# Science in the Schoolhouse:
## An Uninvited Guest

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**Abstract**

Science and scientific thinking have not made a substantial impact on educational practice. In this discussion, we examine the relationship between science and education and delineate four reasons for characterizing science as an uninvited guest in schools: (a) Science is not highly regarded in society; (b) good science and bad science are often mistaken for one another; (c) the amount of current data is overwhelming; and (d) science is not easy for those who practice it (researchers), those who translate it (teacher educators), or those who consume it (teachers). We suggest several strategies to improve this relationship, including promoting standards of educational practice, emphasizing the role of teacher educators as translators of the research base into classroom practice, and linking student outcomes with the use of effective instructional practices.

Crockett (in this issue) provides an excellent analysis of the problems associated with promoting a scientific view of schooling for students with learning problems. It would be easy and comfortable for us to respond in simple agreement with her major points. It would be easy because we agree with almost everything she says. It would be comfortable because the themes we would echo have been discussed by a number of scholars commenting on the research-to-practice dilemma (e.g., Carnine, 1997; Kauffman, 1996). But the pride we take in the empirical progress of our field in developing effective interventions (e.g., Forness, Kavale, Blum, & Lloyd, 1997; Vaughn, Gersten, & Chard, 2000) and the hopelessness we feel about how seldom and haphazardly research seems to find its way into practice (Cook & Schirmer, 2003) prompt us to discuss, instead, some reasons why science has *not* found its way into schools in a systematic way and does not appear likely to do so in the foreseeable future.

Certainly there are examples of classrooms in which research-validated practices are implemented with fidelity and regularity (e.g., Kauffman, Bantz, & McCullough, 2002; Vaughn, Hughes, Schumm, & Klingner, 1998), but these appear to be the exception rather than the rule. As Cook and Schirmer (2003) suggested, the recent growth in special education's knowledge base has resulted in little improvement in the extent to which classroom practice reflects this knowledge. Instead, when science does find its way into schools, it seems to do so by chance at best, as something of an uninvited guest. We refer to science as an uninvited guest because we do not see large numbers of educators or administrators clamoring for more and better research—that is, inviting science into their schoolhouses. But neither do we see unanimous rejection of science by educational professionals.

## The Relationship Between Science and Schooling

What we sense in schools is more an indifference to science, or a lack of awareness about the existing body of scientific evidence that might guide practice. That is, teachers are not consciously avoiding science; they simply have not established any kind of relationship with it. Science drops by unannounced in many schoolhouses, and individuals respond to this guest in different ways. Some welcome it. Others are much more standoffish and slow to warm to it. Still others may be oblivious to its presence, not even recognizing science and scientifically based knowledge when they see it. Landrum (1997) suggested that a large percentage of educators are probably unaware of and unable to describe the research base underlying even those practices that they hold dear. Such educators are not rejecting science; they simply have not been properly introduced.

In this discussion, we explore the awkward nature of the relationship between science and schooling and offer some thoughts on ways in which the foundation for a solid relationship between them might be forged. We delineate four reasons why the relationship is a rocky one from the start:

1. Science is not highly regarded in our society;
2. good and bad science are often mistaken for one another;

3. the amount of data is overwhelming; and
4. science is not easy.

We think these reasons constitute a formidable barrier that could prevent systematic movement toward scientifically based practice in education.

### Science Is Not Highly Regarded

That science is not highly regarded by many members of society may be the greatest obstacle to bringing about significant change in schooling. The antiscience movement in education has been decried by a number of scholars (see Sasso, 2001, for an excellent treatment of special education's retreat from scientific knowledge), but this movement is probably the reflection of a more general antiscience attitude. Sagan (1996) highlighted the general ignorance of simple scientific concepts in American society and the willingness of people to accept fantasy and fable, even when credible evidence and verifiable facts contradict closely held beliefs. Among his amusing but telling examples, Sagan referred to the number of people who believe that crop circles were created by extraterrestrials, despite evidence to the contrary and admissions of deceit by those who perpetrated the hoaxes. Sagan estimated that scores of aliens must be visiting Earth daily—and leaving no evidence behind—if we accept the reported volume of worldwide sightings, visits, and even alien abductions. The naiveté of otherwise intelligent people and their inability or unwillingness to use evidence in making decisions is unsettling, but it should be even more disquieting for those concerned with education (Kauffman, 2002). If we cannot agree that flying saucers are fantasy, should we be surprised when educators, theorists, and researchers disagree about the efficacy of direct instruction, the need for explicit phonics instruction, or the utility of instruction matched to learning styles?

Some members of the educational community dismiss science because it fails to fully answer all questions. Gallagher (1998) seemed to adopt this view in questioning whether there is a reliable scientific knowledge base to guide practice in special education. Gallagher's point, as we understand it, is that an 80% success rate for an intervention leaves practitioners with little to go on, as they can never be certain, when children fail, whether these children are among the 20% of students for whom the practice might not be effective or whether they simply failed to implement the procedure correctly.

Working from a scientific perspective, we view this problem differently. If Educational Practice A has extensive research support suggesting that it produces achievement (e.g., in reading) to an acceptable standard with 80% of children, and no other practice comes close to this level of success, we would argue that teachers should incorporate this practice into their repertoire, implement it with fidelity, monitor students' progress, and modify their instructional programs appropriately. Should reasonable adjustments in Educational Practice A's delivery, pacing, materials, or reinforcement, for example (practices that should be routine for any well-trained special educator), still fail to produce adequate progress for an individual student, a different practice should be tried. In this case, the decision of what to try next would be informed by skillful observation and analysis of the student's failure to perform with the use of the recommended practice.

Although Gallagher's (1998) concern with uncertainty about cause and effect sounds ominous, it is the nature of associations between dependent and independent variables (save some in the hard sciences) to have degrees of relationship rather than perfect correlations. Medical science does not subscribe to the antiscientific view that Gallagher and others might advocate for education. For example, it is estimated that as many as 10% of patients in the general population will experience adverse reactions to penicillin (Salkind, Cuddy, & Foxworth, 2001). Moreover, the rate of *Streptococcus pneumoniae* resistance to penicillin varies from 14.7% to 35.1% (McCormick et al., 2003). Still, penicillin remains the first course of treatment for many common ailments related to infection with *Streptococcus pneumoniae*, such as sinus infections, middle ear infections, and bacterial pneumonia. Instead of abandoning penicillin for its lack of effectiveness with *all* patients and all ailments, physicians rely on it as a first course of treatment because the *majority* of patients will benefit from its application. Then, for those who are intolerant of penicillin or for whom penicillin is found to be ineffective, physicians have other empirically established courses of action to treat the ailment (e.g., erythromycin).

Put simply, science does not fully answer all questions, nor does it result in the same answer when a given question is posed under different sets of circumstances. But we are not aware of any credible social scientists that make such a claim. In fact, scientific methods are based on the very premise that results contain variance because the human condition varies—to expect otherwise would be unscientific. We think science offers us the best chance to answer our most pressing questions to the greatest extent possible. By relying on science, the field of special education has identified and should be able to continue to identify practices that are most likely to benefit the greatest number of students (see Forness et al., 1997). These preferred practices provide educators with the first course of treatment for teaching academic content and social behaviors to students and with other courses of treatment for those students who do not respond well to initial interventions. Crockett's (in this issue) support for turning to science to solve educational problems is consistent with Sagan's (1996) observation that although it remains an imperfect instrument of knowledge, science is still the best tool we have.

## *Good and Bad Science Are Difficult to Discern*

Most of the attention related to linking research with practice is directed toward the observation that teachers do not routinely and consistently implement effective interventions (Kauffman, 1996). In some cases, teachers may be reflecting the disregard for science that characterizes their teacher training institutions. A stinging critique of teacher preparation (Fordham Foundation, 1999) blasted current practice, suggesting that "much of the surest and best-documented knowledge about education is ignored, even denounced, by many approved teacher education programs, while the lore that they instead impart to new teachers—about favored methods and self-esteem enhancement, for example—has little or no basis in research" (p. 6). Analyzing how teachers make distinctions between good and bad science is important in discussing the relationship between science and schools.

By what mechanisms do teachers obtain information about educational practices, evaluate that information, and decide to incorporate a particular practice into their teaching? Tangential evidence from teachers' ratings of the material they learned in college courses suggests that training programs are not the most influential sources of information guiding the interventions used in their classrooms (Landrum, Cook, Tankersley, & Fitzgerald, 2002). Landrum et al. argued that teacher educators should be the most trustworthy sources of useful information for teachers if good science is to become a surer foundation of educational practice. In studying how teachers make choices, Landrum et al. examined teachers' ratings of the various sources from which they might obtain information about educational practices or interventions to use in their classrooms. Teachers were asked to rate these sources along Carnine's (1995) dimensions of trustworthiness, usability, and accessibility. The findings suggested that teachers were more likely to obtain information about practice from other teachers (their colleagues) and from workshops or inservice presentations than from college coursework or the professional literature. More surprising was that teachers also rated these sources as more trustworthy. Although we are loath to blame teacher educators and schools of education, these findings beg the question, Why aren't teacher educators viewed as the most trustworthy source of information on how to teach?

It seems idealistic to expect teachers, and those preparing to become teachers, to make judgments about the quality of the science supporting their selection of effective practices. Even prominent scholars in the field have difficulty sorting this out. Consider the numerous times that reports are released or studies published, only to be followed by rebuttals, re-analyses of data, or simple alternative explanations. Kohn's (1993) critique of rewards as an effective tool for educators, for example, was followed by an essentially contradictory analysis of the literature by Cameron and Pierce (1994). An exchange among Biederman, Davey, Ryder, and Franchi (1994), Ward (1995), and Biederman and Davey (1995) highlighted a disagreement among researchers about whether positive reinforcement can have negative effects. Such debates might be healthy for scholars, but the effect of voluminous, often unclear, and sometimes self-contradictory data on practitioners remains unclear.

## *The Amount of Data Is Overwhelming*

Perhaps one of the most daunting tasks related to using science in education is simply identifying scientifically based practices. Culling professional literature or navigating the more expansive ocean of data available through the Internet to identify effective practices requires a basic knowledge of research methods to separate the good from the bad, the trustworthy from the untrustworthy.

The task of gleaning useful information grows more overwhelming each year. Seven years ago, Landrum (1997) posed the danger of being buried by information, arguing that the capacity to access and store information electronically had far outpaced our human ability to make sense of and use even a fraction of these data. If the capacity of simple desktop computers is a useful indicator, the problem with data overload is growing in geometric progression. The Internet provides an excellent example. On May 2, 2003, we typed the words "learning disabilities" into a number of leading Internet search engines. At google.com, the search yielded 1,420,000 entries. The same search term yielded 1,290,000 entries at yahoo.com, and 1,083,658 entries at lycos.com. In the first few pages of entries were links to Web pages of professional organizations such as the Learning Disabilities Association of America (LDA) and the Council for Exceptional Children's Division for Learning Disabilities (DLD) as well as direct links to pages with more specific information on interventions, including such treatments as diet modifications and the use of colored lenses for reducing the effects of scotopic sensitivity syndrome (SSS) on reading performance. Which among these Web sites should one trust? Who accesses these Web sites (e.g., teachers, parents, school board members, state legislators), and what do they do with the information they find there? We doubt that large numbers of professionals engage in generic Internet searches when they need answers to specific questions, but we suspect that many parents of children with disabilities do, which raises a challenging set of issues for educators.

A similar dilemma with data confronts preservice teachers who are skilled and savvy in pursuing academic knowledge. We fear—and often hear from students—that those who are new to the field of education find its literature to be both overwhelming in volume and self-contradictory in message. These contradictions also are played out among faculty members who hold disparate views of instruction. As Gersten (2001) suggested, "many students of education leave universities feeling bewildered, betrayed, or both" (p. 45).

### *Science Is Not Easy*

Doing good research is difficult, expensive, and time consuming. In our view, becoming a knowledgeable consumer of research is equally challenging. All teachers, including those who are not pursuing advanced graduate studies or engaging in research of their own, must have some basic level of research knowledge so they can read the empirical literature, make sense of it, and apply what this literature offers. For example, to become knowledgeable consumers of science, teachers need to understand the nature of research questions so they can comprehend what a particular study did or did not find. They should appreciate the difference between practical and statistical significance when differences in outcomes are observed, and they should understand the distinction between correlation and causality. Furthermore, they should grasp the importance of replication and the extent to which findings from a study or group of studies might generalize to other settings and participants. These and other basic concepts of educational research are not easily conveyed in a few simple lectures. More likely, exposure to research experiences with multiple examples, repeated practice, and regular visits to the literature is necessary before teachers come to a comfortable level of conceptual understanding. But to what extent does this happen, or is it even possible, in the current structure of teacher preparation?

## Introducing Science in Schoolhouses

Although we have suggested that a number of barriers limit the influence of scientific decision making in education, we also concede that science does make its way into schools at times, albeit haphazardly. How can science and empirically sound practice become a dominant and consistent force in education? We see three strategies that are necessary, if not sufficient, to enhance the probability that professionals might thrive in the roles of researcher, teacher educator, and teacher in an educational system grounded in scientific thought: (a) promoting standards of practice, (b) emphasizing and elaborating the role of the teacher educator, and (c) making the link between science and student outcomes explicit.

### *Promoting Standards of Practice*

One way to ensure that students of education are grounded in instructional principles and effective practices based on scientific evidence is to develop and to adopt standards of practice for the field of special education. As described by Carnine (1995), *standards of practice* delineate specific practices that have been shown through research to produce the most reliable and valid learning and behavioral outcomes for students. Such practices should then become the focus of teacher preparation—providing a unified approach to guiding the profession, training professionals, and affecting students in scientifically determined ways (Walker et al., 1998). To date, however, no agreed-upon set of teaching behaviors, instructional procedures, intervention techniques, or organizational structures have been identified, nor have agreed-upon methods for determining such a set been championed. As Vaughn and Dammann (2001) pointed out, "a rigorous scientifically determined research base does exist, but the implications of the research have not been recognized, agreed upon, or implemented" (p. 21).

By establishing, promoting, and preparing teachers in the implementation of publicly agreed-upon standards of practice, progress would be possible in cataloguing and clarifying the vast amount of data related to the education of students with disabilities (Greenwood & Maheady, 2001). With such standards established, teachers would know where to go to locate practices that have empirical support—the data could be reduced to include only good science, and teachers could make choices about practices with confidence. Standards of practice would further allow teacher educators to become more trustworthy sources of information as they rely on the scientific knowledge base to set the norms for practice.

### *Emphasizing and Elaborating the Role of Teacher Educators*

We have argued here and elsewhere that a key element that is missing or insufficiently examined in discussing research to practice is the teacher educator who is not only skilled in the research process but skilled in translating research into practice through the activities of teacher education (Landrum, Tankersley, & Kauffman, 2003). Teacher educators need more than a passing level of research competence. They should be skilled at reading research literature, determining what is important, and synthesizing from it those practices found to be effective. From these activities, they can then develop curriculum materials that translate recommended practices into observable behaviors in preservice teachers. One can make a compelling case that teacher educators are at the nexus of research and practice in education. But we know little about the extent to which teacher educators are adequately prepared for this task. Are they trained in their doctoral programs to conduct research or to translate existing research into practice? Are they trained specifically to teach preservice teachers, to model effective teaching techniques, and to ensure that their students master these teaching skills? Are they actively making decisions about the effectiveness of various practices based on the degree of empirical support available, or do they leave these decisions to professional organizations or even to individual preservice teachers or their supervisors?

The teacher's role is not to conduct basic science. Teachers need not determine whether praise, or direct instruction, or colored lenses, or mnemonics work with every child in their classroom. Scores of researchers have conducted hundreds of studies with thousands of students to answer questions about what works, and they have produced many valid, trustworthy answers (e.g., Gersten, Schiller, & Vaughn, 2000; Lloyd, Forness, & Kavale, 1998). Neither is the teacher's primary role one of screening the educational research base to discern good science from bad science. Rather, it is the teacher educator who must be responsible for identifying scientifically based effective practices and preparing teachers in their use, evaluation, and modification. The teachers' role, then, is to choose wisely from the set of proven practices taught to them in their preparation programs and, in particular, to find those that are appropriate for the age, skill level, and instructional needs of their students.

This is not to suggest that teachers are incapable of conducting research or identifying effective practices presented in the scientific literature. It is only to emphasize that the educational enterprise becomes inefficient to the extent that practitioners must conduct their own research or must return to the research literature to answer every question they encounter about instruction or intervention. A cleaner division of labor might address this problem to some extent. For example, knowledge producers (researchers), knowledge synthesizers (teacher educators), and knowledge users (teachers) could be recognized as distinct and vital contributors to the linking of research to practice. The same goal—effectively educating students with disabilities—would drive the work of all concerned, but the role functions of each group would be distinctly embraced by the professionals charged with fulfilling them. Specifically preparing professionals for each role and supporting their efforts would seem to offer a better chance for success.

### *Linking Science and Student Outcomes*

Adopting and using standards of practice in teacher preparation programs is one way for teacher educators to become more trustworthy sources of information. As discussed previously, standards of practice that identify scientifically based principles and techniques for instruction should form the basis for teacher education. How teacher educators convey these practices to preservice teachers is also critical, and teacher educators should be proficient at linking those practices to clear, observable empirical results with regard to student achievement and success. As Greenwood and Maheady (2001) argued, the role of all teacher educators is to construct and foster in their university students an attitude that teaching is based on scientific principles. Analysis of cause and effect with respect to at least some simple research designs (e.g., a reversal design using single-subject methodology) could demonstrate clearly to teachers that things they do in the context of classroom instruction can have a direct and causal impact on student performance.

It is critical that teacher educators help their students to make the initial connection between the use of empirically based practices and subsequent child and youth outcomes (Abbott, Walton, Tapia, & Greenwood, 1999; Gersten, Vaughn, Deshler, & Schiller, 1997). When classroom teachers are able to connect the positive effects of practices learned through their teacher education programs to the positive learning and behavior of their students, teacher educators should surely gain more trustworthy status.

## Conclusion

In this discussion, we have examined the relationship between science and education and delineated four reasons for characterizing science as an uninvited guest in schools. First, science and scientific thinking are not valued in society or in our profession. Instead, we seem to go with what feels right, be it scientifically sound or not. Science does make it into schools on occasion, but its visits are random and unpredictable. Second, it is becoming increasingly difficult to discern between good science and bad science. Bad science appears in many visible venues, and some profiteers have learned that to sell products, they must masquerade them as being "scientifically sound." Third, we are overwhelmed with data to the extent that it is virtually impossible to track, obtain, and digest even a fraction of what is written and published about educational interventions—even if we can sort the good from the bad science. Fourth and finally, science is not easy for those who practice it (researchers), those who translate it (teacher educators), or those who consume it (teachers). Some level of advanced training is a prerequisite for each group. Even with preparation, doing science, translating research findings, and being wise consumers of scientific knowledge is difficult and demanding work.

If there is hope of implementing the evidence-based approaches to education that we think would serve children best, science cannot continue to show up uninvited in schools. It is time to address the conditions that have kept science off the guest list. As teachers see that empirically sound practices allow them to do their job more efficiently and that the use of research-based practices is the best way to ensure student achievement, conditions should be ripe for science to receive a proper welcome in schools. As administrators accept their vital role in advocating for and supporting the sustained, buildingwide use of research-based practices, even wider acceptance should be possible. With administrative leadership and support, teachers should be not only more likely but more able to approach their work with an eye toward science. As school officials and state legislators require scientifically proven methods to be used in schools, science should have the opportunity to become a welcomed member of the school community.

Finally, being an invited guest is preferable to not being invited at all, but the ultimate goal for making science the foundation of educational practice for students with learning disabilities is for science to be more than a guest in schools. Science must become a full-time resident, essential to educational decision making in central offices, in principals' offices, and in classrooms. For science to become such an integral part of schools, teachers and other school personnel should be steeped in the scientific tradition early in their own schooling, making their acquaintance with the benefits of science throughout their professional preparation.

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