Math and Science

> *"Students will not be provoked to inquire, learn, or study what they already know or think they know, or what they consider at the moment to be irrelevant."*
>
> Mary Budd Rowe, *Teaching Science as Continuous Inquiry: A Basic*, 1978

Meaningful Tasks

Choosing meaningful learning experiences for students is among the most important instructional decisions a teacher makes. Laboratory work is a distinctive feature of science teaching, while explorations and investigations provide students with tangible mathematical experience. How often are meaningful tasks and concrete materials utilized in today's math and science classrooms and how much value do they have?

Meaningful tasks can be characterized as those that:[1]

- Are challenging, yet within reach of students.
- Pique and take advantage of students' curiosity.
- Are "authentic," building from the students' own involvement.
- Encourage multiple perspectives and interrelated ideas.
- Nest skill development in the context of problem solving and solution making.
- Encourage students to make sense of mathematical and scientific ideas.

Issues

- Learning is enhanced when tasks give students opportunities to use previously learned concepts and techniques in the process of discovering new ones.[2]
- A review of research concerning manipulative use[3] found that:
    - Lessons using manipulative materials are more likely to produce greater mathematical achievement.
    - The inclusion of the concrete stage in a sequence of instruction improves achievement.
    - Studies at every grade level and across a variety of mathematical topics support the importance of the use of manipulative materials.
    - The use of concrete materials is effective with children at all achievement and ability levels.
- Working with concrete materials and in a laboratory also can promote positive attitudes toward math and science. Most students indicate that they prefer lab approaches more than traditional classroom approaches. In the lab, students gain a feeling of being able to achieve curricular objectives independently and an understanding of the experimental aspects within the nature of the subjects.[4]
- Laboratory work provides a wide variety of students with opportunities to be successful in science and math. For low-ability students, concrete representations and laboratory approaches have been proven to be effective since the late 1960s.[5]

- Choosing meaningful tasks involves two important components: the role of context in learning and the role of conceptual conflict in accommodating new knowledge.[6] Context represents the situations in which activities are embedded. These situations become part of what is learned and how the learning is remembered and recalled.[7] Conceptual conflict exists when new information does not seem to fit with what one already knows.
- One complaint of American teachers is that they do not have time to present as many meaningful tasks as they would like. However, the Third International Mathematics and Science Study (TIMSS) revealed that American eighth graders spend more school hours each year studying math and science than students in Japan, who routinely perform better in both subjects. American eighth graders study math an average of 146 hours each school year, and science an average of 139 hours. In Japan, the numbers are 118 hours for math and 91 for science.[8]
- Further research suggests that the advantage of additional time may be negated by the curriculum American teachers are being asked to teach. U.S. teachers, especially mathematics teachers, attempt to teach more topics each year than teachers in most other nations.[9]

Routes and Destinations

- Designing or choosing tasks demands thoughtful and often collaborative planning on the teacher's part. A good investigation is one that not only invites finding one or more solutions but also allows for extensions beyond the immediate problem. Teachers can help facilitate such possibilities by scaffolding questions that allow students to continue reasoning through the problem or by asking challenging questions that motivate students to pursue problem extensions.
- The following list[10] can be used as a guide for evaluating classroom activities and reexamining what students are being asked to do in their textbooks. A rich problem-solving task:
    - Has important, useful mathematics or science embedded in it.
    - May have different solutions or allow for different decisions or positions to be taken or defended.
    - Can be approached by students in multiple ways using different solution strategies.
    - Encourages student engagement and discourse.
    - Requires higher-level thinking and problem solving.
    - Contributes to the conceptual development of students.
    - Promotes the skillful use of mathematical or scientific knowledge or technique.
    - Creates opportunities for teachers to assess what students are learning and where they are having difficulty.
- Engagement is necessary for learning, but it is not enough. Discussion and reflection should accompany active engagement to develop understanding of concepts. While students are engaged in problem-solving tasks, the teacher must listen to students' conversations and ask key questions. This strategy provides the teacher with insights into levels of student understanding and further instructional needs.
- The inherent challenge for the teacher is not only to teach math and science concepts, but also to give meaning and relevance to concepts, applications, and exercises students would otherwise choose not to learn.

Endnotes

1. B. Reys and V. Long, "Implementing the Professional Standards for Teaching Mathematics: Teacher as Architect of Mathematical Tasks," *Teaching Children Mathematics, 1*(5), 1995, p. 297.
2. G. Lappan and D. Briars, "How Should Mathematics Be Taught?" in I. M. Carl (Ed.), *Prospects for School Mathematics,* National Council of Teachers of Mathematics, Reston, VA, 1995.
3. M. N. Suydam, "Using Manipulative Materials to Learn Mathematics," *ERIC/SMEAC Mathematics Education Fact Sheet Number 2,* ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, OH, 1982.
4. J. H. Vance, "The Effects of a Mathematics Laboratory Program in Grades 7 and 8: An Experimental Study." Doctoral dissertation, University of Alberta, Canada, 1969.
5. E. Wasylyk, "Designing Action Mathematics for Low-Ability Students." In *Active Learning in Mathematics, The 1970 Annual of the Mathematics Council of the Alberta Teacher's Association,* Alberta Teacher's Association, Edmonton, Alberta, 1971.
6. M. B. Rowe, *Teaching Science as Continuous Inquiry: A Basic,* McGraw-Hill Book Company, 1978, p. 180.
7. Lappan and Briars
8. M. Martin, I. Mullis, E. Gonzalez, et al., *School Contexts for Learning and Instruction in IEA's Third International Mathematics and Science Study,* Boston College, TIMSS International Study Center, Chestnut Hill, MA, 1999, pp. 72-73.
9. W. H. Schmidt, *A Splintered Vision: An Investigation of U.S. Science and Math Education,* Kluwer Academic Publishing, Boston, MA, 1997.
10. G. Lappan, J. T. Fey, W. M. Fitzgerald, S. N. Friel, and E. D. Phillips, *Getting to Know CMP: An Introduction to the Connected Mathematics Project,* Dale Seymour Publications, Palo Alto, CA, 1996, p. 40.

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