

Our educational system is not nearly as good as people would like it to be. Nor is it as good it can be.

The roots of our current formal educational system go back about 5,000 years, to the time of the invention of reading, writing, and arithmetic. Schools were established to help government and business clerks learn rudiments of reading, writing, and arithmetic. Archeology digs have found classrooms with benches for about 30 people organized in rows, and they surmise that the teacher stood at the front of the room and lectured, much like still occurs in many of today's classrooms.

We have a history of 5,000 years of work by teachers and educational researchers to improve our educational system. I enjoy asking students in my classes and participants in my workshops: "What are some good examples of the progress that we have made—progress that helps students to learn more, better, faster, retain it longer, and learn to transfer their knowledge and skills to settings outside of the classroom?"

Most of my students and workshop participants find this to be a challenging activity. They have no trouble identifying the fact that we now educate both boys and girls, that we educate a much higher percentage of youth than in the past, and that we require many more years of formal schooling than in the past. However, these answers completely miss the point of the question. Is one student-hour of schooling significantly more effective now than it was 50 years ago, 500 years ago, or 5,000 years ago? What evidence do we have to back up your assertions?

Science of Teaching and Learning

Here is an alternative way to ask the question: "What progress have we made during the past 5,000 years in developing and implementing a Science of Teaching and Learning? For example, is there a well developed "science" of teaching a typical student how to read and write, and do arithmetic? If a student has a particular type of learning difficulty, do we have research- and practitioner-based methods that are highly likely to succeed in addressing this learning difficulty?"

Bransford et al. (1999) provides a comprehensive introduction to the science of Teaching and Learning (SoTL). In brief summary, this book argues that SoTL has made a lot of progress during the past 30 years and is now poised to facilitate significant improvements in our educational system. The book, for example, notes that behavioral learning theory has been supplanted by cognitive learning theories and other types of learning theories that better reflect our current knowledge of the theory of learning.
A SoTL Causality Diagrams

A somewhat overly simplified definition of science is: Science is the development and testing of predictive hypotheses. In science, we observe a possible cause-effect, hypothesize that it is indeed a cause-effect, and then work to develop both a theory and empirical evidence that helps us to have confidence in the hypothesis. For example, for thousands of years, people observed eclipses of the moon. Eventually they came to understand that they were observing the earth's shadow falling on the moon. They developed detailed records that allowed them to predict relatively accurately when an eclipse would occur. Eventually they developed a theory of gravitation, and of celestial objects in orbits around other celestial objects. Now we have both empirical evidence and an underlying theory of eclipses of the moon, and we predict the timing of such eclipses quite accurately, many years in advance.

We do not have such strong "scientific" results in education. But, we do observe patterns, and we do formulate and test hypotheses. Figure 1 is a Causality Diagram that summarizes SoTL. Notice that the third box says that "we expect that students will get a better education." That is, we hypothesize that students will get a better education. In a "science," we generate and test hypotheses.

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<td>We have a growing collection of teaching and learning information and knowledge based on careful observation and carefully conducted research.</td>
<td>We can make use of this information and knowledge as we develop curriculum content, instructional methodologies, and assessment procedures.</td>
<td>As a consequence of this research, development, and implementation, we expect that students will get a better education.</td>
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Figure 1. A SoTL Causality Diagram.

A SoTL Example

To illustrate SoTL, let me describe some research work done by Benjamin Bloom and his students during the early 1980s (Bloom, 1984). You have probably heard of Bloom's Taxonomy, which is often used when discussing lower-order and higher-order problem-solving skills.

Bloom and his students hypothesized that students are capable of much better learning than they achieve through the conventional methods of instruction. Thus, they did research comparing the effectiveness of individual or small group tutoring versus teaching in classes of size 25-30 students. They found that over a wide range of grade levels and course areas, tutoring produced an average gain in test scores of two standard deviations (2 sigmas) versus the control groups. That is, instead of the class average being at the 50th percentile, average for the tutored students was at the 98th percentile.

This is an astonishing result! It says that, on average, students can meet much higher standards than they are currently meeting, and it tells us how to achieve this result. This provides an excellent example of SoTL. Unfortunately, we cannot afford to provide all students with well
qualified individual tutors. Thus, a continuing quest in education is for ways to achieve significant gains in student learning without the high cost of individual tutoring.

**Computer-Assisted Learning and the 2-Sigma Goal**

Many people believe that computer-assisted learning (CAL) has the potential to achieve the 2-sigma learning gains that come from tutoring. To date, however, CAL has not had this level of success. Kulik's meta-metastudy (1994) of CAL reports that over a wide range of instructional areas and student levels, a gain of approximately .35-sigmas is achieved. This means that the average student moves from the 50th percentile to the 64th percentile. Moreover, students achieve this gain in approximately 30-percent less time, as compared to control groups.

These CAL results are significant, and research is continuing on improving CAL. CAL is one component of SoTL.

**Moving Beyond the 2-Sigma Goal**

IT brings some other dimensions to the 2-sigma discussion. Suppose, for example, that the instructional goal is to have students become skilled at carrying out simple bookkeeping tasks, including doing the necessary arithmetic swiftly and accurately. We know that it takes hundreds of hours of study and practice to develop a reasonable level of skill at doing paper and pencil arithmetic and bookkeeping.

Contrast this with a person learning to use a spreadsheet or a simple bookkeeping software package. The learning time to achieve a high level of results is often significantly reduced. Computational errors are no longer an issue, and computations are completed in much less time.

With a spreadsheet or computerized accounting system it is feasible to pose and answer "What if?" questions. Posing and answering such questions is a higher-order skill—one of the really important goals in education. Moreover, spreadsheet software makes possible developing spreadsheet models, not only in business, but also in many other disciplines. With appropriate teaching, students learn to transfer their spreadsheet modeling knowledge and skills to many different disciplines. Transfer of learning is one of the important components of SoTL (Mayer & Wittrock, 1996: 47-62)

**In Brief Summary**

Benjamin Bloom's research shows that our educational system can be a lot better. Students can be educated to much higher standards.

Computer-assisted Learning represents one approach to improving our educational system. In essence, CAL can be thought of as an attempt to computerize some of the research results from SoTL.

We used the example of spreadsheet software to illustrate a different way of significantly improving our educational system. There, the focus was on preparing students to function at a higher-order thinking and problem-solving level within a limited domain. The spreadsheet software is so powerful that it has led to major changes in one component of our educational curriculum. It can be thought of as a "Compelling Application"—software that is so compelling and powerful that it can change and significantly improve a component of our educational system.

In the second articles in this series, I will address additional Compelling Applications. Right now, why don't you spend some time thinking about SoTL. What educational research and
practitioner knowledge do you have about ways to "really" improve our educational system? What stands in your way of implementing this knowledge and then helping your fellow teachers learn to implement this knowledge?

References

