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ABSTRACT

This bulletin serves as a guide to those persons interested in conducting or implementing educational research. Research is described as being "controlled inquiry", either in the form of an experiment or a survey. Descriptions are given of the procedures and complications associated with planning and initiating experimental research. A suggested routine would involve: (1) identification of the variables, (2) control of the relevant variables, (3) selection of an appropriate measuring instrument, (4) verification of the sample appropriateness, (5) a pilot study (if possible), and (6) dissemination of the findings. (RS)

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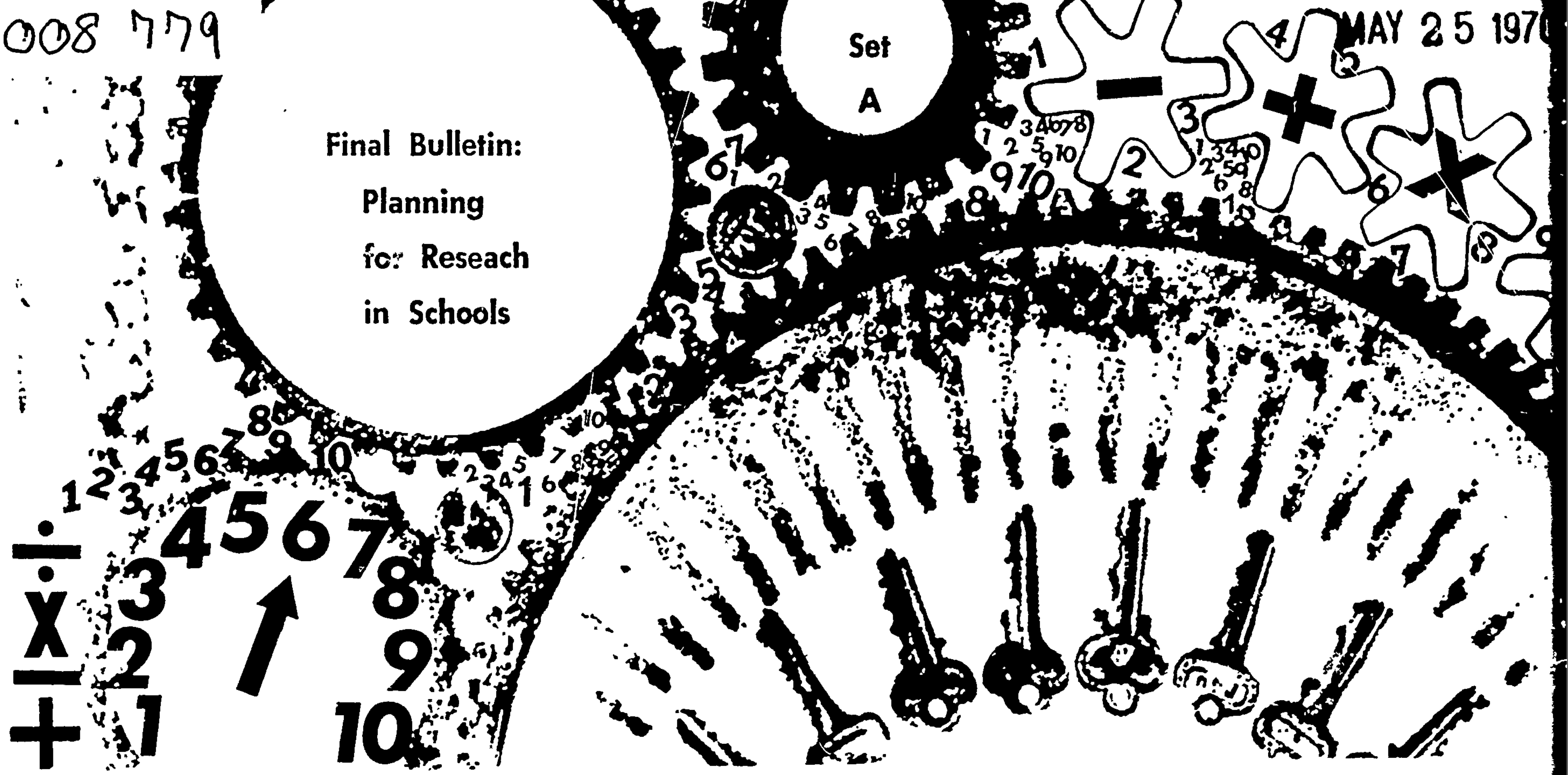

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Using Research: A Key to Elementary School Mathematics

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PLANNING FOR RESEARCH IN SCHOOLS

WHAT IS RESEARCH?

Research is controlled inquiry.

In these bulletins, we discuss research on the elementary school mathematics curriculum and research on the teaching and learning of mathematics. The vast majority of this research is product-oriented; there is, however, other research which is theory-oriented. The task of building a theory of the learning of mathematics concepts still lies before us, as Begle (1968) and Glennon (1966) noted.

Many of the studies we have cited have involved either experimental or survey research. By experimental we mean research in which the investigator has "manipulated" one or more specified variables, such as two methods of teaching, to measure their effect on another variable, such as achievement or attitude, thus testing a carefully formulated hypothesis or hypotheses. The variables which are manipulated are termed "independent," while those affected and measured are "dependent" variables. Experimental research is very difficult to conduct, because of the need to control the independent variable(s) and many other variables--which must be controlled since we want to interpret the results and generalize beyond the sample in the study. By survey we mean research which attempts to ascertain the characteristics of a population by studying a sample which answers a questionnaire or interview or test.

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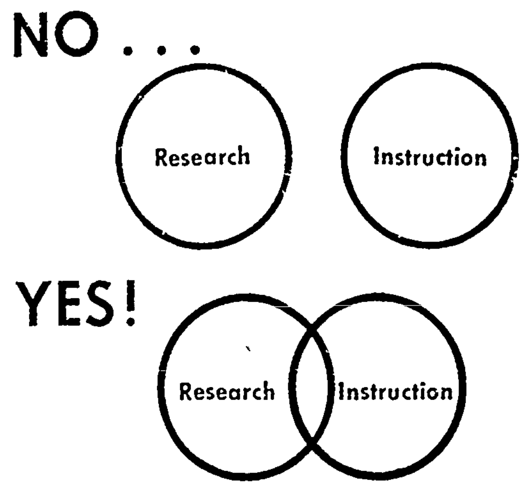
As we continue to discuss "research" in this bulletin, the focus is on experimental research. You should recognize, however, that certain of the things discussed are also applicable to other types of research. We should caution that, despite this focus on experimental studies, we are not thus implicitly stating that such investigations are the only ones which qualify as "true research." Other types of studies also contribute to the improvement of mathematics education.

Research is not independent of instruction. It is derived from and is applied to instruction. Actually, every teacher does a type of "action research" every day--whenever new ideas are tried out. You're constantly trying to find the methods and materials and procedures which will work best for you. You're assessing what pupils have learned, and using what you find out as you plan what to do next. You're concerned with what will help you teach better, or help your pupils learn better. You've been using evaluation, and for some purposes--such as curriculum development --evaluation is vital.



For other purposes, however, research is essential. Research involves more precise controls. In experimental research, we are attempting to secure information which can be generalized to many other teachers and to many different situations. In survey research, we also maintain greater controls than in usual classroom testing--we want a more precise measurement of the status or level of learning.

WHY? Research can provide a foundation on which to make curricular decisions and decisions about how to teach. Nothing has ever been proven by educational research--but it has provided guidelines to aid us in making decisions. It should be noted, however, that not all problems are amenable to research--some decisions must be made on the basis of your philosophy. For instance, research can provide an answer to "Can we teach logic to fourth graders?" but it cannot provide an answer to "Should we teach logic to fourth graders?"

Research has a valid role to play in assessing and improving the quality of instruction. In fact, merely being involved in research helps us to achieve this latter goal. As Pikaart and Berryman (1965) note, "Participating in research and contributing significant ideas was in itself motivating, and it contributed to self-esteem."

Local school systems may at times need to engage in their own research for other reasons. For instance, generalized findings may not be applicable when unique characteristics of the system are considered (e.g., ability level of the pupils).

HOW? First of all, select a question which is important to answer. Then design the study: lay out an overall plan, delimiting the problem to make it researchable. This may be a long-term plan, but don't try to investigate everything at once: order your priorities logically.

You will need to identify and define or describe (1) the independent variable or variables and (2) the dependent variable or variables. You must also identify and control other relevant variables. Suydam (1967) reported that control of variables was one of the two most poorly handled facets of mathematics research studies (sampling was the other one). As Johnson (1966) noted, certain assumptions are made regarding what variables may affect the situation. During an experiment, the groups involved should have common experiences except for the treatment (independent) variables. Then significant differences at the end of the experiment can be attributed to the treatment. Johnson presents an example of an experiment in which many factors are controlled; Wilson (1967) and Worthen (1968) provide other excellent examples of research in which variables are well-controlled.

Some pupil variables may be controlled in one of several ways (Riedesel and Sparks, 1968; Kerlinger, 1964): (1) eliminate the variable as a variable, by studying only a specified subset of the sample; (2) use the statistical procedure of analysis of covariance (but be careful not to "wash out" true differences, as may happen when you apply covariance to a factor of concern); (3) incorporate the factor as another independent variable; (4) match pupil for pupil (this may be difficult, depending on the number of factors on which pupils should be matched); (5) equate on the basis of group means. Or, you can use randomization, where you assume, since pupils are selected by chance, that variables are randomly distributed.

DeVault (1966) and Romberg and DeVault (1967) emphasize our need for realistic research that takes into account the complexity of the classroom setting. On the other hand, if you have a grandiose design that tries to take into account many, many factors, the study will become very complicated. Remember that there is a place to look at small (but not trivial) pieces (Van Engen, 1967).

Select or develop appropriate measuring instruments. Remember especially that "global" or standardized tests are not always appropriate. For example, if you're testing the effect of introducing multiplication in two ways, you'll find that a "global" test has a limited number of items which measure multiplication achievement. The study may result in no significant differences when in fact differences were present--but unmeasured. Instead of a "global" test, a test to measure achievement in multiplication must be constructed.

If two different treatments are to be evaluated, the test must be carefully constructed so it doesn't introduce a bias. Some research has been done in which the test contained a large number of items which only the experimental group would be able to answer (e.g., questions related to a story used to introduce the experimental treatment). Thus the findings of the research favor the experimental group--but not because the pupils did significantly better on the factor being studied.

After you've carefully outlined your research procedures, consider: could I replicate this study, that is, do it over again and expect to get the same results? If you can't answer "yes," replan! Then check your plans with someone who knows research--get professional assistance from your research department or from a university or college, whenever this is possible. This step often makes the difference between good research and a meaningless collection of data, between an answer to your question and no answer. This is the time to clarify questions like "What data should be collected?" and "How will the data be analyzed?" The procedures that are contemplated should not be contemplated independently of consideration of the way in which data are to be collected and analyzed. People have been known to collect data and then wander around trying to find a statistic to use. They don't always find one. In fact, one may not even exist!

Research is improved by being tried out first of all with a pilot study--problems are resolved before they affect your major study. For instance, in doing a survey, the questionnaire should be given to a small group before it is used in the study. A test should be administered to a small group, preferably one much like the group who will be involved in the research. You want to be sure each is valid and reliable, that is, that each measures what it's supposed to measure, consistently.

It is wise to consider the timing of research. Usually it's unwise to plan to begin a study on the first day of school. Beware of other things competing--such as a vacation or other projects which claim priority. Length of time should be appropriate to your problem--remember that most studies can't be done in one day. Also remember that the longer the study, the more problems you may have and the more difficult control becomes.

If you have only two classes at a grade level, the temptation is to have one teacher teach one treatment and the other teach the second treatment. Better yet, have both teachers try both--teaching some pupils by one method and some by the other. This eliminates some confounding, since data for each method can be pooled. The teachers must be doubly careful to not let biases interfere--they must do an honest job with each, despite a special preference for one. The way in which a teacher carries out the research plan is one of the most important factors.

Be sure your sample is appropriate for the population to which you want to generalize your results. There are times when it is reasonable to exclude data for a few children who are very different from the rest of the group, since they may bias the research. Better yet, analyze the data for them separately or differentially.

Whenever appropriate to the design, pupils should be randomly selected and assigned to a treatment. "How many children are needed?" cannot be answered in general: there's a number that will give each study sufficient "power." Remember that it may be wasteful of pupil time to use samples larger than necessary. On the other hand, too small a number raises questions about how representative they are, and how far the findings can be generalized.

There are instances in which it is feasible to conduct research only with intact classes. This situation presents certain problems of research design which need to be considered. Campbell and Stanley (1963) provide some help on this type of situation.

There is a time to pretest--when you think that pupils have some knowledge of the subject matter. But in other cases, when you can assume that pupils have no knowledge or equivalent knowledge (e.g., when non-decimal bases are introduced in grade 1), a pretest is not necessary. A pilot study using a pretest will indicate whether or not a pretest is necessary in the final study.

It is desirable for teachers involved to keep logs of what was done day by day, as well as anecdotal records of particular incidents and reactions. Then departures from the planned procedures can be noted; these are sometimes useful in interpreting findings. Also, there is a need for somebody to keep a finger on things as the study progresses, to make sure procedures are being followed.

Reporting and disseminating information about research should be carefully done. <u>It is important that others know what you have done and found</u>. Accuracy in reporting is essential, as well as readability. As Weaver (1967) noted, "We can go a long way toward extending the impact of research if each investigator accepts the obligation to report all significant aspects of this work as fully as is necessary to establish the integrity of his research and of the conclusions drawn." The interpretations must be derived from the data--and remember that there is a difference between findings and implications.

We have frequently cited differences which are "significant" or "statistically significant." By this we mean that there is a specified likelihood that such differences would not have occurred by chance. Usually, the level of significance is set at .05, or .01, or .001--thus the results might occur by chance only 5 times in 100, or only 1 time in 100, or only 1 time in 1000. "No significant differences" means that a specified level of significance was not reached--thus the results could occur more frequently by chance. Researchers set a level which seems appropriate to them in terms of the content and design of their study.

In summary, as you plan <u>how</u> to develop and implement your research, you may find these questions helpful:

(1) Is the problem practically and/or theoretically <u>significant</u>?

(2) Is the problem clearly <u>defined</u>?

(3) Is the <u>design</u> appropriate to answer the research question?

(4) Does the design <u>control</u> variables?

(5) Is the <u>sample</u> properly selected for the design and purpose of the research?

(6) Are the measuring instruments <u>valid</u> and <u>reliable</u>?

(7) Are the techniques of <u>analysis</u> of the data valid?

(8) Are the <u>interpretations</u> and <u>generalizations</u> appropriate to the data?

(9) Is the research adequately <u>reported</u>?

WHAT? We look only at mathematics research in these bulletins. Some findings from mathematics research, especially those cited in Set A, might be considered in regard to other phases of the curriculum--and research from other areas may be applicable to the teaching and learning of mathematics. One caution is necessary: don't take findings from one field and assume automatically that they are true for mathematics, or any other. It is important to recognize that conceptual learning is particularly important in mathematics. Mathematics may differ from other areas because there is a body of content (unlike language arts, but like science), which also is sequential; therefore there may be different problems for mathematics than for other areas.

Schools probably do not need to do research on those things on which there is "sound" research evidence already (for instance, on the benefits to be derived from meaningful instruction). There are large variations, however--what may be true in general for large groups may not be true for particular, unique groups. What may be true for one topic may not be true for another.

Teachers should test research findings in their own classrooms (Riedesel, 1968). Remember that just because research says that something was best for a group of teachers in a variety of classrooms, doesn't necessarily mean that it would be best for you as an individual teacher in your particular classroom. For instance, we're beginning to get evidence that there is an interaction between teaching and method. Thus research may show that an inductive approach is "good,"--yet some teachers may not be comfortable with it or can't manage it. An expository approach may be better for those teachers. Teachers have individual differences as well as pupils! In this same way, remember that learning modes of pupils differ, and that not all content lends itself to use of inductive strategies.

Teachers must be careful not to let prior judgments influence their willingness to try out and explore: open-mindedness is important in research. Be willing to investigate. But being open-minded doesn't mean you don't have beliefs about things--just that you don't let beliefs bias the conduct of research.

Often research may be generated by informal exploration that teachers make, which in itself is not research. Do this--but don't call it research; use it to generate hypotheses which can then be tested with research.

AND THEN . . . Research is not an end in itself--it should lead to some kind of action. You decide to change, or not to change; you will accept something, you will reject something. It may lead to other research. Do something as a result of research: incorporate the conclusions of research into your daily teaching.

Non-significant differences can be as important as significant differences--don't be disappointed or think automatically that research has "failed" when no significant differences result. There might in fact be no differences--and the decision is up to you!

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In this bulletin, we have been able to give only a glimpse of some of the things which need to be considered as schools conduct research. You may wish to look further into the design and implementation of research as you plan for your own investigations.

Good luck!

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