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Every fall and spring semester, I teach a doctoral seminar on behavioral foundations of education that all students in the College of Education are required to take. The topic of discussion for the second week of class is, "To what degree does educational research contribute to improvements in classroom learning?" The reading assignment for that week is a pair of articles from volume 65, number 7 of *Phi Delta Kappan.* The first article, written by Elliott Eisner, is titled, "Can Educational Research Inform Educational Practice?" The second article, written by Eva Baker, is titled, "Can Educational Research Inform Educational Practice? Yes!" As you can gather from the titles, Eisner was somewhat less sanguine about the relationship between research and practice than was Baker.

In a nutshell, Eisner argued that educational research does not serve the classroom teacher at any level of education particularly well for at least three reasons: (a) Research is not informed by well-developed theories of instruction that specify potential relationships among such variables as teaching methods, subject matter, characteristics of teachers, characteristics of students, and the learning process. As a result, some of the subtle but powerful aspects of teaching, such as values, timing, tempo, gesture, expression, silence, and emphasis are overlooked by most researchers. (b) Contemporary research studies are not sufficiently long to adequately study the variables that are examined. After reviewing all of the experimental studies that were published in one year in a prominent educational journal, Eisner calculated the median treatment time at 72 minutes. (c) Researchers are more interested in conducting studies that address theoretical issues than in studies that address the everyday concerns of teachers.

Baker responded that while the problems cited by Eisner were valid ones, research does inform educational practice, and has done so for some time. This sentiment has been expressed more recently by Herbert Walberg. Writing in volume 71, number 6 of *Phi Delta Kappan,* Walberg cites several psychological elements of instruction (e.g., specific objectives, pretests, graded homework, reinforcement, teacher questions) that have been shown in most studies to have at least moderate positive effects on achievement.

Although I agree with the criticisms made by Eisner, it should come as no surprise to regular readers of this column that I agree even more with the basic argument made by Baker and by Walberg. Part of the reason for my agreement with Baker and Walberg can be seen in the summaries of the following recently published studies, each of which suggests a way to improve student performance in the classroom.

Learning is Believing

Since learning typically begins (or doesn't begin) with the attitudes, beliefs, and values that students bring with them to the classroom, I'm going to begin with a study that has examined the development of high school students' epistemological beliefs and the influence that those beliefs have on overall academic performance.

In 1988, Ron Schmeck, my colleague from the psychology department at Southern Illinois University, speculated about the relationship between epistemological beliefs and learning strategies in a book edited by Claire Weinstein, Ernest Goetz, and Patricia Alexander. Because of the basic nature of such beliefs, he argued that even a small change at this level will have a significant effect on how students approach learning tasks. "What might be the effect," he asked, "if every learning strategies training program included a section that addressed questions such as: What is education? What is learning? and What is the individual student's personal responsibility with regard to these processes?" Recent research by Marlene Schommer of Wichita State University that appeared in volume 85, number 3 of the *Journal of Educational Psychology* indicates that understanding the nature and development of students' epistemological beliefs might well provide an avenue for improving both how well students approach learning tasks and how well they perform.

Schommer administered an epistemological questionnaire to 1,182 male and female freshmen, sophomore, junior, and senior high school students. Statements about knowledge and learning(e.g., "Almost all the information you can learn from a textbook you will get during the first reading") were rated on a five-point scale and reflected a continuum of beliefs that ranged from naive to sophisticated. A factor analysis of the students' responses yielded a four-factor solution that explained 53.3% of the variance. Stated from the naive perspective, these factors were labeled Fixed Ability (the ability to learn is unchangeable), Simple Knowledge (knowledge is discrete, unambiguous, and handed down by authority), Quick Learning (Learning is quick or not at all), and Certain Knowledge (Whatever we have learned we know for certain).

An analysis of how males and females responded to the questionnaire, and how epistemological beliefs develop from the freshman through the senior year of high school yielded two statistically significant findings.

First, girls were less likely than boys to believe in fixed ability or quick learning (which may help explain the often made observation that adolescent girls are easier to raise than adolescent boys). Second, juniors and seniors were less likely than freshmen and sophomores to believe in simple knowledge, quick learning, or certain knowledge (but note that beliefs about fixed ability remained largely fixed). As Schommer notes, however, we shouldn't run to the bank too quickly with this second finding. Since her study used a cross-sectional design, there is no way to tell how many students with unchangeable, naive beliefs dropped out of school at the first opportunity. A longtitudinal design may reveal a different developmental pattern. If this turns out to be the case at some later date, I'm sure it won't bother the readership of the Researcher who recognize that there is little about educational and psychological knowledge that is certain.

An analysis of the relationships among epistemological beliefs, intelligence, and grade-point average (GPA) found that the higher students scored on an IQ test and the less they believed in quick learning, simple knowledge, certain knowledge, and fixed ability, the higher were their GPAs.

Although Schommer's work was not designed to answer the question of whether classroom interventions can accelerate the development of epistemological beliefs, by generalizing from research on Piagetian stages of cognitive development and Kohlbergian stages of moral development, one can assume that the possibility exists, at least to some degree. If you are comfortable with this assumption, you might find the practical implications she offers to be of value. For example, teachers might want to focus more on helping students understand concepts and their interrelationships than on learning isolated facts by rote, assign more complex and time-consuming tasks, assign projects that reveal why conclusions about some phenomenon changed over time, and design test items that allow for alternative acceptable responses.

To Question, or Not to Question? That is the Question

Previous research on student-generated questions tells a good news-bad news story. On the one hand, most studies show that students who ask themselves higher level questions (usually defined as anything above the Comprehension level of Bloom's Taxonomy) as they read score higher on tests of comprehension than do students who generate lower level questions. On the other hand, most of the questions asked by elementary grade students are lower level in nature. Some likely reasons for this deficiency in question-asking are that children are not systematically taught how to generate such questions as they read, most of the question-asking modeled by teachers is of the low level variety, and children do not believe that it is their place to ask questions. Clearly, then, educators need to know how to foster high level question-asking by students. How one might accomplish this goal by using cooperative learning and/or mastery learning techniques was examined by Zemira Mevarech and Ziva Susak of Bar-Ilan University, Israel in an article published in volume 86, number 4 of the *Journal of Educational Research.*

Cooperative learning was chosen as one approach to the training of student question-asking because children in peer groups are more likely to ask questions of peers than of adults, and their answers are likely to be longer and more complex. Mastery learning was chosen as another approach because its practice-with-feedback feature is known to be a powerful method for teaching complex cognitive skills.

Mevarech and Susak randomly assigned 271 third- and fourth-grade Israeli children to either a cooperative learning (CL), mastery learning (ML), cooperative-mastery learning (CML), or control condition, and then randomly assigned teachers to conditions. Over a two month period, each group worked through a common six-step curriculum unit that was linked to the reading text for that grade: distinguish between a question and an answer, understand the meaning of questioning words (e.g., who, what, where, when, why), classify questions according to students' suggestions, distinguish between higher level and lower level questions, generate questions and answer them, and practice asking and answering questions. At each step, students read a paragraph from the text, interpreted it, and then did seatwork activities.

The CL groups were composed of four to six students whose seatwork activities were specially designed booklets and group games. For example, a "fishing game" was used to help students distinguish between lower and higher level questions. Each student had to "fish" questions from a "pool," identify the cognitive level of the questions, and answer the questions. CL students often acknowledged, recognized, and praised each other's contributions. Children in the ML group completed their seatwork activities individually, after which the teacher provided feedback about its quality. Children whose responses did not meet a preset criterion were asked to keep working at the task until they achieved the mastery level. Children in the CML group worked in small, heterogeneous groups on the same activities as did the children in the CL group, were given individual feedback by the teacher, and were required to work at the task until the mastery level was attained. Children in the control group learned the same material via direct instruction. The teacher explained to the whole class the questioning skill in question, provided examples, asked the students to generate examples of their own, and used guided practice of the skill.

After the two-month treatment period, children were assessed for how well they could generate lower level and higher level questions, how fluent, flexible, and original their thinking had become (as measured by the "Improving a Toy" subtest of the Torrance Tests of Creative Thinking), and for how much of the curriculum they had learned (as measured by a 20-item multiple-choice test). Alternate forms of these same instruments were administered prior to the beginning of the experiment.

Although the average number of lower level questions posed by the students exceeded the average number of higher level questions by a wide margin (11.5 versus 3.4), the ML and CML groups exhibited about a fourfold increase in their frequency of higher level question-asking. The CL group increased its higher level question-asking by 33%, while the control group showed a 25% decrease. The ML and CML groups did not differ from each other in frequency of higher level question-asking, but both performed significantly better than the CL group which, in turn, outperformed the control group. For fluency and flexibility, the ML group significantly outscored the CML group, which significantly outscored the CL group. The fluency and flexibility scores of the CL group did not differ from those of the control group. There were no between-groups differences for originality. Finally, there were no significant between-groups differences for achievement.

In sum, this study demonstrates that relatively young children can be taught to improve their frequency of higher level of question-asking, and that either a mastery learning approach or a combined cooperative learning - mastery learning approach is the method of choice. Furthermore, the mastery approach to question-asking produced higher fluency and flexibility scores than did any of the other three approaches.

You Can Get There From Here, But You Need a Good Map

Research by Donald Dansereau and his associates at Texas Christian University in the late 1980s on the effects of knowledge maps found that they enhanced knowledge acquisition and transfer for undergraduates as compared to learning from standard text. Knowledge maps are spatial/visual arrangements of text ideas and their interrelationships that look something like flowcharts. The ideas are paraphrased and enclosed in a circle or ellipse; ideas that are related to each other are linked by lines or arrows that indicate the type of relationship. For example, ideas A and B may be linked by a line labeled with the letter L, indicating that A leads to B.

The likely reason why these knowledge maps work is that they quickly help students see the structure of a passage; that is, how the various concepts and facts that make up a passage relate to each other. But the passages used in these studies all dealt with a single topic. This limitation left open the question of whether knowledge maps would still be effective aids to learning when the passages contained (as most texts do) different but related topics. In a study reported in volume 61, number 1 of the *Journal of Experimental Education*, Richard Hall, Donald Dansereau, and Lisa Skaggs assessed how well each of four conditions (sequential text, comparative text, sequential map, and comparative map) helped students learn the information from a passage that contained two related topics.

In the sequential text condition, the two topics were presented sequentially (e.g., the sympathetic and then the parasympathetic divisions of the autonomic nervous system). The material in the comparative text condition was arranged according to related features (e.g., the part of the spinal cord from which nerves exit for the sympathetic and parasympathetic systems). In the sequential map condition, the maps for the two topics were presented one after another. In the comparative map condition, the knowledge maps for each topic were displayed side by side.

In the first of three 2-hour sessions, 92 undergraduates were given a 15-minute introduction to the nature and use of knowledge maps. They were told that they might be assigned to a map condition, and were shown how to use these maps to study the sequential presentation of information from a single topic and the simultaneous presentation of information from two related topics. Students were then assigned to one of the four conditions. In each condition, students were given material on the autonomic nervous system, and told to study it for four minutes. They then completed a questionnaire about their attitudes toward the subject, and were required to study the material for another 45 minutes.

Two days later, students completed a free recall test of the autonomic nervous system, read a second passage on the topics of descriptive versus experimental research designs for four minutes, completed another questionnaire, and then studied the material again for another 45 minutes.

The final session occurred two days after the second one. Students completed a free recall test on the research design material and vocabulary test that was used as a covariate.

The map groups recalled significantly more ideas than the text groups on the autonomic nervous system passage. There was no significant difference among the groups for recall of ideas on the research design passage. The questionnaire data was consistent with the recall data. Compared with students in the text groups, students in the map groups felt they learned more and found the material to be more organized.

There is Strength in Numbers and (Sometimes) in Diversity

Cooperative learning is an instructional tactic that is in the enviable (and somewhat unusual) position of being both extremely popular among educators from kindergarten through college and strongly supported by research findings. A characteristic of cooperative learning that is presumed to contribute to its effectiveness is heterogeneous groups—groups that are composed of students of different abilities, ethnic backgrounds, social class, and genders. Lower-ability students are supposed to benefit from having the higher-ability students serve as models of good thinking and problem solving, as well as from the direct help they get from higher-ability peers. Higher-ability students are supposed to benefit from the mental reorganization that occurs when they explain things to their peers. But, as Simon Hooper of the University of Minnesota points out in volume 85, number 3 of the *Journal of Educational Research*, research findings on the benefits of heterogeneous groups are inconclusive. Hooper argued that this inconsistency may be due to uncontrolled differences in how group members interact with one another. To test his hypothesis, Hooper provided cooperation training to fifth- and sixth-grade students, and examined how well heterogeneous groups, homogeneous groups, and individual students learned a computer-based lesson on arithmetic skills.

The students who participated in this study were classified as high or average ability according to how well they scored on the mathematics subscale of the California Achievement Test. The mean score for the high-ability students was at the 95th percentile. The mean score for the average ability students was at the 64th percentile.

The cooperation training that each student received was intended to illustrate the efficacy of group work and to promote effective intragroup interaction. The first goal was accomplished by having pairs of students and individual students solve two tasks (calculate the number of sides of a three-dimensional figure and classify objects as examples or non-examples of a concept), and by publicly comparing the performances of the pairs against those of the individuals. The second goal was accomplished by having groups of four students summarize, paraphrase, communicate, and check on the accuracy of a message (definitions of nonsense words and a story represented by a sequence of pictures). Students rotated through the roles of summarizer, paraphraser, and checker.

In addition to providing the students with cooperation training, observers were trained to classify intragroup communication into one of four categories: transmission of lesson content (e.g., reading material from the computer screen), helping behavior (e.g., explaining a solution process, correcting errors), positive social comments (e.g., statements of praise or encouragement), and negative social comments (e.g., statements critical of the learning task or the partner).

The target of both the cooperation training and the observer training was a three-part computer-based mathematics tutorial. In order to progress to the next unit, students had to complete a mastery quiz. Students worked through the tutorial either in pairs or individually, and were paired in one of three ways: two high-ability students, two average-ability students, one high-ability student and one average-ability student. Measures were taken of number of mastery quizzes attempted, intragroup interaction, and achievement. The achievement test contained 40 items that measured factual knowledge, application, generalization, and problem solving.

Having students work through the program in pairs proved to be an efficient instructional tactic as paired students met the mastery criterion for each unit more quickly than did the students who worked alone.

With regard to intragroup interaction, high-ability students gave and received more help when they were paired with another high-ability student than when they were paired with an average-ability student. The average-ability students, on the other hand, did not change their help pattern as a function of group type.

Most research on cooperative learning finds that students who work in groups learn more than students who work alone. This study simply adds one more brick to that pile. Students who worked in pairs obtained higher scores on the achievement posttest than did students who worked alone. But some of Hooper's other findings challenge some of the standard beliefs about cooperative learning and should be investigated further by others. Most notably, high-ability students scored about the same as average-ability students when they were heterogeneously paired, but scored significantly higher than average-ability students when they were homogeneously paired. Finally, students who worked in heterogeneous pairs answered significantly more problem-solving items correctly than did students who worked in homogeneous pairs.

Testing, Testing, 1, 2, 3 (and 4, 5, 6, & 7)

In my last Research Alive column (volume 6, number 3), I summarized a study that reported a moderately positive effect size (about 1/3 of a standard deviation) for increased frequency of classroom testing. That is, students who took more tests during the course of a term scored higher on an end-of-term examination then did students who took fewer tests. Although many other studies and reviews have reported positive effects for this instructional tactic, contrary findings do exist. To clarify the inconsistencies about the effects of more frequent versus less frequent testing, Robert Bangert-Drowns, James Kulik, and Chen-Lin Kulik conducted a meta-analysis of this literature and reported their findings in volume 85, number 2 of the *Journal of Educational Research.*

Bangert-Drowns, Kulik, and Kulik located 40 studies that met their criteria of relevance (the studies had to have been done in real classrooms and used conventional classroom tests) and methodological adequacy, and reported three major findings.

First, the average effect size of frequent testing was .23. Students who were tested relatively more frequently scored .23 of a standard deviation higher on a final criterion test than did students who were tested relatively less frequently. In terms of percentile ranks, this translates to an increase from the 50th percentile to the 59th percentile. Second, a moderately large effect size (.54) was found when the frequently tested group (which, depending on the study, meant anything from 1 to 21 tests) was compared to a control group that received no tests. When the control students took at least one test, the average effect size dropped to .15. The third finding was perhaps the most interesting. Data from eight studies that directly compared three levels of testing frequency found that as the average number of tests taken by students increased, the average effect size increased, but at a diminished rate. Students in the intermediate-frequency conditions took an average of seven tests and scored almost 1/4 of a standard deviation higher on an end-of-term test than did students in the low-frequency conditions, who averaged only one test (average effect size = .23). Students in the high-frequency conditions, on the other hand, took an average of 23 tests and scored almost 1/2 of a standard deviation higher than did the low-frequency condition students (average effect size = .49). Thus, as Bangert-Drowns, Kulik, and Kulik point out, a threefold increase in test frequency (from seven to 23 tests) brings about only a doubling of effect size. This finding suggests that as students take more and more tests over the course of a term, they will probably score higher on a final exam, but the increases will become successively smaller. An additional analysis seemed to bear out this hypothesis. Increasing the number of tests per term from zero to two to four to seven would, according to a regression model constructed by the authors, increase performance on a final exam by .41 standard deviations, .49 standard deviations, and .56 standard deviations, respectively. If one were to give as many as 23 tests, the predicted effect size would be .74. These findings suggest that in most classroom situations a teacher should give somewhere between one and seven tests prior to a final exam.