Teacher as Researcher:
Experimental Designs for Determining the Effectiveness of Technology in Education

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Third in a series of articles on work conducted at the Texas Center for Educational Technology and the University of North Texas, sponsored in part by WICAT and Jostens Learning.

Educators in our schools today are continually being asked to justify the "high cost" of equipment and software. Teachers should, in fact, expect to supply something more than "divining the truth" when asked for evidence that technology is useful in education. This article discusses research designs teachers might use to determine whether or not technology is having the positive impact they desire in their classrooms.

Research and the Scientific Method

Research is a process that asks specific questions about a given situation, tests those questions and, in the end, accurately describes what occurs. The scientific method is widely accepted as the preferred method of conducting research in social sciences such as education. Using science as a way of knowing involves three major steps: 1) the formation of theories, 2) the deduction of consequences, and 3) the verification of predictions (Kemeny, 1959, p. 247). This process is familiar to psychological researchers as hypothesis formulation, followed by a controlled experiment where a single variable is manipulated in order to attempt to confirm the hypothesis.

Problems often arise when one attempts to apply this straightforward approach in a computer laboratory or classroom, however, because such environments are "... complex, often nested conglomerates of interdependent variables, events, perceptions, attitudes, expectations, and behaviors, and thus their study cannot be approached in the same way that the study of single events and single variables can (Solomon, 1991, p.11)." One often needs to study how a certain innovation such as computer technology operates within the complex educational environment as a total system, as well as viewing the effect of a specific variable (e.g., time on task) when all other factors are controlled.

Another factor making it difficult to apply the scientific method to the effectiveness of technology in education is the scarcity of applicable theories from which to derive predictions. The use of information technology in education is relatively new. Teachers and researchers alike will find little in the works of Bruner or Piaget or Skinner that postulates precisely what effect computer use will have in a specific classroom situation. Thus teachers as researchers will often find themselves in the position of being "theory builders" as well as "theoryappers" and "theory testers."

Qualitative vs. Quantitative Research

Understanding the difference between qualitative and quantitative research can help teachers distinguish between their roles as theory builders and theory testers. Qualitative research (theory building) often begins with a question such as, "I wonder if computer use helps my students learn?," then proceeds with systematic observation to gather evidence, then advances toward an explanation, which may lead to a theory (Schumacker, 1990). Checklists, open-ended questions, and videotapes are often used as tools in qualitative research.

Quantitative research (theory testing) begins with a theory that the researcher uses to formulate a hypothesis, then the researcher designs and conducts an experiment to test the hypothesis. Confirmation of the hypothesis strengthens the theory. Failure to confirm the hypothesis may encourage the researcher to conduct additional qualitative research in order to refine the theory and/or hypothesis. then design a new experiment and test it.

Figure 1 provides a three-dimensional model to help narrow the focus of a research question. Along one face of the cube is the type of research to be conducted (i.e., qualitative or quantitative). Either of these is appropriate for the cognitive, affective, or psychomotor domain of behavior, which form the second dimension of the cube. Technology can be applied to many content areas, so these areas (math, science, language arts, etc.) form the third dimension of the cube. Any research question should fit within one or more of the boxes in this cube. Any conclusions drawn from the results of the research should also be restricted to the box in which they fit. For example, the question, "How will extensive keyboard use over many years effect hand and wrist movement?" might be attacked as a qualitative research question in the psychomotor domain, relevant to any content area involving extensive computer use. The question, "Does computer programming improve mathematical analysis skills?" could be addressed as a quantitative research question in the cognitive domain, relevant to the area of mathematics.

![Figure 1. Framework for Research Designs.](image-url)
Experimental Designs

Once an area of focus has been established, the researcher is faced with selecting an appropriate experimental design. A researcher often must choose from one of three alternative designs: (1) Correlational, (2) Quasi-Experimental, or (3) Experimental.

Correlational research is generally used to describe an educational environment, while experimental designs attempt to show the result an independent variable has on a dependent variable. Qualitative research often uses correlational design, while quantitative research is more often experimental. Correlational research design has no control group, while quasi-experimental and experimental generally do. The difference between quasi- and true experimental design is that the latter has each subject randomly assigned to a group. Since this randomization is often difficult or impossible to attain in a classroom environment, most classroom research is quasi-experimental.

Survey research is often associated with correlational studies. Here the researcher sends questionnaires out to a selected sample of the entire group of interest (called the population) and analyzes the results in order to describe the group. Often it is possible to determine that there is a relationship (correlation) between two different variables, but it may not be possible to determine which causes which. For example, survey research could be used to determine if students who use computers at home tend to make higher grades at school, but it might not be possible to tell if the computer use caused the high grades, or vice versa.

Several basic tips should be kept in mind when using questionnaires for survey research. First, distribute the forms to as many members of the population you are working with as possible. In general, the more participants for which you use instruments, the more accurate your assessment can be. Secondly, keep the responses anonymous, but have respondents use an identification number so that later matching of pre- and post-tests can be accomplished. When representing the data obtained from administering the questionnaires, simple frequency plots are often the best place to start.

The most common types of research for experimental or quasi-experimental design require two established groups called treatment (or experimental) and control (or comparison). For example, the treatment group might be using CAI in a mathematics class. The control group would receive the traditional instruction in lecture format. In this case, CAI access (some or none) would be the independent variable of the experiment, to be manipulated by the experimenter. Performance on a math test might be the dependent variable measured to determine the results. If each student is randomly assigned to the CAI or non-CAI group, then this is a true experiment. If the teacher must allow the first period class to have CAI because that is when the computers are free, and then chooses the only other math class to have lecture mode, then it is a quasi-experimental design.

Consistency is important to the proper selection of the groups to be included. Many different elements can influence the group similarities, such as ethnicity, age, gender, socioeconomic status, or cognitive style. One should make each of the groups, control and experimental, as much alike as possible. In general, greater similarity between the control and experimental group enhances any conclusions drawn concerning the effect of the independent variable on the dependent variable.

Administering a pre-test and post-test is recommended. Although the necessity for a pre-test is not absolute, it does tend to provide another measure to support conclusions drawn about the sample once post-tests are completed and scored.

One of the most common research designs for classroom implementation is a quasi-experimental one using a pre-test and post-test with a control group. Only the experimental group receives treatment (such as technology access). The differences in improvement in attitude and content level scores of each group are compared. Standard statistical techniques that may be employed include a t-test and analysis of covariance using the pre-test score as a covariate and the post-test score as the dependent variable.

Statistical Inference

Statistics provide mathematical techniques for analyzing, sorting, interpreting, and giving meaning to data. The data may have been collected through a variety of different techniques, such as an interview form or a Likert scale instrument. Interviews, surveys, and attitude tests all yield data about individuals. To make the data collected about a group of individuals meaningful, we use statistics.

Descriptive statistics, such as means and standard deviations are used to classify and summarize data. In cases where it is time consuming or too expensive to test every member of a population, then we can use statistics to make inferences from a sample of that population. A sample is a group of individuals who share the same characteristics as the population. Using sample data to describe the larger population is called inferential statistics.

Statistical tests yield probabilistic, rather than deterministic answers to research questions. Typically, the researcher reads the level of significance off the computer printout or looks it up in a table. A common level of significance, which should be chosen by the researcher before the test is carried out, is alpha = .05. This means the researcher will accept his hypothesis as true if the odds of such an arrangement in the data occurring purely by chance are less than 5 in 100. The researcher usually hopes to find the probability of his/her results to be less than .05. Failure to reach significance leads to possible reformulation of a new hypothesis, or perhaps a return to qualitative research to reformulate the theory.

Summary

The role of the teacher is increasingly requiring more attention to research in the classroom. Whether using qualitative or quantitative research methodology, correlational or experimental design, or whether measuring content improvement or attitudinal change, proper design of the experiment will assist in arriving at meaningful results. While in this article a general discussion of research was undertaken, the next article in this series will address the assessment and evaluation of student gains in the classroom.

References

