Teaching for Meaning and Understanding
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A Summary of Underlying Theory and Research

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Overview

We contend that a core goal of schooling is to educate for meaning and understanding. For us, teaching for meaning and understanding are two sides of the same coin. They both occur when students explain and interpret ideas, put facts into a larger context, inquire into "essential" questions, and apply their learning in authentic situations.

What is the research base that supports this goal? How do we know that educating for meaning and understanding will enhance student achievement? And what does the research suggest for classroom application?

In the remainder of this article, we review findings from cognitive psychology, studies of student achievement, and research on instruction that, taken together, lend strong support to meaning and understanding based approaches.

Research Findings from Cognitive Psychology

A summary of the past thirty years of research in learning and cognition supports the importance of learning with understanding (Bransford, Brown and Cocking, 2000, p. 8). One avenue of this research explored the differences between novices and experts in various fields. Psychologists learned that experts have more than a large body of information - they actually think differently from novices. "Usable knowledge is not the same as a mere list of disconnected facts" (p. 9); "...expertise requires well-organized knowledge of concepts, principles and procedures of inquiry" (p. 239). This research suggests that students, in order to become knowledgeable and competent in a field of study, should not only develop a solid foundation of factual knowledge but also develop a conceptual framework of concepts and ideas that facilitates meaningful learning.

A synthesis of cognitive research endorses the idea that deep understanding of subject matter transforms factual information into usable knowledge. Knowledge learned at the level of rote memory rarely transfers; transfer most likely occurs when the learner knows and understands underlying concepts and principles that can be applied to problems in new contexts. Learning with understanding is more likely to promote transfer and application than simply memorizing information from a text or a lecture.

Achievement Research

TIMSS Research

The Third International Mathematics and Science Study (TIMSS) tested mathematics and science achievement of students in 42 countries at three grade levels (4, 8, and 12) and was the most comprehensive and rigorous assessment of its kind ever undertaken. While the outcomes of TIMSS are well known - American students do not perform as well as students in most other industrialized countries (Martin, Mullis, Gregory, et. al., 2000) - the results of its less publicized curriculum and teaching studies offer explanatory insights.

TIMSS researchers found that, in the United States, the mathematics and science curricula included too many topics and were highly unfocused (Schmidt, McKnight and Raizen, 1997), whereas, in high achieving countries, more coherent, focused, developmental curricular offerings enabled teachers and students to gradually build more complex understandings in mathematics, to delve deeply into subject matter, and to attain higher levels of achievement (Schmidt, Housing and Cogan, 2002; Schmidt, 2004).

Also, in an exhaustive analysis of mathematics instruction in Japan, Germany, and the United States, Stigler and Hiebert (1999) present striking evidence of the benefits of teaching for meaning and understanding in optimizing performance. For example, in Japan, a high achieving country, mathematics teachers state that their primary aim is to develop conceptual understanding in their students. They cover less ground in terms of discrete topics, skills, or pages in a textbook, but they emphasize problem-based learning, in which rules and theorems are derived and explained by the students, thus leading to deeper understanding.

A recent TIMSS analysis of data from seven countries indicates that all high achieving countries use a percentage of their mathematics problems to help students explore concepts and make connections, while United States teachers tend to emphasize "algorithmic plug in" of procedures, instead if genuine reasoning and problem solving (Hiebert, Gallimore, Garnier, et. al, 2003, pp. 203-204; Stigler and Hiebert, 2004, pp. 15-16).

Other research in mathematics and science education also supports the need for curriculum and instructional practices that focus on core ideas and not on superficial facts and procedures. Weiss et. al. (2003) analyzed more than 300 lessons in a cross-section of mathematics and science classrooms in the United States, K-12. They found that a common characteristic of successful lessons was that students learned how to make sense of mathematical or scientific content by understanding the underlying concepts and then apply their learning to new situations.

Authentic Pedagogy Study

In the mid-1990s, Newmann et al. (1996) conducted an ambitious study to determine whether schools with high levels of authentic pedagogy and academic performance in mathematics and social studies significantly increased achievement over those that measured at low levels. High levels were defined by a number of criteria, such as whether students were asked to explore connections and relationships so as to produce relatively complex understandings; to organize, synthesize, interpret or explain complex information; to elaborate on their understanding through extended writing; or to make connections to the world beyond the classroom (Newmann, Secada, and Wehlage, 1995).

Similar students in classrooms with high and low levels of authentic pedagogy and performance were compared, and the results were striking: students in classes with high levels of authentic pedagogy and performance substantially increased achievement levels. Another significant finding was that the inequalities between high- and low-performing students were greatly decreased when normally low-performing students were in classrooms where teachers used authentic pedagogy and performance strategies and assessments.

Achievement Studies in Chicago Public Schools

Two recent studies of factors influencing student achievement were conducted in Chicago public schools. In the first study, Smith, Lee, and Newmann (2001) focused on the link between different forms of instruction and learning in elementary schools. Test scores from more than 100,000 students in grades 2–8 and surveys from more than 5,000 teachers in 384 Chicago elementary schools were examined.

The study compared teachers who used "interactive vs. non-interactive teaching methods" and their achievement results in reading and mathematics. Interactive instruction methods are described as follows:

> *"Teachers ... create situations in which students . . . ask questions, develop strategies for solving problems, and communicate with one another. . . . Students are often expected to explain their answers and discuss how they arrived at their conclusions. These teachers usually assess students' mastery of knowledge through discussions, projects, or tests that demand explanation and extended writing . . . students discuss ideas and answers by talking, and sometimes arguing, with each other and with the teacher. Students work on applications or interpretations of the material to develop new or deeper understandings of a given topic. Such assignments may take several days to complete. Students in interactive classrooms are often encouraged to choose the questions or topics they wish to study within an instructional unit designed by the teacher. Different students may be working on different tasks during the same class period." (p. 12).*

The study found clear and consistent evidence that interactive teaching methods were correlated with higher levels of learning and achievement.

In a related study, Newmann, Bryk, and Nagaoka (2001) examined the relationship of the nature of classroom assignments to standardized test performance. Researchers in Chicago systematically collected and analyzed classroom writing and mathematics assignments in grades 3, 6, and 8 from randomly selected and control schools over the course of three years.

Assignments were rated according to the degree to which they required "authentic" intellectual work, which the researchers described as follows:

> *"Authentic intellectual work involves original application of knowledge and skills, rather than just routine use of facts and procedures. It also entails disciplined inquiry into the details of a particular problem and results in a product or presentation that has meaning or value beyond success in school. We summarize these distinctive characteristics of authentic intellectual work as construction of knowledge, through the use of disciplined inquiry, to produce discourse, products, or performances that have value beyond school." (pp. 14-15)*

The study concluded that students who received assignments requiring more challenging intellectual work also achieved greater than average gains on the Iowa Tests of Basic Skills in reading and mathematics, and demonstrated higher performance in reading, mathematics, and writing on the Illinois Goals Assessment Program.

High Schools That Work (HSTW)

High Schools That Work (Bottoms, Presson and Johnson, 1992) is a nationally recognized program for integrating academic and vocational education, and grounds its practices in four principles that support meaning and understanding based teaching and learning:

> A *challenging curriculum* that "equips students to think analytically, to reason, to judge, and to balance opposing points of view." Such a curriculum "encourages students to ...use academic and technical content and processes to complete tasks typical of those found in the workplace and the community; [and] construct new meanings and understandings from information and ideas."
>
> *Teaching for understanding* "creates challenging situations in which students test their knowledge by solving problems, building products, and giving performances or writing reports that synthesize thorough analysis of a topic, a concept, or an idea."
>
> *Teaching in a meaningful context* "provides a way to apply academic learning to important 'real-world' problems" and helps students "see meaning and purpose in their studies."
>
> *Setting clear performance standards* so that assessments of learning are "based on clearly stated standards that require students to demonstrate their understanding of new knowledge and skills." (Bottoms & Sharpe, 1996, pp. 20-24)

Research conducted by the National Center for Research in Vocational Education (2000) has confirmed the effectiveness of high school programs that embody these principles. For example, one study over a two-year period found that *High Schools That Work* sites significantly increased the percentages of students in their senior classes who met the HSTW achievement goals in mathematics, science, and reading and the percentages of students in their senior classes who completed the HSTW-recommended program of study" (Frome, 2001).

Research on Mathematics Curricula

In 1989, the National Council of Teachers of Mathematics (NCTM) issued a set of standards for mathematics that reduced the emphasis on rote learning of mathematical formulas and procedures and increased emphasis on conceptual understanding of mathematics. Since then, a number of new curriculum materials based on this approach, focusing on understanding underlying mathematical concepts, complex problem solving, student explanation of their work, and authentic performance and assessment have been developed. Most have been implemented within the last six years.

Senk and Thompson (2003) summarized the results of thirteen studies of mathematics curricula that follow the NCTM approach. While much of this research is still in the preliminary stages, the results are suggestive. For example, children who used a program called *Investigations* in the elementary school[1] "performed better than their counterparts from other curricula with respect to word problems, more complex calculations embedded in word problems, and problems that involved explaining how an operation worked" (p. 127). Longitudinal data from middle schools show that students using understanding-based mathematics curricula demonstrate superior performance in both non-routine problem solving and mathematical skills (Senk & Thompson, 2003, p. 288-289).

Finally, a series of studies using high school mathematics reform programs "...offer overwhelming evidence that the reform curriculum can have a positive impact on high school mathematics achievement. It is not that students in these curricula learn traditional content better but that they develop other skills and understandings while not falling behind on traditional content. These evaluations present more solid scientific evidence than has ever before been available about the impact of curriculum materials" (Senk & Thompson, 2003, p. 468).

Research on Technology

Wenglinsky (1998) conducted a study of the relationship between the various uses of technology and achievement in mathematics. Achievement data on the 1996 National Assessment of Educational Progress (NAEP) were analyzed and correlated with survey data including the frequency of computer use for mathematics and the kinds of instructional uses of computers in the schools. After factoring out variables such as socio-economic status, class size and teacher qualifications, Wenglinsky found significant achievement relationships in the eighth grade between NAEP test scores and the use of technology that focused on mathematical projects, problems and simulations that promoted application of knowledge and higher order thinking. Surprisingly, using computers in the eighth grade for drill and practice was negatively related to student achievement.

Research on Instructional Practices

Numerous studies of instruction have confirmed the effectiveness of specific instructional strategies for improving student achievement, many of which support meaning and understanding-based approaches. For example, Stone (1983) used a meta-analysis technique to examine 112 studies on the use of advance organizers to help students organize and connect information and ideas. Overall, advance organizers were shown to be associated with increased learning and retention of material at all grade and ability levels, but lower-ability students tended to profit the most. A meta-analysis of eighteen experiments by Redfield and Rousseau (1981) concluded that the predominant use of higher-level questions during instruction yielded positive gains on tests of factual recall and application of thinking skills. Andre (1979) describes a study that investigated the effects of having students respond to higher-order questions that were inserted every few paragraphs in a text. The researchers concluded that such a procedure facilitates better textbook learning than do fact question inserts. Pressley and colleagues (1992) showed that asking students for explanatory responses to higher-level questions *prior* to instruction activates prior knowledge and focuses attention, resulting in better learning.

A considerable body of research supports the use of meaning-based reading strategies to improve reading. For example E.D. Hirsch, Jr. (2003) demonstrates that using strategies to systematically build "word and world knowledge" - student understanding of what language refers to - is the key to bridging the reading gap between socioeconomic groups and solving the fourth grade slump problem. In the same issue of American Educator[2], researchers and educators suggest specific types of strategies, such as reading and discussing ideas and vocabulary instruction, in order to help students improve reading comprehension ad fluency.

Recent research by Marzano, Pickering, and Pollock (2001) summarized and analyzed multiple studies in order to show that a number of types of instructional strategies significantly affect student achievement. Several strategies found to be highly effective explicitly assist students in making connections, conceptualizing knowledge, and explaining and applying knowledge and ideas to new situations:

> *Identifying similarities and differences;*
>
> *Using "nonlinguistic representations" - primarily graphic organizers, models, mental pictures, artistic expression, and kinesthetic activity;*
>
> *Generating and testing hypotheses through systems analysis, problem solving, historical investigation, invention, and experimental inquiry; and*
>
> *Asking students to explain their thinking.*

Implications for the Classroom

A significant research base exists that supports meaning and understanding based approaches in schools and classrooms. Cognitive psychology research indicates that student learning is enhanced when students are able to explore, organize, connect, process, and apply information and ideas. Student achievement is strengthened when the curriculum is coherent, developmental, and allows for in-depth learning; when instruction focuses on the underlying concepts and ideas to be learned rather than on learning and memorizing discrete bits of information; when students are engaged in the learning process through the use of authentic pedagogy and academic performance tasks that enable them to apply their learning; when they ask questions and develop strategies for problem solving.

Research also supports the idea that meaning and understanding-based instructional strategies make a difference in learning, such as graphic organizers, higher order questions, generating and testing hypotheses, asking students to explain their thinking, and the use of specific reading strategies that enlarge vocabulary and student conceptual frameworks.

Much of this research goes against the prevailing emphasis on "covering" factual knowledge and practicing low-level procedures in an attempt to improve standardized test scores. The research cited here suggests that we need a greater focus on meaning and understanding-based education if we want to promote deep understanding of content, engage learners, and foster genuine student achievement on both traditional and performance measures.

Based on this research, we hope that more schools and districts will view education for meaning and understanding as a long term, significant framework for educating students in the 21st century.

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[1] *Investigations* is a K-5 mathematics education program developed by TERC, funded in part by the National Science Foundation, and published by Pearson Scott Foresman.

[2] See articles and research by Hart and Risley, Chall and Jacobs, Stahl, Biemiller, Walsh, Duke, et.al., and Beck, et. al. in American Educator, Spring 2003.

References

Andre, T. (1979). Does answering higher-level questions while reading facilitate productive learning? *Review of Educational Research, 49*, 280–318.

Bottoms, G., Presson, A. and Johnson, M. (1992). *Making high schools work through the integration of academic and vocational education.* Atlanta, GA: Southern Regional Education Board.

Bottoms, G., and Sharpe, D. (1996). *Teaching for understanding through integration of academic and technical integration.* Atlanta, GA: Southern Regional Education Board.

Bransford, J., Brown, A., and Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Research Council.

Frome, P. (2001). *High Schools That Work: Findings from the 1996 and 1998 assessments.* Triangle Park, NC: Research Triangle Institute.

Hiebert, J., Gallimore, R., Garnier, H. et. al. (2003). *Teaching Mathematics in seven countries: Results from the TIMSS 1999 video study.* Washington, D.C.: U.S. Department of Education.

Hirsch. E.D. Jr. (2003). Reading comprehension requires knowledge – of words and the world, in *American Educator, Volume 27, No. 1*, pp. 10-22, 28-29.

Martin, M., Mullis, I., Gregory, K., Hoyle, C., Shen, C. (2000). *Effective schools in science and mathematics: IEA's Third International Mathematics and Science Study.* Boston: International Study Center, Lynch School of Education, Boston College.

Marzano, R., Pickering, D., and Pollock, J. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

National Center for Research in Vocational Education. (2000). *High Schools That Work and whole school reform: Raising academic achievement of vocational completers through the reform of school practice*. Berkeley, CA: University of California at Berkeley.

Newmann, F., Secada, W. and Wehlage, G. (1995) *A Guide to authentic instruction and assessment: Vision, standards and scoring*. Madison, Wisconsin: Wisconsin Center for Education Research.

Newmann, F., et al. (1996) *Authentic achievement: Restructuring schools for intellectual quality*. San Francisco: Jossey-Bass Publishers.

Newmann, F., Bryk, A., and Nagaoka, J. (2001). *Authentic intellectual work and standardized tests: Conflict or coexistence?* Chicago: Consortium on Chicago School Research.

Pressley, M., et. al. (1992). Encouraging mindful use of prior knowledge: Attempting to construct explanatory answers facilitates learning. *Educational Psychologist*, *27*(1), 91–109.

Redfield, D. L., and Rousseau, E. W. (1981). A meta-analysis of experimental research on teacher questioning behavior. *Review of Educational Research, 51*, 237–245.

Senk, S., and Thompson, D. (2003). *Standards-based school mathematics curricula: What are they? What do students learn?* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Schmidt, W., McKnight, C. and Raizen, S. (1997). *A splintered vision: An investigation of U.S. science and mathematics education.* Norwell, MA: Kluwer Academic Publishers.

Schmidt, W., Houang, R., and Cogan, L. (2002). A coherent curriculum: The case for Mathematics. *American Educator, Volume 26, No. 2,* 10-26.

Schmidt, W. (2004). A vision for mathematics. *Educational Leadership, Volume 61, No. 5,* 6-11.

Smith, J., Lee, V., and Newmann, F. (2001). *Instruction and achievement in Chicago elementary schools*. Chicago: Consortium on Chicago School Research.

Stigler, J., and Hiebert, J. (1999). *The teaching gap*. New York: The Free Press.

Stigler, J., and Hiebert, J. (2004) Improving mathematics teaching. *Educational Leadership, Volume 61, No. 5,* 12-16.

Stone, C. L. (1983). A meta-analysis of advance organizer studies. *Journal of Experimental Education*, *54*, 194–199.

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics.* New Jersey: Educational Testing Service.

Weiss, I. R. et. al. (2003) *Looking inside the classroom: A study of K-12 mathematics and science education in the United States.* Horizon Research, Inc. www.horizon-research.com

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