



Standards, Learning Goals, and Assessment

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This section reports on the development of national education standards in mathematics, science, and technology education. It also provides an overview of the MST course with learning goals for students and suggested strategies for assessing student learning. An overview of the national school-to-work legislation also is provided.

National Education Standards for Curriculum, Assessment, and Teaching Strategies

Just six years ago, the nation's political and education leaders recommended that national education standards be developed for all core subjects. The precedent for this national effort was the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* completed in 1989. In 1991, NCTM issued teaching standards to be used in conjunction with the 1989 standards.

The National Research Council's (NRC) National Committee on Science Education Standards and Assessment (NCSESA), with input from groups such as the National Science Teachers Association (NSTA) and the American Association for the Advancement of Science (AAAS), have developed national standards in five areas of science education: science teaching, professional development assessment, content and science education systems.

Although similar standards for technology education have, to date, been developed only at the state level, considerable discussion has occurred about the role of technology in the national standards for mathematics and science.

National standards are not intended to be pronouncements from on high about what goes on in classrooms. Standards are the goals for which we strive, the "banners" under which we define and teach the curriculum and assess student learning. Standards define demanding but attainable learning goals that impart a vision of what we want all our young people to know and be able to do. But they are not prescriptions; they are suggested guidelines. And they must be backed by a nationwide consensus support.

Why do we want standards? First, standards give everyone a common language to communicate agreement on high-quality education. Standards can identify, reward, and defend best practices. For example, supervisors of innovative mathematics teachers will be faced with a

strong counterargument in the standards if they tell teachers that they must drill students on meaningless computational exercises. And publishers and producers of instructional materials and tests that do not align with the standards will face opposition from teachers aware of national standards. Standards can, and ultimately will, influence the context in which every student and teacher functions.

The National Education Standards and MST

As we continue to develop the MST curriculum and the strategies for teaching and assessing student learning, we are ever conscious of our desire to align with the emerging national standards in science, mathematics, and technology education.

Much of what we are now coming to know as national standards was present from the beginning of MST. For example, the interdisciplinary nature of MST reflects the national standards that address the value of connecting and interrelating the disciplines. Following are passages from the science, mathematics, and technology standards, respectively, that call for connections among the disciplines:

“...include all natural sciences and their interrelationships, as well as the natural science connections with mathematics, technology, social science, and history.”

“...use and value the connections between mathematics and other disciplines.”

“...articulate the concepts of mathematics, science, social studies and the arts in the context of technology education.”

The standards have challenged educators to see the content differently and have led to new understandings of science, mathematics, and technology in the classroom. Commonalities among the three disciplines are evident in the standards. All three call for active learning where all students, not just a talented few, gain an in-depth understanding of the subject. The standards call for varied groupings in the classroom in contexts that model the process of inquiry that real-life scientists, mathematicians, and technologists use to uncover new knowledge and solve problems. MST models this process.

The standards-setting process is very new in our nation, and it is not complete. Therefore, the results of that process are only now becoming widely known. As we learn more about the standards, more will be incorporated in MST.

'We are living in a world where what you earn is a function of what you learn.'

—President Bill Clinton

School to Work Opportunities Act

MST provides an environment where all students can develop knowledge and skills useful in a science and technology workplace. Not only does the course reach those 75% of the student population who do not pursue baccalaureate degrees, it also appeals to students in the so-called academic track. The course integrates academic and vocational learning to the extent that it simulates the environment in which scientists and technologists uncover knowledge and solve problems, the kind of school-based learning that assists students in their transition from school to work.

In combination with structured work-based learning and attention to connecting activities, MST fulfills purposes of the new federal legislation President Clinton signed into law in May 1994. The School to Work Opportunities Act is a national effort to develop a school-to-work system to assist students in making the transition from school to the adult workforce. The goal of the Act is to create well-marked paths students can follow to move from school to good first jobs or from school to continued education and training.

The Act focuses on broadening educational and career opportunities for all students by encouraging state and local partnerships between businesses and education institutions. The partnerships will help students make the connection between what they learn in the classroom and what they will be required to do in the workplace.

Although administered and funded by the U.S. Departments of Education and Labor, the initiative puts the onus on state and local partners (students, teachers, parents, business, labor representatives, community-based organizations) to build school-to-work systems to benefit their communities. Four major types of grants are available to help states and localities build their own customized systems. However, every school-to-work system must include three core elements: school-based learning, work-based learning, and connecting activities to help bridge the gap between school and work—the kinds of activities that are a part of MST.

The School to Work Opportunities Act was introduced as a result of increasing national concern about students who pursue little or no formal education beyond high school. Currently, 75% of students in the nation attempt to enter the workforce directly from high school or following only 1 or 2 years of college. Many are not successful in moving from school to work, particularly in areas requiring knowledge and skill in science, mathematics, and technology. They lack basic academic and entry-level occupational skills necessary to succeed.

Although originally designed to deal with students not earning a college degree, the final version of the School to Work Opportunities Act stressed that a school-to-work transition system serve all students, even those bound for college. MST is an example of a curriculum that serves this purpose.

MST Course Content Outline

The following course outline is one example of content to be included in an MST course. You can develop your own as you create a program that fits your district.

Introduction

- Materials - The basic nature and properties of materials
- Solid state - Materials divided into two categories: crystalline and amorphous

Body of Course

- Nature of metals - Properties and characteristics of metals
- Nature of ceramics - Properties and characteristics of ceramics
- Nature of glasses - Properties and characteristics of glasses
- Nature of polymers - Properties and characteristics of polymers
- Nature of composites - Properties and characteristics of composites

Topics to be Integrated

- Physical Properties
 - Thermal properties of materials
 - Electrical properties of materials
 - Strength of materials
 - Optical properties of materials
- Chemical properties
- Periodic table of elements
- Methods of scientific inquiry
- Significant developments in the history of materials
- Application of materials
- Systems of technology development

Integrating MST into Existing Classes

Because MST is a study of “stuff,” it is a relatively simple task to incorporate much of the MST curriculum into an existing physical science class. Typically, MST materials have been used as an integral part of chemistry, substituting more relevant MST experiments for the recipe format found in a most supplemental chemistry manuals. The following is a brief description of one way to integrate MST materials into sections of a first year chemistry course:

Chemistry Topic	MST Experiments/Demonstrations
Chemical elements	Classification of materials
Metals and their properties	Drawing a wire Crystal structure Alloys Pb/Sn alloy Sterling silver Pewter Metals project
Non-metals	Crystal structure Sulfur and its allotropes Amorphous vs crystalline structure Glass Glass project
Carbon chemistry	Polymers Nylon Soft and hard foams RTV Epoxy Polymers project
Oxidation/Reduction	Raku
Stoichiometry	Formulas for glass Heat change of Zn/Al alloy
Chemistry notebook	MST journal
Chemistry text	MST resources, including teacher guide

Learning Goals

Possible learning goals related to the example content outline are highlighted in the box below. The goals are not meant to be tied to specific units of the MST course.

On completing the course, the student will be able to:

- identify materials specific to our environment
- classify materials as metallic or non-metallic
- classify materials as crystalline or amorphous
- describe through writing and discussion the basic properties of materials: mechanical, thermal, chemical, optical, and magnetic
- characterize materials on the basis of chemical bonding and crystal structure
- demonstrate that the properties of materials can be altered by changing their chemical makeup or physical makeup by treating them in various ways through experiments, projects, and written/oral explanations
- use terms specific to materials science and technology in writing and oral presentations
- demonstrate through writing and oral explanations the application of the powers of observation, measurement, and comparison to analyze materials, their properties, and applications
- demonstrate the basic processes of extracting, preparing, and producing materials used in the course through laboratory exercises and projects
- select materials for specific uses based on the properties, characteristics, and service of the materials
- flourish in an environment of creativity
- demonstrate critical thinking skills through problem solving in manipulating and controlling the materials used in the course
- use writing to record observations, procedures, and experiments and as a tool for thinking, studying, and learning the subject matter
- demonstrate in writing and discussion an appreciation and understanding of significant developments in the history of materials
- select, design, and build a project or projects demonstrating the creative and innovative application of materials
- work in a cooperative group setting to solve problems
- demonstrate practical reasoning, and hands-on/minds-on, problem-solving skills in designing, fabricating, and constructing projects during the course.

Assessment

Assessing student learning and instructional quality is an important part of the MST course as it is for all science, mathematics, and technology education. And for MST, assessment means more than just testing. You would be hard pressed to design a multiple choice or short answer test to measure the outcomes of this course. MST's activity-oriented approach requires that you look at assessment differently.

Because the instructional approach focuses on hands-on/minds-on processes, assessment also should focus on evaluating these processes and thinking skills. Assessment techniques should emphasize asking students to generate their own answers and measure scientific thinking and laboratory skills.

Some common characteristics of this kind of assessment, called "authentic" assessment, include the following:

- asking students to perform, create, produce or do something
- tapping higher level thinking and problem-solving skills
- using tasks that represent meaningful instructional activities
- invoking real-world applications
- using people, not machines, to do the scoring, using human judgment
- requiring new instructional and assessment roles for teachers (Herman et al. 1992, p. 6).*

Using authentic assessment, which mirrors MST's problem-solving approach to teaching, you can assess both product and process. You might ask students, for example, to perform a laboratory experiment or solve a real-life problem, using the equipment, materials, and procedures as they would in class. By observing and asking questions, you can evaluate both the process students use and their understanding of the major concepts involved.

Other approaches you might use to assess process include clinical interviews, documented observations, student learning logs and journals, student self-evaluation (oral or written), debriefing interviews about student projects (where the student explains what, why, and how and reflects on possible changes), and student think-alouds in conjunction with standardized or multiple choice tests.

To assess products, you may use essays with prompts, projects with a rating scale, student portfolios with a rating scale, posters/presentations (which mirror the way scientists often present results), student demonstrations of paintings, drama, dances, and stories with a rating scale, and standardized or multiple choice tests, perhaps with a section for explanations (Herman et al. 1992, p. 7).

*Herman J.L., P.R. Aschbacher, and L. Winters. 1992. *A Practical Guide to Alternative Assessment*. Association for Supervision and Curriculum Development, Alexandria, Virginia.

Recent Trends in Assessment

As approaches to teaching and learning have changed, so has assessment and its role in ensuring effective instruction. Recent trends in assessment, highlighted in the box below (Herman et al. 1992, p. 13), show some of these changes.

- Changes from behavioral to cognitive views of learning and assessment
 - From sole emphasis on the products or outcomes of student learning to a concern for the learning process
 - From passive response to active construction of meaning
 - From assessment of discrete, isolated skills to integrated and cross-disciplinary assessment
 - From behavioral manipulations to attention to metacognition (self-monitoring and learning to learn skills) and conative skills (motivation and other areas of affect that influence learning and achievement)
 - Changes in the meaning of knowing and being skilled—from an accumulation of isolated facts and skills to an emphasis on the application and use of knowledge.
- From paper-pencil to authentic assessment
 - From standardized testing to relevance and meaningfulness to students
 - From single skills to an emphasis on complex skills
 - From single correct answers to multiple solutions
 - From hidden standards to public standards, known in advance
 - From uniform expectations to individual pacing and growth.
- Portfolios: from single occasion assessment to samples over time
 - As a basis for assessment by teacher
 - As a basis for self-assessment by students
 - As a basis for assessment by parents.
- From single attribute to multi-dimensional assessments
 - For recognition of students' many abilities and talents
 - For growing recognition of the malleability of student ability
 - For opportunities for students to develop and exhibit diverse abilities.
- From near exclusive emphasis on individual assessment to group assessment
 - Through group process skills
 - Through collaborative products.

Assessment Techniques

In designing assessment strategies you should keep in mind that the keys to assessment are defining goals to be assessed and the criteria used to assess them. As with other formal assessment, you should ensure that the strategy you use specifies the 1) nature of the skills and accomplishments students are to develop, 2) illustrative tasks that would require students to demonstrate these skills and accomplishments, and 3) criteria and standards for judging student performance on the tasks. You also need to develop a reliable rating process and use your results to refine assessment and improve curriculum and instruction (Herman et al. 1992, p. 8). Some example techniques that have been developed to rate student performance are highlighted below.

Task Sheet

One team of MST teachers developed the task sheet shown in Figure 3.1 to track student progress. All projects and experiments on which students work are listed on the sheet. A five-point rating system is defined for the tasks. When a student completes a task, you check the appropriate column. The point values have criteria assigned to them, which the students should know. One point means the task was completed; three points means the task was completed, and the student can explain the process; and five points means the task was completed, and the student was capable of teaching another student how to do the task.

Task Sheet	Name _____		
Experiment/Demonstration	1 pt	2 pts	5 pts
Crystal Study			
Properties of Metals			
Alloying Copper and Zinc			
Drawing a Wire			

Figure 3.1. Task Sheet for MST Assessment

Scoring Guide

The California Assessment Program 1990 developed a Scoring Guide: Group Performance Task form that can be adapted for the MST evaluation. Figure 3.2 shows the four components and five levels of accomplishment. Each level has been defined so you, the student, and others know the assessment criteria. Figures 3.3 and 3.4 show a CAP generalized rubric and an objectives rating form.

Figure 5.1
California Assessment Program 1990
History-Social Science Grade 11
Scoring Guide: Group Performance Task

	Level I Minimal Achievement	Level II Rudimentary Achievement	Level III Commendable Achievement	Level IV Superior Achievement	Level V Exceptional Achievement
Group and Collaborative Learning <u>20</u>	(1-4) Exclusive reliance on one spokesperson. Little interaction. Very brief conversations. Some students are disinterested or distracted.	(5-9) Strong reliance on spokespersons. Only one or two persons actively participate. Sporadic interaction. Conversation not entirely centered on topic.	(8-12) Some ability to interact. At least half the students confer or present ideas. Attentive reading of documents and listening. Some evidence of discussion of alternatives.	(13-16) Students show adeptness in interacting. At least 3/4 of students actively participate. Lively discussion centers on the task.	(17-20) Almost all students enthusiastically participate. Responsibility for task is shared. Students reflect awareness of others' views and opinions and include references to other opinions or alternatives in presentation and answer. Questions and answers illustrate forethought and preparation.
Critical Thinking <u>30</u>	(1-6) Demonstrates little understanding and only limited comprehension of scope of problem or issues. Employs only the most basic parts of information provided. Mixes fact and opinion in developing a viewpoint. States conclusion after hasty or cursory look at only one or two pieces of information. Does not consider consequences.	(7-12) Demonstrates only a very general understanding of scope of problem. Focuses on a single issue. Employs only the information provided. May include opinion as well as fact in developing a position. States conclusion after limited examination of evidence with little concern for consequences.	(13-18) Demonstrates a general understanding of scope of problem and more than one of the issues involved. Employs the main points of information from the documents and at least one general idea from personal knowledge to develop a position. Builds conclusion on examination of information and some consideration of consequences.	(19-24) Demonstrates clear understanding of scope of problem and at least two central issues. Uses the main points of information from the documents and personal knowledge that is relevant and consistent in developing a position. Builds conclusion on examination of the major evidence. Considers at least one alternative action and the possible consequences.	(25-30) Demonstrates a clear, accurate understanding of the scope of the problem and the ramifications of the issues involved. Employs all information from the documents and extensive personal knowledge that is factually relevant, accurate, and consistent in the development of a position. Bases conclusion on a thorough examination of the evidence, an exploration of reasonable alternatives, and an evaluation of consequences.
Communication of Ideas <u>20</u>	(1-4) Position is vague. Presentation is brief and includes unrelated general statements. Overall view of the problem is not clear. Statements tend to wander or ramble.	(5-9) Presents general and indefinite position. Only minimal organization in presentation. Uses generalities to support position. Emphasizes only one issue. Considers only one aspect of problem.	(8-12) Takes a definite but general position. Presents a somewhat organized argument. Uses general terms with limited evidence that may not be totally accurate. Deals with a limited number of issues. Views problem within a somewhat limited range.	(13-16) Takes a clear position. Presents an organized argument with perhaps only minor errors in the supporting evidence. Deals with the major issues and shows some understanding of relationships. Gives consideration to examination of more than one idea or aspect of the problem.	(17-20) Takes a strong, well-defined position. Presents a well-organized, persuasive argument with accurate supporting evidence. Deals with all significant issues and demonstrates a depth of understanding of important relationships. Examines the problem from several positions.
Knowledge and Use of History <u>30</u>	(1-6) Reiterates one or two facts without complete accuracy. Deals only briefly and vaguely with concepts or the issues. Barely indicates any previous historical knowledge. Relies heavily on the information provided.	(7-12) Provides only basic facts with only some degree of accuracy. Refers to information to explain at least one issue or concept in general terms. Limited use of previous historical knowledge without complete accuracy. Major reliance on the information provided.	(13-18) Relates only major facts to the basic issues with a fair degree of accuracy. Analyzes information to explain at least one issue or concept with substantive support. Uses general ideas from previous historical knowledge with fair degree of accuracy.	(19-24) Offers accurate analysis of the documents. Provides facts to relate to the major issues involved. Uses previous general historical knowledge to examine issues involved.	(25-30) Offers accurate analysis of the information and issues. Provides a variety of facts to explore major and minor issues and concepts involved. Extensively uses previous historical knowledge to provide an in-depth understanding of the problem and to relate it to past and possible future situations.

Figure 3.2. California Assessment Program 1990 Scoring Guide (from Herman et al.1992, pp. 46, 47)

Figure 5.3**CAP Generalized Rubric**

(California State Department of Education 1989)

Demonstrated Competence**Exemplary Response . . . Rating = 6**

Gives a complete response with a clear, coherent, unambiguous, and elegant explanation; includes a clear and simplified diagram; communicates effectively to the identified audience; shows understanding of the open-ended problem's mathematical ideas and processes; identifies all the important elements of the problem; may include examples and counterexamples; presents strong supporting arguments.

Competent Response . . . Rating = 5

Gives a fairly complete response with reasonably clear explanations; may include an appropriate diagram; communicates effectively to the identified audience; shows understanding of the problem's mathematical ideas and processes; identifies the most important elements of the problems; presents solid supporting arguments.

Satisfactory Response**Minor Flaws But Satisfactory . . . Rating = 4**

Completes the problem satisfactorily, but the explanation may be muddled; argumentation may be incomplete; diagram may be inappropriate or unclear; understands the underlying mathematical ideas; uses mathematical ideas effectively.

Serious Flaws But Nearly Satisfactory . . . Rating = 3

Begins the problem appropriately but may fail to complete or may omit significant parts of the problem; may fail to show full understanding of mathematical ideas and processes; may make major computational errors; may misuse or fail to use mathematical terms; response may reflect an inappropriate strategy for solving the problem.

Inadequate Response**Begins, But Fails to Complete Problem . . . Rating = 2**

Explanation is not understandable; diagram may be unclear; shows no understanding of the problem situation; may make major computational errors.

Unable to Begin Effectively . . . Rating = 1

Words do not reflect the problem; drawings misrepresent the problem situation; copies parts of the problem but without attempting a solution; fails to indicate which information is appropriate to problem.

No Attempt . . . Rating = 0**Figure 3.3.** CAP Generalized Rubric (from Herman et al. 1992, p. 56)

Figure 5.7
PART II: Objectives Rating Form — Individual

Title of the Task: _____ Task # _____ Student ID # _____

Teacher ID #: _____ Date: _____

The group should be able to...	Where to Find Evidence				E	G	N.I.	*
1. Identify and apply physical and/or chemical properties for the purpose of identification.					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
2. Identify information and steps needed to solve a problem.					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
3. Communicate the strategies of a study through written means.					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
					<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
* Check if students' work is a strong and clear example of rating given.								

(Connecticut Department of Education 1990) E = Excellent G = Good N.I. = Needs Improvement

Figure 3.4. Connecticut Department of Education 1990 Objectives Rating Form (from Herman et al. 1992, p. 56)