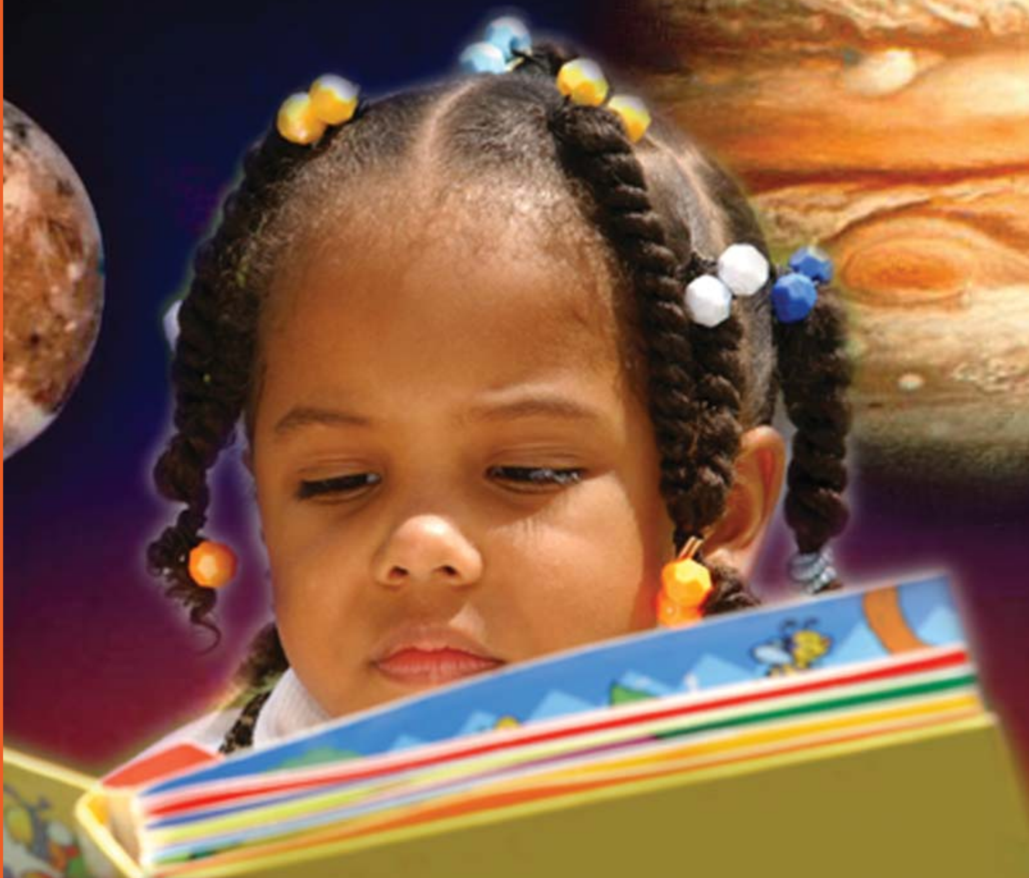
Using Research and Reason in Education

What is Scientifically Based Research?

A Guide for Teachers



National Institute for Literacy
The Partnership for Reading

Early in the 17th century, two astronomers competed to describe the nature of our solar system.

Galileo built a telescope and found new planets and moons. Francesco Sizi ridiculed Galileo's findings. There must be only seven planets, Sizi said. After all, there are seven windows in the head—two nostrils, two ears, two eyes, and a mouth. There are seven known metals. There are seven days in a week, and they are already named after the seven known planets. If we increase the number of planets, he said, the whole system falls apart. Finally, Sizi claimed, these so-called satellites being discovered by Galileo were invisible to the eye. He concluded they must have no influence on the Earth and, therefore, do not exist.

Sizi's most valuable contribution to history may have been to remind us that true understandings of the world, and how it works, cannot be based on pure thought alone, no matter how logical, creative, or contemporary such thought may seem.

True understandings require some measure of science and the willingness to seek information when making decisions.

Becoming a Wise Consumer of Education Research

More than ever, educators are expected to make decisions that guarantee quality instruction. As knowledge emerges, so do philosophies, opinions, and rhetoric about definitions of instructional excellence. From policy makers to classroom teachers, educators need ways to separate misinformation from genuine knowledge and to distinguish scientific research from poorly supported claims.

Effective teachers use scientific thinking in their classrooms all the time. They assess and evaluate student performance, develop Individual Education Plans, reflect on their practice, and engage in action research. Teachers use experimental logic when they plan for instruction: they evaluate their students' previous knowledge, construct hypotheses about the best methods for teaching, develop teaching plans based on those hypotheses, observe the results, and base further instruction on the evidence collected.

In short, teachers use the concepts of rigorous research and evaluation in profoundly practical ways.

Teachers can further strengthen their instruction and protect their students' valuable time in school by scientifically evaluating claims about teaching methods and recognizing quality research when they see it. This booklet, distilled from the monograph *Using Research and Reason in Education: How Teachers Can Use Scientifically Based Research to Make Curricular and Instructional Decisions*, provides a brief introduction to understanding and using scientifically based research.

The federal perspective on scientifically based research

The No Child Left Behind (NCLB) Act of 2001 encourages and, in some cases such as Reading First, requires the use of instruction based on scientific research. The emphasis on scientifically based research supports the consistent use of instructional methods that have been proven effective.

To meet the NCLB definition of "scientifically based," research must:

- employ systematic, empirical methods that draw on observation or experiment;
- involve rigorous data analyses that are adequate to test the stated hypotheses and justify the general conclusions;
- rely on measurements or observational methods that provide valid data across evaluators and observers, and across multiple measurements and observations; and
- be accepted by a peer-reviewed journal or approved by a panel of independent experts through a comparatively rigorous, objective, and scientific review.

RECOGNIZING EFFECTIVE RESEARCH

Teachers can use a simple set of questions to distinguish between research that confirms the effectiveness of an instructional practice and research that does not:

- Has the study been published in a peer-reviewed journal or approved by a panel of independent experts?
- Have the results of the study been replicated by other scientists?
- Is there consensus in the research community that the study's findings are supported by a critical mass of additional studies?

Independent peer review

Peer review subjects a paper to scrutiny by scientists in the relevant field of specialization. This happens in two ways. In one method, a paper submitted for publication in a peer-reviewed journal is examined by other scientists in the field before an editor (usually an expert in the field) passes judgment on it. The second method is review by an independent panel of experts who, using rigorous criteria, determine whether the findings of the paper are credible.

Peer review provides a baseline of quality control because it exposes ideas and experimentation to examination and criticism by other researchers. Its absence should raise doubt about the quality of the research. Presentations at education conferences that make claims about specific educational practices should also be held to this standard.

It is relatively easy for teachers to determine if a paper has been published in a peer-reviewed journal; it can be more difficult to determine whether a panel review (without publication) has occurred unless it is specified in the paper.

Not all education journals are peer-reviewed

Education journals have different purposes that contribute to our understanding of teaching. The *American Educational Research Journal*, the *Journal of Educational Psychology*, and *Reading Research Quarterly* are examples of journals that conduct peer reviews and contain empirical evidence about teaching techniques. *Phi Delta Kappan* and *Educational Leadership*, by contrast, contain original thought, but neither publishes peer-reviewed original research.

Peer-reviewed journals on other topics such as cognitive psychology and other social sciences can also make useful contributions to educational practice.

Replication of results by other scientists

Teachers should look for evidence that an instructional technique has been proven effective by more than one study. Knowledge generated by one study without scrutiny and criticism by others cannot be fully scientific. To be considered scientifically based, a research finding must be presented in a way that enables other researchers to reach the same results when they repeat the experiment.

True scientific knowledge is public and open to challenge. It is held tentatively, subject to change based on contrary evidence.

Consensus within a research community

A single experiment rarely decides an issue, supporting one theory and ruling out all others. Issues are most often decided when the community of scientists in a field comes to agreement over time that sufficient evidence has converged to support one theory over another. Scientists do not evaluate data from a single, perfectly designed experiment. They evaluate data from many experiments, each containing some flaws but providing part of the answer.

Scientific Investigation Proceeds by Stages

Becoming more aware of how the scientific process manifests itself every day in both research and teaching can enhance a teacher's effectiveness, depth of expertise, and ability to justify the choice of instructional methods to parents, peers, and administrators. As in formal evaluations of educational programs, the tenets and themes of scientific research have relevance and application in the classroom. But because there are different stages of scientific investigation, teachers should take care to use data generated at each stage in appropriate ways.

For example, some teachers rely on their own observations to make judgments about the success of educational strategies. A collection of observations leads to some understanding of the world, but observations have limited value. Scientific observations must be structured in order to support or reject theories about the causes that underlie events. Scientists—and teachers—make predictions about causes based on their structured observations and then use other techniques to test specific outcomes.

In the early stages of investigation, **case studies**—highly detailed descriptions of individuals or small groups and the context surrounding them—can be useful. Case studies provide descriptive information about how an educational program operates in a classroom, for example, descriptions of instructional strategies, amount of time, and types of materials used in a new vocabulary program. This qualitative design uses a variety of data collection methods from multiple sources to study a single entity in depth, over a period of time, and in its context. Case studies lack the comparative information needed to determine cause-effect relationships, but they can point researchers to variables that deserve further study and help generate hypotheses. They can be helpful in developing theories about what is or is not working instructionally. However, case studies cannot provide the measurable results that are necessary to understand and confirm outcomes.

Correlational studies take things a step further by testing whether there are links between variables and outcomes. They are useful in early and middle stages of an investigation once hypotheses have been developed. For example, if a researcher hypothesizes that vocabulary instruction leads to improved reading comprehension, he or she could conduct a correlational study, using statistical techniques, to determine if there is a link between vocabulary instruction and reading comprehension. If the study finds a link, the researcher could design a randomized controlled trial, or true experiment, to confirm whether the vocabulary instruction causes the improvement in comprehension.

In order to draw conclusions about outcomes and their causes, data must come from **true experiments.** True experiments, or randomized field or controlled trials, test specific predictions and rule out alternative explanations. In an experiment, an investigator assigns subjects randomly to experimental and control groups, varies the apparent cause (the independent variable) and looks at the apparent effect (the dependent variable) while holding all other variables constant. Only true experiments can provide evidence of whether an instructional practice works or not.

The experimental method controls for the many other variables that could have an impact on an outcome. Unlike case studies and correlational methods, experiments use techniques such as random assignment of subjects to treatment and control conditions and the matching of subjects in the treatment groups on background and ability variables.

For example, imagine an experimental study that investigates whether vocabulary instruction has a positive effect on reading comprehension. A sample of third-grade students is selected and half of the students are then randomly assigned to the treatment group and half are assigned to the control/comparison group. Random assignment ensures (if the sample size is sufficient) that the two groups will be relatively matched on various demographic characteristics and on overall ability level. This is why random assignment is so important—it ensures the equivalence/comparability of the students in the treatment and control groups. Students in the treatment group then receive instruction in learning 100 new vocabulary words, while students in the control group do not receive instruction in learning the new vocabulary words (they engage in an alternative activity). At the end of the instructional period, students are given a standardized comprehension test.

Results of the study will demonstrate whether students in the treatment condition do better than comparable students in the control group on the test of reading comprehension. If the treatment group shows reading comprehension scores that are higher than those of the control group to a statistically significant degree, then the experiment provides evidence that helps to establish a causal relationship between vocabulary instruction and reading comprehension. As mentioned earlier, multiple studies that replicate these methods and find similar results would need to be conducted for further confidence in the results.

While teachers certainly would not be expected to carry out true experimental research in the classroom, understanding the role of experimental research as well as the other stages of scientific investigation and the data they generate—from observations to standardized assessments—can prepare teachers to interpret research better, decide what and how to teach, and make legitimate, defendable statements about the impact of their instructional choices.

Using the Research Literature as a Guide

In many cases, science has not yet provided the answers teachers and others need to make fully informed decisions about adopting, or dropping, particular educational strategies. What if an area of education lacks a research base, has not been evaluated according to the principles of scientific evaluation described above, and no consensus exists? In those cases, teachers have to rely on scientific reasoning to find their way. An important first step is to look at the findings and principles from the established research base.

Imagine, for example, that two untested treatments for children with extreme reading difficulties have emerged. The first treatment suggests a new strategy for teaching phonemic awareness by using only songs and clapping to teach children how language can be broken down into sound segments, or phonemes. The second treatment trains children in vestibular sensitivity by having them walk on balance beams while blindfolded. In this hypothetical case, neither of these new treatment ideas has been tested.* Neither has produced empirical evidence to prove that it is effective.

The lack of such evidence need not automatically lead to the conclusion that the methods do not work. Even without empirical evidence, one might find support for one or both methods from other studies conducted on similar strategies. In this case, the strategy featuring awareness of sound segments merits consideration first, because it makes contact with a broad consensus in the research literature that children with severe reading difficulties are hampered by an insufficiently developed awareness of language's segmented structure. The second does not have a comparable link to existing research. A teacher thinking scientifically can make a reasonable conclusion that the first method is preferable by knowing that there is a link to the broader research base.

Teachers supporting teachers

It can be difficult for a teacher to sort through claims of educational impact. Teachers may want to form reading/discussion groups to talk about research studies and to challenge each other in a collegial way about what works, or does not work, in the classroom.

The Institute of Education Sciences' What Works Clearinghouse (www.whatworks.ed.gov) can be a resource for summaries of scientifically based studies. By talking and learning more about how to apply the findings of scientific research in their teaching, educators can practice and refine their skills—and follow the example of Galileo in bringing new knowledge to the world.

**Some treatments related to phonemic instruction have, in fact, been scientifically tested and proven effective. This hypothetical example imagines a new strategy—using only songs and clapping—that has not been proven effective.*

In Summary

Teachers play a variety of roles in their work—instructor, coach, advocate, and learner—but they also act as scientists in several ways. As they make the important decisions about what and how to teach, they must evaluate the claims associated with educational strategies and programs. And in the classroom, they must constantly assess and reassess the value of programs and their impact on students.

The basic principles of the scientific method

- Science progresses by investigating testable problems.
- A testable theory yields predictions that could possibly be proven wrong.
- Scientific knowledge has passed some minimal tests.
- Data and theories are considered in the public domain, or included in the research base, only after a peer review, either by a journal or a panel.
- Published data and theories allow for replication and criticism by other scientists.
- Theories are tested by systematic observation bound by the logic of true experiments.
- Correlational studies, useful when experiments can not be carried out, only help rule out hypotheses.
- Researchers use many different methods to reach conclusions. Most often, they draw conclusions only after a slow accumulation of data from many studies.

This brochure is based on *Using Research and Reason in Education: How Teachers Can Use Scientifically Based Research to Make Curricular and Instructional Decisions,* written by Paula J. Stanovich and Keith E. Stanovich of the University of Toronto, and published by The Partnership for Reading.

For copies of the original monograph, or for more copies of this brochure, download PDF or HTML versions at www.nifl.gov/partnershipforreading. To order print copies, contact the National Institute for Literacy at ED Pubs, PO Box 1398, Jessup, Maryland 20794-1398. Call 1-800-228-8813, or email edpubs@inet.ed.gov.

The Partnership for Reading, a project administered by the National Institute for Literacy, is a collaborative effort of the National Institute for Literacy, the National Institute of Child Health and Human Development, the U. S. Department of Education, and the U. S. Department of Health and Human Services to make scientifically based reading research available to educators, parents, policy makers, and others with an interest in helping all people learn to read well.

The National Institute for Literacy, an independent federal organization, supports the development of high quality state, regional, and national literacy services so that all Americans can develop the skills they need to succeed at work, at home, and in the community.

This brochure was written, edited, and designed by RMC Research Corporation under National Institute for Literacy Contract No. ED-00CO-0093. The views expressed herein do not necessarily represent the policies of the National Institute for Literacy. No official endorsement by the National Institute for Literacy of any product, commodity, service, entity, or enterprise is intended or should be inferred.

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2005