# Mathematics, Science & Technology

## PART I.2



**NOTE: This document is a work in progress. Parts II and III, in particular, are in need of further development, and we invite the submission of additional learning experiences and local performance tasks for these sections. Inquiries regarding submission of materials should be directed to: The Mathematics, Science, and Technology Resource Guide, Room 681 EBA, New York State Education Department, Albany, NY 12234 (tel. 518-474-5922).**

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# Planning for Scope and Sequence

MST

1 2 3 4
5 6 7

Scope & Sequence

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

Many local districts are already engaged in revising their curriculum, instruction, and assessment to align with the new standards. Others are just beginning. They are looking for suggestions about how to go about the process. This is a compendium of ideas gleaned from those who are involved in developing new curriculum and assessment.

Districts may use many different strategies for implementing the standards in the seven content areas. Some districts may choose to work on all seven simultaneously, appointing committees for each. Others may decide to focus on one content area, establish a solid foundation for that one, and then move to another. Since implementation of the standards plays out differently at elementary, intermediate, and commencement levels, some districts may choose to focus on one level at a time, while others work for vertical integration.

No matter what the structure, it is important to tailor a plan to the local needs of the students in the community. Thus, all segments of the community—teachers, administrators, parents, students, and community leaders—should be actively involved in devising a plan.

## HOW TO BEGIN

To begin, conduct an analysis designed to answer these questions:

- Where is the district (or school) now with regard to this content area?
- Where does the district (or school) want to be with regard to this content area, based on the needs of the community and the direction suggested by the standards?
- What does the district (or school) have to do to get from where it is to where it wants to be? What is the action plan? What is the timeline? How will resources be allocated?
- How will progress be evaluated? How might feedback from evaluation be used as the basis for further revision?

## Teacher Actions in Support of the Standards

- Select content, adopt, or design curricula to meet interests, skills, knowledge, and experience of students.
- Encourage students to talk together as they formulate ideas. Demand respect for ideas of all students.
- Structure time available so that students are able to engage in extended investigations and activities.
- Challenge students to take responsibility for their own work and also to work collaboratively.
- Respond positively to student diversity, encourage all students to participate fully in classroom activities.
- Analyze assessment data to guide further teaching.
- Give students a significant voice in the content and context of their own work.

- Provide developmentally appropriate curriculum in which real world contexts are relevant to students' experiences and children's language.
- Give children enough time to construct sound understanding and to develop their ability to reason and communicate. Give them time to think about ideas and to look beyond what they appear to know.
- Recognize that motivation and emotions are important in students' willingness to continue to study.
- Instill in students a sense of confidence in their own ability to think and to solve problems, to make appropriate decisions in selecting strategies, to recognize familiar structures in unfamiliar settings, to detect patterns, and to analyze data.
- Make available needed tools and resources.

## School Actions in Support of the Standards

- Involve teachers in planning and developing effective programs.
- Encourage and support teacher's efforts to collaborate.
- Give teachers a voice in decisions about allocation of time and resources, restructure the school day so that more time is available to teach.
- Encourage teachers to plan and implement professional development for themselves and their colleagues.
- Build on teachers' content knowledge and incorporate ongoing reflection about the process and outcomes of learner-centered approaches.
- Provide integrative opportunities which help teachers connect content across subject areas.
- Provide planning time across disciplinary borders so that teachers may provide integrated experiences for students.
- Provide students access to appropriate material resources for conducting their studies (e.g., books, mathematical manipulatives, art and science supplies, tools). Provide regular access to calculators and computers.

## Professional Development in Support of the Standards

- Help teachers pose and find answers to common questions such as: "What kind of planning is needed to precede learner-centered teaching?" "What do I do if students don't respond as expected?"
- Provide for follow-up opportunities after institutes and workshops, chances for teachers to compare notes and reflect on their attempts to teach according to the standards.
- Provide teachers opportunities to communicate with teachers in other schools.
- Conduct professional development in an interactive, facilitative style that models behaviors for teachers to adopt in the classroom.
- Introduce teachers to professional literature, media, and technological resources that expand their knowledge and enhance their ability to gain further knowledge.

# Thinking About Change in the Face of Educational Restructuring

MST

1 2 3 4
5 6 7

Scope & Sequence

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

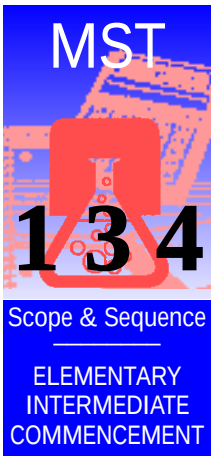
Teachers at Emerson Junior High School, Yonkers, identified the following characteristics of *change* as they moved to create an inquiry approach to teaching and learning in their school.

## Steps to success included:

- identifying a vision for teaching and learning
- establishing a steering committee to coordinate efforts
- rewriting a master schedule collaboratively
- creating a teacher technology center for workspace
- relinquishing leadership to teachers by administrators
- facilitating teaching and learning through discipline, facility cleanliness, and order
- moving to inquiry-based teaching and learning through curriculum integration and alternative assessment
- encouraging teachers to see themselves as *Experts*
- compensating teachers with money and intrinsic rewards
- hearing dissenting points of view.

Adapted from: Heldman, Pamela. Emerson Junior High School, Yonkers City Schools.

# Checklist for Selecting Quality Mathematics and Science Materials and Programs




**DIRECTIONS**

This checklist is intended to be used by educators to examine and evaluate instructional materials. It is organized into three sections: ***Contextual View, Examine Closer, and Verification.***

The four questions under Contextual View are intended to be the filter for the instructional materials. If those questions cannot be answered positively, then the materials should not be considered for use with students. If the questions can be answered positively, then the materials should be analyzed using the questions posed under ***Examine Closer*** and then confirmed with the ***Verification*** section.

**CONTEXTUAL VIEW**

Are the materials/activities safe for both the teacher and the students and/or include the appropriate safety precautions and directions?

___ Do the materials stimulate students' interest and relate to their daily lives?

___ Do the materials actively engage the students in learning?

___ Do the materials contain substantive ideas and strategies?

**EXAMINE CLOSER**

*Do the materials stimulate students'interest and relate to their daily lives?*

___ Are the materials appropriate for diverse student populations and diverse learning styles?

___ Are the materials, instructional strategies, and assessments bias free and do they promote equity (culture, gender, ability, etc.)?

___ Do the materials reflect the high expectations for ALL students regardless of race, culture, gender, religion, physical ability, or socioeconomic status?

___ Does the material/activity utilize and model for the teacher and learner appropriate use of technology?

___ Are there connections made with real world life situations and within disciplines?

*Do the materials actively engage students in learning?*

___ Do the materials provide numerous and varied experiences that require students to reason and think critically, use problem solving techniques, and promote higher level thinking?

___ Do the materials present a logical sequence of related activities that will help students build conceptual understanding through multiple learning opportunities?

___ Do the materials provide the learner opportunities to communicate ideas orally and in writing in the development of the appropriate language of science and/or mathematics?

___ Do the materials provide opportunities for students to express in a variety of ways what they know, can do, and how they think about math and science?

___ Does the material/activity provide opportunities for students to work both independently and collaboratively with others?

*Do the materials contain substantive ideas and strategies?*

___ Do the materials provide students opportunities to investigate important mathematics and science concepts in depth over an extended period of time?

___ Do the materials use multiple means of assessment that can be integrated with instruction?

___ Do the materials address the domains in mathematics and science described in the national standards and the State frameworks?

___ Do the materials allow teachers to take into account the students' prior knowledge, experience, and prerequisite skills?

*Other Considerations*

___ Are the materials and activities safe?

___ Do the materials/activities meet rules, regulations, and policies?

___ Are the materials accurate, error-free, and up-to-date?

___ Are the materials cost effective?

___ Are the materials readily available?

**VERIFICATION**

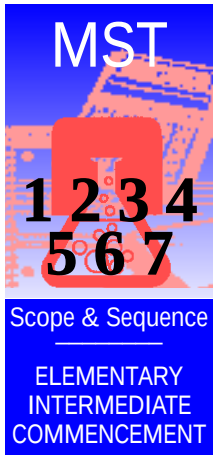
___ Do the materials/activities incorporate appropriate research, strategies, and methods?

___ Can the material/activity be adapted or modified to meet the needs of the students or program?

___ Is the assessment relevant, unbiased, and aligned with instruction?

Adapted from: George, Y.S. and VanHorne, V.V., *Science Education Reform for All (SERA),* AAAS. 1996.

# Raising the Ceiling for Students Advanced in Mathematics and Science




During the ongoing pursuit of higher academic standards for mathematics, science, and technology, we cannot afford to let advanced students march in place. High academic standards for all students should include attention to the needs of the most able. Without direct and challenging instruction matched to their talent, even the most able students will not advance far on their own.

Teachers must recognize mathematical and scientific talent, develop higher expectations for all, including those with the highest potential, and contine adjusting a student's learning program to match his/her demonstrated level and pace of learning.

Teachers are the single most important factor in the development of academic talent. They need to know how to recognize high ability, how to use out-of-level assessment tools to probe for advanced skills and understanding, and how to adjust instruction.

Advanced students strive to make sense of the world by noticing spatial and quantitative relationships and connections in everything. These skills can be reinforced and enhanced in the classroom. If the students are always given pre-selected problems to solve, then teachers will miss the opportunity to know who can perform at the top levels. It should be noted that the best problem-solvers may not always be the ones with the best computational skills.

## How can I recognize specific mathematical and/or scientific talent?

Look for students who display many of the following characteristics:

- ease in mastering the typical mathematics, science, and technology curriculum
- early curiosity and understanding of quantitative information and mathematics symbols
- ability to perceive, visualize, and generalize patterns and relationships
- ability to reason analytically, deductively, and inductively
- ability to switch reasoning methods with ease
- advanced problem-solving and/or computational skills
- ability to hold unsolved problems in mind for future consideration
- fluency in representing mathematical and scientific ideas in different media such as manipulatives, drawings, equations, or models.

## What kind of mathematics/science educational environment will offer academic challenges?

- **Core curriculum** must be delivered at an appropriate pace followed by the chance for the advanced students to study topics in greater depth.
- **Examples of superior student work** should be provided as important stimulus to further achievement. Top students need to be challenged by each other. As an example,

Adapted from: Aldrich, Phyllis, Coordinator, Gifted and Talented Resource Center, Washington-Saratoga-Warren-Hamilton-Essex BOCES.

think of how Olympic athletes reach higher levels of performance because they compete against high achieving peers.

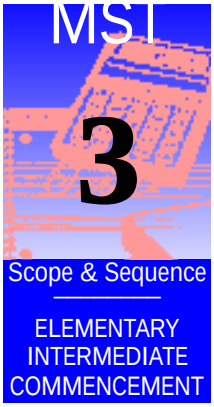
- Students need a chance to work on **complex problems** beyond the repetition and review that dominate most math instruction in the United States.
- Teachers should try to cover fewer topics at **greater depth,** rejecting the current practice of covering many topics superficially.

## How can I teach the mathematically or scientifically talented?

- Top students need to be given multiple opportunities to **apply** their math or science knowledge **in new situations** where the answer is not obvious, and they have no preset rule on which to rely.
- In addition to solving problems that others have suggested, students must be challenged to create, define, or pose new problems.
- Some students may create or discover the mathematics or scientific processes necessary to solve problems they have formulated. Teachers can model strategies necessary to arrive at this sophisticated level by going beyond memorized rules and previously solved problems to pointing out possible new relationships or patterns.

Mathematics- and science-talented children have the potential for advanced thinking about numbers, patterns, and connections. While often rewarding to teach, they constitute a special responsibility for teachers. Unless the most advanced are challenged, given room to grow, and incentives to do so, their talent can be seriously endangered. They need instruction to develop their talent. Boredom and repeated experiences with work well below their level of mastery can erode their joy and passion for exploring mathematics or science.

In sum, talented students need what all students need to grow intellectually—a challenging setting. When teachers see students as individuals, ask intriguing questions, nudge children to pose problems, and listen carefully to their thinking, then they can create an "optimal match" whereby talented students will no longer be left to march in place.




# Summary of Changes in Content and Emphasis

These charts from the National Council of Teachers of Mathematics highlights K-12 content areas where emphasis should be increased in order to focus on higher order thinking. The charts also list content areas where emphasis should be decreased. This information is a useful reference as districts align their curriculum with the State standards.

## K–4 Mathematics

| INCREASED ATTENTION | DECREASED ATTENTION |
|---|---|
| **NUMBER**<br>◆ Number sense<br>◆ Place-value concepts<br>◆ Meaning of fractions and decimals<br>◆ Estimation of quantities | **NUMBER**<br>◆ Early attention to reading, writing, and ordering numbers symbolically |
| **OPERATIONS AND COMPUTATION**<br>◆ Meaning of operations<br>◆ Operation sense<br>◆ Mental computation<br>◆ Estimation and the reasonableness of answers<br>◆ Selection of an appropriate computational method<br>◆ Use of calculators for complex computation<br>◆ Thinking strategies for basic facts | **OPERATIONS AND COMPUTATION**<br>◆ Complex paper-and-pencil computations<br>◆ Isolated treatment of paper-and-pencil computations<br>◆ Addition and subtraction without renaming<br>◆ Isolated treatment of division facts<br>◆ Long division<br>◆ Long division without remainders<br>◆ Paper-and-pencil fraction computation<br>◆ Use of rounding to estimate |
| **GEOMETRY AND MEASUREMENT**<br>◆ Properties of geometric figures<br>◆ Geometric relationships<br>◆ Spatial sense<br>◆ Process of measuring<br>◆ Concepts related to units of measurement<br>◆ Actual measuring<br>◆ Estimation of measurements<br>◆ Use of measurement and geometry ideas throughout the curriculum | **GEOMETRY AND MEASUREMENT**<br>◆ Primary focus on naming geometric figures<br>◆ Memorization of equivalencies between units of measurement |
| **PROBABILITY AND STATISTICS**<br>◆ Collection and organization of data<br>◆ Exploration of chance | |
| **PATTERNS AND RELATIONSHIPS**<br>◆ Pattern recognition and description<br>◆ Use of variables to express relationships | |
| **PROBLEM SOLVING**<br>◆ Word problems with a variety of structures<br>◆ Use of everyday problems<br>◆ Applications<br>◆ Study of patterns and relationships<br>◆ Problem-solving strategies | **PROBLEM SOLVING**<br>◆ Use of clue words to determine which operation to use |
| **INSTRUCTIONALPRACTICES**<br>◆ Use of manipulative materials<br>◆ Cooperative work<br>◆ Discussion of mathematics<br>◆ Questioning<br>◆ Justification of thinking<br>◆ Writing about mathematics<br>◆ Problem-solving approach to instruction<br>◆ Content integration<br>◆ Use of calculators and computers | **INSTRUCTIONALPRACTICES**<br>◆ Rote practice<br>◆ Rote memorization of rules<br>◆ One answer and one method<br>◆ Use of worksheets<br>◆ Written practice<br>◆ Teaching by telling |

Source: *Curriculum and Evaluation in Standards for School Mathematics*, National Council of Teachers of Mathematics.

# 5-8 Mathematics

## INCREASED ATTENTION

**PROBLEM SOLVING**
- Pursuing open-ended problems and extended problem-solving projects
- Investigating and formulating questions from problem situations
- Representing situations verbally, numerically, graphically, geometrically, or symbolically

**COMMUNICATION**
- Discussing, writing, reading, and listening to mathematical ideas

**REASONING**
- Reasoning in spatial contexts
- Reasoning with proportions
- Reasoning from graphs
- Reasoning inductively and deductively

**CONNECTIONS**
- Connecting mathematics to other subjects and to the world outside the classroom
- Connecting topics within mathematics
- Applying mathematics

**NUMBER/OPERATIONS/COMPUTATION**
- Developing number sense
- Developing operation sense
- Creating algorithms and procedures
- Using estimation both in solving problems and in checking the reasonableness of results
- Exploring relationships among representations of, and operations on, whole numbers, fractions, decimals, integers, and rational numbers
- Developing an understanding of ratio, proportion, and percent

**PATTERNS AND FUNCTIONS**
- Identifying and using functional relationships
- Developing and using tables, graphs, and rules to describe situations
- Interpreting among different mathematical representations

**ALGEBRA**
- Developing an understanding of variables, expressions, and equations
- Using a variety of methods to solve linear equations and informally investigate inequalities and nonlinear equations

**STATISTICS**
- Using statistical methods to describe, analyze, evaluate, and make decisions

**PROBABILITY**
- Creating experimental and theoretical models of situations involving probabilities

**GEOMETRY**
- Developing an understanding of geometric objects and relationships
- Using geometry in solving problems

**MEASUREMENT**
- Estimating and using measurement to solve problems

**INSTRUCTIONALPRACTICES**
- Actively involving students individually and in groups in exploring, conjecturing, analyzing, and applying mathematics in both a mathematical and a real-world context
- Using appropriate technology for computation and exploration
- Using concrete materials
- Being a facilitator of learning
- Assessing learning as an integral part of instruction

## DECREASED ATTENTION

**PROBLEM SOLVING**
- Practicing routine, one-step problems
- Practicing problems categorized by types (e.g., coin problems, age problems)

**COMMUNICATION**
- Doing fill-in-the-blank worksheets
- Answering questions that require only yes, no, or a number as responses

**REASONING**
- Relying on outside authority (teacher or an answer key)

**CONNECTIONS**
- Learning isolated topics
- Developing skills out of context

**NUMBER/OPERATIONS/COMPUTATION**
- Memorizing rules and algorithms
- Practicing tedious paper-and-pencil computations
- Finding exact forms of answers
- Memorizing procedures, such as cross-multiplication, without understanding
- Practicing rounding numbers out of context

**PATTERNS AND FUNCTIONS**
- Topics seldom in the current curriculum

**ALGEBRA**
- Manipulating symbols
- Memorizing procedures and drilling on equation solving

**STATISTICS**
- Memorizing formulas

**PROBABILITY**
- Memorizing formulas

**GEOMETRY**
- Memorizing geometric vocabulary
- Memorizing facts and relationships

**MEASUREMENT**
- Memorizing and manipulating formulas
- Converting within and between measurement systems

**INSTRUCTIONALPRACTICES**
- Teaching computations out of context
- Drilling on paper-and-pencil algorithms
- Teaching topics in isolation
- Stressing memorization
- Being the dispenser of knowledge
- Testing for the sole purpose of assigning grades

# 9–12 Mathematics

## INCREASED ATTENTION

- The active involvement of students in constructing and applying mathematical ideas
- Problem solving as a means as well as a goal of instruction
- Effective questioning techniques that promote student interaction
- The use of a variety of instructional formats (small groups, individual explorations, peer instruction, whole-class discussions, project work)
- The use of calculators and computers as tools for learning and doing mathematics
- Student communication of mathematical ideas orally and in writing
- The establishment and application of the interrelatedness of mathematical topics
- The systematic maintenance of student learnings and embedding review in the context of new topics and problem situations
- The assessment of learning as an integral part of instruction

## DECREASED ATTENTION

- Teacher and text as exclusive sources of knowledge
- Rote memorization of facts and procedures
- Extended periods of individual seatwork practicing routine tasks
- Instruction by teacher exposition
- Paper-and-pencil manipulative skill work
- The relegation of testing to an adjunct role with the sole purpose of assigning grades

## TOPICS TO RECEIVE INCREASED ATTENTION

**ALGEBRA**
- The use of real-world problems to motivate and apply theory
- The use of computer utilities to develop conceptual understanding
- Computer-based methods such as successive approximations and graphing utilities for solving equations and inequalities
- The structure of number systems
- Matrices and their applications

**GEOMETRY**
- Integration across topics at all grade levels
- Coordinate and transformation approaches
- The development of short sequences of theorems
- Deductive arguments expressed orally and in sentence or paragraph form
- Computer-based explorations of 2-D and 3-D figures
- Three-dimensional geometry
- Real-world applications and modeling

**TRIGONOMETRY**
- The use of appropriate scientific calculators
- Realistic applications and modeling
- Connections among the right triangle ratios, trigonometric functions, and circular functions
- The use of graphing utilities for solving equations and inequalities

**FUNCTIONS**
- Integration across topics at all grade levels
- The connections among a problem situation, its model as a function in symbolic form, and the graph of that function
- Function equations expressed in standardized form as checks on the reasonableness of graphs produced by graphing utilities
- Functions that are constructed as models of real-world problems

**STATISTICS**
**PROBABILITY**
**DISCRETE MATHEMATICS**

## TOPICS TO RECEIVE DECREASED ATTENTION

**ALGEBRA**
- Word problems by type, such as coin, digit, and work
- The simplification of radical expressions
- The use of factoring to solve equations and to simplify rational expressions
- Operations with rational expressions
- Paper-and-pencil graphing of equations by point plotting
- Logarithm calculations using tables and interpolation
- The solution of systems of equations using determinants
- Conic sections

**GEOMETRY**
- Euclidean geometry as a complete axiomatic system
- Proofs of incidence and betweenness theorems
- Geometry from a synthetic viewpoint
- Two-column proofs
- Inscribed and circumscribed polygons
- Theorems for circles involving segment ratios
- Analytic geometry as a separate course

**TRIGONOMETRY**
- The verification of complex identities
- Numerical applications of sum, difference, double-angle, and half-angle identities
- Calculations using tables and interpolation
- Paper-and-pencil solutions of trigonometric equations

**FUNCTIONS**
- Paper-and-pencil evaluation
- The graphing of functions by hand using tables of values
- Formulas given as models of real-world problems
- The expression of function equations in standardized form in order to graph them
- Treatment as a separate course

# Bibliography

The resources included in this bibliography will assist teachers as they realign their curriculum to inform the State mathematics, science, and technology standards.

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