1966.

Dooley, (Mother) M. Constance. The Relationship Between Arithmetic Research and the Content of Arithmetic Textbooks (1900-1957). Arithmetic Teacher 7: 178-183, 188; April 1960.

Earhart, Eileen. Evaluating Certain Aspects of a New Approach to Mathematics in the Primary Grades. School Science and Mathematics 64: 715-720; November 1964.

Fincher, Glen E. and Fillmer, H. T. Programed Instruction in Elementary Arithmetic. Arithmetic Teacher 12: 19-23; January 1965.

Folsom, Mary. Teachers Look at Arithmetic Manuals. Arithmetic Teacher 7: 13-18; January 1960.

Goebel, Laurence Gayheart. An Analysis of Teacher-Pupil Interaction When Programed Instructional Materials Are Used. (University of Maryland, 1966.) Dissertation Abstracts 27A: 982; October 1966.

Harshman, Hardwick W.; Wells, David W.; and Payne, Joseph N. Manipulative Materials and Arithmetic Achievement in Grade 1. Arithmetic Teacher 9: 188-191; April 1962.

Haynes, Jerry Oscar. Cuisenaire Rods and the Teaching of Multiplication to Third-Grade Children. (Florida State University, 1963.) Dissertation Abstracts 24: 4545; May 1964.

Hicks, Randall C. Elementary Series and Texts for Teachers - How Well Do They Agree? Arithmetic Teacher 15: 266-270; March 1968.

Hollis, Loye Y. A Study to Compare the Effect of Teaching First and Second Grade Mathematics by the Cuisenaire-Gattegno Method with a Traditional Method. School Science and Mathematics 65: 683-687; November 1965.

Jacobs, James N. and Bollenbacher, Joan. Teaching Seventh Grade Mathematics by Television. Mathematics Teacher 53: 543-547; November 1960.

Jamison, King W. An Experiment with a Variable Base Abacus. Arithmetic Teacher 11: 81-84; February 1964.

Kalin, Robert. The Use of Programed Instruction in Teaching an Advanced Mathematical Topic. Arithmetic Teacher 9: 160-161; March 1962.

Lerch, Harold H. and Mangrum, Charles T., II. Instructional Aids Suggested by Textbook Series. Arithmetic Teacher 12: 543-546; November 1965.

Lucas, James Stanley. The Effect of Attribute-Block Training on Children's Development of Arithmetic Concepts. (University of California, Berkeley, 1966.) Dissertation Abstracts 27A: 2400-2401; February 1967.

Lucow, William H. An Experiment with the Cuisenaire Method in Grade Three. American Educational Research Journal 1: 159-167; May 1964.

Marksberry, Mary Lee; McCarter, Mayme; and Noyce, Ruth. Relation Between Cognitive Objectives From Selected Texts and From Recommendations of National Committees. Journal of Educational Research 62: 422-430; May/June 1969.

Neuhouser, David Lee. A Comparison of Three Methods of Teaching a Programmed Unit on Exponents to Eighth Grade Students. (The Florida State University, 1964.) Dissertation Abstracts 25: 5027; March 1965.

Smith, Henry Lester and Eaton, Merrill Thomas. An Analysis of Arithmetic Textbooks (1790 to 1940). Indiana University School of Education Bulletin 18: 1-52, January 1942; 18: 1-108, November 1942; 19: 1-58, July 1943; 19: 1-41, November 1943.

Sole, David. The Use of Materials in the Teaching of Arithmetic. (Columbia University, 1957.) Dissertation Abstracts 17: 1517-1518; July 1957.

Suppes, Patrick and Morningstar, Mona. Computer-Assisted Instruction: The 1966-67 Stanford Arithmetic Program. New York: Academic Press, 1969.

Toney, Jo Anne Staley. The Effectiveness of Individual Manipulation of Instructional Materials as Compared to a Teacher Demonstration in Developing Understanding in Mathematics. (Indiana University, 1968.) Dissertation Abstracts 29A: 1831-1832; December 1968.

Traweek, Melvin W. The Relationship Between Certain Personality Variables and Achievement Through Programmed Instruction. California Journal of Educational Research 15: 215-220; November 1964.

Trueblood, Cecil Ross. A Comparison of Two Techniques for Using Visual-Tactual Devices to Teach Exponents and Non-Decimal Bases in Elementary School Mathematics. (The Pennsylvania State University, 1967.) Dissertation Abstracts 29A: 190-191; July 1968.

Van Engen, Henry and Parr, Robert B. Using Mass Communication Media To Improve Arithmetic Instruction. Audiovisual Instruction 14: 34-36, 38; February 1969.

Weaver, J. Fred. Patterns in Arithmetic: A Three-Year Report. Arithmetic Teacher 12: 291-293; April 1965.

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