Mathematics, Science & Technology

PART I.4

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).

http://www.nysed.gov

Teaching and Learning Strategies Introduction

As teachers plan and reflect with their students and with each other on the best practices they can employ to illustrate the learning standards, their work will include elements of planning, instructional design, assessment development, professional development, etc. They will be aware of inquiry approaches, mathematics / science / technology integration, equity concerns, attention to all seven standards, and components of effective scope and sequence activities as they develop new teaching strategies. The following examples are representative of work now underway by teachers in New York State schools who are attempting to develop standards-based approaches to instruction.

Teaching/Learning

Essential Components of Curriculum, Instruction, and Assessment

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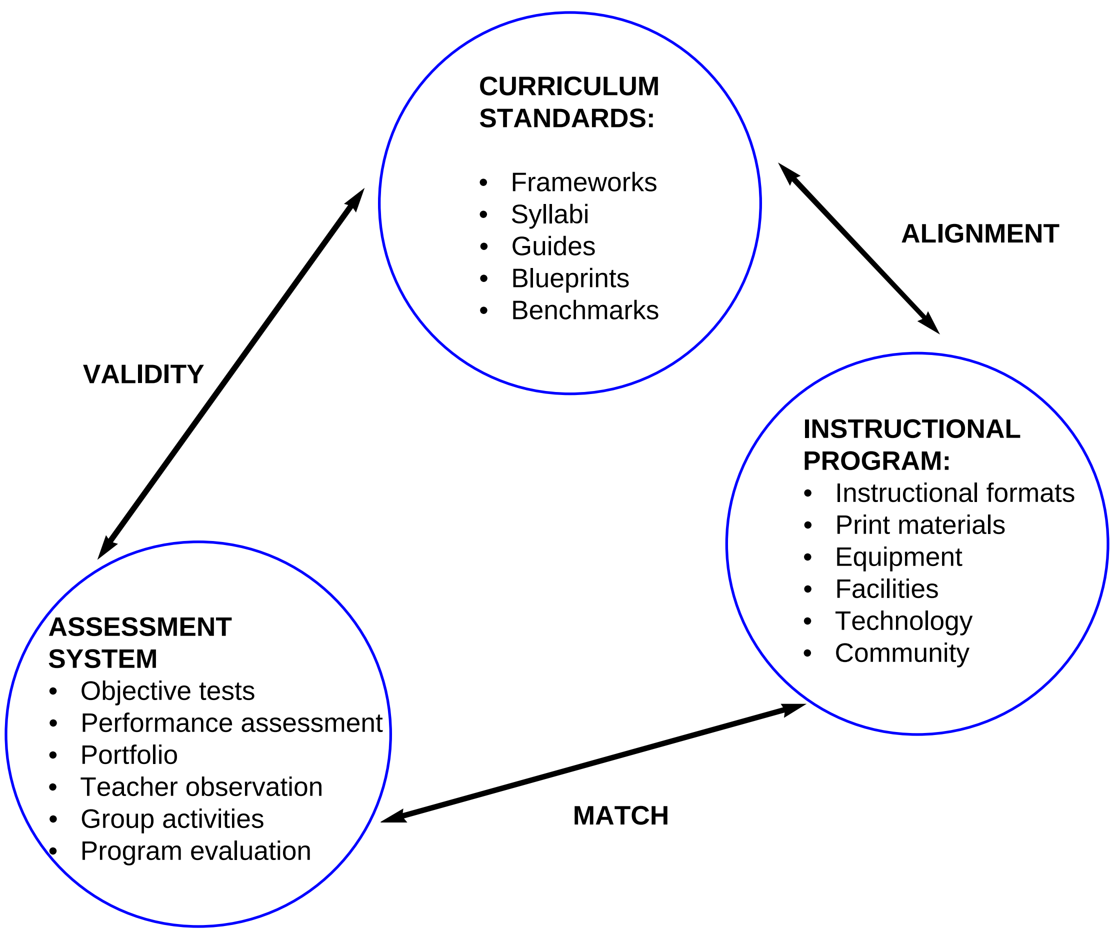
1 2 3 4
5 6 7

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

This chart illustrates the relationships among curriculum, instruction, and assessment and the tools employed by teachers and curriculum developers to ensure validity and alignment. Curriculum, instruction, and assessment become a seamless web of interconnected activities.



Source: Reynolds, Douglas S., Doran, Rodney L., Allers, Robert H., and Agruso, Susan A. *Alternative Assessment in Science: A Teacher's Guide*, The New York State Education Department, University of Buffalo, 1996.

Teaching/Learning

Reflecting on the Seven Standards

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5 6 7

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

J. Valenti has shared his quick procedure to gain instant feedback on the curriculum and whether it is meeting the mathematics, science, and technology standards or not. Using these six simple steps provides accountability to the mathematics, science, and technology framework team that he is part of in his school. "I could not imagine waiting to the end of the year and then beginning this reflection process," states Valenti.

1. Photocopy two copies of the Mathematics, Science, and Technology Standards Chart in the Resource Guide Appendix.

2. Tape one copy on your classroom desk and the second copy in your planbook.

3. When you plan your lessons / unit, record the number(s) of the mathematics, science, and technology standards that correlate.

4. At the end of the school week, evaluate the curriculum and its correlation to the mathematics, science, and technology standards.

5. Record any immediate revisions, recommendations, or comments.

6. Every 4-6 weeks, perform a general overview of your reflections and indicate how you plan on improving the curriculum for next year to meet the mathematics, science, and technology standards. Ask the following:
   a) Does the curriculum have a strong, medium, or weak correlation to the mathematics, science, and technology standards?
   b) Am I over emphasizing, under emphasizing, etc. certain mathematics, science, and technology standards?

Source: Valenti, J. *Science Teacher's Association of New York State Newsletter*, 1996.

Teaching/Learning

-To Explain
-Why explain?
-What does EXPLAIN mean?

MST

1 3 4 5

COMMENCEMENT

Teachers know that the verb *explain* is used frequently in the performance indicators that accompany the mathematics, science, and technology learning standards—especially at the commencement level. The term refers to student descriptions or arguments which account for observations and reveal underlying understandings of a phenomena. These understandings are referred to as mental models, conceptual or explanatory frameworks, or conceptualizations. Explanations can be in the form of :

- oral or written statements
- drawings
- mathematical formulations / calculations
- demonstrations
- construction of physical models

Documentation of student work could include:

- ✔ Problem Statement Articulated
- ✔ Research Done
- ✔ Media Used
- ✔ Scientific Investigations Used
- ✔ Mathematics, Science, and Technology Knowledge / Skills Learned and / or Applied
- ✔ Alternative Solution Ideas Generated
- ✔ Drawings and Sketches Created
- ✔ Charts, Tables, and Graphs Used to Present Data
- ✔ Patterns and Relationships Analyzed
- ✔ Solution / Path to Solution Evaluated
- ✔ Plan Used to Present Solution Outlined.

Ex-pláin: To make plain or understandable.

MST

1 3 4 7

ELEMENTARY

Teaching/Learning Of Puddles and Perimeters

Natalie White teaches at an urban school with 87 percent of its students living in poverty. She knew that if she could infuse lessons with excitement for an urban, disadvantaged six-year-old, she could launch that child on a lifetime adventure of reading books and learning. She was confident in her ability to teach, but still she was troubled. “I could see that children could pass a math test, but I knew they didn’t understand the concepts behind it. I became obsessed with what they really knew. I wanted them to possess something—to have real understanding.”

These days, the 10-year veteran of Southside couldn’t be happier about her students’ comprehension. Ms. White began using inquiry techniques with her first graders and learned to quit thinking in terms of ‘right’ and ‘wrong’ answers to questions that focused on higher-level thinking skills. She loves the results she is getting.

“I have a book called Puddle Questions,” she says. “The first question was, ‘How do you measure a puddle?’ I placed objects such as a ruler, string, and toothbrush on a table—some were measuring devices, some not—and the students picked what they felt they could measure with and drew pictures of those devices, which we evaluated. Then we went outside and actually measured a puddle. Some students stuck a ruler in, to see how deep it was. Some used cup measures, to see how much water it held. Some used a sponge; others measured by walking around the puddle with a string.”

“In that way, we wound up discussing perimeter and volume—in the first grade!” she exults. “The students didn’t realize they were doing it, but they were. And they learned there was no one right answer. The students who used the string were right and the students who used the ruler were right, too.”

“I think when you’re taking into account what the children know and what they understand, you’re considering each individual child. Before, they would pass a test or fail a test, and I wouldn’t know why. Now I’m taking the time to find out what they know. I find out exactly what the level of understanding is. I think these students will be more successful. If this method of teaching is continued, then we’re bound to meet their needs.”

White, Natalie. First-grade teacher, Southside School, Buffalo City Schools.

Teaching/Learning

Constructing/Reconstructing Mathematics Education

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3

ELEMENTARY

There is a new way of talking about mathematics instruction called constructivism. It is based on the premise that learning is primarily a process of concept construction and active interpretation, as opposed to the absorption and accumulation of information.

Students in Ginny Brown's third-grade classroom have been organized into groups of four, each with a jar containing six layers of 15 jelly beans on the table in front of them. After determining the number of jelly beans in each jar—90—the children have been asked to share the jelly beans among themselves. Since they may not open the jars until after lunch, they must now figure out how many jelly beans each will receive without actually distributing them.

As one group uses a set of base-ten blocks to represent the jelly beans, students realize that it will not "come out even." Their first response to this new problem is that they have made a mistake in the process, so they count the blocks again. Then they count them again using 90 cubes as opposed to eight rods of ten plus ten cubes. Still they have two left over. The students are becoming frustrated by this apparent mistake, when the teacher asks them what they will do when they open the jar and have two jelly beans left over. Thinking once again in terms of jelly beans rather than blocks, the students come up with some ideas. One is to give the extra two jelly beans away; another is to cut the two beans in half so that each student gets another half of a jelly bean. After further discussion with the teacher, they discover that there are two ways to represent this idea on paper: 22 1/2or 22 r 2.

This experience helped students expand their concept of divison. Through group work and nondirective questioning by the teacher, students were able to discuss ideas among their peers and increase understanding by explaining those ideas.

Adapted from: Schifter, D. and Fosnot, C. *Reconstructing Mathematics Education: Stories of Teachers Meeting the Challenge of Reform,* New York: Teachers College Press, 1993.

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1 4
INTERMEDIATE

Teaching/Learning Exploring Density

Note: Many different learning styles/intelligences can be expressed among the choices the teacher gives to students.

DIRECTIONS:

Select <u>two</u> activities from the list below to do. The purpose of this project is for you to demonstrate your understanding of density and how volume and mass affect it. Each activity is worth 15 points. Students who had an average of 93 or higher in the first marking period must do one of the * (starred) activities.

1. Solve the 15 density problems using your understanding of the relationship of mass and volume to density. Each problem is worth 1 point. (Obtain these problems from the teacher.)

*2. Explain the Rising Raisins demonstration in terms of the relationship of mass and volume to density. You will put raisins into clear soda.

3. Create a short story, cartoon, poem, song, dance, video, or computer (hyperstudio) program which shows the relationship of mass and volume to density. Anyone doing a video, dance, song, or computer program should be prepared to show it to the class. You may record the song and play the recording to the class.

4. Determine if the mineral or piece of jewelry which your teacher has is pure gold. This activity should be written up in lab format:
   Problem: Is this object (jewelry or mineral) pure gold?
   Hypothesis: (1/2 point)
   Materials: (1/2 point)
   Procedure: Include both a written description and picture. (3 points)
   Results: Include a data table. (6 points)
   Conclusions: Answer the problem, indicate if your hypothesis was successful, list sources of experimental error, and explain your results. (5 points)

5. Explain how the Cartesian Diver works in terms of the relationship of mass and volume to density.

*6. Build a device that you can use to teach the concept of density. You will be expected to present your device to the class and explain how it can be used to illustrate the density concept. Check with your teacher before doing this activity. Simple devices in which various liquids and solids are mixed together to show varying densities will not be accepted for this project.

Source: Cappiello, Jane, Eighth-grade physical science teacher, Bethlehem Central Middle School, Bethlehem Central Schools.

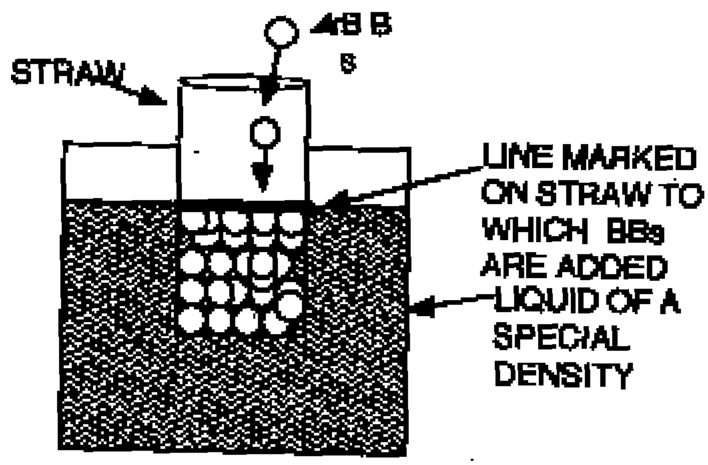
7. Determine the temperature of water at which a special metallic cylinder will go from being more dense to being less dense than the water. Write this up in the following lab format:

   Problem: At what water temperature will the cylinder go from being more dense to being less dense than the water?
   Hypothesis: (1/2 point)
   Materials: (1/2 point)
   Procedure: Include both a written description and picture. (3 points)
   Results: Include a data table. (6 points)
   Conclusions: Answer the problem, indicate if your hypothesis was successful, list sources of experimental error, and explain your results. (5 points)

*8. Solve the following problem in lab format. As part of the *results* section you will be expected to graph the volumes of the two liquids on the horizontal axis and their masses on the vertical axis. You will then be expected to determine the **slope** of the line.

   Problem: Do the densities of water and oil increase as their volumes increase?
   Hypothesis:
   Materials:
   Procedure: Include both a written description and picture. (2 points)
   Results: Include a data table. (9 points)
   Conclusions: Answer the problem, indicate if your hypothesis was successful, list sources of experimental error, and explain your results. (4 points)

*9. Using the straw device provided by your teacher, determine how many BBs it requires to sink the straw to a marked point on the straw in 3 liquids in which you have calculated the densities. Make a line graph in which the number of BBs required is put on the horizontal axis and the densities of the liquids on the vertical axis. Next determine the density of an unknown liquid using your graph, straw and BB device. Show your teacher your graph and density of the unknown liquid.



10. If you have a different idea, please see your teacher about it.

Teaching/Learning

NYSTEP: A Model for Teaching and Learning in the Intermediate Science Classroom

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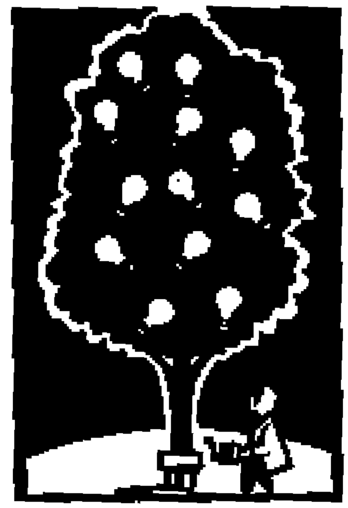
1 3 4
5 7

INTERMEDIATE

The New York State Science, Technology & Society Education Project has produced eight modules for intermediate science. They cover solid waste, wildlife, water, energy, the human body, and other topics. For more information about workshops and materials contact Dr. William Peruzzi, New York State Education Department (518) 473-9471.

PREMISES



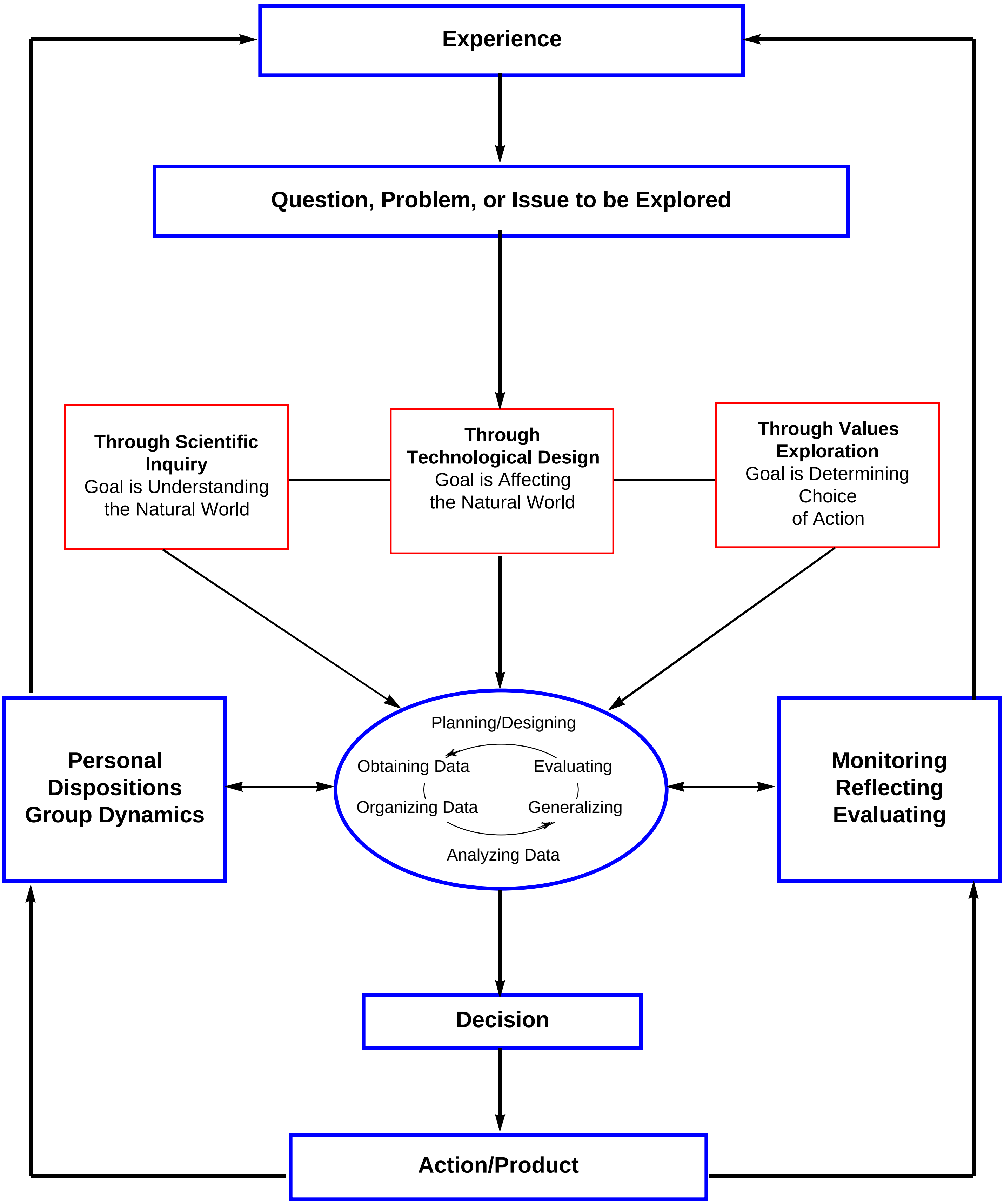
- Students actively construct meaning for themselves as a result of direct, hands-on science experiences with concrete materials, minds-on simulations, and social interactions with other students and / or the teacher.
- Values are an integral part of science teaching and learning.
- Group or cooperative learning is both important to the learning process and somewhat different from learning as an autonomous individual.
- Worthwhile science learning begins with an engaging experience or set of experiences and should culminate in informed responsible action and / or a product.
- All aspects of the model are highly interactive in a way that cannot be accurately captured in two-dimensional space.

The model begins with an *Experience* such as a teacher demonstration or simulation, a hands-on lab, or a field-based investigation. The purpose of the experience is to stimulate students to generate a list of *Questions, Problems, or Issues* that they wish to explore (i.e., the purpose is to create a need to know). This part of the model calls for initial engagement, brainstorming, prioritizing, and decision making as to which particular questions, problems, or issues are both feasible and desirable to explore.

The selected questions, problems, or issues are then explored through a combination of three avenues that converge at the activity-centered oval in the diagram. "Scientific Inquiry" techniques, methods, and theories must be a primary focus of the activities in a science course. On the other hand, the model reminds us that *Technological Design* and *Values* are also important components of student learning in the science classroom. *Ethics* and *values* underlie all scientific and human action. The intent here is not to turn the science class into a philosophy and religion class, but to help students recognize the implicit and explicit role of ethics and values in scientific endeavors.

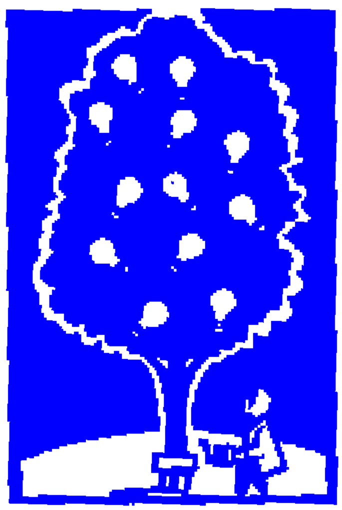
Source: Teacher Guide, *New York Science Technology & Society (STS) Education Project*, New York State Education Department, 1996.

MODEL


Experience
Question, Problem, or Issue to be Explored
Through Scientific Inquiry
Goal is Understanding the Natural World
Through Technological Design
Goal is Affecting the Natural World
Through Values Exploration
Goal is Determining Choice of Action
Personal Dispositions Group Dynamics
Planning/Designing
Obtaining Data
Evaluating
Organizing Data
Generalizing
Analyzing Data
Monitoring Reflecting Evaluating
Decision
Action/Product

The oval in the model is the core focus for activities that follow the initial experience. Groups or individuals need to plan and design, obtain data, process it, generalize from it, and evaluate its worth. This process may be started from any point within the oval, and can be repeated as many times as necessary. The end results are *Decision* and an *Action/Product.* The arrows to the left and right boxes indicate additional factors that come into play when students engage in problem solving as depicted by the oval.

The problem-solving process should result in an individual or group decision that leads to an *Action/Product. Action* refers to anything from a new investigative procedure to informed social action. *Product* refers to anything from a written scientific explanation or an articulate letter to a Congressional representative to a technological device or system created to address a local issue, (e.g., a school recycling program). In addition to objects, the product can be an effect, such as an improved habitat for wildlife on school grounds.



Teaching/Learning

Technology Projects Promote Learning

MST

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ELEMENTARY

I use a thematic approach, revolving around holidays to work with my English as a second language (ESL) students. Using literature as a springboard, students read, discuss, build vocabulary, and complete many language arts activities. At the end of each literature piece, a culminating project evolves from the readings—sometimes teacher-directed and other times student-directed.

Since we are a mathematics, science, and technology magnet school, I use inquiry and design technology strategies with the students. All projects are hand-on / minds-on. They require some type of math and science concept to complete. All projects also have a technology challenge.

Students are placed in cooperative groups of two or three. They discuss the task at hand and research and plan their course of action. Students take charge of their own learning; the teacher facilitates. Students handle a variety of tools and materials. They decide which tools to use and design their projects. Any problems that come up must be solved using higher level thinking skills. Students keep logs of all their plans, designs, and work. They complete a tech-folio and make a presentation at the end of each project.

Through design technology, English as a second language students are much more eager to read, write, and speak the second language. The use of technology becomes a hook to get them interested in learning.

> “*As an English as a second language teacher, I have found technology a great way to develop students’ expressive language skills.*
>
> Ann Rossi

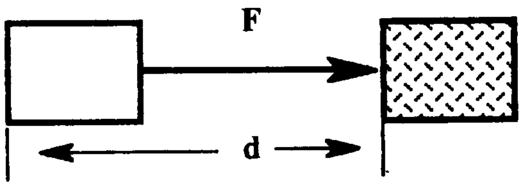
Source: Rossi, Ann. English as a second language teacher, School #14, Yonkers City Schools.

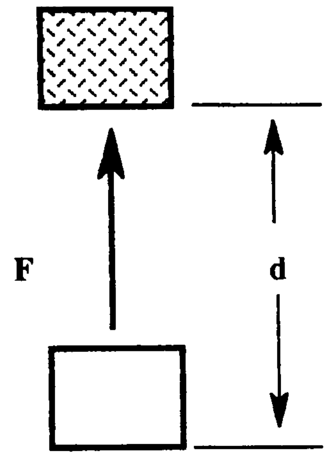
Teaching/Learning

Simple Machines: Concepts and Learning Activities

Two basic scientific concepts need to be understood by the teacher when teaching the simple machines unit. The first is the *conservation of energy*. Put simply, you can't get something for nothing. Energy put into a system cannot be increased or lost. What does change when using machines is the amount of force required to accomplish a given amount of work. The concept of *work is* the second scientific concept to keep in mind when teaching this unit.

Work = Force x Distance





Simple machines are used to reduce the amount of Force required to do the work. The trade off is that the distance the force must be exerted is increased.

Work = Force x Distance
W = F x d
100 = 50 x 2
100 = 20 x 5

> *I've found that when I'm working with design technology, my interest is very high. I have found the same to be true of my students. Most of the time, they become so engaged that they are reluctant to leave school at the end of the day.*
>
> Nelson Gonzalez. Second-grade bilingual teacher, School #14, Yonkers City Schools.

Simple Machine Activities

A. Lever Activity

-idea of fractions, cut the length in half
-compare distances traveled visually
-draw picture of the lever and "discover" triangles

Extensions:

-change fulcrum
-look for a verbal relationship, as the distance from the end of the lever to the fulcrum point increases, the force required _______?

B. Pulley System

-counting
-measuring of distances
-read the "scale", rounding, estimation, place values
-create two data tables as follows:

Table #1

# of pulleys used	force required

Table #2

distance object moved	distance string moved

Look for relationships

1. You can develop verbal and numerical relationships based upon the data collected.
2. Does F' x d' = F x d where F' is the force as measured by the "scale," d' is the distance moved by the scale? F is the force of the object attached to the pulley, and d is the distance the object attached to the pulley moved.

Draw a picture of the pulley system. Indicate with arrows the direction "things" moved.

C. Lego Activity

-draw a picture of the lever constructed using building card 1.

-indicate using arrows the direction for the motion of each joint

-identify the shapes (square, parallelogram, triangles, etc.)

-measure the distance traveled by each "end."

-compare

-change the position of the "pins"

-observe (measure) the changes in distance traveled

-determine any relationships

-measure the distance traveled down and the distance traveled up (for distance, is it circular or vertical?)

-compare

-will the distance change if the brick is removed?

> "*Design technology has provided another method of challenging children to a higher degree of learning. It gives me great pleasure to have a classroom of children working together with such enthusiasm in solving problems. The children's thirst for knowledge accelerates as they solve their problems in a more creative way.*
>
> Marsha Spar. Fourth-grade teacher, School #14, Yonkers City Schools.

Teaching/Learning

Understanding Technology Education

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ELEMENTARY
INTERMEDIATE
COMMENCEMENT

Technology is a word in common parlance which is used in different ways. Sometimes we use the term to mean "technical means". Sometimes we refer to artifacts as technology. Sometimes we mean procedures. Sometimes—and this is a common misperception—we use it to mean technology is synonymous with computer hardware and software.

4 ways to think about technology:

- as an artifact or hardware (e.g., a chair, building, computer, or videotape)
- as a methodology or technique (e.g. painting, using a microscope or pocket calculator)
- as a system of production (e.g., the automobile assembly line or an entire industry)
- as a sociotechnical system (An airplane, for example, suggests a multitude of interrelated devices, human resources, and artifacts such as airports, passengers, pilots, mechanics, fuel, regulations, and ticketing).

3 attributes of technology:

- Technological problem solving is circular; one solution often reveals problems leading to revised, better solutions.
- There is no "right answer." There are multiple solutions with different benefits and burdens. The search is for an *optimal* solution.
- Trade offs are made between what is desired and what is feasible within real-world constraints of time, money, laws of nature, politics, etc. (This also may mean that certain groups profit while other groups are disadvantaged).

3 components of problems in technology:

- given set of resources
- given conditions (constraints)
- state goals.

"Design under constraint" problems have multiple solutions, so students and teachers become focused on the *process* of problem-solving. Therefore, rather than being faced with situations that can only result in success or failure, students experience situations where each outcome offers some opportunity for learning. Through this approach, students learn not only techniques of design and engineering, but gain problem-solving experience in mathematics and science principles.

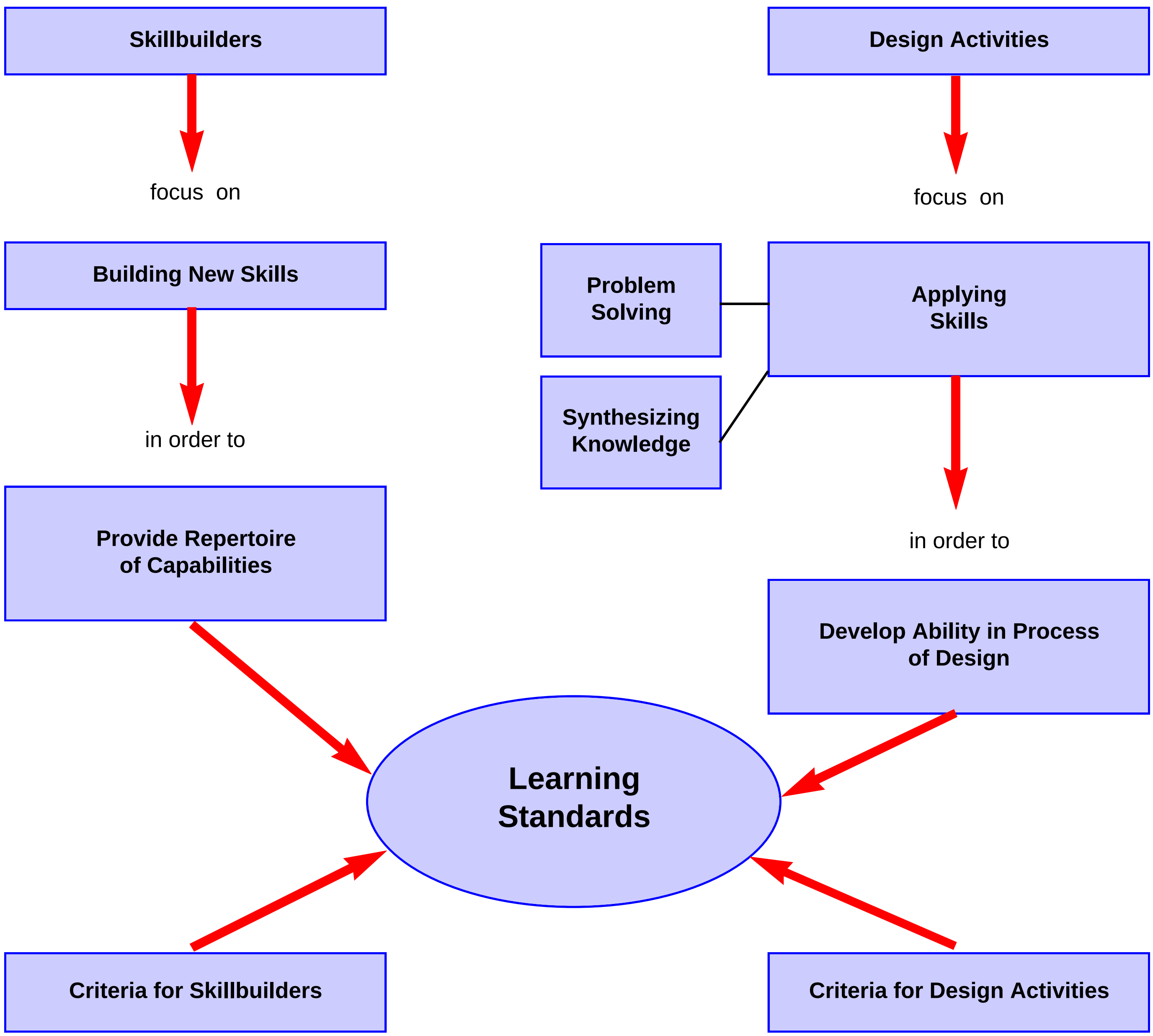
5 hallmarks of a technology education program:

- focus on important ideas in technology
  - ideas that are transferable
  - ideas that provide scaffolding to new learning
- use design as core process through which learning occurs
- use engaging hands-on, minds-on activities
- include contemporary pedagogical methods
  - cooperative learning
  - constructivist teaching
  - authentic assessment
- focus on integrating and synthesizing knowledge
  - from prior experience
  - from prior learning in mathematics, science, and technology and other disciplines.

9 criteria for technology education activities:

- include important ideas (e.g., the learning standards)
- engage interest and be relevant to students
- require a model or product
- be accessible to all students (low cost, accomplished in a school lab)
- be bias-free and developmentally appropriate
- state student expectations clearly
- provide clear instructions to students
- require students to document work
- include opportunities for reflection and self-evaluation of activity.

2 Types - Technology Education Activities



Skills are:

- Useful, transferable
- Acquired in prior learning
- Accomplished over time

- Open-ended
- Important, interesting, familiar
- Require research
- Require scientific inquiry and mathematical analysis
- Require individual and coopera-tive work
- Accomplished over extended time