Appendix E

Best Practices in Science Assessment

Assessment in science is everywhere. It is present in the form of a simple clarifying question, a paper and pencil test, an investigation, or a large-scale assessment. The National Science Teachers Association Position Statement on Assessment states:

> *"Science assessments are necessary tools for managing and evaluating efforts to ensure all students receive the science education necessary to prepare them for participation in our nation's decision-making processes and lifelong learning of science in a technology-rich workplace.*" [32]

As a content area, science is something that students actively do, rather than something that is done to them or for them. Science is not merely a collection of concepts; it involves the development of skills in investigation, measurement, observation, analysis, discourse, and synthesis. Science also involves problem solving and the application of new knowledge gained through the process of connecting evidence to form conclusions.

Measurement of student learning of these skills and concepts requires a variety of assessment strategies and tools. Assessment in science is organic to instruction and learning. Assessment, by its very nature, can be likened to a scientific process. It involves careful planning, entails the design of measurement tools and instruments, necessitates the collection of data along with analysis and discussion, and, ultimately, requires decision-making based upon conclusions drawn from the data.

What Does Assessment Look Like In A Science Classroom?

The word science is derived from the Latin verb *scire* which means to know. Students have an innate desire to discover, explore, and investigate. Our goal as science educators is to capitalize on that natural curiosity and build understanding. To determine student understanding, science educators ask questions and listen to student responses, observe how students engage in activities, and study their work. Student discourse, inquiry, and the free flow of ideas should be encouraged. The ideal orchestration and measurement of science instruction is a blend of purposeful and spontaneous teacher-to-student, student to-teacher, and student-to-student verbal and written interactions that involves a variety of assessment techniques.[33] These assessment techniques are used to aid students in thinking deeply about their ideas in science, uncover pre-existing ideas students bring to their learning, and help teachers and students determine how well individuals and the class are progressing toward developing scientific understanding.

In a comprehensive assessment system, science educators must accommodate the variety of purposes that the assessments will serve. Of the three assessment types outlined in the *Criteria and Guidance*, research strongly supports the use of formative assessment to strengthen students' understanding of science.[34] Science educators need to spend time understanding how their students think and what they know prior to and during instruction and use that information to design opportunities to learn that help students develop conceptual understanding. These opportunities to learn are historically defined as *"what schools and teachers must do if curriculum and achievement standards are to be met"*.[35] They exist as a result of educator awareness of the experiences and understandings that students bring into the classroom. It is incumbent upon the educator to connect these experiences with learning goals. This "bridging" process comes about with the careful and cohesive use of formative assessment to inform instruction.

With respect to a comprehensive local assessment system, collaboratively-designed and administered interim assessments in science are useful for assessing progress of students at the grade or course level. For example, collaboratively-designed assessments may be constructed at the school level using item banks that have been aligned to standards. If the assessments are administered as part of a guaranteed and viable curriculum, the data garnered over prescribed intervals (approximately 6-8 weeks) will provide important guidance to students, teachers, schools, families, and LEAs.

A summative assessment in science may take many forms. For instance, an end-of-unit assessment determines student learning over the course of several lessons. Science projects as well as topic papers and lab reports may be used in a summative way as well. Summative assessments could be either objective or subjective in nature, or some combination of the two. An example objective assessment item would be those that generate clear correct or incorrect responses (i.e., multiple choice, true and false, fill in the blank) whereas subjective items would be open-ended in design such as constructed response or performance based tasks. Objective tasks can be scored easily and fairly quickly. Subjective tasks, on the other hand, require calibration, as well as more time and analysis. The scorer must possess requisite knowledge of the concepts in order to make proper judgments of learning. Table E.1 describes various assessment formats that may be used in a science classroom.

Regular administration of a variety of assessments produces rich data that science educators can use to adjust instruction and carefully monitor students' progress. Science educators are the critical agents in aligning assessment, instruction, and learning with a guaranteed and viable curriculum that will boost student achievement in science classrooms.

Table E.1: Assessing Student Learning In the Science Classroom

Objective-Response Formats		***Subjective-Response Formats***		
		Product	**Performance**	**Process-Focused Assessment**
▪ Multiple-choice ▪ True-false ▪ Matching ▪ Enhanced multiple choice ▪ Simple calculations	▪ Fill in the blank ▪ Phrase(s) ▪ Label a diagram ▪ Visual representation	▪ Constructed response ▪ Concept maps ▪ Research paper ▪ "Show your work" ▪ Portfolio ▪ Model ▪ Video/audiotape ▪ Charts/Graphs ▪ Lab report ▪ Student notebooks	▪ Oral presentation ▪ Science lab/demonstration ▪ Hands-on inquiry task ▪ Data analysis task	▪ Debate ▪ Teach-a-lesson ▪ Oral questioning ▪ Observation checklist ▪ Interview ▪ Conference ▪ Process description ▪ "Think aloud" ▪ Lab skills

Adapted from McTighe and Ferrara (1998)

Sources

[1] Trimble, S. (2003). NMSA research summary #20: What works to improve student achievement. Westerville, Ohio: National Middle School Association. Retrieved from: http://www.nmsa.org/portals/0/pdf/publications/On_Target/achievement/achievement_4.pdf

[2] Hattie, J. and Timperley, H. (2007). The power of feedback. *Review of Educational Research,* 77(1), 81-112. doi: 10.3102/003465430298487

[3] Popham, W.J. (2008) Transformative Assessment. Alexandria, VA: ASCD.

[4] Wiliam, D. (2009). *Assessment for Learning: Why, what, and how?* London: Institute of Education University of London.

[5] Rowe, M. B. (1974). Wait time and rewards as instructional variables, their influence on language, logic and fate control: Part one-wait-time. *Journal of Research in Science Teaching*, 11, 81-94. doi: 10.1002/tea.3660110202

[6] Shavelson, R. J. (2006). *On the integration of formative assessment in teaching and learning with implications for teacher education.* Paper prepared for the Stanford Education Assessment Laboratory and the University of Hawaii Curriculum Research and Development Group. Available at www.stanford.edu/dept/SUSE/SEAL

[7] Perie, M., Marion, S., Gong, B., & Wurtzel, J. (2007). The role of interim assessments in a comprehensive assessment system: A policy brief. Retrieved from http://www.achieve.org/files/TheRoleofInterimAssessments.pdf

[8] Perie, M., Marion, S., & Gong, B. (2007). A framework for considering interim assessments. Washington, D.C.: National Center for the Improvement of Educational Assessment. Retrieved from http://www.nciea.org/publications/ConsideringInterimAssess_MAP07.pdf.

[9] The Council of Chief State School Officers (2008). Interim assessment practices and avenues for state involvement TILSA SCASS interim assessment subcommittee. Retrieved from http://www.ccsso.org/Documents/2008/Interim_Assessment_Practices_and_2008.pdf

[10] American Educational Research Association, American Psychological Association, National Council on Measurement in Education (1999). *Standards for Educational and Psychological Testing.* Washington, D.C.: Author.

[11] Trochim, W. (2006). Research methods knowledge base: Reliability & validity. Retrieved from http://www.socialresearchmethods.net/kb/relandval.php

[12] National Research Council. (2001). *Knowing what students know: The science and design of educational assessment.* Washington, D.C.: National Academy Press.

[13] Edwards, P.A., Turner, J.D., & Mokhtari, K. (2008). Balancing the assessment *of* learning and *for* learning in support of student literacy achievement. *The Reading Teacher*, 61(8), 682-684. doi: 10.1598/RT.61.8.12

[14] Rhodes , L. K., & Shankin, N. L. (1993). *Windows into Literacy: Assessing learners K-8*. Heinemann: Portsmouth, NH.

[15] Torgesen, J.K. (2006). A comprehensive K-3 reading assessment plan: Guidance for school leaders. Portsmouth, NH. RMC Research Corporation, Center on Instruction.

[16] Webb, N.K. (2002) Depth-of-Knowledge Levels for Four Content Areas. Wisconsin Center for Educational Research.

[17] Olinghouse, N. G. (2009). Writing assessment for struggling learners. *Perspectives in Language and Literacy*, Summer, 15-18.

[18] NCTE Writing Assessment: A Position Statement (2009).

[19] NCTE Writing Assessment: A Position Statement (2009).

[20] Routman, R. (2005). *Writing Essentials: Raising Expectations and Results While Simplifying Teaching.* Portsmouth, NH: Heinemann.

[21] Strickland, K. & Strickland, R. (2000). Making Assessment Elementary. Portsmouth, NH: Heinemann.

[22] Newkirk, T. & Kent, R. (2007). *Teaching the Neglected "R": Rethinking Writing Instruction in the Secondary Classrooms.* Portsmouth, NH: Heinemann.

[23] National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics*. Reston, VA: Author.

[24] American Federation of Teachers. (2008). Making classroom assessments work for you: Training Materials. Washington, DC: Author.

[25] Webb, N.& Collins, M. (2008). *Depth of knowledge: Descriptors, examples and question stems for increasing depth of knowledge in the classroom.* Kirksville, MO: Truman State University.

[26]Kentucky Department of Education (2007). Support materials for core content for assessment version 4.1: Mathematics. Retrieved from http://www.education.ky.gov/kde/instructional+resources/curriculum+documents+and+resources/core+content+for+assessment/core+content+for+assessment+4.1/content+specific+core+content+for+assessment+dok+support+materials.htm

[27] Bush, W.S. & Leinwand, S.(Eds.). (2000). *Mathematics assessment: A practical handbook for grades 6-8*. Reston, VA: National Council of Teachers of Mathematics.

[28] Sutton, J. & Krueger, A. (Eds.). (2002). *ED thoughts: What we know about mathematics teaching and learning.* Aurora, CO: Mid-continent Research for Education and Learning.

[29] Ibid.

[30] Bush, W.S. & Leinwand, S.(Eds.). (2000). *Mathematics assessment: A practical handbook for grades 6-8*. Reston, VA: National Council of Teachers of *Mathematics*.

[31] Lesh, R. & Lamon, S.J. (1992). *Assessment of authentic performance in school mathematics*. Washington, DC: American Association for the Advancement of Science.

[32] National Science Teachers Association. (2010). Science education assessments - NSTA's official position on assessment. Arlington, VA: Author. Retrieved from http://www.nsta.org/about/positions/assessment.aspx

[33] Keeley, P. (2008). *Science formative assessment: 75 practical strategies for linking assessment, instruction, and learning.* Thousand Oaks, CA: Corwin Press.

[34] Black, P. & Wiliam, D. (1998). Assessment and classroom learning. *Education: Principles, Policy and Practice*, 5, (1), 7-71.

[35] Porter, A. (1993). *Brief to policymakers: Opportunity to learn*. Center on Organization and Restructuring of Schools. Retrieved from http://www.wcer.wisc.edu/archive/cors/brief_to_principals/BRIEF_NO_7_FALL_1993.pdf

[36] National Council for the Social Studies. (2008). A vision of powerful teaching and learning in the social studies: Building effective citizens. *Social Education*, 72 (5), 277-280.

[37] Ibid.

[38] Alleman, J. & Brophy, J. (1999). The changing nature and purpose of assessment in the social studies classroom. *Social Education,* 65 (6), 334-337.

[39] Ibid.