Mathematics, Science & Technology

Resource Guide

INTRODUCTION

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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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Acknowledgments

Many State Education Department staff members have made significant contributions to the *Mathematics, Science, and Technology Resource Guide.* ***Edward Lalor and Roseanne DeFabio*** originated the concept of the resource guides and served as primary motivating forces in its development. ***Sigrin Newell and Patricia Webster*** reviewed and selected materials for inclusion in Parts I and III of the document and offered their subject area expertise to the overall document. ***Anne Schiano, Jeanette Canaday, and Virginia Hammer*** developed and coordinated the process used to request and review learning experiences from teachers across the State, many of which appear in Part II. Special thanks to ***Sandra LaTourelle, Rose Ambrosino, and Barry Borakove,*** who served as consultants / coaches for Part II and who worked patiently and persistently with teachers to refine the learning experiences. ***John Maryanopolis, Jan Christman, Major Capers, and Patricia Mulligan*** contributed their creative and technical capabilities to the overall design of the Resource Guide. ***Patricia Webster, Judith Golombiski, Carol Anne Stiglmeier, and Edith Toohey*** served as coordinating editors.

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Teachers from many schools and districts served as pioneers by submitting their work for review in Part II. Although the work of each of these teachers may not appear in this edition, all are commended for their contributions. In addition, many teachers and educators contributed information for Parts I and III. Their names can be found with their contributions.

Foreword

New York State is engaged in a serious effort to raise standards for students. The strategy for raising standards, as clearly articulated by Commissioner Richard Mills, includes three elements:

1. Setting clear, high expectations / standards for *all* students and developing an effective means of assessing student progress in meeting the standards;
2. Building the local capacity of schools / districts to enable *all* students to meet standards; and
3. Making public the results of the assessment of student progress through school reports.

The learning standards approved by the Board of Regents reflect the intensive, collaborative work conducted over the past few years by the State Education Department and by national groups, such as the National Center for Restructuring Education, Schools and Teaching (NCREST), the Council of Chief State School Officers, and the New Standards Project.

Learning standards have two primary dimensions. **Content standards** describe what students should know, understand, and be able to do. **Performance standards** define levels of student achievement pertaining to content. However, the teaching and learning which takes place in between is the heart of the matter. This addressess **opportunity to learn standards** and is, perhaps, the most crucial element of the entire process.

Classroom teachers have a tremendous challenge. They must bring reality to the **teaching and learning** process in order to assure that *all* of their students will perform at higher levels. They also have a wonderful opportunity for both professional and personal growth. Numberless occasions are available for teachers to really examine their instructional practice, to share what it is they do each day with their students, to work in collaboration with other teachers and students and, thereby, to grow in their understanding of the craft of teaching. In his book, ***Teaching: Making Sense of an Uncertain Craft*** (Teacher's College Press,1992), Joseph McDonald states that:

> "Real teaching. . .happens inside a wild triangle of relations—among teachers, students, subject—and all points of the triangle shift continuously."

This Resource Guide has been developed to get inside this triangle and provide some clarity, to demonstrate concretely how colleagues across the State are tackling the job of standards-based teaching and learning, and to offer examples of resource / research materials which can serve to inform local curriculum development. The standards define the points of the triangle; they are the starting point. Assessments are simultaneously ends and beginnings; they serve both as benchmarks to ascertain what and how well students are learning and as springboards for further teaching and learning. Real teaching shifts continuously in response to the needs of students as they strive to understand the content and to demonstrate their understanding in a variety of assessment contexts.

The Board of Regents recognizes the diversity of students in New York State, including students with disabilities, students with limited English proficiency, gifted students, and educationally disadvantaged students, and has made a strong commitment to integrating the education of all students into the total school program. The standards in the framework apply to all students, regardless of their experiential background, capabilities, developmental and learning differences, interests, or ambitions. Aclassroom typically includes students with a wide range of abilities who may pursue multiple pathways to learn effectively, participate meaningfully, and work toward attaining the curricular standards. Students with diverse learning needs may need accommodations or adaptations of instructional strategies and materials to enhance their learning and / or adjust for their learning capabilities.

The ***Mathematics, Science, and Technology Resource Guide*** has been conceptualized using these philosophical bases. The content has been selected to address important aspects of the teaching and learning process. It is our hope that all the partners in all learning communities in New York State will find the document useful, practical, and informative.

Introduction

The *Mathematics, Science, and Technology Resource Guide* is the third of a series of resource guides to accompany the New York State Frameworks and Learning Standards documents. This resource guide: (1) **establishs connections** between State learning standards and classroom instruction and (2) suggests ways to plan grade level curriculum based on the State standards. It is the hope of all those who worked on the development of this resource guide that teachers and students will find the support they need to give students the opportunity to learn and achieve.

The guide has been developed with significant input from local districts, schools, and teachers who are currently working to align their instructional practices with State learning standards. The document is not comprehensive or exhaustive. Yet it provides teachers with information, strategies, learning experiences, sample assessments, research, and specific discipline materials which can be used in the curriculum development process within each school / district.

The *Mathematics, Science, and Technology Resource Guide* is divided into three major sections:

Part I: Planning a Standards-Based Curriculum: Curriculum Essentials

This section outlines the elements considered essential in planning a standards-based mathematics, science, and technology curriculum. It contains information on strategies for integrating mathematics, science, and technology at various grade levels, suggestions for creating equitable learning environments for all students, and examples of best mathematics, science, and technology practices from teachers around the State. Samples of locally developed curricula, scope and sequence materials, and assessments are also included.

Part II: Planning a Standards-Based Curriculum: Learning Experiences

This section presents standards-based learning experiences developed and reviewed by classroom teachers throughout New York State, including activities that teachers presently use to bring the learning standards to life in the classroom.

Part III: Planning a Standards-Based Curriculum: Assessment Models

Assessing student achievement of the learning standards is an on-going process. This section provides teachers with a variety of assessments which have been used in pilot situations, examples of mathematics, science, and technology integrated tasks, and assessment materials developed by teachers and administrators throughout the State.

This resource guide is not a final, complete document; rather, it represents a beginning. The guide will continually be updated and improved as educators throughout the State send locally developed curricular materials, assessments, or other resources for inclusion in subsequent editions.

The peer review process used to select the learning experiences included in the guide is a valuable and insightful staff development opportunity. The teachers who reveiwed and selected the learning experiences included in this draft of the guide hope that this process will be replicated in schools across the State to help teachers share their work with colleagues and receive useful feedback to inform their own practice and to generate additional learning experiences for inclusion in future editions of this resource guide.

The final version of ***Mathematics, Science, and Technology Resource Guide*** will be available through your local school district. It will be available in hardcopy or on Compact Disc for use on CD Rom, It is now on the Internet at the following address:

http://www.nysed.gov

The New York State Systemic Initiative

The New York State Systemic Initiative is in the fourth year of a National Science Foundation funded program to improve mathematics, science, and technology teaching throughout New York State. In its early years, New York State Systemic Initiative worked in ten urban schools, known as Research and Demonstration Schools. The grant focused on helping teachers learn new and effective approaches to teaching mathematics, science, and technology.

Now the focus of the work is on implementing the mathematics, science, and technology learning standards in schools across the State. In Parts I and III of this Resource Guide, classroom activities from the ten State Systemic Initiative schools in New York are shared to convey what has been learned in these schools. Teachers, given opportunities to work together, have created dynamic classrooms where students demonstrate high levels of achievement.

As the philosophy of inquiry-based instruction espoused by the State Systemic Initiative expands to include more schools in New York State, greater numbers of students will be challenged to pose questions and search for solutions. Staff of the New York State Systemic Initiative which participated in the writing of this Resource Guide with New York State Education Department staff, believe that the examples of best practices shared here will inspire other teachers to develop habits of planning and teaching in order to guide students to deeper understanding of concepts and applications of knowledge.

Mathematics, Science & Technology

Part I.1

Best Practices: 5 Guiding Principles............2

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5 Guiding Principles of Best Practice in Mathematics, Science, and Technology

There is an emerging consensus about what activities in education constitute *Best Practices*. The following five guiding principles reflect the best practices of mathematics, science, and technology teachers and are the basis for the work which follows in this Resource Guide. Attending to these principles will result in teaching and learning activities which will provide rich and rigorous curriculum, instruction, and assessment for all students in classrooms of New York State.

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Planning Strategy

ELEMENTARY
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INQUIRY APPROACHES

Standard one is not just first in a series. Rather it is the over-arching umbrella for all the other standards. Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

MATHEMATICS, SCIENCE, AND TECHNOLOGY INTEGRATION

Today's students will be adults in a technological society. They must see connections across the three disciplines as they work and function as effective citizens.

EQUITY

All planning for mathematics, science, and technology education must take specific steps to include females and people of lower socioeconomic classes. In a technological society these groups could be marginalized by their lack of knowledge and by traditional attitudes which denied them opportunity.

SEVEN STANDARDS

People accustomed to thinking about separate disciplines may be tempted to emphasize Standards 3, 4, and 5. Best practices remind us that each of the seven standards is critical in the total education of all students.

SCOPE AND SEQUENCE

Planning effective learning contexts for students requires attention to the continuity and progression of content throughout schooling. Teachers will create developmentally appropriate lessons for all students which are grounded in mathematics and science, and which can be applied in the design activities of technology.

Exploring Inquiry Approaches to Learning

The teacher asks:

What makes something inquiry? Was the problem we just worked on an inquiry?

Students respond:

Nah.

Teacher:

Why not?

Students respond:

I got the answer too fast.

It was just "draw a picture."

We didn't get help from anyone.

We didn't need each other.

> "*I find, as a person who gets asked about inquiry a lot, that it's very hard to define. You almost have to inquire in order to talk about inquiry really well. I hear over and over, 'Can we see a sample lesson plan?' Teachers are accustomed to a formula, and this kind of teaching is absolutely non-formulaic. Before, I was headed in this direction, but I didn't feel I had permission to move forward. Now, with. . . the backing of my colleagues, I feel I can take that risk.*
>
> Lynn Gatto. Fourth-grade teacher, School #39, Rochester.

Standard One sets the tone of all the mathematics, science, and technology standards by focusing on inquiry. It is based on the belief that such an approach is essential in enabling all children to learn. Every child's question about a phenomenon can lead to learning. Any approach a child takes in working out a problem is worth delving into as a path toward understanding.

It's not an easy philosophy, and it takes time. Ateacher who has been involved in inquiry learning for three years said, "You can't easily pass it along to another. You have to experience it, to be physically involved." Teachers find themselves in a new role as facilitator of students' learning rather than as the repository of knowledge. The new role makes different social demands and requires different social and communication skills.

As one teacher remarked, "It's not one of those things that's, 'Now say to the children. . . . There are no short cuts.'" Another teacher noted, "I'm a very structured person, and planning an inquiry is hard. It takes a lot of time." Teachers have to try out different ways of being together with their students in the classroom.

Still, teachers are finding it liberating to be a learner of mathematics, science, and technology along with their students. Teachers are astonished by the depth of thinking they observe when students are allowed to investigate phenomena at their own pace, to follow their own questions, and during whole group discussions, to show and to reflect on the different approaches they and their classmates have taken in investigating a problem.

Students who learn in an inquiry environment expect to be finding out things about what they want to know. Their curiosity drives learning. One teacher, new to inquiry, borrowed a container of brine shrimp and put it in the back of the classroom directing every student to write

Source: Dr. Sybillyn Jennings. Consultant, New York State Systemic Initiative.

down in a class log one thing they observed. Aweek later the students were still observing and asking many questions about the brine shrimp. Another teacher commented, "We need to continue growing as teachers. We need to experience what the children are experiencing."

Teachers, principals, district mathematics, science, and technology supervisors, and families who are unfamiliar with the inquiry philosophy may be put off by classroom investigations they catch a glimpse of or hear about. Hearing, for example, that seventh-graders are using manipulatives and second-graders are doing mental mathematics may lead them to think that content is not being covered appropriately.

> "
> ***Teachers need to build their own capacity to recognize the right circumstance for good inquiry and how to capitalize on it. It's all about getting students to ask questions that will help them develop inquiry skills in mathematics, science, and technology.***
> ***Asking why something was designed a certain way is rich in inquiry possibilities for students. It can develop the curiosity of children to ask questions and build on their existing knowledge of the world. Working with students this way is what I call 'guided inquiry' and it can be an effective way to teach critical thinking.***
>
> Thomas Liao. Department of Science, Technology, and Society, State University of New York at Stony Brook.

Hands-on learning is often a starting point for inquiry, but inquiry goes deeper, requiring experimentation, reasoning, and the communication and testing of explanations. Inquiry cuts through the concrete-abstract opposition that pervades school thinking about younger and older learners, basic and higher content, bottom and top students. This is one reason why it is so significant that inquiry is identified explicitly in the first mathematics, science, and technology learning standard.

Why Integrate Mathematics, Science, and Technology ?

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The growth of mathematics, science, and technology in recent decades has had significant effects on human society and the designed world. An important goal of an integrated approach to mathematics, science, and technology education is to prepare students to assume a constructive role as adults.

As citizens in a highly technological society, students must to be able to use mathematics, science, and technology to improve their lives, the lives of others in their community, and the lives of other organisms on the planet. In addition, because so many jobs now demand more knowledge of mathematics, science, and technology, all students need to have access to these fields of study.

In the everyday world, mathematics, science, and technology are not separate and distinct, but are used in combination to analyze and solve problems in research, business, communications, humanities, and the arts. Integrating mathematics, science, and technology education will help students to function in the challenging environment of the 21st century. Other discipline areas such as language arts and social studies can also be included through science, technology, and society units.

There are compelling reasons for integrating the three subjects:

- We cannot explain scientific inquiry well without also discussing how mathematical analysis and engineering design expand the power of such inquiry.
- Today's engineers and technologists need principles and theories produced by scientific inquiry to help design and build optimum technological tools and techniques.
- Many complex ethical issues resulting from interactions of mathematics, science, technology, and society will face citizens of tomorrow. Studying these subjects now will prepare students to deal wisely with issues such as environmental protection and health care.
- Motivation to study mathematics and science is enhanced when students deal directly with real-world applications.

What are some Approaches to Mathematics, Science, and Technology Integration?

As shown in the diagram on page 7, integrating mathematics, science, and technology can be viewed as a continuum that ranges from changes made by individual classroom teachers, to developing interdisciplinary units, to team teaching mathematics, science, and technology courses and programs.

For teachers who want to strengthen their teaching in relation to the State standards, a good way to start might be to meet with other mathematics, science, and technology teachers to think about ways to enrich their own teaching by making connections to the other disciplines.

Questions to ask:

- *How can we help our students make connections between what they learn in our classes with what they are learning in other classes?*
- *How can we realign units so that students can make associations between what is being taught in the various disciplines?*
- *How can we integrate the common themes from Standard 6 into the material already being taught?*
- *Who can we use as resources to help us and our students learn more about the other disciplines?*

Teachers who want to take another step in the continuum might want to develop an interdisciplinary unit, either on their own, or with other teachers. Examples of how to go about developing such units are included elsewhere in this Resource Guide. Or one might adopt integrated programs such as the New York Science Technology Education Program (NYSTEP) modules for middle school. For information about the NYSTEPmodules, contact Dr. William Peruzzi, 674 EBA, New York State Education Department, Albany, NY 12234. 518-473-9471.

Avaluable resource for technology education exists in school districts. Technology teachers at the middle school can help elementary teachers who want to strengthen their technology education program. Discussions and brainstorming sessions among mathematics, science, and technology teachers at various levels in districts can help generate ideas and resources for interdisciplinary units.

Afurther step along the continuum is team teaching. Teachers who are interested might begin with one team-taught class. Courses such as Principles of Engineering at the high school level lend themselves to team teaching because they incorporate all three disciplines.

Schools that are furthest along on the integration continuum have developed mathematics, science, and technology courses and programs.

A Continuum of Mathematics, Science, and Technology (MST) Implementation Models

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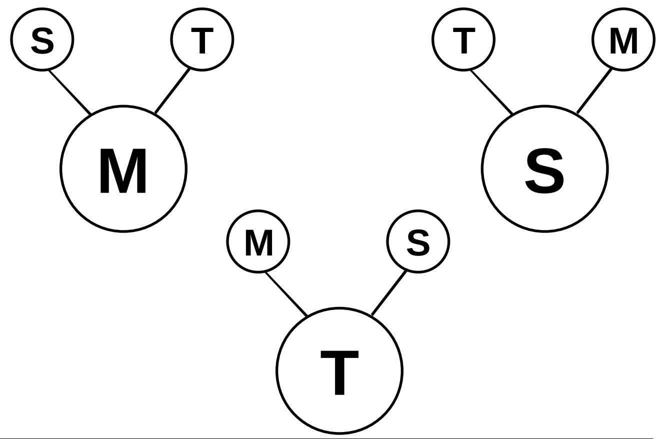
The three models below illustrate ways that schools across the State are integrating mathematics, science, and technology instruction.

MODEL 1

In this model, individual teachers help students make explicit connections between what they learn in a particular M, S, or T class and what they are learning in other classes. (School 14, Yonkers, DeWitt Middle School, Ithaca, and Stuyvesant High School, New York City)

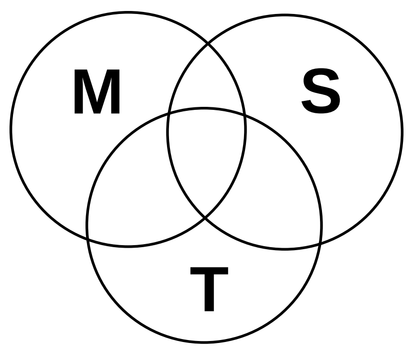
MST and/or STM and/or TMS



MODEL 2

In this model, teachers work together to develop interdisciplinary units. (Pelham Central School District and Smithtown Central School District)

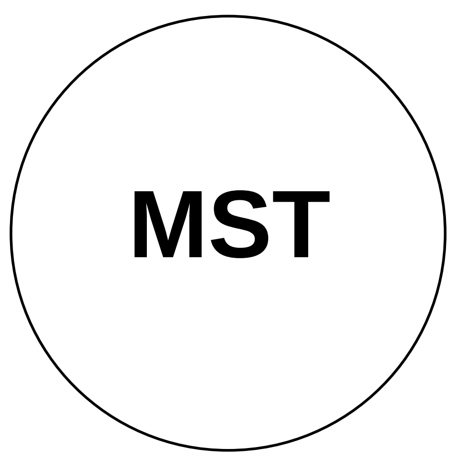
M + S +T+ (MST)



MODEL 3

This model illustrates a fully integrated approach. Students are either block-scheduled into three periods of mathematics, science, and technology or an integrated mathematics, science, and technology course where teachers team teach. (North Colonie Central School District and Bayshore Union Free School District)

MST Integrated Program



A Nature Study Center to Integrate Mathematics, Science, and Technology

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Teaching and Learning Strategy

ELEMENTARY

In the Chenango Forks Central School District, the John Harshaw Primary School's principal, staff, and students are in the first stage of creating a Nature Study Center on school grounds. This is a project that integrates mathematics, science, and technology in order to meet the mathematics, science, and technology learning standards.

Some students, after measuring and designing small garden plots, planted a variety of bulbs in the fall. Other students observed the head of a sunflower, estimated, and then counted the seeds. Some seeds were planted and their growth monitored in the classroom for future transplantation to a garden area.

The principal and all second grade students, for the last several Arbor Days, have planted black walnut trees on school grounds. Future activities for the Nature Study Center include:

(l) research for developing a butterfly garden

(2) research to find shrubbery that will attract wildlife

(3) construction of bird and bat houses.

Anearby wetland area will be prepared for safe access for extending this mathematics, science, and technology project.

Source: Robert Bundy, Principal, and Merri Earl and Colleen Cawley, Teacher coordinators, Chenango Forks Central Schools.

Strategies For Assuring Students Access to Mathematics, Science, and Technology Education

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The National Science Foundation suggests that school districts ask the following questions as they move to create equitable access to mathematics, science, and technology programs for all students.

Ask:

Do school, district, and State policies ensure that teacher and administrators values diversity?

Do partnerships with parents and businesses provide opportunities to discuss value related to equity?

Do public awareness activities and educational opportunities exist to lesson inequities and to encourage participation by traditionally underrepresented groups?

Are curriculum and instructional materials planned and selected to ensure that they are free from bias, represent all groups, and encourage participation?

Do educational and professional development prepare and support all teachers—including those who are themselves from underrepresented groups—to teach in diverse populations of students in K-12 classrooms?

Are methods of student assessment sensitive to diverse student populations and aligned to teaching strategies and instructional materials which are also sensitive to all students?

Do students have equitable access to technology education and equipment?

Are all school activities geared toward increased inclusiveness?

Do student performance measures demonstrate a significant increase in the rate of achievement of traditionally underrepresented students in mathematics and science?

> “*The way science is presented in many classrooms makes it irrelevant to most students. . . The key is that science learning must begin with phenomena that have meaning to the students, that are significant to them. Science is concerned with making meaning of the world, both physical and cultural. By focusing on that world through scientific inquiry, students develop scientific knowledge. They begin to see that science is not just in books. It’s not just in an alien middle-class world. If they apply themselves to inquiry and investigations, they will become scientifically literate.*
>
> Adapted from: Hubert Dyasi. Ph.D. Professor of Science Education, City College of New York.

Adapted from: George, Y.S., and Van Horne, V.V., *Science Education Reform for All: ALook at How Departments of Education are Infusing Equity and Excellence into PreK-12 Systemic Reform.*

Posing Questions
Seeking Answers
Developing Solutions

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1

Teaching and Learning Strategy

ELEMENTARY

For Susan Gillen, the power of inquiry in the classroom can best be seen in the new found enthusiasm and excitement that her students have for science and mathematics. “When we came back from vacation break my students kept asking, “When are we going to do science again?”

Susan and colleague Patty Schmidt have developed new curriculum units and instructional strategies to promote active, independent learning.

“Inquiry creates a *healthy hum* in the classroom,” reports Patty. “Because you’re asking so many questions of the students, with so much give-and-take, the children are totally engaged in what they are learning. Students are truly on task when they are engaged in inquiry.” Susan states that: “It’s wonderful having someone like Patty to work with; it’s really made a difference.”

Principal Joan Valerius agrees. “The partnership with the college and university professors has had a powerful and positive impact at Meachem. Without this support it would have been extremely difficult to make these changes at Meachem.”

Gillen, Susan. Second-grade teacher, Meachem Elementary School, Syracuse City Schools and Schmitt, Dr. Patricia. Le Moyne College, Syracuse.

“

There are lessons that lend themselves to inquiry very naturally. You pose a question, a very broad question, and you have the students come up with questions and answers. That’s a form of inquiry. I call it ‘gut learning.’ It comes directly from them. Students create their own drive, their own motivation. If they seem not to have that, then the role of the teacher is to get it going.

I think teaching in this way encourages females, particularly, to want to learn more math, science, and technology. You’re not limiting them to one problem, one answer, with inquiry learning. It’s so stifling when you do it that way. Not everyone finds their forte in math, but it’s something you need to know. I never get my kids to memorize formulas anymore. They can look those up. It’s much, much better to get them to research, and to think independently.

Therese Bennett. Seventh-grade math teacher, Hackett Middle School, Albany City Schools.

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Teaching and Learning Strategy

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Homework Hotline

Anew program in Yonkers using communications technology is making a big impact on the way teachers and parents communicate with each other. The program was piloted at Emerson Junior High School.

With a $140,000 grant from a consortium of corporations seeking to help working parents, the district has installed voice-mail systems in the schools for use by parents, teachers, and administrators. Parents can now dial their child's school 24 hours a day and get information about homework assignments, testing, special events, and other activities at the school such as the sports schedule and conference days. For many parents with busy schedules, the voice-mail operation at Emerson has made a real difference in their ability to keep up with what's going on in school.

Parent Kathy Harris says, "In the middle school there are seven or eight instructors, and it's hard to keep in touch with all of them. With the voice-mail set up at Emerson, I can dial into a teacher's individual mailbox and get a message about lesson plans, homework assignments, and when the tests are. Teachers update their messages daily, so I always know what's going on. I can leave messages, too, if I have a question or concern. This system makes a really important connection between home and school—it's great."

Emerson Junior High School, Yonkers City Schools.

Advantages of Graphing Calculators

Today's graphing calculators provide the mathematics community with a tool that facilitates students' investigation of problems by using multiple representations: numeric, analytical, and graphical. The advantages of teaching with them include:

- Students can move from one mode of presentation to another in a seamless environment.
- Students' conjectures can be tested and verified independent of their mastery of older computational algorithms.
- Users have access to investigations and explorations that would have been prohibitive in the past.

Graphing calculators used within mathematics instruction can:

- allow students to process real life data
- conjecture as to the relationships between and among data

 * allow students to hypothesize as to the meaning behind the relationships

 * make mathematics come alive for students

 * help students to conceptualize mathematics through visualization and multiple representations.

Source: Caroscio, William. Technology teacher, Elmira Southside High School, Elmira City Schools.

Interdisciplinary Computerized Travels

For the past two years, students at Emerson Junior High School have participated in MayaQuest, an interdisciplinary, interactive archaeological adventure. Using the PRODIGY program, students communicated with archaeologists who were touring Mayan ruins in Mexico and Central America. The students helped to direct the expedition by posing questions and suggesting site investigations. On March 21, 1996 a satellite-beamed video allowed students to participate in a live question and answer session.

As an outgrowth of MayaQuest, students studied units in tropical rain forests, Mayan mythology, and modern Mayan society. They also created a model archaeological ruin.

Mrs. Pat Guski, head teacher for MayaQuest, felt that the project and its accompanying technology, "Opened up the world for students and teachers."

Source: Teachers from Emerson Junior High School, Yonkers City Schools.

Gardens and Geometry

MST 3

Teaching and Learning Strategy

ELEMENTARY

The children at School #14 in Yonkers apply their knowledge of geometry and math to real world situations in the school garden. One challenge was to decide how they could create a perfect circle around each of two weeping cherry trees so that they create a circular planting area.

Working cooperatively, they used their inquiry skills to try to come up with feasible solutions. The groups decided which plans they wanted to try. The most successful solution was to use a string the length of the radius of the circle and tie it to the trunk. The other end was tied to a plastic bottle with a narrow neck that was filled with flour (ecologically correct). As they walked around the tree trunk they created their first circumference. Two smaller ones were created inside the circle later, to denote where planting would occur.

These circles were used to plan a bulb planting project. The children worked cooperatively to come up with the best plan they could agree on to plant tulips and daffodils for the spring. The students surveyed the area, and were asked to try to come up with a plan. After a time of trial and error, they realized they did not have enough information.

It was only then that they were given what they asked for, namely, how many bulbs of each kind and color had been purchased. After that, even though they did begin to create a key for their plan, they realized that they were not accurately planning the spacing of the bulbs in the circles they had drawn on their planning sheets. After awhile, the concept of a grid and scale was introduced and the children worked cooperatively to plan their designs for the area. They decided among themselves which was the best plan. The entire class used this plan to plant the bulbs. As problems arose in executing the plan, the designers were called to meet with the class to interpret their symbols or explain their markings.

This same process was used with a group of children who planted bulbs in a bed that was the shape of a scalene triangle. This project can be adapted to any similar geometric shape.

Source: Lacchia, Linda, Science magnet teacher, School #14, Yonkers City Schools.

> “*I teach classes that include [some] students with learning disabilities, and I have found that inquiry lends itself very well to teaching in this setting. All students get excited about learning when they initiate the questions and that’s what inquiry is all about. I help all students design simple, hands-on investigations to explore their questions, and I guide them to where they can go to get additional information—the library, the computer, textbooks—and they report back to their classmates with their results.*
>
> *Linda Jeffress. Fourth-grade inclusion teacher, Meachem Elementary School, Syracuse City Schools.*

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Teaching and Learning Strategy

ELEMENTARY

Square Foot Gardening

Urban children used their math skills in a real world setting, based on the practices of Mail Bartholomew, the author of the book, *Square Foot Gardening.* The garden is divided into square foot units and students must plan the planting of vegetables and flowers in this space. The raised beds were measured by the students. Using the concept of planting within the squares, a plan for each kind of plant was developed.

For instance, peppers and tomatoes grow to be fairly large, so one plant was planted in each square foot. Radishes, scallions and carrots (to feed our little animals) were planted three inches apart so that 16 fit into each square foot planting grid. In some cases children brainstormed, using grids and manipulatives, how to get more plants in their space. They came up with the idea of staggering the rows. In some cases, after studying the growth patterns of the plants, they decided that a trellis or stake was needed to support a plant in its designated area.

Students used both measuring skills and calculating skills in order to determine the number of seeds, plants, plant markers, starter pots, and potting soil needed. Mathematical opportunities in this garden were many and varied. For instance, the largest tomato was shown to all the children and they weighed it using pounds and ounces as the measure. They were challenged to convert the weight into grams.

The longest carrot was measured in inches and the children were challenged to convert its length into centimeters. We also tallied our sunflower seed yields after inventing a process to do it. Solutions ranged from *guesstimating*, to measuring the diameter of the seed area and calculating how many seeds in a square inch, to counting by tens and hundreds. Aserendipitous happening was the arrival of flocks of American golden finches who came to dine on our Mexican sunflower seeds.

Source: Lacchia, Linda, Science magnet teacher, School #14, Yonkers City Schools.

MST 4

Teaching and Learning Strategy

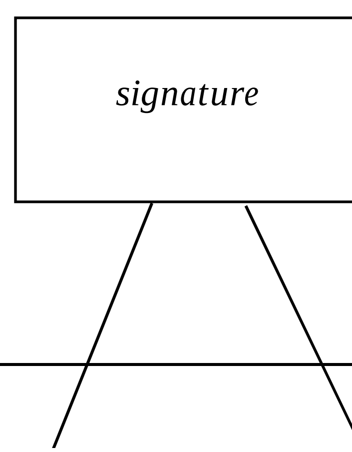
COMMENCEMENT

A Real World Application of Chemistry

This activity is an example of a real world application of chemistry in which students at Glens Falls High School have engaged.

The mole is a unit of measurement used by chemists to "count" particles of matter, to relate the mass of an element or compound to the number of particles in a sample, and to relate the volume of a gas to either the mass of a sample or the number of particles in the sample. This study of the quantitative relationships derived from chemical formulas and chemical equations is termed *stoichiometry*.

"In this lab performance test, you will use stoichiometry and whatever lab equipment necessary to determine the number of formula units of calcium carbonate in your signature written in chalk. You will also calculate the number of atoms of Ca, C, and O in your signature. Your report should include materials used, procedure, results, and a discussion. GOOD LUCK!!"



Source: Danna, Steve and Parrott, Pamela. Glens Falls High School, Glens Falls City Schools.

Interdisciplinary Study of the Iroquois Nation

MST 5

Teaching and Learning Strategy

ELEMENTARY

Students at School 39 in Rochester are involved in an interdisciplinary study of the Iroquois. Their social studies, English language arts, and science teachers have collaborated to develop a curriculum that makes connections between three core subject areas and aligns with mathematics, science, and technology standards.

Highly motivating interdisciplinary units, based on science topics, provide a forum for children to see how math, science, technology, social studies, and language arts are related to one another within the context of meaningful experiences.

Decorations in the hallway leading to our classroom makes the unit we are studying quite obvious. The Iroquois longhouse in progress invites anyone who walks through it to share in what we've learned about the "old ways" of the Iroquois Nation. The hallway entrance has been covered with a deerskin. Hanging on it is our clan sign made from a large piece of bark and decorated with a charcoal drawing done by one of the students. Students made authentic clay pots and corn husk dolls which are displayed on shelves made by lashing twigs together. The clay pots hold leaves, pine cones, rocks, gourds, and herbs the children collected. Dried ears of corn, life-sized animal-skin cutouts, medicine wheels, dream catchers, and baskets are suspended from the longhouse ceiling poles. Alarge bunkbed—made by lashing branches together—hangs from one of the longhouse walls. Tools made from rocks, leather strips, and branches are also displayed on the walls.

The Iroquois were farmers. Corn, beans, and squash, their three main crops, were called the "Three Sisters." Students made a collage honoring the three sisters which hangs by the entrance to the longhouse.

To sum up and assess the unit, students held a pow wow. All the information students learned contributed to create a Native American environment complete with handmade costumes, authentic food, and Iroquois music and dance.

This unit helped students gain respect for their environment and appreciate another culture. They understand, as the Iroquois did that, "We all share the earth together and we must leave it for those that come after us."

Source: Teachers from School 39, Rochester City Schools.

1 Making Connections: Through a Theme

MST 6

Teaching and Learning Strategy

INTERMEDIATE COMMENCEMENT

As teachers focus on integrating instructional approaches, they will want to help students see the connection in mathematics, science, and technology to other disciplines. The following three examples suggest natural connections to other areas of the core curriculum.

Magnitude and Scale

Mathematics
Students express the sizes of planets to Earth in ratios and use exponents to express the distance of planets from the sun.

Technology
Students learn how technological devices have enabled people to observe the planets and measure their sizes and distances from the sun.

Science
Students learn about the relative sizes and distances from the sun of the planets.

Activities
Students make a scale model of the solar system, using calculators and measuring tools to determine the sizes and locations of planets in the model.

Other Connections:
Music: listen to *The Planets* by Holtz
Art: draw pictures of the planets
Social Studies: research the history of knowledge about the solar system
English Language Arts: read and/or write poems about the planets; read a science fiction story about life on another planet

Making Connections: Through a Topic

2

Human Genetics

Mathematics
Students apply probability to predicting the traits of offspring.

Technology
Students learn about the technology used to make prenatal diagnoses of genetic conditions.

Science
Students learn the basic Mendelian patterns of inheritance and apply them to analyzing patterns of inheritance in humans.

Activities
Students construct a pedigree for their families, showing transmission of a specific trait, such as eye color.
Students analyze photographs of karyotypes to identify specific chromosomal conditions.
Students make squashes of onion root tips to observe and draw chromosomes.

Other Connections:
Music: make analogy between musical notation and genetic code
Art: draw pictures of chromosomes seen through a microscope; raw pedigrees
Social Studies: investigate effect of eugenics on immigration policies in the first half of the 20th century
English Language Arts: write a report on a human genetic condition; read an article in a magazine or newspaper about a recent advance in genetics

3 Making Connections: Through an Issue

> *One thing I have learned from paying close attention is the importance of context in children's learning. For young children, . . . that means connecting the problem to some previous experience, some person or persons or some event in their lives. It's important for children to find those connecting points.*
>
> *When I hear a child say, "Oh, yeah, it's like. . ." then I know that child has found a connection and is fitting new ideas into an already existing framework. . . . when [I]. . . hear what a child says. . . [it] teaches me how to build context as I present new mathematical ideas and concepts.*
>
> Caren, Ann. In-school staff developer, Beverly J. Martin Elementary School, Ithaca City Schools.

Should Fishing Off the New England Coast be Suspended?

Mathematics
Students graph catch data for fish in New England coastal waters and learn basic equations for population growth.

Technology
Students learn how technology has changed the fishing industry in recent years and how it is used to estimate fish populations.

Science
Students study the dynamics of wildlife populations.

Activity
Students participate in a simulation to demonstrate effects of different policies on fish populations.

Other Connections:
Music: sea chanteys
Art: paintings of fishing
Social Studies: effect of suspension of fishing on the industry and fishermen
English Language Arts: write letters to Congressmen from viewpoints of fishermen, environmentalists, etc.; read stories about the lives of fishermen

MST

7

Teaching and Learning Strategy

ELEMENTARY
INTERMEDIATE

Native Americans: The Iroquois Nation

This chart reflects interdisciplinary activities related to the Iroquois Nation that teachers can use with their students to illuminate the mathematics, science, and technology standards.

ACTIVITIES

- Keeping journals
- Participating in a nature retreat
- Researching, planning, and planting Three Sisters Garden
- Visiting Ganondagan Site
- Reading *The Indian In the Cupboard*
- Visiting Rochester Museum and Science Center (Iroquois Exhibit)
- Researching, planning, and constructing a hallway longhouse
- Researching, designing, sewing, and constructing clothing and tools for a Pow Wow

GOALS AND OBJECTIVES

Science

- Design experiments and explain the outcomes. Show how plant pollen depends on environmental conditions for dispersal.
- Describe form and function of plants and how they are important to the reproductive cycle.
- Create classification systems.
- Explain how changes in the environment can affect a habitat.
- Observe and illustrate details.
- Create and interpret graphs to show data collected.
- Create an awareness of scientific careers related to archeology, conservation and horticulture.

Values

- Develop teamwork attitudes and skills.
- Respect and understand the importance of our New York State environment.
- Heighten awareness of environmental issues in our community.
- Ask questions.
- Create respectful attitudes for personal and cultural differences.

Mathematics

- Introduce area and perimeter.
- Reinforce multiplication and division through arrays.
- Improve measurement to the nearest inch.
- Solve problems using measurement, division, and multiplication.
- Estimate to the nearest thousand.
- Introduce coordinate points.

Social Studies

- Compare and contrast life in an 18th century Iroquois village to their own lives today.
- Identify science and technology in history.
- Learn New York State geography.
- Acquire map reading and directionality skills.

English Language Arts

- Improve reading fluency and comprehension.
- Develop written skills through opinion, comparison, reporting, and description essays, as well as letters.
- Develop oral skills through reporting, explaining, and defending.
- Increase vocabulary and correct spelling through thematic related words.
- Introduce and study skills by using reference books and the computer.

Source: Teachers from School 39, Rochester City Schools.

Mathematics, Science & Technology

PART I.2

Scope and Sequence 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).

http://www.nysed.gov

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

MST 1 3 4
Scope & Sequence
ELEMENTARY
INTERMEDIATE
COMMENCEMENT

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

MST
1 2 3 4
5 6 7
Scope & Sequence
ELEMENTARY
INTERMEDIATE
COMMENCEMENT

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

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

5-8 Mathematics

INCREASED ATTENTION	DECREASED 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	**PROBLEM SOLVING** ◆ Practicing routine, one-step problems ◆ Practicing problems categorized by types (e.g., coin problems, age problems)
COMMUNICATION ◆ Discussing, writing, reading, and listening to mathematical ideas	**COMMUNICATION** ◆ Doing fill-in-the-blank worksheets ◆ Answering questions that require only yes, no, or a number as responses
REASONING ◆ Reasoning in spatial contexts ◆ Reasoning with proportions ◆ Reasoning from graphs ◆ Reasoning inductively and deductively	**REASONING** ◆ Relying on outside authority (teacher or an answer key)
CONNECTIONS ◆ Connecting mathematics to other subjects and to the world outside the classroom ◆ Connecting topics within mathematics ◆ Applying mathematics	**CONNECTIONS** ◆ Learning isolated topics ◆ Developing skills out of context
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	**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 ◆ Identifying and using functional relationships ◆ Developing and using tables, graphs, and rules to describe situations ◆ Interpreting among different mathematical representations	**PATTERNS AND FUNCTIONS** ◆ Topics seldom in the current curriculum
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	**ALGEBRA** ◆ Manipulating symbols ◆ Memorizing procedures and drilling on equation solving
STATISTICS ◆ Using statistical methods to describe, analyze, evaluate, and make decisions	**STATISTICS** ◆ Memorizing formulas
PROBABILITY ◆ Creating experimental and theoretical models of situations involving probabilities	**PROBABILITY** ◆ Memorizing formulas
GEOMETRY ◆ Developing an understanding of geometric objects and relationships ◆ Using geometry in solving problems	**GEOMETRY** ◆ Memorizing geometric vocabulary ◆ Memorizing facts and relationships
MEASUREMENT ◆ Estimating and using measurement to solve problems	**MEASUREMENT** ◆ Memorizing and manipulating formulas ◆ Converting within and between measurement systems
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	**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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Mathematics, Science & Technology

PART I.3

Scope and Sequence 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).

http://www.nysed.gov

Local Examples

Hunter College Elementary School Planning Documents

Hunter College Elementary School is one of the oldest self-contained elementary schools for the intellectually gifted in the nation. It is a coeducational laboratory school which serves as a research and demonstration center. Excerpts from their planning documents show two ways to lay out expectations for students.

The Science excerpt, related to standard 1, scientific inquiry and mathematical analysis, shows age appropriate introductions of various inquiry skills. The Mathematics excerpt, related to measurement, performance indicator 5 of standard 3, delineates measurement concepts and skills. It describes at which grade level each skill should be introduced and points out that children need continued practice to achieve mastery as they move through elementary school.

MATHEMATICS
Measurement: Length and Area

CONCEPTS AND SKILLS

The student will:

1. compare directly concrete objects to determine which is longer and which is shorter
2. measure objects using non-standard units
3. understand the need for a standard unit
4. use the meter stick to measure meters or centimeters
5. combine meters and centimeters when measuring
6. use feet, inches, and yards in measuring; include fractional parts
7. use equivalent measures in both metric and English measurement
8. use non-standard units to measure the distance around an object (perimeter)
9. use standard units to measure the distance around objects
10. develop an algorithm for finding the perimeter of regular shapes

INTRODUCE	PRACTICE	EXTEND/MASTER
N	K	1
K	1	2
1	1-2	2
1	2	3
2	3-5	6
K-1	2-4	5-6
2	3-5	6
K-1	2-3	4
1	2-4	5
2-3	4-5	6

Source: Hunter College Elementary School, New York City.

SCIENCE

PLANNING	**N**	**K**	**1**	**2**	**3**	**4**	**5**	**6**
Communicating Information	1	E	E	E	E	E	E	E
Predicting		1	E	E	E	E	E	E
Creating Models			1	E	E	E	E	E
Formulating Hypotheses				1	E	E	E	E
Recording Data					1	E	E	E
Questioning					1	E	E	E
Using Cues								1
Manipulating Ideas								1

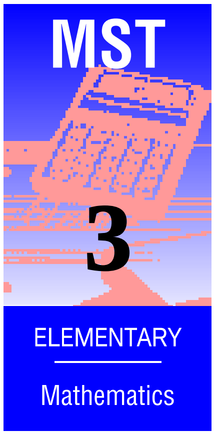
OBTAINING DATA	**N**	**K**	**1**	**2**	**3**	**4**	**5**	**6**
Aquiring Information	1	E	E	E	E	E	E	E
Developing Vocabulary	1	E	E	E	E	E	E	E
Observing	1	E	E	E	E	E	E	E
Using Numbers		1	E	E	E	E	E	E
Measuring		1	E	E	E	E	E	E
Recording Data			1	E	E	E	E	E
Manipulating Materials			1	E	E	E	E	E
Using Clues			1	E	E	E	E	E

ORGANIZING DATA	**N**	**K**	**1**	**2**	**3**	**4**	**5**	**6**
Classifying	1	E	E	E	E	E	E	E
Communicating Information	1	E	E	E	E	E	E	E
Creating Models		1	E	E	E	E	E	E
Using Numbers			1	E	E	E	E	E
Manipulating Materials			1	E	E	E	E	E
Manipulating Ideas			1	E	E	E	E	E
Manipulating Ideas					1	E	E	E
Replicating								

Key
I = Skill introduced during the school year by conducting a lesson specifically on this skill
E = Skill extended with students during the school year

Local Examples

Planning Curriculum to Address Mathematics, Science, and Technology Standard 3 for Kindergarten Students



Ten area school districts in the Franklin-Essex-Hamilton BOCES have banded together in a regional effort to plan curriculum to match the new standards. These schools decided to begin at the early elementary level and continue on to all grade levels. Primary teachers representing all ten component districts of the Franklin-Essex-Hamilton BOCES met to develop higher standards in English language arts and mathematics, science, and technology.

The following standard 3 at the elementary (Kindergarten) level.

[STANDARD 3-Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.]

Mathematical reasoning Students use mathematical reasoning to analyze mathematical situations, make conjectures, gather evidence, and construct an argument		
Students:		
use models, facts, and relationships to draw conclusions about mathematics and explain their thinking	Data gathering (charts, graphs, tables, and tallying)	Count, sort, and graph objects (i.e., color, size, and shape)
use patterns and relationships to draw conclusions about mathematics and explain their thinking	Patterning/sequencing	Given teacher-made pattern of students, identify pattern, and continue it Create a pattern using unifix cubes Sequencing time-read *The Very Hungry Caterpillar* and sequence the fruit the caterpillar ate during the week; act out the story
justify their answers and solution processes	Problem-solving	Given ten buttons, each child will sort them into two groups and explain why the buttons belong in the groups (big/small, rough, smooth, etc.)
	Recognize that ten is the same quantity,whether it refers to ten shapes or ten apples	Demonstrate the quantity of ten by counting a variety of objects and matching

Source: Jacanski, Carol. Franklin-Essex-Hamilton BOCES.

Numbers and Numeration: *Students;* use number sense and numeration to develop an understanding of the multiple uses of numbers in the real world, the use of numbers to communicate mathematically, and the use of numbers in the development of mathematical ideas		
Students:		
use whole numbers and fractions to identify locations, quantify groups of objects, and measure distances	Count by ones to 50 Introduce counting by fives and tens	Verbally count by ones to 50 Write by ones to 20 Use manipulatives to count number of notes played on a xylophone
use concrete materials to model numbers and number relationships for whole numbers and common fractions, including decimal fractions	Use concrete materials to model numbers and number relationships and common fractions	Use manipulatives to show greater than, less than, equal to, and solve simple stories
relate counting to grouping and to place value	Compare numbers to 10	Given groups of objects, discuss more than and equal to

Vertical Articulation Science Model for Use With Elementary Students

The Port Washington Union Free School District teachers and administrators have developed a science concepts and skills model that aligns with mathematics, science, and technology standard 4.

During the 1995-96 school year, all teachers and administrators in the Port Washington School District met to identify core curriculum, concepts, and skills by subject and grade level. The following excerpt shows their plans for vertical articulation.

Pre-K – 2

EARTH SCIENCES

CONCEPTS

Understanding that the earth is made up of land and water areas
Understanding that the earth changes as a result of natural causes
Understanding that the earth changes as a result of human behavior

CONTENT

Seasonal changes
Air and weather
Caring for the environment
Solar system
Physical properties of rocks
Beach studies

LIFE SCIENCES

CONCEPTS

Understanding that living things change and grow
Understanding that living things have basic needs
Understanding that living things reproduce the same kind of living things
Understanding that plants and animals are dependent on one another

CONTENT

Growth and change in the plant kingdom
Needs of plants
Growth and change in the animal kingdom
Needs of animals
Animal babies and their parents
Interdependence of plants and animals
Living healthy: nutrition, exercise, and emotional health

PHYSICAL SCIENCES

CONCEPTS

Understanding that matter has forms and properties
Understanding that physical changes occur in matter
Understanding that chemical changes occur in matter
Understanding that energy has forms and properties
Understanding that matter and energy interact

CONTENT

Simple machines
Light
Sound
Electricity
Properties of matter (powders and crystals)

Source: Port Washington Union Free Schools.

CONCEPTS

Understanding that the earth changes as a result of natural causes
Understanding that the earth changes as a result of human behavior

CONTENT

Ecosystems
Oceanography
Conservation of natural resources
Rocks and minerals
Astronomy
Meteorology
Terrestrial bioforms

LIFE SCIENCES

CONCEPTS

Understanding that living things change and grow
Understanding that living things have basic needs
Understanding that living things reproduce
Understanding that plants and animals are interdependent

CONTENT

Plant life cycles
Animal life cycles
Environmental adaptations
Food chains/food webs
Body systems
Issues of healthy living: nutrition, alcohol, tobacco, drug abuse, and AIDS, heredity

PHYSICAL SCIENCES

CONCEPTS

Understanding that matter has forms and properties
Understanding that physical changes occur in matter
Understanding that chemical changes occur in matter
Understanding that energy has forms and properties
Understanding that matter and energy interact

CONTENT

Simple machines
Light
Sound
Electricity
Properties of matter (powders and crystals)

Local Examples

Elementary Mathematics Scope and Sequence

The Schenectady City Schools have developed a scope and sequence for elementary mathematics that aligns with mathematics, science, and technology standard 3.

Philosophy of Mathematics Curriculum

The Schenectady City School District recognizes that the understanding of mathematics is necessary for students to compete in today's technological society. Adevelopmentally appropriate mathematics curriculum will incorporate a strong conceptual knowledge of mathematics through the use of concrete experiences. To assist students in the understanding and application of mathematical concepts, the mathematics curriculum will provide learning experiences which promote communication, reasoning, and problem solving skills. Students will be better able to develop an understanding for the power of mathematics in our world today.

Elementary School Mathematics Curriculum - Grades K-5

Goals and Objectives

Major Curriculum Strands:

1. Number and numeration
2. Operations with whole numbers
3. Operations with fractions and decimals
4. Probability and statistics
5. Geometry and measurement

The strands are interrelated, with each topic supporting and enhancing many others. The best lessons are those which integrate topics from other strands and other areas of the curriculum. Problem solving is a basic approach to the program which is utilized in every stand. Measurement involves practical experiences similar to those encountered in daily life situations. Basic mathematical skills will be applied in problem solving experiences. Computers and calculators are valuable tools which may be used in developing concepts, finding patterns, and checking work.

Student goals:

1. As a foundation each student will:
   - a. think logically and creatively
   - b. apply reasoning skills to solve problems
   - c. perform mathematical calculations
   - d. determine what information is necessary in a particular situation
   - e. acquire, organize, and use information in solving a problem
   - f. master computational skills.

Source: Schenectady City Schools.

2. Each student will learn methods of inquiry, reasoning, and knowledge through mathematics and use the methods and knowledge in interdisciplinary applications.

3. Each student will learn that mathematics can be used as a problem-solving tool in other areas of the curriculum and in every day problems outside of school.

I. NUMBER AND NUMERATION

A. Conservation of number
B. Counting (cardinal and ordinal)
C. Place value
D. Rounding / estimating
E. Even and odd numbers
F. Prime numbers
G. Integers (positive and negative)
H. Comparing numbers
I. Number Patterns.

II. OPERATIONS WITH WHOLE NUMBERS AND INTEGERS

A. Addition and subtraction of whole numbers
B. Multiplication and division of whole numbers
C. Interrelatedeness of operations
D. Factors / multiples.

III. FRACTIONS AND DECIMALS

A. Concept of fractions and decimals
B. Comparison of fractions and decimals
C. Addition and subtraction of fractions and decimals
D. Multiplication and division of fractions and decimals
E. Percent
F. Ratio and proportion.

IV. PROBABILITY AND STATISTICS

A. Collect data (information)
B. Organize and classify data
C. Compare and analyze data
D. Make predictions
E. Arrangements and combinations.

V. GEOMETRY AND MEASUREMENT

A. Length, distance, mass, capacity, time, temperature, and money
B. Perimeter, area, and volume
C. Shapes
D. Symmetry, similarity, and congruence
E. Coordinates.

I. NUMBER AND NUMERATION

A. Conservation of number
   1. develop the idea that if two groups of objects can be matched in a one-to-one correspondence, they have the same cardinal number
   2. develop an awareness of concepts, words, and symbols related to numbers in daily living

B. Counting (cardinal and ordinal numbers)
   1. develop the concept that the last number counted in a group of objects tells how many things are in the group (cardinal number)
   2. identify number names orally through 15, read and write numerals 0-10, and count forward and backward
   3. develop the concepts of first, middle, and last
   4. use ordinal numbers names from 1st through 10th

C. Compare sets of objects using terms: more than, bigger than, less than, one more than, the same size, equal to, before, after, and between.

II. OPERATIONS WITH WHOLE NUMBERS AND INTEGERS

A. Addition and subtraction of whole numbers
   1. combine simple sets to produce new sets
   2. explore the idea of “one more”

B. Share sets of objects such as cookies or crayons (multiplication and division).

III. FRACTIONS AND DECIMALS

A. Awareness of fractions and decimals in daily life(money)

B. Concept of *half.*

IV. PROBABILITY AND STATISTICS

A. Organize and classify data
   1. categorize objects using attributes such as likeness and differences in color, shape, and size
   2. simple bar graphs using stacks of blocks

B. Observe likenesses and differences using two categories at a time; concepts of *more, less, and the same*

C. Discuss certainty and uncertainty of events; terms *more and less likely*; anticipate outcomes by guessing and estimation.

V. GEOMETRY AND MEASUREMENT

A. Compare dimensions of various objects using terms like *larger than, taller than, smaller than, shorter than, as long as, farther, or nearer;* measure objects using non-standard units

B. Compare capacity of containers using sand and water

C. Compare temperatures and durations of time

D. Weighing experiences using terms *heavier than and lighter than*

E. Practice the estimation of ske

F. Observe objects in the environment that have geometric shapes; make geometric pictures, patterns, and designs using geometric shapes.

I. NUMBER AND NUMERATION

A. Counting
   1. count forward and backward by ones and twos on a number line
   2. count to 100 on a number line
   3. whole number immediately before and after a given number; between whole numbers
   4. match words and symbols from 0 to 15
   5. use tallies to record the size of a group of objects

B. Place Value
   1. study the meaning of each digit in two digit numbers
   2. use expanded notation to represent a two digit number (17 = 10 + 7)

C. Estimate quantity and grouping by using manipulatives

D. Introduce the concept of odd and even numbers

E. Introduce the symbols =, <, >

F. Investigate patterns for sum and differences using concrete models.

II. OPERATIONS WITH WHOLE NUMBERS

A. Addition and subtraction
   1. use models to develop the terms *larger than, smaller than, and equivalent to*
   2. introduce the special role of zero in addition and subtraction
   3. practice the addition of sums through 10; subtraction facts through 10
   4. add three numbers, sum less than or equal to 10
   5. add and subtract 2 digit numbers with no regrouping/trading
   6. develop the concept that the order in which addends are written does not change the answer(commutative properly of addition).

III. FRACTIONS AND DECIMALS

A. Develop the concept of unit fractions(1/2, 1/3, 1/4)

B. Develop the concept of oneness (2/2 = 3/3 = 4/4 =1)

C. Explore many to one in preparation for the study of ratio (5 fingers to 1 hand)

D. Continue to use money notation to practice decimals.

IV. PROBABILITY AND STATISTICS

A. Collect data, record results with tallies, blocks, pictographs, etc.

B. Practice predicting outcomes by tossing coins, paper cups, or dice

C. Solve problems such as *how many different pairs of numbers add to 10?*

V. GEOMETRY AND MEASUREMENT

A. Study time to the hour, day, month, and year using clocks and calendars

B. Investigate how to make change for amounts of money

C. Use meter, centimeter, and decimeter for measuring length

D. Introduce kilogram, liter, and Celsius thermometer

E. Identify shapes in everyday life: *square, rectangle, triangle, and circle*

F. Continue to measure objects using non-standard units.

Grade 2

I. NUMBER AND NUMERATION

A. Counting
   1. use ordinal numbers to 31st
   2. count to 1,000
   3. count by 2's, 3's, 4's, 5's, 10's using a number line and number charts
B. Place value
   1. represent 2 and 3 digit numbers to 999 using concrete models
   2. study the meaning of zero in the place value system
   3. two and three digit numbers in expanded notation (325 = 300 + 20 + 5)
C. Rounding off numbers using a number line.

II. OPERATIONS WITH WHOLE NUMBERS

A. Addition and subtraction
   1. master addition and subtraction facts (sums through 18)
   2. add and subtract 2 digit numbers which require regrouping
   3. explore inequality in number sentences (2+1<4)
   4. explore different groupings when adding three or more numbers (associative property)
   5. show that addition and subtraction are inverse operations
B. Multiplication and division
   1. explore multiplication and division through sharing sets or groups
   2. show that the order of factors in a multiplication problem does not change the answer
   3. relate multiplication to be repeated additions (3 x 5 = 5 + 5 + 5)
   4. show that multiplication and division are inverse operations
C. Practice estimation of answers with and without story problems.

III. FRACTIONS

A. Relate unit fractions to *one whole*
B. Unit fractions to 1/8, 1/10, and 1/100
C. Locate halves on a number line or ruler
D. Find 1/2, 1/3, and 1/4 of a collection
E. Explore two-to-one correspondence to expand the concept of ratio
F. Explore addition and subtraction using money notation (2 place decimals).

IV. PROBABILITY AND STATISTICS

A. Collect and tabulate data using measurement of common items
B. Arrange data in tables and illustrate with graphs
C. Compare data in terms of number, equality, inequality, similarities, and differences
D. Perform experiments with three or more equally likely outcomes
E. Make predictions of outcomes and explain
F. Combinations and arrangements (How many different groups of 3 numbers will add to 12?)
G. Investigate beginning logic concepts.

V. GEOMETRY AND MEASUREMENT

A. Weigh objects using grams, kilograms
B. Measure time in half hours, quarter hours, and 5 minutes intervals
C. Make change of amounts of money up to $1.00
D. Measure liquids in liters, milliliters
E. Practice addition of measures
F. Use shapes to create designs
G. Observe two and three dimensional objects in every day experience
H. Introduce English units of measure
I. Measure using meters, centimeters, and kilometers
J. Continue to measure using non-standard units
K. Estimate using actual units of measure.

Grade 2

I. NUMBER AND NUMERATION

A. Counting
   1. Count cardinal numbers through 100,000
   2. Ordinal numbers through 500
   3. Count to 100 by 2's, 3's, 4's, 5's, and 10's

B. Place value
   1. Use activities with money to explore place value to the right of the decimal point
   2. Use and read numbers through 100,000

C. Rounding
   1. Round numbers using the number line and measuring instruments (thermometer, meter stick, and yard stick)

D. Predict when sums will be odd or even

E. Introduce the concept of positive and negative numbers.

II. OPERATIONS WITH WHOLE NUMBERS

A. Addition and subtraction of whole numbers
   1. Master addition and subtraction facts with sums through 25
   2. Add 2, 3, and 4 digit numbers with sums less than 10,000
   3. Subtract two numbers each less than 10,000

B. Multiplication and division
   1. Explore the special role of 0 and 1 in multiplication
   2. Experiment with grouping 2 or more factors (associative law)
   3. Work with multiplication and division (products through 100)
   4. Study short and long algorithms for division
   5. Develop the concept that the order in which factors are written does not change the product (commutative property)
   6. Explore division as finding the number of equal groups of items
   7. Emphasize multiplication and division being inverse operations

C. Concepts of equality and inequality in problems involving all four operations.

Grade 3

Grade 3

III. FRACTIONS AND DECIMALS

A. Order unit fractions using < and > symbols

B. Review the concept of 1 = 2/2 = 3/3 = 4/4= etc.

C. Use terms "numerator and denominator"

D. Develop the concept of equivalent fractions and decimals (1/2 = .5, 1/4 = .25, and 3/4 = .75)

E. Add and subtract fractions with like denominators

F. Add and subtract decimals with one place (tenths)

G. Continue to use concrete problems to explore the meaning of ratio.

IV. PROBABILITY AND STATISTICS

A. Organize data using tables and bar graphs

B. Discuss graphs found in everyday publications

C. Conduct experiments and predict outcomes

D. Use fractional notation to express the probability of the outcome of an experiment

E. Use orderly methods, like tree diagrams, to count the number of outcomes in an experiment

F. Continue to introduce beginning logic concepts.

V. GEOMETRY AND MEASUREMENT

A. Identify equivalent measures within a measuring system(1,00 centimeters = 1 meter; 12 inches = 1 foot)

B. Relate the clock to circle construction and fractions

C. Find the perimeter of polygons

D. Investigate the properties of plane figures including diameter and radius of a circle

E. Construct plane figures(polygons and circles)

F. Explore 3 dimensional figure to begin the understanding of volume (taking up space)

G. Learn how to use a compass and protractor

H. Continue to investigate symmetry(reflections)

1. Locate points in a plane using a grid

J. Investigate properties of solid figures.

I. NUMBER AND NUMERATION

A. Counting
   1. Read and write whole numbers to hundred millions
   2. Skip count to numbers greater than 100
B. Extend place value to concepts to millions and hundredths
C. Round numbers to the nearest whole number, ten, hundred, and thousand
D. Predict when the product of two numbers will be odd or even
E. Continue the discussion of positive and negative numbers with applications in daily life
F. Look for patterns in sequences of numbers; write the rules for a sequence.

II. OPERATIONS WITH WHOLE NUMBERS

A. Addition and subtraction
   1. Add and subtract whole numbers, sums less than 1 million
   2. Subtract whole numbers when zero is in the minuend, renaming/trading if necessary
   3. Continue to estimate sums and differences prior to computation
   4. Find missing addends in an addition sentence (23 + ? = 30)
B. Multiplication and division
   1. Multiplication and division; products through 144
   2. Introduce the concept of a “prime factor”
   3. Multiplication of three digit numbers by two digit numbers
   4. Multiplication by multiples of 10
   5. Find common factors of groups of numbers less than 100
   6. Begin the concept of least common factor and greatest common multiple
   7. Find the quotient and remainder when a three digit number is divided by a one digit number
   8. Use the inverse operations to check division by multiplication
C. Investigate distributive property (326 x 4 = 300X4 + 20 x 4 + 6).

III. FRACTIONS AND DECIMALS

A. Study the order of unit fractions (1/2>1/3>1/4)
B. Compare fractions on a number line
C. Correlate the common fraction notation for decimals to the tenths place
D. Addition and subtraction
   1. add and subtract fractions with unlike denominators
   2. add and subtract decimals to the hundredths place
E. Multiplication and division
   1. multiply decimal to tenths
   2. practice locating decimal points in products
F. Continue to develop the concept of ratio in every day problems.

Grade 4

IV. PROBABILITY AND STATISTICS

A. Collect statistical data from newspapers, magazines, polls, and activities in other subject areas
B. Make frequency tables from tallied data
C. Use models, pictures, and tree diagrams to organize data
D. When organizing data examine the range(difference between smallest and largest)
E. Develop the concept *average* (arithmetic mean)
F. Continue to investigate beginning logic concepts.

V. GEOMETRY AND MEASUREMENT

A. Find the perimeter, area, and volume of specific figures, using appropriate units
B. Use rulers, protractors, and compasses to construct plane geometric figures
C. Use terms such as *polygon, circle, chord, radius, diameter, face edge, vertex, line segment, point parallel, and perpendicular*
D. Extend work in coordinate geometry to both positive and negative coordinates.

Grade 5

I. NUMBER AND NUMERATION

A. Read and write numbers to one billion
B. Investigate powers of 10 to develop an understanding of exponents
C. Express numbers in expanded notation using powers of 10 (6425 = 6 x 103 + 4 x 102 + 2 x 10 + 5)
D. Round off numbers to nearest 10,000; nearest hundredth
E. Continue to use a number line as an aid in understanding negative numbers.

II. OPERATIONS WITH WHOLE NUMBERS

A. Quick review of addition, subtraction, multiplication, and division facts
B. Literal problems using single operation(stress integration with other subjects)
C. Develop concept of order of operations
D. Continue to find greatest common factor and least common multiple.

III. FRACTIONS AND DECIMALS

A. Develop the concept of proper and improper fractions
B. Continue addition and subtraction of fractions with like and unlike denominators
C. Change improper fractions to mixed number
D. Compare fractions and decimals using terms *less than, greater than, equivalent to, and between*
E. Practice writing equivalent forms of decimals and fractions
F. Addition and subtraction of decimals with hundredths and thousandths
G. Multiply and divide (using whole number divisors) decimals to hundredths
H. Multiply and divide decimals by powers of 10 (move decimal point to right or left)
I. Round off decimals to thousandths
J. Use pictures and / or graphic illustrations to demonstrate multiplication and division of fractions.

IV. PROBABILITY AND STATISTICS

A. Continue to explore methods of collecting and organizing data
B. Use tables, graphs, and diagrams to represent collected data
C. Use compass and protractors to construct circle graphs
D. Compare bar, line, and circle graphs which represent the same information
E. Identify events which have probability =0, probability =1 (certainty); probability between 0 and 1
F. Continue to investigate logic concepts.

V. GEOMETRY AND MEASUREMENT

A. Be familiar with common metric units used in every day life; prefixes, *milli, centi, kilo*
B. Continue to study perimeter, volume, and area using graph paper and manipulatives
C. Develop formulas for the area and perimeter of squares and rectangles
D. Measure the area and perimeter of rectangles, triangles, and irregular polygons using blocks, geoboards, graph paper, and other informal methods
E. Continue to measure volume
F. Continue to measure temperature using Celsius and Fahrenheit thermometers
G. Continue to draw and measure plane figure using rulers, protractors, and compasses
H. Use pictures to explore similar and congruent figures; symmetry.

Local Examples

MST 7

ELEMENTARY

Mathematics Science Technology

New York State Standards for Mathematics, Science, and Technology

Grade 5

This fifth-grade scope document from the Utica City Schools details the connections to mathematics, science, and technology standard 7.

New York State mathematics, science, and technology standard 7-interdisciplinary problem solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Standards of Performance/Dimensions of Learning (Objectives)	Student Activities/Tasks	Assessment/Measurement (Descriptors and Rubrics)	Technology (Integration/ Connections)
CONNECTIONS *Students will show:* 1. that knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science, technology/society, consumer decision making, design, and inquiry into phenomena.	Students: • analyze science/technology/society problems and issues that affect their home, school, or community, and carry out a remedial course of action • make informed consumer decisions by applying knowledge about the attributes of particular products and make cost/benefit trade offs to arrive at an optimal choice • design solutions to problems involving a familiar and real context, investigate related science concepts to inform the solution, and use mathematics to model, quantify, measure, and compute • observe phenomena and evaluate them scientifically and mathematically by conducting a fair test of the effect of variables, and use mathematical knowledge and technological tools to collect analyze, and present data and conclusions.	Teacher Observation Connections Rubric Informal Inventory	Internet Web Browser; Research Software (CDs): Encarta, World Book Ency., Compton's Ency., Grolier's Ency., other subject specific CDs, etc. Desktop Publishing Software: Children's Writing and Publishing Center, Word, Works, TLC's Student Writing Center, First Choice, Story Book Weaver, etc.
STRATEGIES *Students will show:* 2. solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to: • work effectively • gather and process information • generate and analyze ideas • observe common themes • realize ideas • present results.	Teacher Observation Strategies Rubric Informal Inventory	

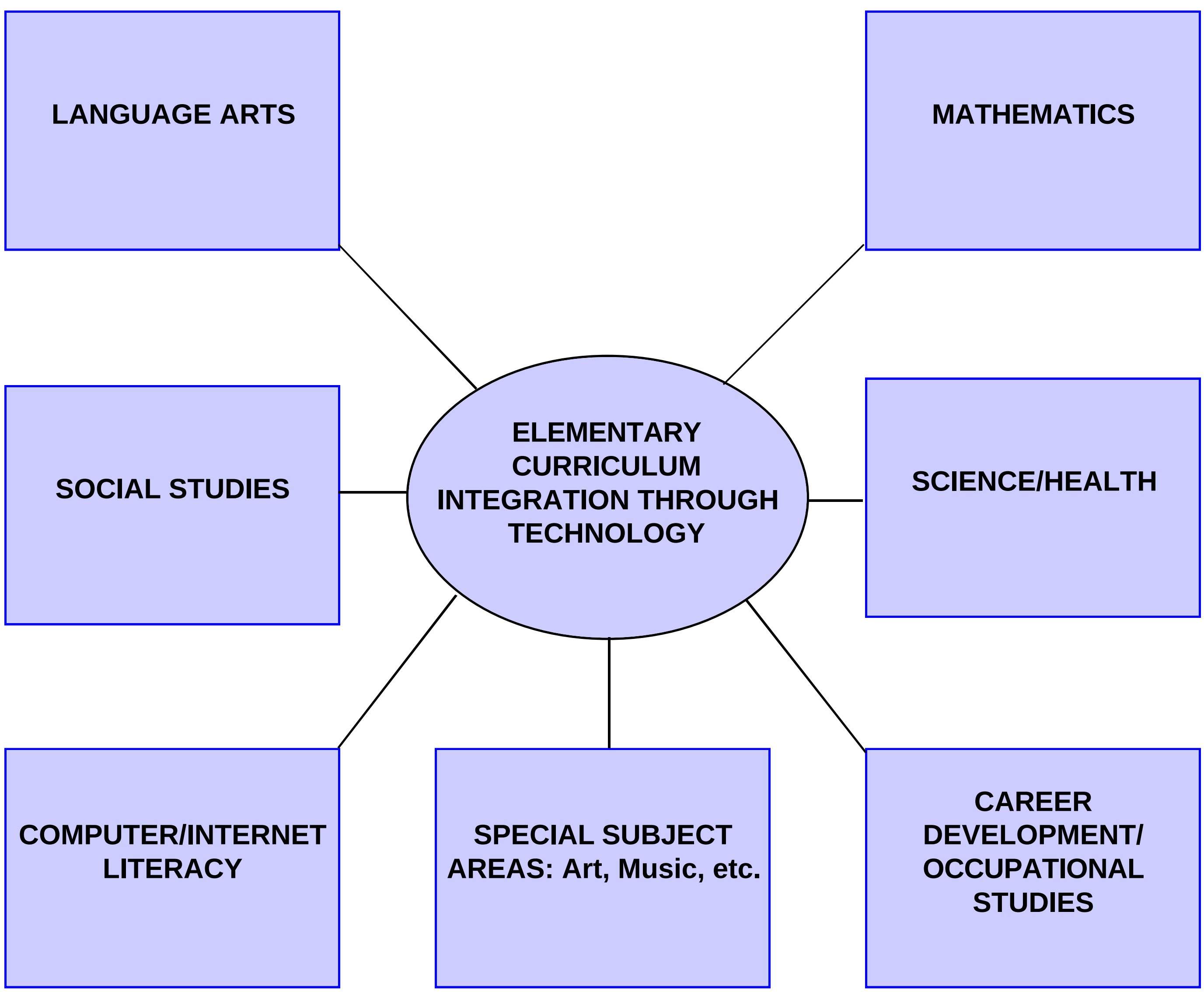
Source: *Technology and Elementary Curriculum Integration Plan*, Grade 5, Utica City Schools, 1996.

UTICA CITY SCHOOL DISTRICT
Technology and Elementary Curriculum Integration Plan

Promotes Magnet School Themes and Projects: Careers, Communications Technology, Computer Technology, Dance, Drama, Early Childhood Development, Literature, Multiculturalism, Mathematics and Science, Media Arts, Micro Society, Pathways to the Future, and the School to Work Program.

MISSION OF THE TECHNOLOGY AND ELEMENTARY CURRICULUM INTEGRATION TASK FORCE: In keeping with the Exit Standards for the Utica City School District, our mission is to empower students to become “technologically proficient learners” with the ability to “utilize technology as a communications tool, to access information, to analyze information, to prepare for career opportunities, to develop a career portfolio, and to understand the effects of technology on society.” Our goal is to prepare students to become knowledgeable, skillful participants in a technologically advanced society.

PLAN OUTLINE



Local Examples

Intermediate Mathematics Scope and Sequence

The Schenectady City Schools have developed a scope and sequence for intermediate mathematics that aligns with mathematics, science, and technology standard 3.

Philosophy of Mathematics Curriculum

The Schenectady City School District recognizes that the understanding of mathematics is necessary for students to compete in today's technological society. Adevelopmentally appropriate mathematics curriculum will incorporate a strong conceptual knowledge of mathematics through the use of concrete experiences. To assist students in the understanding and application of mathematical concepts, the mathematics curriculum will provide learning experiences which promote communication, reasoning, and problem solving skills which will enable students to develop an understanding of the power of mathematics in our world today.

Grades 6-8

Goals and Objectives

The middle school mathematics curriculum is designed to improve the problem solving abilities of students while continuing a development of skills and concepts. Problem solving situations are an integral part of each of the strands of study:

1. number concepts
2. ratio, proportion, and percent
3. probability and statistics
4. algebra and coordinate geometry
5. geometry and measurement.

Problem solving is the basic approach to the program and is utilized in every strand. Integration of topics should occur naturally, not be forced. Although students must demonstrate competence in mathematical operations, computers and calculators are valuable tools which will be used in developing concepts, finding patterns, checking work, and removing some of the computational drudgery from problem solving experiences.

Goals for students include the following:

1. As a foundation each student will:
   a. think logically and creatively
   b. apply reasoning skills to issues and problems
   c. perform mathematical calculations
   d. determine what information is necessary in a particular situation
   e. acquire, organize, and use information in solving a problem
   f. master computational skills.

2. Each student will learn methods of inquiry, reasoning, and knowledge through mathematics and use the methods and knowledge in interdisciplinary applications.

3. Each student will learn that mathematics can be used as a problem solving tool in other areas of the curriculum and in every day problems outside of school.

Source: Schenectady City Schools.

NUMBER CONCEPTS

Concepts/Skills	*Grade*
read and write numbers through billions continue to practice and improve operational skills (addition, subtraction, multiplication, and division) practice finding least common multiple and greatest common factor reinforce place value using expanded notation(3862= 3x1000+8x1 00+6x10+2) find succeeding terms in a presented sequence round off whole numbers through 10 thousands use of exponents up to 5 introduce the concept of negative integers add, subtract, multiply, and divide fractions with common and non-common denominators, and mixed numbers add, subtract, multiply, and divide decimals compare fractions and decimals using concepts of less than, more than, and between equivalent forms of fractions, decimals, per cents(1/2's, 1/3's, 1/4's, 1/5's, 1/8's, and 1/10's)	6
read and write numbers through trillions find the missing term in a sequence and write the rule round off whole numbers through hundred billions reinforce place value by using the expanded form of a number using exponents addition, subtraction, multiplication, and division of integers introduce the concept of absolute value identify elements for addition and multiplication additive inverse introduce the concept of perfect square numbers and their positive square root terminating and repeating decimals conversion of fractions, decimals, and percents (percents less than 100 percent) express numbers in scientific notation (numbers greater than 1)	7
introduce the concept of zero as an exponent comparison of integers including the concept of absolute value find the missing term in a sequence with positive and negative integers and write the rule positive and negative square root of a perfect square estimate the square root of a non-perfect square number compare positive and negative fractions and decimals using more than, less than, and between conversion of fractions, decimals, and percents (percents greater than 100 percent and less than 1 percent) express numbers in scientific notation (numbers less than 1) introduce the concept of irrational numbers	8

RATIO, PROPORTION, PERCENT

Grade	Concepts/Skills
6	extend the use of fractional notation to ratios understand the concept that 2 or more equivalent ratios form a proportion find the missing term in a proportion where terms are whole numbers use of circle graphs to understand percent investigate intuitively the concept of similar polygons construct scale drawings
7	find the missing term in a proportion where terms can be rational numbers and integers define means and extremes introduce the concept of rates (distance, time, and unit pricing, etc) construct circle graphs to explain percent find the percent of a number find what percent one number is of another number find a number when a percent of the number is known
8	introduce indirect measure in the study of similar polygons to find missing parts of geometric figures percent of increase and percent of decrease

PROBABILITY AND STATISTICS

Grade	Concepts/Skills
6	use average (mean) to interpret data collect data to describe an experiment construct bar graphs and line graphs to demonstrate data collected conduct and predict outcomes of experiments with independent events
7	mean, mode, and median organize data using terms such as range, intervals, and frequency identify sample spaces by listing all elements or tree diagrams
8	construct histograms use frequency tables introduce the counting principle to determine the number of outcomes investigate compound probability with independent events

ALGEBRA AND COORDINATE GEOMETRY

Concepts/Skills	*Grade*
determine the order of operations develop the concept of a solution to an open sentence use an ordered pair to locate a point on a grid use ordered pairs to construct figures	6
find the solution to mathematical sentences using more than one step use algebra to translate verbal phrases into mathematical form (more than, less than; increase, decrease) evaluate algebraic expressions using integers as substitutions graph number pairs using integers in all four quadrants use line graphs to demonstrate the solution to inequalities	7
find the solution to mathematical sentences using more than one step use the distributive law in finding the solution to equations combine like algebraic terms to make a single term use algebra to translate verbal sentences to mathematical sentences use mathematical sentences to find the solutions of literal problems interpret tables to form equations write a mathematical sentence based on number pairs in a table and draw the straight line picture	8

GEOMETRY AND MEASUREMENT

Concepts/Skills	*Grade*
find the area and circumference of circles find the area and perimeter of polygons such as triangles, rectangles, and squares compute the volume of rectangular prisms identify and construct angles with protractor and compass (acute, right, obtuse, and straight) develop the concept of parallel and perpendicular lines	6
introduce geometric terms (point, line, plane, segment, and ray) name and define angles (acute, obtuse, right, straight, and reflex) discover and define angle pairs (vertical, supplementary, and complementary) construct and classify triangles by angles and sides construct and classify quadrilaterals (rectangle, square, parallelogram, and trapezoid) determine the formulas for area and circumference of a circle find the surface area of a rectangular prism determine the formula to find the volume of rectangular prism, cube, and cylinder determine the formula to find the area of triangles and quadrilaterals use parallel lines to determine specific angle pairs	7
find the volume and surface area of 3 dimensional solids introduce sphere, cone, pyramid, and triangular prism use compass and straight edge to bisect line segments and angles use compass and straight edge to construct parallel and perpendicular lines use compass and straight edge to construct triangles, rectangle, square, and regular hexagon use the Theorem of Pythagoras to discuss the relationship between the sides of a right triangle find the missing side of a right triangle use parallel lines and transversal to identify and measure resulting angle pairs	8

Local Examples

Smithtown Technology Curriculum

Teachers at Smithtown Middle School use this activity model to organize their technology curriculum to integrate with other subject areas, thereby illuminating standard 5.

The following is a brief outline of the activities covered, including the grade levels and other subject areas that the activities tie into.

SIXTH GRADE (TEN WEEK PROGRAM)

1. Bow saw (mathematics and technology development)
2. Center of gravity device (science and technology)
3. Noteholder (technology)
4. Resources of technology
5. Communications (computer)
6. Marine technology (mathematics, science, and technology)
7. Introductory electronics (science and technology)
8. Bridge construction (mathematics, science, and technology-problem solving)

SEVENTH GRADE (TWENTY WEEK PROGRAM)

1. Structures—straw tower (computer spread sheets, science, and technology)
2. Spinning top (mathematics, science, and technology)
3. Safety vehicle (mathematics, science, and technology)
4. Wind turbine (mathematics, science, and technology)
5. Catapult (history, mathematics, science, and technology)
6. Aerospace—an introduction to flight and rocketry (history, mathematics, science, and technology)
7. Electronics—simple control systems (mathematics, science, and technology)
8. Research project (library skills, English language arts)
9. Enrichment
   - Playground design—modeling (mathematics and technology)
   - Micro Baha vehicle (mathematics, science, and technology)
   - Yo-yo—flywheel on a string (science and technology)
   - Oral presentation (related to research project)

EIGHTH GRADE (TEN WEEK PROGRAM)

1. House of cards (mathematics, science, technology, and computers)
2. Electronics (mathematics, science, and technology)
3. Magnetic levitation (mathematics, science, and technology)
4. Save the world—should an asteroid threaten the Earth (mathematics, science, technology, and English language arts)
5. Compressed air vehicle (mathematics, science, and technology)
6. Enrichment
   - Manufacturing activity (processing resources)
   - Newsletter (communications)

Source: Ruiz, Ernest, *Technology Education*, Smithtown Middle School, Smithtown Central Schools.

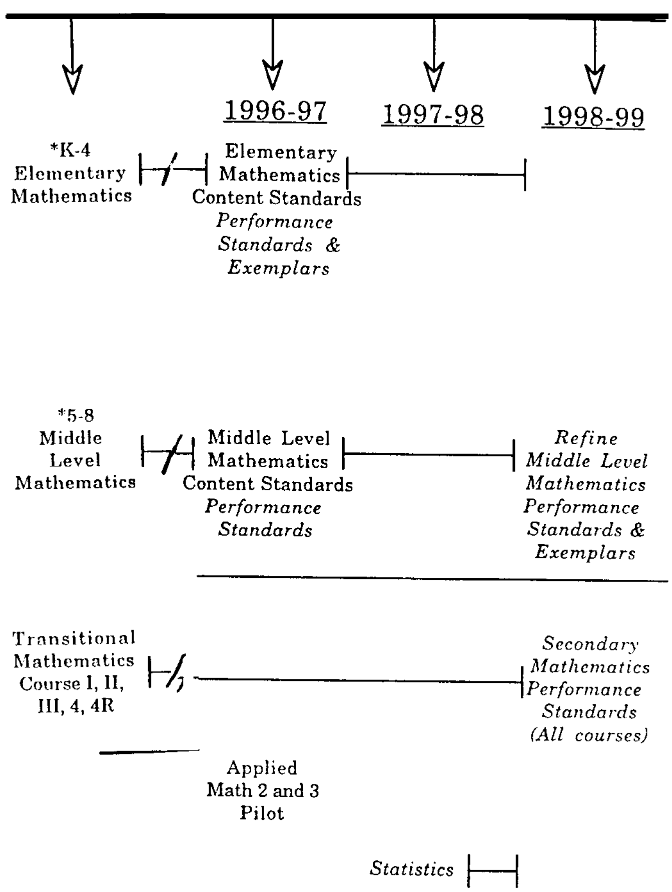
Local Examples

Curriculum Development Time Line for Mathematics and Science

Williamsville Central Schools have planned their curriculum development for mathematics and science using a timeline as a tool for organizing their activities. This example is provided to demonstrate a chronological approach to aligning curriculum with the State standards.

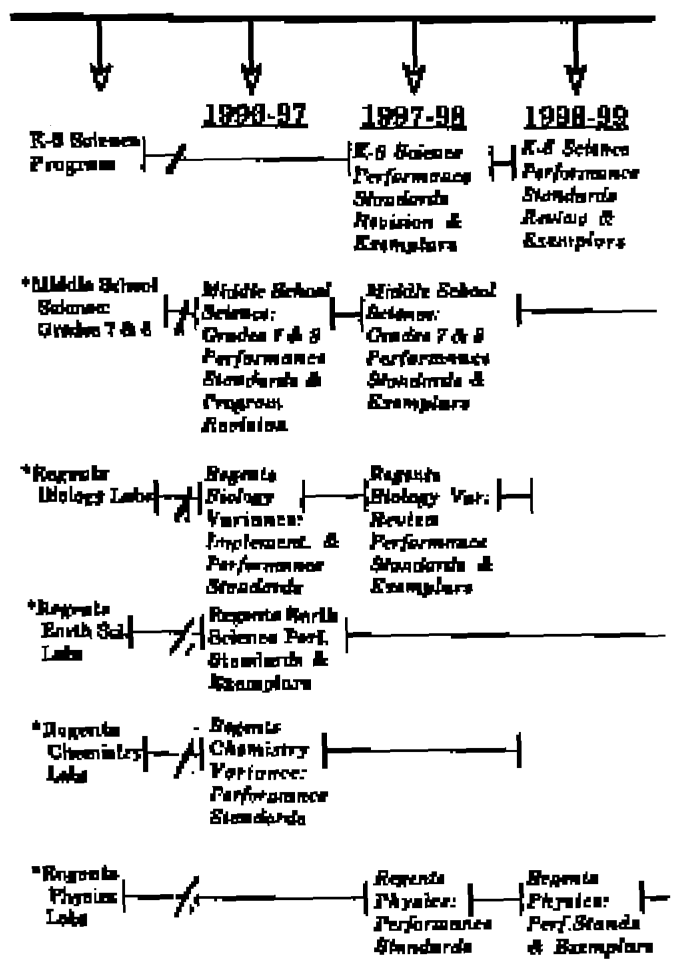
Mathematics Education

- Curriculum Development Time Line



Science Education

- Curriculum Development Time Line



Source: Williamsville Central School District.

Local Examples

Integrated Regents Program

MST

1 2 3
4 5 7

COMMENCEMENT

Integrated Approach

PROGRAM OVERVIEW

The program is an integrated approach to the teaching of math, science, business education, home economics, and technology education and is designed to encourage students to take four years of these subjects. It is targeted at those students who would normally take general level courses in math and science or who are experiencing difficulty in Regents level courses. Curriculum planning provides extended time for the mastery and application of mathematics and science topics so that students can achieve at a Regents level.

The first two years of the program are divided into four semester blocks generally as follows:

9th grade	10th Grade
first semester mathematics (portions of 1R) science (biology) home economics or technology	*first semester* mathematics (portions of 1 R) science (biology / earth science) business or technology
second semester mathematics (portions of 1 R) science (biology / earth science) technology or home economics	*second semester* mathematics (finish 1R / portions of 2R) science (earth science / physical science) technology or business

At the end of two years, students will earn 2 credits for mathematics, 2 credits for science, 1 credit for technology (.5 credits twice), .5 credit for business and .5 credit for home economics. Additionally, 1 unit of Regents credit for both math and science can be achieved by successfully passing the Regents examination in SM 1R and a modified science examination at the end of tenth grade. The Proficiency examination in introduction to occupations will also be administered at this time.

Continuation in the program during the junior and senior year will enable the student to achieve an additional 2 credits for mathematics, 2 credits for science, and 2 credits in either business, home economics or technology. Also, one unit of Regents credit for both math and science can be achieved at the end of the fourth year by successfully passing a Regents examination. A student will then need one additional outside credit in either business, home economics, or technology for a five unit sequence. Afive unit sequence in art or music can be achieved through appropriate elective selection and independent study activities.

Source: Swinton, Dr. Steven. Science Supervisor, Shaker High School, North Colonie Central Schools.

A typical four year program would be:

Period/Grade	9th	10th	11th	12th
1	IRP	RP	IRP	IRP
2	IRP	IRP	IRP	IRP
3	IRP	IRP	IRP	IRP
4	ENGLISH	ENGLISH	ENGLISH	ENGLISH
5	SOCIAL	SOCIAL	SOCIAL	SOCIAL
6	PHYSICAL ED.	PHYSICAL ED.	PHYSICAL ED.	PHYSICAL ED.
7	ART/MUSIC	ELECTIVE	HEALTH/ELE	SEQ. ELECTIVE

IRP= Integrated Regents Program

Several Additional Points:

1. The program involves a **two-year commitment** from the student. Students who fail math or science at the end of one year must remediate the failure over the summer by attending summer school. Students who fail either the home economics or technology component may continue with the program, but will need another half credit during the last two years of high school.

2. It is a four-year program, however, students may leave or enter after two years. **Tenth-graders not new to the district will not be eligible for this program.** Therefore, students enrolled in SM 1R or Earth science R as ninth-graders will need to take SM 2R and biology R as 10th-graders to satisfy the two unit math / science requirement.

3. Students who leave the district at the end of the ninth grade will have earned:
   a. one credit each for general mathematics and general science
   b. half credit each for home economics and technology.

4. Movement into the program from the traditional Regents program in January of the ninth grade is possible but will be difficult and is probably not desirable. Movement could mandate summer school, resulting in credit loss or jeopardizing sequence eligibility. Questions concerning student placement should be answered as soon as possible, preferably by October 1 of the ninth grade, so that adjustments can be made in a timely fashion. Movement into the program in January of the 10th-grade is not possible.

5. For the rare student that leaves the program at the end of the ninth grade, he / she will have earned:
   a. one credit each for general mathematics and general science
   b. half credit each for home economics and technology. Therefore, this student can enroll in business mathematics or SM 1R and Earth science R or biology R.

Integrated Regents Program *Years 3 and 4*

Program Overview

The program will continue to be integrated and have a hands-on focus. As in the first two years, students will be best served if they make a two-year commitment to the program. It will rely on the same team teaching structure as years 1 and 2. Continuation in years 3 and 4 of the program will enable the student to achieve an additional 2 credits in mathematics, 2 credits in science, and 2 credits in either business education, home economics, or technology education. Students will select only 1 of the occupational education areas (technology, home economics, or business) to focus on during these last two years. One unit of Regents credit for both mathematics and science can also be achieved by passing a Regents exam (locally developed) in January of year 4 and by completing a guided interdisciplinary problem-solving activity in the final semester of the program. The student will also need to complete an additional unit in occupational education (business education, home economics, or technology education) **outside of the program** in order to meet a five unit sequence requirement.

Overview of Program Components (Thematic Approach)

Mathematics

The mathematics component of the program will include the topics of:

- Advanced algebra
- Trigonometry
- Statistics and probability
- Computer programming

Science

The science component of the program will include the topics of:

- Energy
- Chemical bonding
- Dynamics
- Waste management
- Greenhouse effect

Note: Students will select one of the following occupational education areas.

Business Education

The Business Education component of the program will include the topics of:

- Information processing (desktop publishing, graphics, word processing, etc.)
- Accounting / record keeping
- marketing
- law

Home Economics

The Home Economics component of the program will include the topics of:

- Housing
- Fashion and textiles
- Food science
- Quantity foods
- Global foods
- Family studies

Technology Education

The Technology Education component of the program will include the topics of:

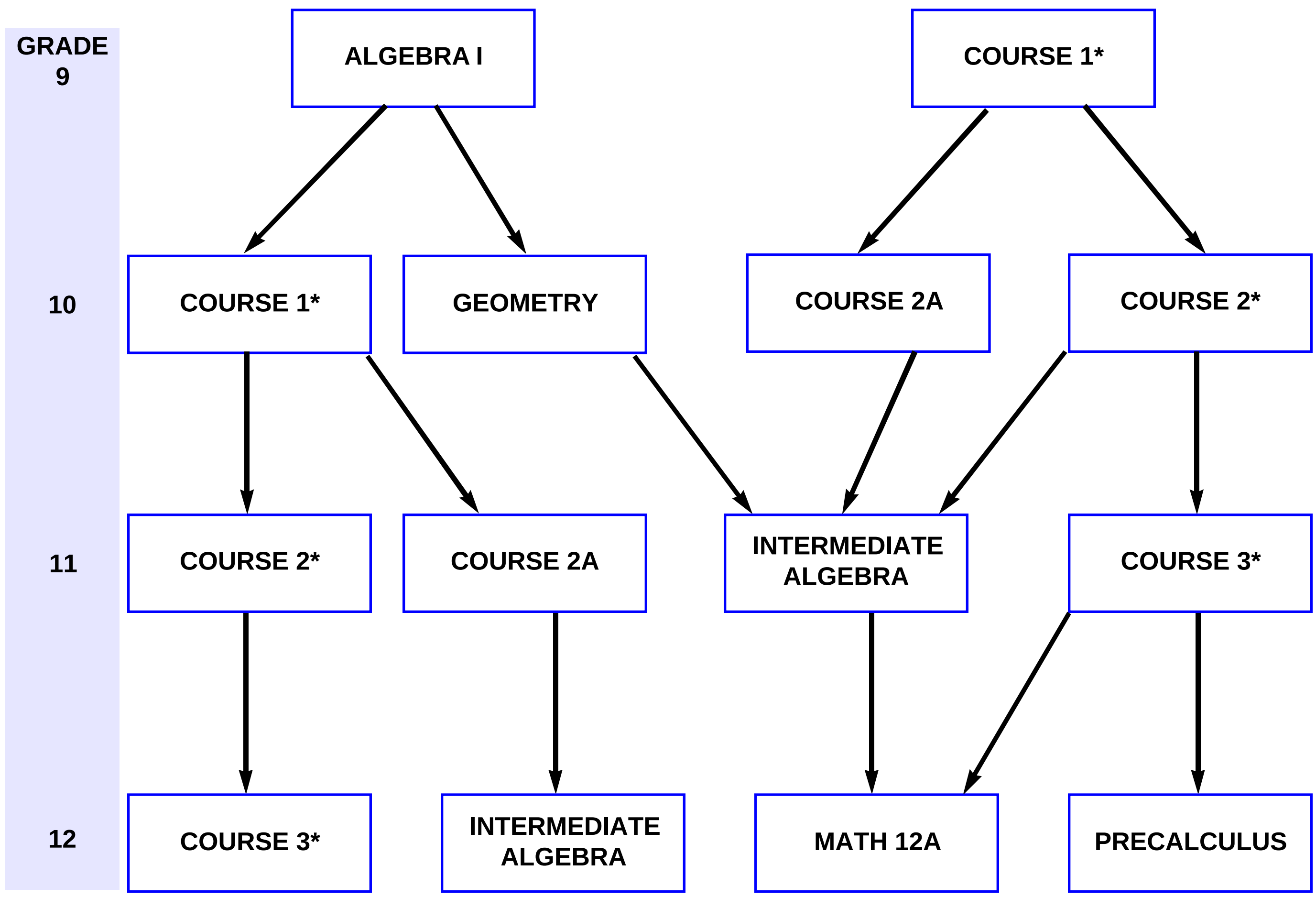
- Construction
- Manufacturing
- Transportation
- Electronics
- Communications / video production

Local Examples High School Mathematics Sequence

Students in the Syracuse City School District are presently able to earn a sequence in mathematics by starting with either Algebra I or Course 1 as ninth-graders. They may pursue various routes to achieve a sequence designation as twelfth-graders. **Chart A** portrays current practice in Syracuse, while **Chart B** indicates how that practice could be modified by the introduction of the new Mathematics Aassessment in June, 1999. Though schools can continue to use Course 1 for a minimum requirement, and Course 2 and 3 develop a sequence until January 2002, teachers will wish to begin thinking about new patterns toward a Mathematics Sequence designation.

Chart A

Suggested High School Mathematics Sequences for College-Bound Students Starting with Algebra I or Course 1 in the Ninth Grade



* Courses which culminate with a Regents Examination

Source: Collins, William. Mathematics Supervisor, Syracuse City Schools.

Chart B

Phase-In of High School Mathematics Assessment for the Freshman of 1997 and Thereafter

Students would have to pass one of these mathematics assessments before they graduate. For example, the student entering in September 1997 could pass Course 1 in June 1998 (or continue to challenge it until January 2002) or they could wait and take the Math "A" exam in June 1999 (or later). Schools with variances would be permitted to use their assessments in June 1998, but after that they would have to choose between Course 1 or Math "A" exams beginning in June 1999.

MATH PHASE-IN

Enter Grade 9 Sept. 1997	Enter Grade 9 Sept. 1998	Enter Grade 9 Sept. 1999	Enter Grade 9 Sept. 2000	Enter Grade 9 Sept. 2001	Enter Grade 9 Sept. 2002
Course 1 55/65*	Course 1 55/65	Course 1 55/65	Course 1* 55/65		
or	or	or	or		
Math "A" 55/65 in June 1999	Math "A" ** 55/65 in June 1999	Math "A" 55/65	Math "A" 55/65	Math "A" 65	Math "A" 65

* Freshmen of 1997-2000 can receive local diploma credit by attaining a score of 55-64 on a Regents examination (if permitted by their district), but they would need a 65 minimum score for a Regents diploma. Freshmen of 2001 and thereafter will need a minimum score of 65 for a diploma.

** *Math "A"* based on the Mathematics Standard of the *Learning Standards for Mathematics, Science, and Technology*. (Specific content outline for the assessment in the March 1997 *MST Resource Guide*.) Prototype exam available in Spring 1998.

Mathematics, Science & Technology

PART I.4

Teaching and Learning Strategies 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).

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

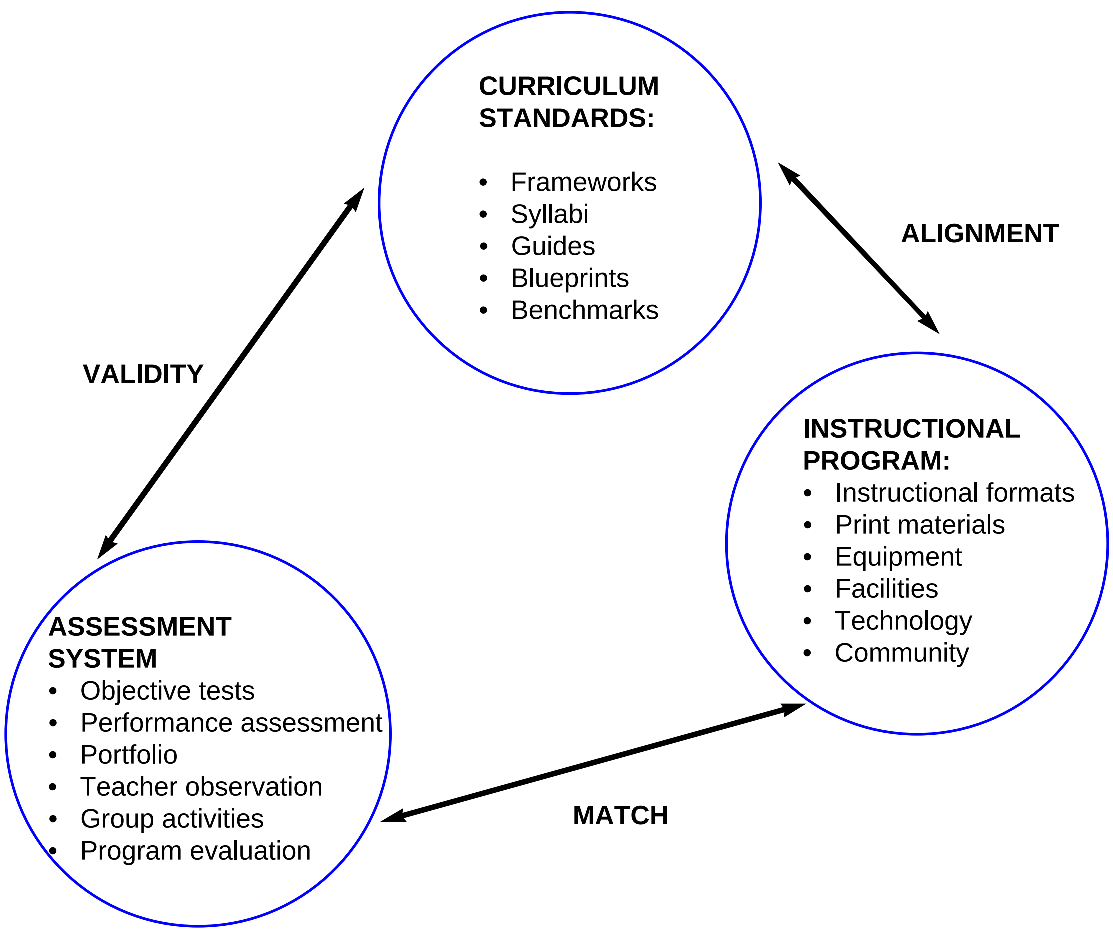
Essential Components of Curriculum, Instruction, and Assessment

MST

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

MST

1 2 3 4
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.

Teaching/Learning

Of Puddles and Perimeters

MST

1 3 4 7

ELEMENTARY

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

MST

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.

Teaching/Learning

Exploring Density

MST

14

INTERMEDIATE

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

DIRECTIONS:

Select two 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.

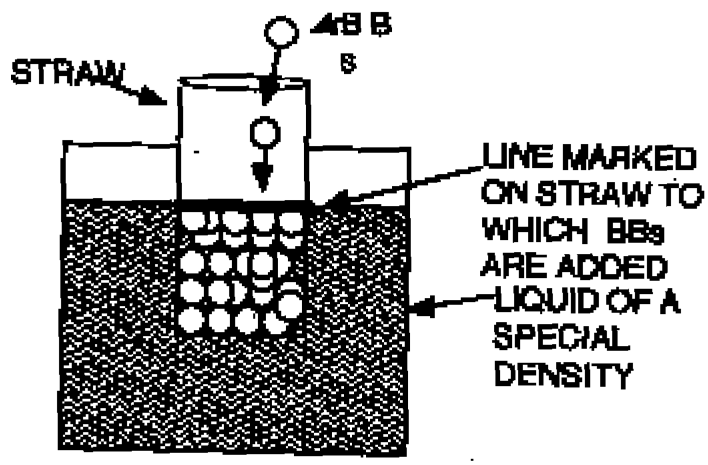
7. Determine the temperature of water at which a special metallic cylinder will go from being more dense to being less dense than the water. Write this up in the following lab format:

   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

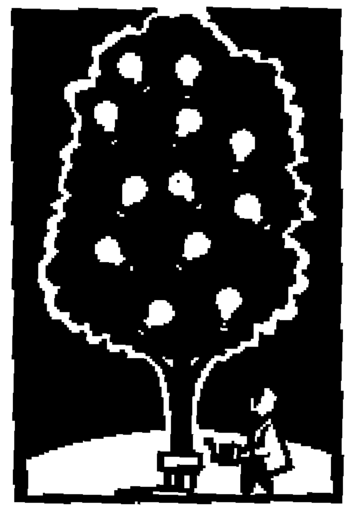
MST

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



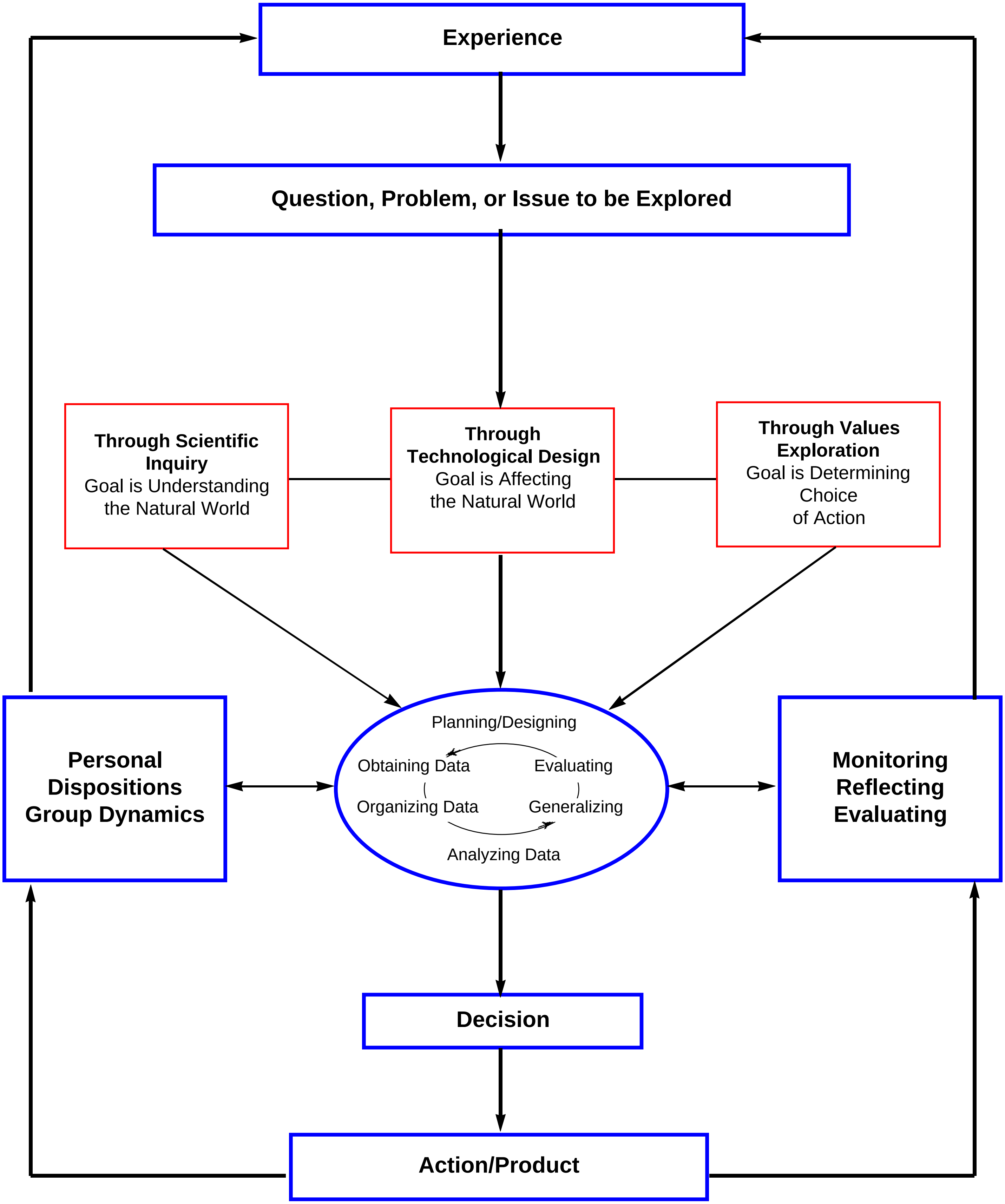
- Students actively construct meaning for themselves as a result of direct, hands-on science experiences with concrete materials, minds-on simulations, and social interactions with other students and / or the teacher.
- Values are an integral part of science teaching and learning.
- Group or cooperative 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.

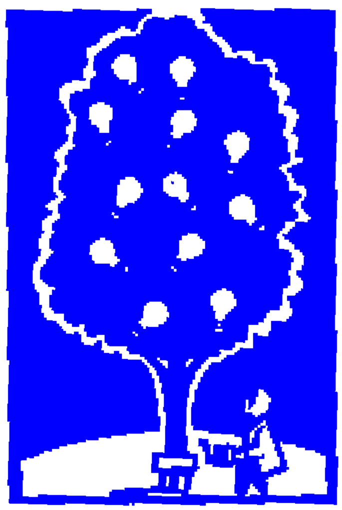
Source: Teacher Guide, *New York Science Technology & Society (STS) Education Project*, New York State Education Department, 1996.

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

1 5

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.

MST 5

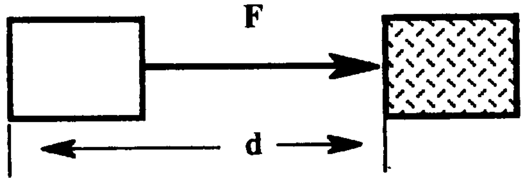
INTERMEDIATE

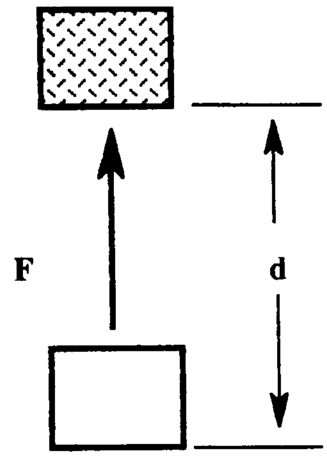
Teaching/Learning

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.

MST

5

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

Teaching/Learning

Understanding Technology Education

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.

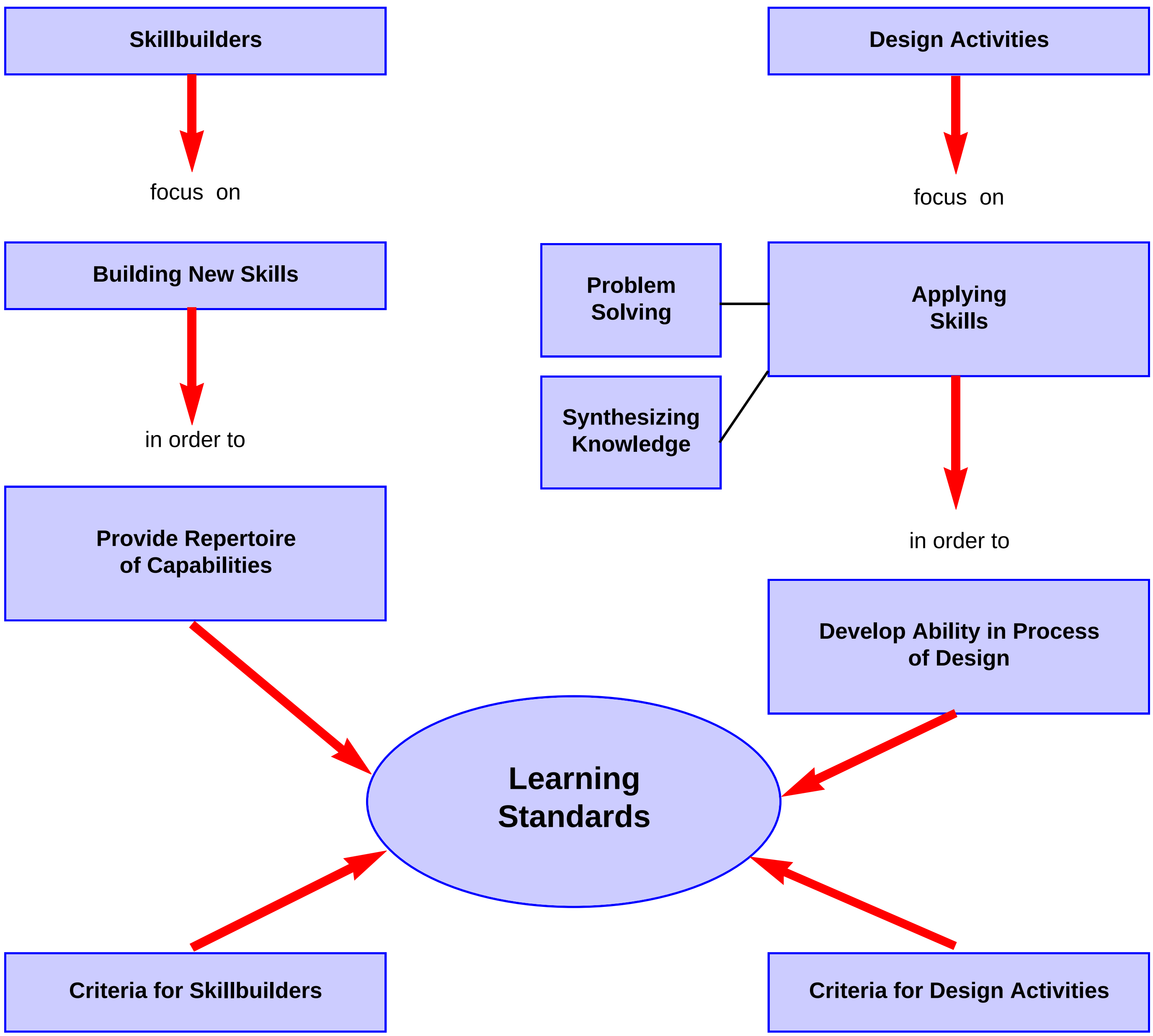
5 hallmarks of a technology education program:

- 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

Mathematics, Science & Technology

Part II.1

Seedlings

Seed Bingo 2

Seeds by Design 6

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

NEW YORK
THE STATE OF LEARNING

http://www.nysed.gov

INTERMEDIATE

Standards & Performance Indicators

SEEDLINGS

MST 1
- ▲ formulate questions
- ▲ construct explanations
- ▲ make further observations
- ▲ interpret organized data
- ▲ modify understanding

MST 4
- ▲ variation in organisms
- ▲ species competition
- ▲ developmental patterns
- ▲ living/nonliving environment

MST 6
- ▲ determine best decision
- ▲ decision making graphs

MST 7
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ present results

A suggestion for how the assignment can better meet the needs of ALL learners is to provide a practice session of categorizing seeds according to their method of seed dispersal as a pre-activity to the learning experience.

Teacher

Seedling A: Seed Bingo

Joyce G. Valenti
Windham-Ashland-Jewett Central School
P.O. Box 429
Main Street
Windham, NY 12496
(518) 734-3400 (518) 734-6050 FAX

Grade 7

Students collect and classify seeds on the basis of five methods for seed dispersal. These methods include:

1) wind carried
2) floats
3) pops out or shoots out
4) catches on animal fur
5) attracts an organism

This learning experience emphasizes the skills of observation and classification and the ability to compare and contrast.

Through the observations of seed structures and methods of seed dispersal, students will construct knowledge on:

- adaptive advantages for seed dispersal to distribute seeds away from the parent plant
- adaptive advantages to intermittent dispersal of seeds as opposed to dispersing seeds all at once
- the beneficial impact of humans and animals on seed dispersal
- the close relationship between structure of seed and its function for seed dispersal

Students are divided into small groups to examine real seeds brought in by teacher. Individual students should also view pictures and illustrations from reference materials provided by the teacher. Student groups should focus on the various seed examples in terms of structure and how the structure fits the means of seed dispersal method. After the observation activity, a teacher-directed class discussion will focus on the similarities and differences among the seeds. Emphasis will be placed on how the structure of the seeds helps to determine the method of seed dispersal. At the end of the class discussion, the seed dispersal field study assignment, *Seed Bingo* will be introduced to the class. Acopy of the *Seed Bingo* template will be distributed to each student. The assignment requires each student to reach "bingo" either horizontally, vertically, or diagonally. Aminimum of ten seeds are to be used. Extra credit will be awarded for more than ten seeds. "Jackpot" occurs when the entire card is filled with seeds. This encourages students to reach for higher expectations of the assignment.

Note: It is an excellent opportunity for inclusion of gifted and talented students to extend the assignment to the "Jackpot level."

Under teacher discretion, you may assign all students to reach "Jackpot Level" for a more vigorous and challenging activity. Rubrics would have to be modified.

Students must design their own display for the *Seed Bingo*. The seeds may be glued or taped on poster board, wood, Styrofoam, cardboard, etc. If the seeds need more reinforcement, Saran wrap may be used to enclose the seeds before gluing or taping down to the display.

The four supplementary questions to the assignment are reviewed. Students are informed that these questions may be answered in the regular "question-answer format" or answers may be incorporated in an essay form. Academically challenged students may tape record answers.

The collecting, organizing, classifying, construction of the *Seed Bingo* display, and prepa-

SEED BINGO RUBRICS

Seed Bingo Display

1. Appearance of Display
   - -overall neatness and quality of presentation — 4 pt
   - -headings clearly stand out — 4 pt

2. Contains minimum of ten seeds — 10 pt
   (1 pt for each seed)

3. Accomplishes Seed Bingo — 10 pt

4. Accuracy of Seed Bingo
   —-classifies seed to proper seed dispersal method (1 pt for each seed) — 10 pt

Supplementary Questions

1. Format Selected
   _____ written answers
   _____ written essay
   _____ tape recording

   - —-communicates logically — 2 pt
   - —-full development of ideas — 2 pt
   - —-clear articulation/concise — 2 pt
   - —-uses science-appropriate language — 2 pt
   - —-few mechanical/communication errors — 2 pt

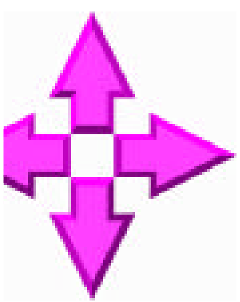
2. Demonstrates a thorough understanding of the major biological concept asked

   - Question #1 — 3 pt
   - Question #2 — 3 pt
   - Question #3 — 3 pt
   - Question #4 — 3 pt

SEED BINGO TEMPLATE

	Seed Sample 1	Seed Sample 2	Seed Sample 3	Seed Sample 4	Seed Sample 5
Wind Carried					
Floats					
Pops Out or Shoots Out Free Space					
Catches on Animal Fur					
Attracts An Organism					

ration of written material are done at home by the students. Learning resource and basic academic teachers can assist students in school.



It is highly recommended that the students be allowed to decide on the nature of the display material and the format for answering the four supplementary questions. This will allow the accommodation for the range of abilities and meet the diverse learning styles of all students.

The Ifs . . .

- **If** students do not have access to the natural world due to living accommodations and environmental factors, the *Seed Bingo* may be accomplished by using seeds from store-bought foods, household and garden plants, and certain spices or flavorings.

- **If** Lyme disease is a consideration for your area and you wish to still use seeds from the natural world, then it is highly recommended for the teacher to gather many samples of seeds from non-Lyme disease areas or purchase seeds from a horticultural society.

- **If** weather is a limiting factor in your area, then you must schedule the learning experience to coincide with the best time for seed formation in your area.

- **If** the classroom has space limitations, then the teacher may distribute the material to be used for the mounting of the seeds. Suggestions are: 8″ by 11″ cardboard or construction paper, manila folders, or small gift boxes. **NOTE:** This is also an excellent opportunity for students to pursue a wood project in a technology class. Students could design and build their bingo boards.

ASSESSMENT

Students are assessed on the two final products:

- the *Seed Bingo* display
- the written or oral answers to the four supplementary questions.

The assessment is based on the rubrics attached.

Note (optional):

1) Students present *Seed Bingo* displays to peers and teachers during a two-minute informal oral presentations. Separate oral presentation rubrics may be included in the final assessment of the project. This action allows for two modes of communicating the knowledge constructed during the learning experience.
2) *Seed Bingo* displays are set-up for a school display in the library for all students to view. In our case all students in the K- 12 school have a chance to view the student works.

SEED BINGO
SUPPLEMENTARY QUESTIONS

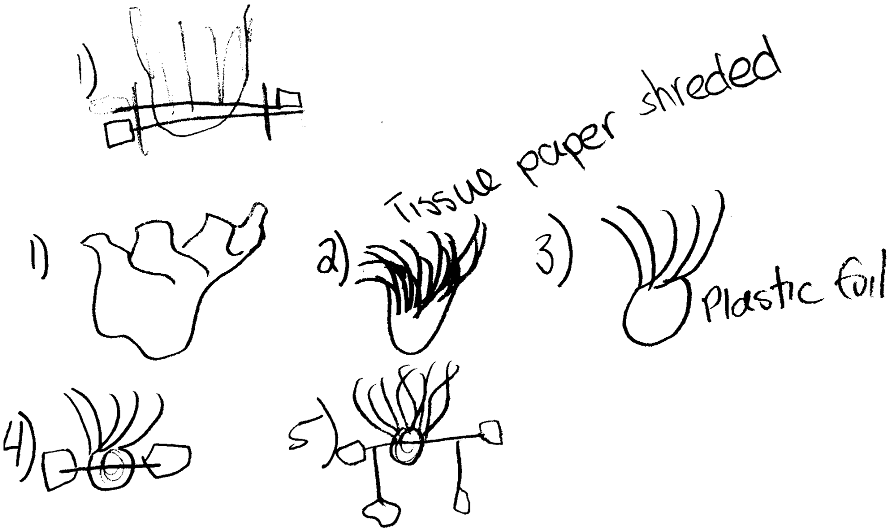
1. What are some advantages of seeds getting away from the parent plant?

2. Why do plants not drop all their seeds at exactly the same time ?

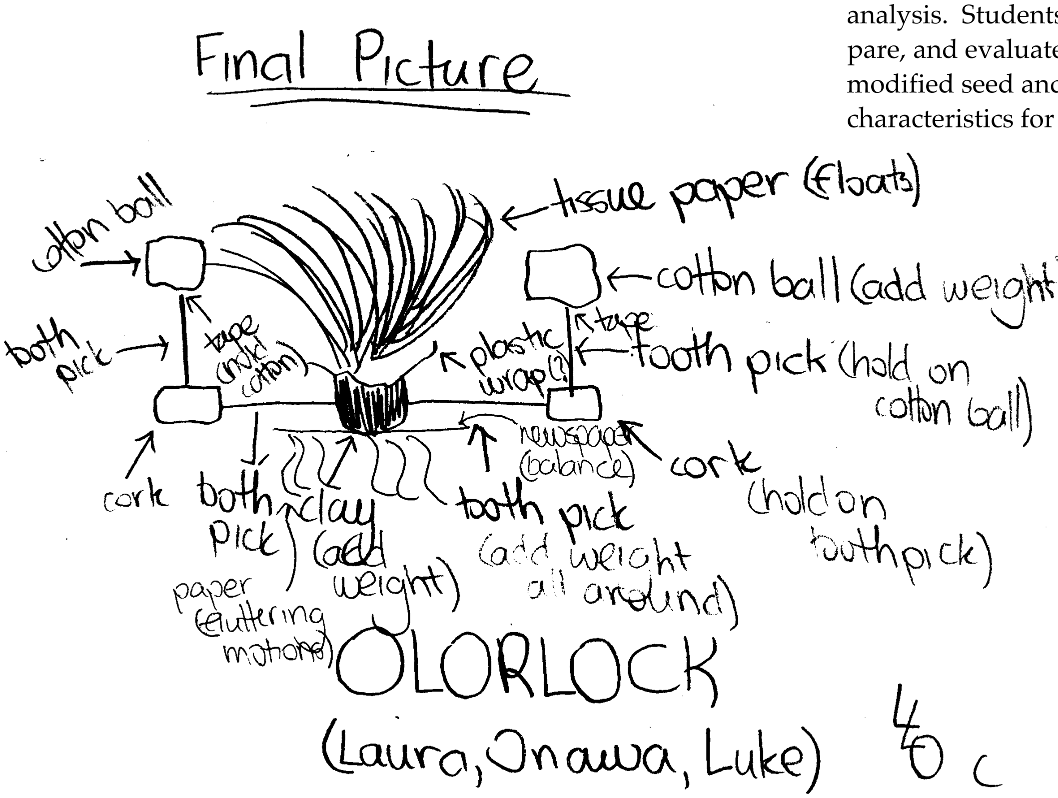
3. What would happen if all seeds dropped together and fell in the same spot?

4. How might humans and animals help disperse seeds?

Seedling B: Seeds by Design



After examining samples of naturally-occurring wind-dispersed seeds, student will design, construct, and test student-designed "artificial wind-dispersed" seeds under a controlled environment. After analysis of data collected from trial runs, students will then assess and determine modifications for a "redesign" of their artificial seeds. Modified seeds will then be tested under the same controlled environment and data will be recorded for analysis. Students then interpret, compare, and evaluate the original to the modified seed and determine desirable characteristics for wind-dispersed seeds.



Through this learning experience, students will construct knowledge by being able to:

- identify desirable characteristics of wind-dispersed seeds and explore the different structures and how each plays a role in the flight of the seeds
- choose the "best" of these desirable characteristics and indicate how they enhance the distance dispersed
- discuss the concept of competition and natural selection in terms of wind-dispersed seeds.

It is a learning experience that supports the creative spirit and curious nature of students.

Teacher

DAY 1 Pre-activity of sample seed packet:

For the pre-activity of this learning experience, the teacher needs to have a sample of naturally-occurring wind-dispersed seeds. It is highly recommended that the teacher collects samples of seeds throughout the year and stores them for later retrieval. Examples of seeds include: dandelion, cottonwood, milkweed, maple tree, and grass seeds. Any park or woodland area will provide seeds as well as most backyards.

Sample seeds should be distributed to cooperative teams consisting of three students in each team. Each team should select students to serve in each of the following roles: the "facilitator" whose task is to keep the team members focused on each of the tasks; the "recorder" whose task is to record all observations, notes, final draft of design, and data collection; the "materials handler and timer" whose task is to keep track of materials used in the design and manage time to complete all phases of the task.

CIRBM Seed Dispersal Lab modified to adapt to the Life Science and High School Biology classes and emphasize the learning standards.

Each team should examine the seeds within the teacher-prepared packet of seeds. Students should be reminded to handle the seeds *gently*. Observations should be recorded in terms of the following: general shape; length, width, and depth of seed; mass of seed; surface area characteristics; description of any attachments; and other characteristics.

DAY 2 Trial test runs of sample seed packet:

Students will take part in the class activity of gathering data of wind-dispersed seeds from the seeds examined on **Day 1**. Data collected will be the drop time of the seeds and the time and distance traveled by the seeds when "artificial wind" is applied to them. During this teacher-directed activity, each team will take turns collecting data for the entire class on each seed type. All students should record the data collected on each seed type.

NOTE: The distance measured by how far the seeds travel will be the horizontal distance traveled from point of release to point of contact on the classroom floor. The parabolic distance is not used as a measurement in the learning experience as outlined. However, teachers may adapt the learning experience for this purpose.

Protocol 1:

1. Measure a distance of 2 meters above the classroom's floor. Mark this distance by placing tape on wall, hanging string from the ceiling, etc.
2. Hold seed at the measured distance. Using a stop watch, record the time it takes to reach the ground upon release.
3. Repeat 2 more times and calculate the average from all three timings. Record average in data chart.
4. Repeat procedures #1-3 by having each team alternate and come forward to perform steps on a new seed type.
5. After all seeds have been tested, a general class discussion should occur. Some possible questions to pose are:
    - Does the mass of a seed affect the time it takes to reach the ground?
    - How does the surface area affect the time it takes to reach the ground?
    - What factors might have contributed to the fastest seed time? Slowest seed time?
    - Is there any relationship to the data collected and how seeds are adapted for competition and natural selection in the natural environment?

I would like to acknowledge, Mr. Patrick Haines, a regional biology mentor, who inspired me with the topic of seed dispersal.

OBSERVATIONS OF NATURALLY-OCCURRING
WIND-DISPERSED SEEDS

	Seed Sample 1	Seed Sample 2	Seed Sample 3	Seed Sample 4	Seed Sample 5
general shape					
length (mm)					
width (mm)					
depth (mm)					
mass (g)					
surface area characteristics					
descriptions of attachments					
other characteristics					

Protocol 2:

1. Measure a distance of 2 meters above the ground. Place a fan on a support structure at this height. Depending on the power of the fan and the amount of wind you desire for this activity, you will have to determine the speed adjustment of the fan and whether more than one fan is needed. Whatever you determine suitable, make sure this "wind speed" stays consistent throughout the extent of the learning experience.
2. Turn fan(s) on. Each team will then alternate with one seed type and follow steps 3-6.
3. Release the seed at the 2 meter height above the floor. Record time the seed takes to reach the ground in the data chart. Determine the distance traveled by the falling seed by measuring the distance traveled from the "marked tape" on the floor to where the seed landed. Record distance traveled in the data chart.
4. Repeat 2 more times and calculate the average.
5. All members of class should record data from each of the team's trial runs.
6. After all seeds have been tested, a general class discussion should occur. Some possible questions to pose are:
   - Is there any relationship between the mass of a seed and the distance traveled from point of release?
   - How does the surface area affect the distance traveled from the point of release?
   - What factors might have contributed to the farthest distance traveled? Shortest distance traveled?
   - Is there any relationship between time traveled to distance traveled?
   - Is there any relationship to the data collected and how seeds are adapted for competition and natural selection in the natural environment?

Only the teacher should touch the fan(s) used. All students should be careful around any electrical devices.

Have students analyze and interpret data for conclusions to share with class. Format can either be written or discussed orally.

To address different student learning styles and heterogeneous groupings, individual students or cooperative teams can:

- construct spreadsheets on data collected from *Protocols 1* and *2*
- construct line-graphs:
  - √ drop time (seconds) from *Protocol 1* on the x-axis and the distance traveled (meters) from *Protocol 2* on the y-axis
  - √ drop time (seconds) from *Protocol 2* on the x-axis and the distance traveled (meters) from *Protocol 2* on the y-axis
- construct bar graphs:
  - √ seed type to drop time from *Protocol 1*
  - √ seed type to drop time from *Protocol 2*
  - √ seed type to distance traveled from *Protocol 2.*

DAY 3 AND 4 Student-designed "artificial wind-dispersed" seeds:

Students group into cooperative teams formed at beginning of the learning experience. *Teacher's discretion:* Teacher may wish to reassign individual task roles within cooperative teams to give students a chance to practice a new role. Each cooperative team is given a packet of human-made materials.

It is highly recommended that student teams be given *Seeds By Design* rubrics ahead of time. This will guide them through the design process and can allow for on-going evaluation of their product. *Teacher's discretion:* Teacher may want to give student teams "steps to procedure" in written form as an aid instead of relying on verbal directions.

Procedure:

1. Design the best possible "artificial wind-dispersed" seed using any of the materials provided to you in the packet. You do not have to use all the materials found in the packet, nor the entire amount of any specified material(s) chosen.
2. Each cooperative team must submit:
   - a graphic representation of the seed design with labeling of materials used
   - lab notes recording the materials used and the amount of materials used
   - reasons for using the designated materials for seed construction.
3. Each cooperative team builds the artificial seed for testing purposes.
4. Each cooperative team constructs a data chart for recording three trial runs of drop time (refer to *Protocol 1*) and three trial runs of distance time and distance traveled (refer to *Protocol 2*). Averages for both protocols are calculated.
5. Each cooperative team studies data collected and interprets results in relation to the "artificial seed design." Teams should indicate whether the trial runs support or refute the seed design and suggest ways to refine or redesign the experiment for further investigation.

NOTE: When all teams have constructed and tested seeds using *Protocol 1s and 2*, a "time-out" should occur where all groups can share: 1) first design of seed, 2) test results, and 3) conclusions and reflection.

DAY 5 and 6   The redesign of "artificial wind-dispersed" seeds:

1. Each cooperative group will now modify their "artificial seed." Some of the modifications may include: varying mass, varying surface area, varying shape. Anew packet of materials will be given to each team.
2. Each team must submit:
   - a new graphic representation of the seed design with labeling of materials used
   - lab notes recordings "modifications" made to original design in terms of type and amount material.
   - reasons for these "modifications" for the redesigned "artificial seeds."
3. Each cooperative team builds "artificial seeds" for testing purposes and constructs data chart for new trial runs on the redesigned seed.
4. Perform trial runs.
5. Data is recorded on each team's chart.
6. Feedback and suggestions are recorded on bottom of chart given by team members and peer team members.

POST-ACTIVITY

After all teams run trial tests, each cooperative team will write a conclusion from the data collected on the modifications of the redesigned seed. Emphasis should be placed on the performance level of this seed in comparison to that of the original design. Each individual member of the cooperative teams will reflect on the learning experience by writing comments on *Student Self-Evaluation Worksheet*.

MATERIALS

for the student

- sample packet of naturally-occurring wind-dispersed seeds

- packet of artificial materials suggestions:

  1 small cork
  3 rubber bands
  sheet of newspaper
  4 paper clips
  2 cotton balls
  1 ft. sewing thread
  ball of clay
  1 piece of tissue paper
  6 small post-its (38 mm X 50 mm)
  sheet of composition paper
  2 feathers
  piece of Saran wrap (12 cm X 12 cm)
  3 sheets of Kimi wipes
  1 ft. fishing line
  2 tags(1cm x 3cm) with string attached

- stopwatch
- metric ruler
- unlimited use of glue/masking tape/scotch tape

for the teacher:

- fan(s)

DROP TIME OF NATURALLY-OCCURRING WIND-DISPERSED SEEDS (in seconds)

	Trial 1	Trial 2	Trial 3	Average
Seed 1				
Seed 2				
Seed 3				
Seed 4				
Seed 5				

HORIZONTAL DISTANCE TRAVELED BY NATURALLY-OCCURRING WIND-DISPERSED SEEDS (in meters)

	Trial 1	Trial 2	Trial 3	Average
Seed 1				
Seed 2				
Seed 3				
Seed 4				
Seed 5				

TIME TAKEN FOR HORIZONTAL DISTANCE TRAVELED BY NATURALLY-OCCURRING WIND-DISPERSED SEEDS (in seconds)

	Trial 1	Trial 2	Trial 3	Average
Seed 1				
Seed 2				
Seed 3				
Seed 4				
Seed 5				

ASSESSMENT

- Students are assessed for Pre-activity (**Day 1** and **2**) by *Class Participation Criteria Checklist*.
- If graphs are assigned, students are assessed by *Graphing Rubrics Checklist*.
- Students are assessed for student-designed "artificial wind-dispersed" seeds by *Seeds By Design* rubrics worksheet.
- Students are assessed as cooperative workers within the teams.
- Students are assessed for level of impact and meaning to them by the *Reflection-Self Evaluation Sheet*.

REFLECTION:

REFLECTION

The learning experience can accommodate all learning styles and all academic levels. It also can provide gender equity. I found the girls were just as engaged as the boys in all aspects of the activity.

The learning experience is an excellent way to integrate math, science, and technology. I found that my seventh-graders and tenth graders thoroughly enjoyed the entire experience and the heterogeneous grouping of my students was fine for the learning experience. The fact that students work in cooperative teams and that there is a diversity of activities within the learning experience helps to meet the needs of all learners. The activity certainly engaged students' interest and press them toward learning.

Adrienne Murray
Life Science

Seed Collection Lab Report

1. Some advantages of getting seeds are that we get more of those kind of plants and if we don't kill them all they won't become extinct and we can find more species. Getting away from their parent plant is better than staying there because they can spread and go into different areas.

2. Plants don't drop their seeds all at one time because they may not all be ready or to space out their seeds. If the wind was blowing to the east and they dropped them all they would all go to the east. Or if they dropped some of the seeds some would go to east and when they dropped the others the wind might be blowing to the west and the seeds would travel west.

3. If the plant dropped the seeds and they all landed in the same spot the seeds wouldn't go anywhere and you wouldn't find them anywhere else. It would also have a lot of plants growing in the same spot and therefore some or all plants may die.

4. Humans and animals can help when they brush up against a plant and the seeds get stuck onto the clothing or fur and fall off somewhere else or, humans or animals brush against a plant the seeds fall off and travel by the wind somewhere else.

To better meet the needs of all learners, the teacher may need parent volunteers or students from high school classes to come and assist in the logistics of the trial runs.

The learning experience can support student progress toward attainment of the learning standards by having students keep a "learning log," throughout the entire time. The "learning log" can be collected at the end of each day for the teacher to read to monitor students' progress and also modify or further expand on directions given.

Use a digital camera or video camcorder to record actual seeds to computer memory. With the help of digitized software, students can analyze structure of the seeds (e.g.. surface area and the distance traveled for wind seed dispersal). Test runs of student-designed "artificial wind-dispersed" seeds could also be videotaped. This would allow teams to view "instant replay" trial runs for further observations and comments.

The entire learning experience allows students to construct their knowledge. The learning experience can be performed not only by life science students, but biology, applied sciences, physics, technology, and math students. Modifications can be made to any level. It can be a stepping-stone for other connections between "mother nature" and technological applications. It is a learning experience that could relate to a future bioengineering problem in the real world. It provides the process for real-world application and problem-solving strategies.

STUDENT REFLECTION AND SELF-EVALUATION

1. Describe the purpose of this learning experience.

____

____

____

2. What new learning occurred for you as a result of doing this learning experience?

____

____

____

3. If you could continue working on the Seeds By Design learning experience, what would you do next?

____

____

____

4. Explain two new understandings that you learned from doing Seeds by Design.

____

____

____

5. What skills did you use in this project that you will be able to use in other ways in your life?

____

____

____

SEEDS BY DESIGN RUBRIC

CRITERIA	*SCORING*			
PROCEDURE FOR DESIGN OF SEED				
• submits labeled graphic of seed design	4	3	2	1
• submits lab notes which include:				
—-detailed list of type/amount of materials	4	3	2	1
—-reasons for materials used for general strategy	4	3	2	1
• safety procedures followed	4	3	2	1
DATA COLLECTION				
• expresses data in labeled charts	4	3	2	1
• takes accurate measurements and observations	4	3	2	1
• correctly labels with proper SI units	4	3	2	1
• completes data table	4	3	2	1
CONCLUSION				
• forms a conclusion from test run	4	3	2	1
which indicates whether data supports or refutes the seed design	4	3	2	1
• suggests ways to refine or redesign seed for further investigation	4	3	2	1
PROCEDURE FOR REDESIGN OF SEED				
• submits labeled graphic of seed redesign	4	3	2	1
• submits lab notes which include:				
—-detailed list of type/amount of materials	4	3	2	1
—-reasons for materials used for general strategy	4	3	2	1
• safety procedures followed	4	3	2	1
DATA COLLECTION				
• expresses data in labeled charts	4	3	2	1
• takes accurate measurements and observations	4	3	2	1
• correctly labels with proper SI units	4	3	2	1
• completes data table	4	3	2	1
CONCLUSION				
• discusses and accounts for differences between performance of initial seed and redesigned seed	4	3	2	1
• suggests ways to improve overall seed	4	3	2	1
APPEARANCE				
• written material is neat and legible	4	3	2	1
• uses correct grammar and spelling	4	3	2	1
REFLECTION				
• demonstrates a self-perspective	4	3	2	1
• relates how learning may be used in the future	4	3	2	1

CLASS PARTICIPATION CRITERIA CHECKLIST

LEVEL 4

CONDUCT:

___ respects the learning process
___ shows initiative by encouraging others in the group
___ speaks to all participants
___ adheres to class rules and encourages others

SPEAKING REASONING:

___ understands questions before answering
___ cites appropriate evidence from background information
___ expresses in complete thoughts
___ displays logic and insight
___ synthesizes ideas

LISTENING:

___ pays close attention and records details
___ responses include comments of others
___ identifies logical errors
___ overcomes distractions

PREPARATION:

___ understands concepts fully
___ comes prepared to take part in discussion
___ crucial points have been identified

LEVEL 3

CONDUCT:

___ supports the learning process
___ may be impatient with confusing ideas
___ comments often without encouraging others
___ may address only the teacher
___ adheres to class rules

SPEAKING REASONING:

___ responds to questions voluntarily
___ comments indicate thought and reflection
___ ideas draw interest from others

LISTENING:

___ generally pays attention
___ responds thoughtfully to others
___ questions logical structures
___ self-absorption may distract the ideas of others

PREPARATION:

___ has reflected upon ideas and come with relevant questions
___ understands most concepts

LEVEL 2

CONDUCT:

___ may interfere with the learning process
___ shows insight but may insist too forcefully
___ may not contribute to conversation
___ tends to debate rather than discuss
___ doesn't adhere to class rules

SPEAKING REASONING:

___ responds when called upon
___ comments indicate little effort in preparation
___ comments may be illogical and may ignore important details
___ ideas may not relate to previous comments

LISTENING:

___ attention wavers
___ classifies ideas inappropriately
___ requires inordinate repetition of questions
___ shows interest in own ideas

PREPARATION:

___ has briefly considered important ideas
___ misunderstands key concepts

LEVEL 1

CONDUCT:

___ has little respect for learning process
___ may be argumentative
___ takes advantage of minor distractions
___ may use inappropriate and speak about irrelevant topics
___ intentionally does not adhere to class rules

SPEAKING REASONING:

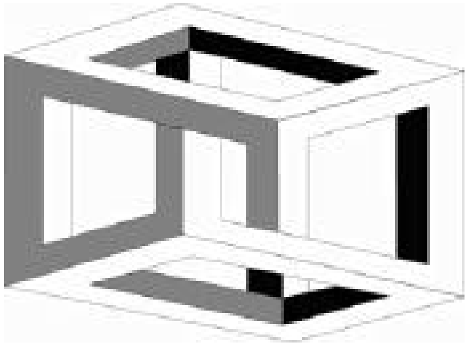
___ extremely reluctant to participate
___ comments are illogical and meaningless
___ has incomplete thoughts
___ makes little relationships between comments and text

LISTENING:

___ acts uninvolved in discussion
___ misinterprets previous comments and ideas
___ shows ambivalence towards any ideas presented

PREPARATION:

___ has not prepared for discussion
___ important ideas are unfamiliar
___ no attempt has been made to deal with difficult ideas



BAR GRAPHING RUBRICS

Type: computer/ink/pencil	1 pt
Includes:	
Title of Graph	1 pt
X-axis labeled with variables and units	2 pt
X-axis units evenly spaced	1 pt
y-axis labeled with variables and units	1 pt
y-axis units evenly spaced	1 pt
bars accurately plotted	2 pt
overall neat and legible	1 pt
TOTAL POINT VALUE OF GRAPH	**10 pt**

LINE GRAPHING RUBRICS

Type: computer/ink/pencil	1 pt
Includes:	
Title of Graph	1 pt
X-axis labeled with variables and units	1 pt
X-axis units evenly spaced	1 pt
y-axis labeled with variables and units	1 pt
y-axis units evenly spaced	1 pt
points plotted accurately	2 pt
points connected accurately	1 pt
overall neat and legible	1 pt
TOTAL POINT VALUE OF GRAPH	**10 pt**

COOPERATIVE WORKER RUBRIC

LEVEL 3

___ accepts role assigned with enthusiasm
___ discusses tasks and ideas with group
___ completes all tasks defined by role and contributes to the group effort
___ follows class rules and encourages others to do so
___ respects individual differences
___ positively responds to others
___ encourages positive behavior in others
___ helps to overcome setbacks to insure success

LEVEL 2

___ accepts role assigned
___ discusses tasks and ideas with group
___ completes a fair amount of work agreed upon by the group
___ follows class rules
___ accepts individual difference
___ responds to others
___ is not disruptive to others
___ does not work against group

LEVEL 1

___ agrees to complete very little or no work
___ discourages equal distribution of work
___ does not follow class rules
___ negatively responds to others' differences
___ actions or conversations disrupt others
___ leaves several assigned tasks unfinished
___ usually does not take part in group discussion
___ may work against the group

Laura Constantinides

OBSERVATIONS OF NATURALLY-OCCURRING WIND-DISPERSED SEEDS

	Maple SEED 1	Ragweed SEED 2	PineSeed SEED 3	Milkweed SEED 4	Goldenrod SEED 5
general shape	•Round Bit •Wing •Fan •Backbone	Funnel Shaped	oval w/ point end	← fuzzy top, flat bottom	Round
length (mm)	4cm 40mm	.5cm 5mm	.75 cm 7.5 mm	3.5 cm 35 mm	1cm 10mm
width (mm)	1cm, 10mm; 1.5cm 15mm	.25 cm 2.5mm	.25cm 2.5mm	5.25cm 52.5mm	1cm 10mm
depth (mm)	.75 cm 7.50mm	.25 cm 25 mm	.25cm 2.5mm	3.5 cm 35 mm	.5cm 5mm
mass (g)	1/10 Gram	.1 gram	1/10 Gram	Less than .1 gram	1/5 Gram
surface area characteristics	Round Small Helocopter	•little strands coming out of base	•Brown with light spots •Fat	Fuzzy	Fuzzy White Small
descriptions of attachments	Wing •thin •rough •light •Float on air	Brown base	None Really	Fuzzy Strands of hair	Fuzz Balls Attached
other characteristics	•Mostly Brown •Small	very small	Light at one end dark at other	Light White Gray	Dark Middle, Light Fuzz

Mathematics, Science & Technology

PART II.2

How is this Disease Being Transmitted? 2

The Parachute...12

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).

NEW YORK

THE STATE OF LEARNING

http://www.nysed.gov

INTERMEDIATE

How Is This Disease Being TRANSMITTED?

Standards & Performance Indicators

MST 1
- ▲ defend formal proposals

MST 4
- ▲ living/nonliving environment

MST 6
- ▲ study processes
- ▲ different models

MST 7
- ▲ design solutions
- ▲ observe phenomena
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ observe common themes
- ▲ realize results
- ▲ present results

Adapted from activity 1.3 from the *New York Science, Technology, & Society Education Project* (NYSTEP) Module "Epidemics: Can We Escape Them?"

Resources
- Epidemics Data Book which includes a copy of the NYSTEP module, "Epidemics: Can We Escape Them?" NYSTEP, 89 Washington Ave, Room 674 EBA, Albany, NY 12234, (518) 486-0858
- Stereotypical scientist props (e.g. white lab coat, large magnifying glass, clipboard, etc.)
- Copies of mortality cards
- Copies of Host and Environmental Messages
- Poster paper for wall-sized map

This lesson is implanted in a thematic unit on water pollution. The issue is made relevant to the students through preliminary data collection on a toxic waste site which is located in the middle of the community.

After introducing the unit through minor play acting, the teacher supplies students with the "Epidemic Scenario" and the *Epidemics Data Book* and describes the "Let's Find the Killer" activity. Over the next 15-20 class sessions, the teacher will post mortality cards, "Host messages," and "Environmental Messages" in a common location. Students will record the mortality data and 'messages' daily.

Students begin the lesson during the conclusion of the local toxic waste site data collection

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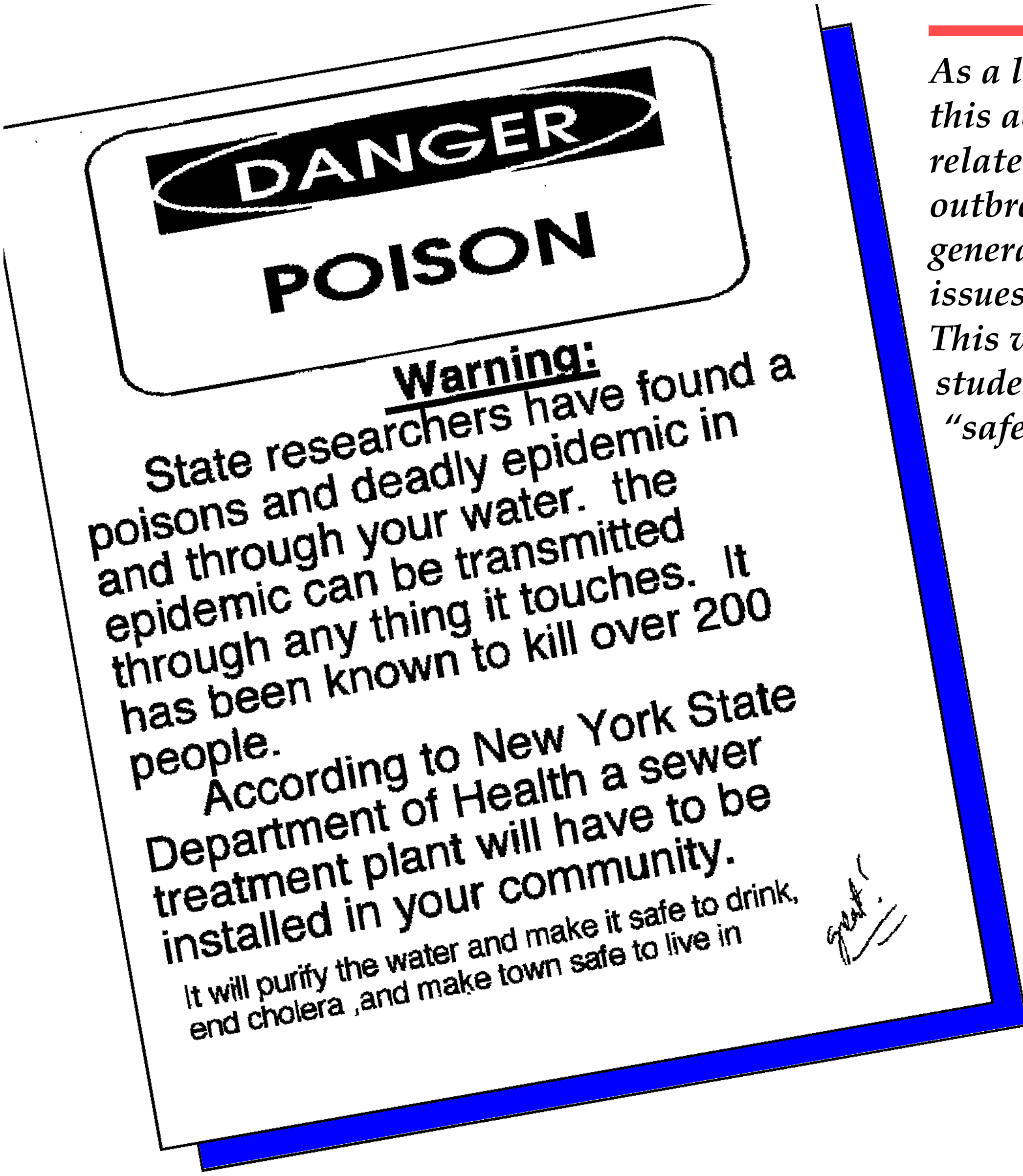
Grade 8



As a lead-in or extension to this activity, current events related to the Ebola virus outbreak can be used to generate discussion related to issues surrounding epidemics. This will eliminate the student's sense of historical "safety" from epidemics.

Teacher

and *before* discussion begins on sewage treatment. They begin this lesson by reading the "Epidemics Scenario" describing the events surrounding deaths from a mysterious 'killer' in a model city. Using a data booklet tilted, *Epidemics Data Book*, the students record information on deaths caused by a mysterious "killer" during several days of class. Students plot mortality data on a grid of the city for a more graphical representation of the location and frequency of the deaths. They use their data and evidence related to the *host* and the *environment* to try and determine the cause of the deaths as well as the location of the killer. At the end of the investigations, students take action to help stop the killer through a public awareness poster campaign.

Using local resources (County Health Department, village offices, the Department of Environmental Conservation, and newspapers), I assembled materials related to water contamination issues in Groton. As my students work though recording the mortalities on the map activity, there is a component strand of lessons that takes the students through an information search related to two toxic waste sites in town. I use a worksheet format for each of the searches that employs a similar mapping approach as the one used in the NYSTEP activity.

Although the materials illustrated here are specific to my region, the common sources of information used in retrieving materials makes it easily adaptable to most other regions of the State.

ASSESSMENT

"Let's Find the Killer" Grading sheet

Name ______________________________

> This grading sheet is to be attached to your data booklet, graph, facts, definition and poster at the completion of this topic. Use this sheet as a check list before you submit your work to insure you have included all the required components.

You have been following the deaths caused by a mysterious killer. Your goal was to use the data to figure out where the killer was located. Now that the assignment is over, you must complete the following for your grade:

Hand-in your *completed* EPIDEMICS DATA BOOKLET **(40 points):**

0	10	20	30	40	
not submitted	incomplete	poorly completed	proficient	exceptional	______

A **graph** of the death per day **(20 points)**

Proper graphing rules used

0	2	4	6	8	10	
no graph			proficient		all rules applied	______

Accurate representation of data

0	2	4	6	8	10	
no graph		incomplete data	proficient		data accurate	______

Prediction about where the killer is located [NOTE:this must be supported with **three (3)** facts drawn from your data.] **(15 points/ 5 points each properly supported prediction)**

Fact #1

0	5
no evidence	correlates to data

Fact #2

0	5
no evidence	correlates to data

Fact #3

0	5	
no evidence	correlates to data	______

Describe the disease known as **Cholera (10 points)** yes no ______

A **public notice** promoting a sewer treatment plant in the city. This is a 1 page poster that **must** include the following: **(15 points)**

Heading (to quickly tell what you are saying) **(5 points)** yes no ______

List of several (3-4) advantages a sewer treatment plant will give to the city . **(5 points)**

0	1	2	3	4	5	
none listed			proficient		exceptional	______

Artistic merit (How good does it look ?) **(5 points)**

0	1	2	3	4	5
none		poorly drawn		proficient	exceptional

Total points (out of 100) ______

J. Overhiser (Groton Middle School)

EPIDEMICS
DATA
BOOK

"Let's Find the Killer!"

NYSTEP Module "Epidemics: Can We Escape Them?"
Activity 1.3 "How is this disease being transmitted?"

NAME ______________________________

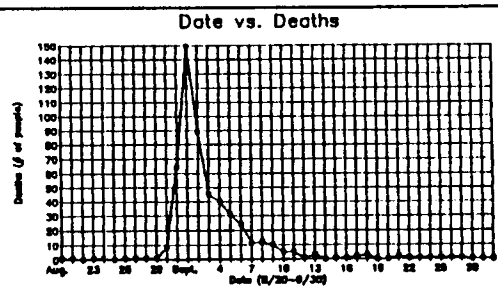
1. STUDENT WORK: EXCELLENT SAMPLE

Teacher Commentary

The sample:

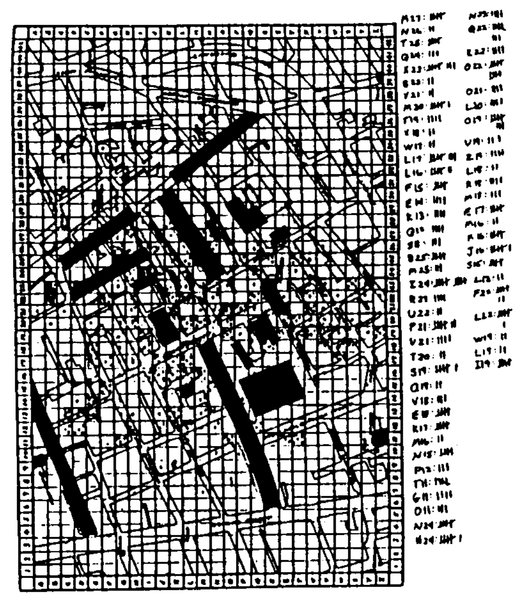
- demonstrates that students organized and interpreted data.
- describes questions raised and explores task-related science concepts and principles.
- considers costs, benefits, and risks of building a sewage treatment plant.
- uses computer-generated drawings to illustrate a plan for the sewage treatment plant.
- presents an appropriate solution to the problem.

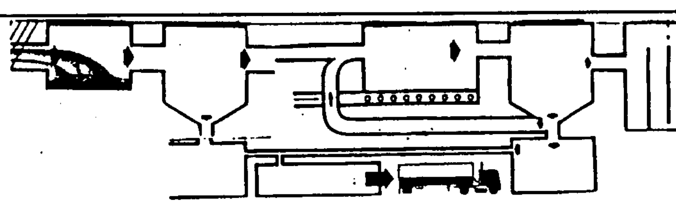
Student Work #1



Date (8/20–9/30)	# of Deaths	Date (8/20–9/30)	# of Deaths
Aug. 20	1	Sept. 10	3
21	1	11	5
22	0	12	1
23	1	13	3
24	1	14	0
25	0	15	1
26	1	16	1
27	1	17	2
28	1	18	3
29	1	19	0
30	0	20	0
31	64	21	2
Sept. 1	149	22	1
2	89	23	1
3	45	24	1
4	40	25	1
5	31	26	1
6	24	27	1
7	11	28	0
8	12	29	0
9	10	30	0

Brian Bartholomew & Eric Gobel





Possible Location of Killer:
We think that the killer is located near the pump at the corner of Broad Street and Little Windmill Street.

Three reasons that we think this are:

- There were 10 deaths in the area right next to the pump.
- There were 10 deaths in two areas near the pump that would most likely use it, housing of the very poor and near the street vendors, when someone might want to get a free drink after eating.
- The priest found that almost all of the people using the pump died later, but when the priest removed the pump handle, few people died near the pump.

Raw sewage may be the cause of this rampant epidemic! Some officials now believe that this present epidemic is caused by the raw sewage that our town has produced recently. A few ambitious locals have suggested building a sewage treatment plant to rid our town of this problem. Yet, despite of this tragic epidemic that has taken the lives of literally hundreds of our neighbors, some people in our town refuse to accept the building of a sewage treatment plant by using their tax dollars. As of September 10, today, the deaths due to this plague has been lowered to merely one. But their is no guarantee that this epidemic is finished with us yet. If we, in London, all band together to ward off this plague, then one weapon we might employ would be this proposed sewer treatment plant. Without this establishment to be rid of pathogens, or harmful bacteria, we might never be free of this infectious plague. Please, as a salute to those who have already died, and for those who still live, support the creation of this sewer treatment plant.

Epidemics Project:
Cholera is a very serious disease caused by the bacteria Vibrio cholerae. The way infection occurs is usually through contaminated drinking water. You may suspect you have this disease if you experience the symptoms of: excessive diarrhea, and vomitting. After this you would experience muscle cramps, be very thirsty, and have cold, wrinkled skin. The preceding are a result of lost fluids due the diarrhea experienced earlier. If the lost fluids are not returned to the body, you may go into a coma, and death would come within twenty-four hours. The best way to prevent this is to have a pure drinking water source. But, if you happen to contract this disease, this disease may be treated by a drug called Tetracycline. Taking a saline by IV could save your life, but it costly.

2. STUDENT WORK: PROFICIENT SAMPLE

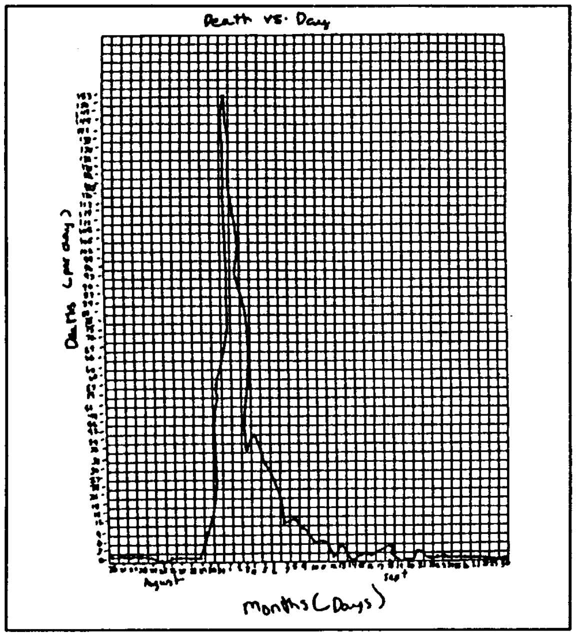
Teacher Commentary

The sample:

- demonstrates that students organized and interpreted data.
- describes questions raised and explores task-related science concepts and principles.
- uses a variety of sources to present accurate and relevant information.
- presents an appropriate solution to the problem.

Student Work #2

Day	deaths
August 20	1
August 21	1
August 23	1
August 24	1
August 25	
August 26	1
August 27	1
August 28	1
August 29	1
August 30	8
August 31	56
Sept 1	149
Sept 2	89
Sept 3	48
Sept 4	40
Sept 5	31
Sept 6	29
Sept 7	11
Sept 8	12
Sept 9	10
Sept 10	
Sept 11	5
Sept 12	1
Sept 13	3
Sept 14	0
Sept 15	1
Sept 16	1
Sept 17	3
Sept 18	3
Sept 19	0
Sept 20	0
Sept 21	2
Sept 22	1
Sept 23	1
Sept 24	1
Sept 25	1
Sept 26	1
Sept 27	1
Sept 28	0
Sept 29	0
Sept 30	0



I think the killer was located on Broad Street because:

1. That's where the pump was. When the pump was removed the deaths decreased.
2. In host message #4, the women wasn't sick until she came into town from the countryside. Therefore you know the killer is located somewhere in the town.
3. The pump was contaminated, and when people drank water coming from that pump they got cholera and died.
4. In host message #3 it describes the symptoms these people had. They are the same symptoms of cholera, which means there has to be a contaminated well. The only pump is on Broad Street, so you know that's the killer.

Cholera:

Cholera is an acute infectious disease in humans caused by the bacterium Vibrio cholerae. It usually occurs from drinking contaminated water. Symptoms of this disease are: diarrhea, vomiting, loss of fluid and salts, muscle cramps, severe thirst, and cold, wrinkled skin. The preventive is a supply of pure drinking water.

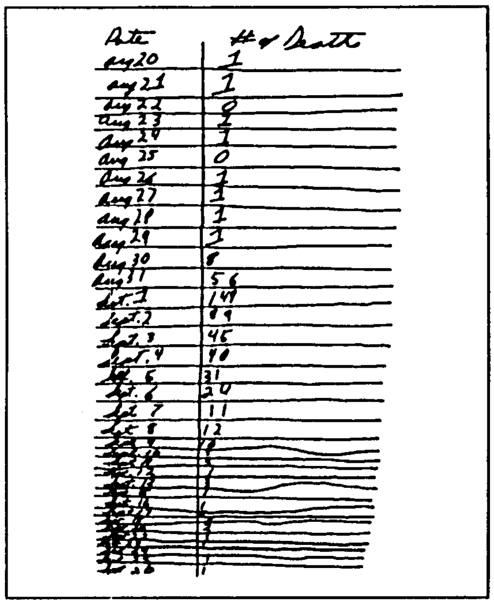
3. STUDENT WORK: ACCEPTABLE SAMPLE

Teacher Commentary

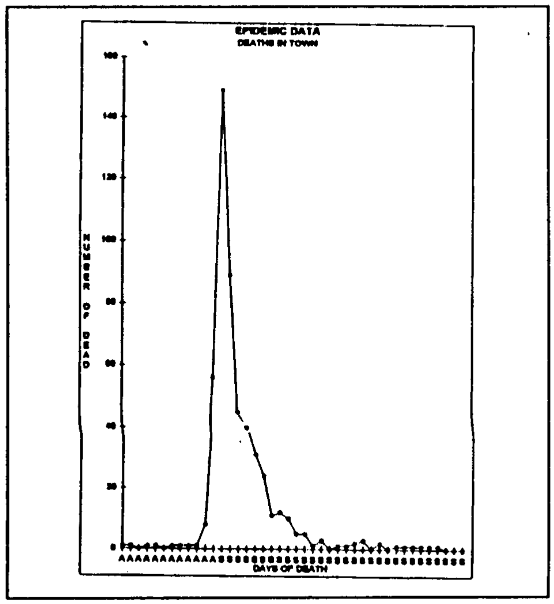
The sample:

- demonstrates that students organized and interpreted data.
- uses the computer to display data.
- presents an appropriate solution to the problem.

Student Work #3



Date	# of Death
aug 20	1
aug 21	1
Aug 22	0
Aug 23	1
Aug 24	1
Aug 25	0
Aug 26	1
Aug 27	1
Aug 28	1
Aug 29	1
Aug 30	8
Aug 31	56
Sept. 1	149
Sept. 2	89
Sept. 3	45
Sept. 4	40
Sept. 5	31
Sept. 6	20
Sept. 7	11
Sept. 8	12
[illegible]	[illegible]



I think that the killer is between and on Broad Str., Little Wind Mill Str., Nevy Str., and the School. I think they are there because that is where most of the deaths are happening, the pump is there, and because they are blocked in all directions by the new sewer system.

Cholera is an infectious disease that is caused by the bacteria Vibrio Cholerae. People get infected by the bacteria through contaminated drinking water. The symptoms are usually diarrhea, dizzyness and faintness before vomiting. That lets go of some of the salts and other fluids in the body, gives people muscles cramps, severe thirst, and cold, wrinkled skin. The fluid have to be returned to the body or a person may go into a coma and die in less that 24 hours. Saline solution can save your life, but it cost a lot ornf money. Tetracycline may also help in the recovery of a person.

4. STUDENT WORK: UNACCEPTABLE SAMPLE

Teacher Commentary

The sample:

- is missing a prediction and justification about the identity of the killer.
- does not demonstrate interpretation of data.
- does predict benefits in building a sewage treatment plant.
- presents an appropriate solution to the problem, but does not explain why it is important.

Student Work #4

Poster:

We need it! Groton needs a sewer treatment because 150 died from having Cholera in their water system. If we have a sewer treatment we will be able to cloranate the wataer. Which will kill the bacteria and it will save many peoples lives.

REFLECTION

Although the lesson is designed to be a convergent, problem-solving activity, it has divergent potential. I feel the data does not serve to make the answer too obvious, thus allowing students to arrive at varying conclusions. Furthermore, the database is complete enough to support various conclusions. Allowing for personal interpretation can create a sense of ownership to students, giving them confidence in a learning environment.

There is a current, overall emphasis being placed on a constructivist approach to teaching/learning. One major component of constructivist learning models is making learning *relevant* to the learner. Compared to a canned, textbook-style lab activity, the design of this activity supports the students generating their own response based on their own data by conveniently framing science inquiry, mathematics, and technology into the socially relevant issue of epidemics.

COMMENCE-MENT

Standards & Performance Indicators

The Parachute

MST 1

- ▲ elaborate explanations
- ▲ test observations
- ▲ present proposals
- ▲ complete research plan

MST 4

- ▲ motion of objects

MST 6

- ▲ collect information
- ▲ predictions

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Grades 11 & 12

The Parachute is an activity in which students design and then conduct an experiment to investigate the effects of various factors on the rate of fall of parachutes.

This learning experience was designed as a variance for the Physics Regents examination (35percent Option). In addition to supporting student progress toward meeting the Mathematics, Science, and Technology learning standards, the goal of this experience was to incorporate performance tasks into the examination to assess the skills, processes, and kinds of thinking that are essential in an investigatory science project but are not adequately evaluated in the traditional Regents examination. In this experience, the students were assessed on experimental design, observational skills, graphing and interpretation, critical thinking and synthesis, and error analysis.

Aconstructivist learning model is implicit in this learning experience, with students first engaged, and then involved in exploring a natural phenomenon, explaining their observations, and then applying the knowledge they have constructed to make predictions. Assessment occurs throughout the experience.

To succeed with this learning experience, students need to have an understanding of the concepts of free fall and gravity as well as skills in solving a problem by designing, conducting, and evaluating a scientific experiment using an appropriate model.

Resources

The parachutes are muslin obtained from a local fabric store. The basket was obtained at a party supply house (plastic wedding basket favors). The paper clasps may be purchased at an office supply store. It may be necessary to put a dot of glue on the rope knots to prevent slipping or unraveling due to drops.

STEPS

1. After engaging student interest in parachutes (by referring to Leonardo da Vinci's plans for such a device, for example, and the effect of free fall on human bodies), students are asked to write a procedure to determine the effect of different size parachutes and different masses on the time it takes the masses to fall. Students are asked to study the nature of a parachute and the factors that affect the time of fall.

2. The students are divided into groups and each group is given a stopwatch, several masses, a balance, a meter stick, and materials to construct parachutes.

3. The students work in groups to perform a mutually agreed upon procedure. They record all their data, and repeat steps as needed. From this point on, the students work as individuals consistent with the protocol for an exam. If this were a class activity they might continue to work in groups.

4. After completing the experiment, students are asked to write three observations they made, plot a graph, interpret the graph, and evaluate the reliability of the data and sources of error. They also interpret their experimental data to determine the mathematical relationship between time of fall and the parachute mass.

5. Students are asked to perform the following experiment at home. They push a plastic cup into a sink full of water and observe the resistance to the pushing as they make a hole; and then enlarge the hole in the bottom of the cup. They are then asked to apply their results with the plastic cup to the use of an adjustable hole in the top of a parachute. They are to predict the effect of a hole in the parachute and then cut the hole and actually measure the effect.

6. Students are presented with a diagram of a parachute with an attached basket, and are asked to draw and label the forces acting on this combination which causes its vertical motion. They also must calculate the speed with which the parachute hit the ground.

7. Students are provided with an experimental procedure for measuring the relationship between the diameter of a parachute and the time of fall. They are asked to critique the procedure, indicating if it is clear and if it is adequate to obtain the desired information. They must also compare this procedure to their own procedure.

During the experimental phase, **Step 2**, the teacher coaches the groups to insure that, for example, they construct a functioning parachute, measure the drop distance, and discard the results if the parachute hits an obstacle.

The Activity

THE PARACHUTE

No one knows when the first person took a large piece of cloth, held it over his/her head, and jumped off a hill to experience the effect of a parachute. We do know that Leonardo da Vinci provided detailed plans for such a device. Obviously, it is important to anyone who plans to jump out of a plane that manufacturers of parachutes understand how they work.

You will be conducting a series of experiments which will give you some insight into the behavior of a parachute. Working as a group you will have the opportunity to discuss what to do and how to do it. Before a group meeting you may be asked to describe what you think should be done or, after a group meeting, you may be asked to describe, analyze, assess, or critique what was done. Although you will, in part, be working with a group, you are free to report your own results.

ASSESSMENT

Students are assessed throughout the activity on the following:

1. the procedure for the experiment
2. the data obtained.

THE EXPERIMENT

Each group will have been given the following materials:

a stopwatch, a meter stick, four circles of cloth of differing diameters to use as parachutes, five weights, a small basket to hold the weights, and a triple beam balance. The basket has four equal length cords tied to it with clips on the end of each cord so that the basket can be attached to the parachute material.

The aim of the experiment is to determine the effect of different size parachutes and different masses on the time it takes the mass to fall.

Based on the aim of this experiment and the equipment given, describe the procedures you would use to accomplish this aim. Your description may be in outline form, but you must use complete sentences. Be as clear as you can be about what must be done. If something is to be repeated, be clear as to how many times. You may use any or all of the equipment. Use the worksheet provided for your description.

SECTION 1

Write the description of your experiment in the space below. You may use the back if needed. (*5 points*)

RUBRIC *(5 points)*

a) Student provides a procedure which is logically ordered and complete.

b) Student uses at least four different weight combinations.

c) Student shows the need to repeat a given procedure at least three times to obtain an average.

d) Student shows awareness of changing only one variable (parachute or mass) at a time.

e) Student indicates the need to drop from the same height in all trials.

(4 points)
Any four(4) of the above, etc.

height from ceiling to floor: 2m 66in

REGENTS OPTION
SECTION 2

NAME Milissa Giuco

Now go to your group and perform the experiment. To provide some uniformity please make sure of the following:

a) Attach the basket clips to the parachute so that the spacing is roughly even.
b) Drop the parachute so that its top is touching the ceiling.

Be sure to share with your group your opinions as to how you thought the experiment should be performed. If the group disagrees with you and fails to perform a part of the experiment you think is essential, feel free to perform that part on your own. Use this sheet so that you will have your own copy of the data. If you performed a part by yourself or without the whole group the data collected need not be shared.

Without Weights: 15.49 g

	Parachute 1	Parachute 2	Parachute 3	Parachute 4
Trial 1:	.83	1.40	1.79	1.83
Trial 2:	.93	1.74	1.76	1.78
Average	.88 sec.	1.57 sec.	1.77 sec.	1.81 sec.

#With weights # Parachute #1 23cm diameter

	10g	20g	30g	40g	50g
Trial 1:	1.19 sec.	1.26	1.05	.89	.51
Trial 2:	1.14	1.06	.81	.77	.52
Average:	1.165 sec.	1.165 sec.	.93 sec.	.83 sec.	.515 sec.

Parachute #2 31 cm diameter

	10g	20g	30g	40g	50g
Trial 1	.98	.79	.79	.74	.73
Trial 2	.98	.93	.76	.81	.67
Average:	.98 sec.	.86 sec.	.775 sec.	.775 sec.	.7 sec.

SECTION 2

Now go to your group and perform the experiment. To provide some uniformity, please make sure of the following:

a) Attach the basket clips to the parachute so that the spacing is roughly even.
b) Drop the parachute so that its top is touching the ceiling.

Be sure to share with your group your opinions as to how you thought the experiment should be performed. If the group disagrees with you and fails to perform a part of the experiment you think is essential, feel free to perform that part on your own. Use this sheet so that you will have your own copy of the data. If you performed a part by yourself or without the whole group, the data collected need not be shared.

RUBRIC
This section is not marked. It is performed as a group. Asheet of "Lab Hints" has been provided to encourage a degree of uniformity in the actual procedures of each group. This is done because some of the following parts rely on the data gained in this section.

SECTION 3

A. What are three observations you made based on the parachute experiment you performed? *(3 points*)

RUBRIC *(3 points)* Student describes any three(3) of the following:

a) The greater the mass the shorter the time of fall (the "faster it went" or "the greater the acceleration" will not be accepted since they are measuring time.)
b) The larger the diameter of the parachute, the greater the time to fall.
c) The parachute swung from side to side as it fell.
d) The parachute fell at an angle.
e) Depends on response. "It fell" without descriptor will be given no credit.

(2 points) Any two of the above, etc.

B. Using the data collected for any one of your weights, plot a graph of the time to fall (dependent variable) vs. the diameter of the parachute (independent variable). The diameter axis should extend to 0.5 m. It should be clear as to what this graph shows. Use the graph paper provided. Be sure to put your name on the graph paper. *(3 points)*

RUBRIC *(3 points)*
Both axes are correctly labeled w/units and scaled. The plot contains at least four(4) points. A smooth curve representing the best average line is drawn.

(2 points) The axes are not labeled w/unit or they are not scaled correctly or less than four points have been chosen but the best average line is drawn.

(1 point) The axes are not labeled w/units or are not scaled correctly. Four(4) points have been chosen but the best average line is not drawn.

C. Based on the graph you have drawn, what would be the time for a diameter of .48 m? Use the graph you have drawn to find your answer. Be sure you have made it clear how your answer was found. *(2 points)*

RUBRIC *(2 points)* The student has made a reasonable attempt to extend the line until it passes the .48 m mark. The student has indicated how the point was determined (guidelines, etc.) The answer includes units.

(1 point) The point does not lie on the best average line or the answer does not include units.

D. Extrapolation of given data, though correctly done, can still lead to inaccurate results. What are two possible reasons for this? Use the space below. (*2 points)*

RUBRIC *(2 points)* Any two of the following answers:

a) The line drawn is the best average line and does not represent any point specifically, just the average.
b) When extrapolating, I assumed that the curve followed the trend shown. This may not be true.
c) The best average line or the guidelines may have been drawn incorrectly.

(1 point) Any one of the above.

SECTION 4

A. What are two specific sources of error in the parachute experiment which would have caused your data to be inaccurate? *(2 points)*

RUBRIC *(2 points)* Any two of the following errors:

a) Human timing error at the initial drop or the point of hitting the floor.
b) The basket may have been at different heights since the parachutes deformed differently.
c) Agiven parachute did not always fall at the same angle.
d) Some parachutes swung from side to side more than others.

Hitting the table or the parachute not opening are not errors. They are mistakes causing that trial to be discarded.

B. Based on your experiment, was there a linear relationship between the time to fall and the mass? Justify your answer. *(2 points)*

RUBRIC *(2 points)* The answer depends upon the data. The answer is yes if a given multiple of mass produces the same multiples of time. The answer is not if not. Agraph sketch of the data will be acceptable providing a "yes" or "no" answer is also given.

(1 point) Either the correct answer based on the data or the reason.

C. Actual parachutes have an adjustable hole in the top of the chute. With reference to the experiment you performed at home with the cup, what do you think is one reason for that adjustable hole? *(2 points)*

RUBRIC *(2 points)* The answer must show that the experiment was performed by noting any observation (e.g., It went down straighter, the hole size changed the force necessary for a given descent; it went down faster as hole increased in size, it was more stable.) and the relationship this had to their experiment.

(1 point) Astatement as to what an adjustable hole might do without reference to the experiment they performed at home.

SECTION 5

A. Draw and label the vector forces acting on this combination which cause its vertical motion to increase or decrease. Be sure to show the direction of the force and where it is acting. *(3 points)*

RUBRIC *(3 points)* The diagram shows the force acting down on the basket due to the gravitational pull on the weight and is so labeled. The diagram shows the upward force of the air on the parachute and is so labeled.

(2 points) The diagram shows both forces but only one is labeled or the diagram shows both labels but only one force.

(1 point) The diagram shows only one of these forces which is labeled.

The force of the air acting up on the basket will not be counted.

REGENTS OPTION
TAKE-HOME EXPERIMENT
INSTRUCTIONS

a) You have each been given a plastic cup in order to perform the following experiment at home.

1) Fill your bathroom sink to just below the drainage hole.

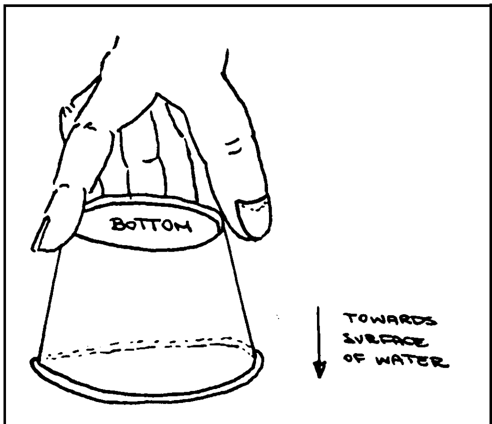
2) Holding the cup gently as close as possible to the bottom invert it so that the open end faces the water (see diagram below).

3) Push the cup slowly down into the water as far as it will go noting the effect as you push it down. Repeat as often as you wish.

4) Remove the cup from the water and punch a small hole (the size of a pencil point) in the bottom of the cup. Repeat step '3' above.

5) Enlarge the hole (bigger than the point but not as big as the width of the pencil) and repeat step '3'.

6) Enlarge the hole to the width of the pencil and repeat step '3'.



B. In speaking to various sky-diving schools, one finds that many factors affect the speed with which you hit the ground. Arough estimate is that it is similar to jumping off a 5 ft. (1.5 m) table.

Note: In the items below you must show your work to receive credit. *(6 points)*
1) Calculate the slowest speed obtained during your parachute experiment.
2) Calculate the speed with which one would hit the floor if jumping off the table noted in "B" above.
3) Using percent of error compare the speeds calculated in "1"and "2" above.

RUBRIC (6 points) The answer must contain the following:

a) The formula to find velocity given height and the acceleration of gravity.
b) The formula to find the velocity given displacement and time.
c) The formula for percent of error.
d) Correct substitution into these formulae.
e) The correct answer reported to the proper number of significant figures.
f) The units of the answer provided (percent of error must be stated in percent, not in decimals.)

(5 points) Any 5 of the above, etc.

SECTION 6

B) The following is an experiment to determine the relationship between the diameter of a parachute and the time it takes for a mass to fall. The equipment is the same as was available previously.

1) Attach the basket to one of the parachutes using the cord and clips provided.
2) Place one of the weights in the basket.
3) Hold the parachute by its top above the floor.
4) Let the parachute drop and time its descent to the floor.
5) Repeat steps “3” and “4” three times more.
6) Place another weight in the basket and repeat steps “3” through “5”.
7) Choose another parachute and repeat steps “1” through “6”.

Consider the above experiment in comparison to the one your group did. It has some good points as does yours, and some problems.
Critique the above procedure by stating five(5) reasons why yours is better, or five(5) reasons why this is better or as good, or five(5) reasons why this is worse, or any combination of better, the same, or worse as long as you have a total of five(5).

As you critique, say to yourself, “If I was doing a lab, would this be sufficient? Is it clear? Does it accomplish the aim?”, etc.

RUBRIC
(5 points) Any five(5) of the following:

a) It is easier to control a given variable.
b) The variables are truly independent.
c) There is less chance of the equipment malfunctioning or causing an error.
d) There is less chance of human error.
e) This approach is less complicated.
f) The order of operations is more logical.
g) The diagram helps to explain the setup.
h) The approach gives more consistent results.
i) The approach clearly defines what to use and how to use it.
j) Other (Depends on response. Personal preference is not acceptable.)

Use below and the back for your critique. *(5 points)*

REFLECTION

The use of cooperative learning groups promotes meaningful student dialog, encouraging student discussion as they construct relationships, see connections, and make sense of what they are observing. With these approaches, this learning experience is likely to enable students with a wide range of learning styles to meet the targeted learning standards. This activity, as noted, was designed to be a commencement test. However, it lends itself easily to being a research project, or class enrichment activity.

Mathematics, Science & Technology

Part II.3

Biology Career Exploration..........................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).

NEW YORK
THE STATE OF LEARNING

http://www.nysed.gov

COMMENCEMENT

Standards & Performance Indicators

Biology *Career Exploration*

MST 2

▲ access/select/collate/analyze

MST 7

▲ analyze problems/issues

▲ consumer decisions

Recommendation—Send a computer floppy to Susan and ask for her Student Handout. It contains the following chapters:

- **Biology Career Exploration**
- **Scoring Guide for Biology Career Exploration Project**
- **Careers Involving Biology**
- **Career Summary Sheet**
- **Interview or Shadowing Verification Sheet**
- **Modified project for use with non-Regents level classes**
- **Information on "Common Application"**

In the temple of science there are many mansions... and various indeed are they that dwell therein and the motives that have led them there.

Albert Einstein

Yes, I know this is a strange one. But it is also one that I feel is a critical part of my biology program. Some things you do in teaching have a strange history of development. They start with a small, real-life experience and develop through trial and error experiences in the classroom. The idea for this project began when my daughter was a senior going through the process of applying for college. She said, " Mom, somebody should have told me what these applications look like when I was in 9th grade. I would have made a lot of changes in what I did during high school. I would have...." The next year, I took her suggestion and began a small scale career exploration project.

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Grades 9 & 10

I quickly learned that I needed to help students develop skills for career research. I also learned that I needed to go beyond the traditional career research to get students started on the process of thinking about their future. What started as a three-day research project has gradually grown into a project theme that I will use for 11 weeks at the beginning of the school year.

Assessment of student work is embedded in the project.

Each year, I weigh the advantages and disadvantages of allowing students to select careers—particularly ones that have a distant relationship to biology. But I still feel that it is critical that we encourage students to tie this project to a career that is truly relevant to their future. The intrinsic motivation that occurs when students are allowed choice is essential to this project.

Each year, I wrestle with justifying the use of potential "content time" for this activity. But for many reasons, the project seems to grow in importance and in size each year. It enables students to see biology careers extend beyond research scientists and doctors. But more importantly, it encourages students to think about their own future—to realize that what they do in 9th and 10th grade is important for college admissions and future careers. I have found that class averages and student motivation increase significantly after completion of this project. The project also gives me an opportunity to talk with students about their talents and interests.

When people think of biology careers they tend to think of careers such as doctors, laboratory research scientists, and ecologists. They do not realize that there are many different kinds of biologists including genetic counselors, sports trainers, and farmers. We would like you to be aware that even careers that seem far removed from biology may rely on a knowledge of biology. Lawyers, sales people, and elementary school teachers, for example, may find that their careers involve a need to understand biology.

Teacher

What the students do:

- select a biology or biology-related career for research
- use school and community resources to gather and apply for information on this career
- use these resources in preparation for this career
- complete a college application
- share what they have learned with classmates
- reflect on how this project increased their understanding of careers, career resources, and skills for long-term assignments
- more detailed information is provided in the form of student handouts and a scoring guide.

What the teacher does:

- assigns project and monitors student progress toward completion
- arranges for access to career center, computer lab, and community resources
- answers questions regarding information-seeking process or career information
- helps students see possible relationship between their career and biology.

For my non-Regents biology class that includes a wide range of student abilities and motivation levels, this project is modified significantly. Most of the modification involves breaking the assignment into many smaller assignments and providing additional class time for helping students master research, writing, and speaking skills. Copies of the simplified assignments that I use are included at the end of the student handouts. I also provide information on, and applications for, training programs that do not require college education. The special education staff in my building has been fantastic in working with me to provide both resources and teaching support.

This career project requires serious thought for use with special education students. Because I teach in a wealthy suburb, many of my students have unrealistic plans for careers. Students who are working toward IEP diplomas may wish to become vets, doctors, or marine biologists. I never tell students that their dreams are impossible, but I do try to make them aware of related careers that require less academic preparation. Other students may have no plans beyond that day. Use of classified ads from the newspaper and patience with exploring their current interests can help to steer students to beginning to think about their future.

I have learned that this project can trigger intense animosity from at-risk students, but I have also learned that if you are accepting of their anger, you can help them begin to think about their future.

Physical modifications of the classroom setting:

- Prepare a quiet, private conference area so that you can talk to individual students without an audience, yet still keep an eye on the rest of the class.
- If available, move the class to a career center, school library, or community library for some of the work on this project.

Week 1 - What careers are you considering?

Begin by making a list of 10 possible careers that you are currently considering for your future. These do not have to be biology careers. Try to make a list that includes career options that are as different from each other as you can imagine. Write a "B" after careers that you consider to be biology careers. Write an "I" after careers that you think might involve biology. For each career, write a paragraph that explains why the career appeals to you.

Week 2 - What biology -related careers would you consider?

Visit the career center with your class to learn about the resources available for your use. Spend the period simply looking for additional careers that are related to your areas of interest and to biology.

If you are considering a career in biology already, you will need to think about what specific types of biology careers you could pursue. For example, you could become a biophysicist, a museum curator, a laboratory technician, a nurse, or a professor. Try to explore and find unusual and interesting careers—careers that are out of the ordinary and really appeal to you.

If you are considering other careers, you will need to think of ways your career interests could be related to biology. Many people have found that they are more employable if their training and background involves combining two different areas of specialty. For example, if you envision a career in business, you could become a sales representative for a science supply company, the administrator of a nursing home or hospital, or the owner of a pet shop. If you are interested in a career in art, you could become an illustrator for biology textbooks, a nature photographer, or a landscape designer. If you want to become a writer, you could write children's science books, technical manuals, science fiction, or science magazine articles. You could become a lawyer or politician who specializes in environmental or bioethical issues.

You will be expected to turn in a list of six careers in biology or related to biology. For each of these six careers you should:

- Write a paragraph that explains why you are considering this career.
- Write a paragraph that explains how a knowledge of biology is important to the career.

Week 3 - How can you learn about the careers that you have selected?

Visit the Career Center with your class and look up information on the careers that you have selected. You will need to complete a career summary sheet for at least three careers in biology or related to biology that you might seriously consider for your future. Include the following sections in your summary sheet:

- Description of the type of work done
- Potential places of employment
- Education and training required
- Salary range
- Job outlook
- Related occupations
- Addresses to write to for further information

Visit the Internet center with your class. Use the Internet to obtain additional information about the careers that you have selected. Make a list of at least three Internet addresses that could be used to get more information about the career. Print information from each of these sources.

Type a business letter requesting further information on the three careers that you have selected. Give these letters and stamped, self-addressed envelopes to your teacher.

Week 4 - How can you gather more detailed information on a career?

Review the information that you have researched. Select one career in biology or related to biology that you feel would be the most interesting to research. Return to the career center, Internet center, or use community library facilities to obtain additional information on the career that you selected.

Write a report that includes the following information.

- Description of the type of work done
- Typical work day—types of tasks the career involves
- Potential places of employment
- Working conditions
- Education and training required
- Salary range
- Related occupations
- Job outlook
- Addresses to write to for further information
- An explanation of why you chose this career
- An explanation of why you eliminated the other two careers
- An explanation of what you can do now to work toward this career
- Alist of 10 questions you would ask if you had an opportunity to interview someone in this career
- An explanation of what chapters in your textbook would be relevant to someone with this career
- Asummary sheet for two related occupations
- An explanation of why exploring related occupations might be important in the career decision making process.

Week 5 - What educational programs are involved in preparing for this career?

Visit the career center. Identify a college that offers a degree program which could lead to the career that you have selected. Use the catalog from that college to:

- Identify an appropriate degree program
- Identify a college that offers this degree program
- Make a copy of the pages in the college catalog that describe the general requirements for graduation
- Make a copy of the pages in the college catalog that describe the specific requirements for the degree that you are planning
- Explain what high school courses you would need as background for college admission and success
- List the kinds of courses you should take in college to obtain a degree in the field that you have selected
- Explain what education beyond this college program might be required for entry into this career
- Explain what education beyond this college program might be required for advancement in this career.

Arrange for a career interview or shadowing with someone in the community who is involved in the career that you have researched. Complete the upper part of the career shadowing/interview form and hand it in to your teacher.

Week 6 - What is it like to complete a college application?

Your teacher will provide copies of the "Common Application," a sample college application that is used by a cooperating group of colleges. Complete the "Common Application" based on what you think your high school record will be like by the beginning of your senior year.

Be sure to include at least one fictitious recommendation form from each of the following:

- science teacher
- guidance counselor
- employer or an extracurricular advisor.

Your teacher will provide copies of essays that were selected from a variety of college applications. Select one of these and write a 200-word essay to illustrate how you would answer this on a college application.

Interview at least five seniors who have applied to college about their experiences with the college application process. Ask them, "What advice would they give to freshman or sophomores about ways to improve their chances of getting into college?" and "What have they done to gain experience related to their planned career?"

Write an essay in which you explain what you could do from now until your senior year to improve your chances of getting into college and to gain experience related to your career.

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Week 7 - How can you use the community beyond the school to develop a deeper understanding of the career?

You should complete at least five of the following additional components:

- An idea web in which you brainstorm career directions (20) that you could take that would be related to your original career choice.
- Acollection of classified newspaper advertisements (10) from the Help Wanted column that advertises the career.
- Acollection of current event newspaper articles (10) that might involve individuals with the career.
- Aresource folder of 10 brochures, computer printouts, and copied references that provide more information on the career.
- Aposter that could be used to recruit individuals for this career.
- An original *Spotlight on Careers* section that could be included in a high school biology textbook. See your textbook for exemplars. Explain where in your textbook this should appear.
- An application for East's Student Internship Program for this career.
- An observation log of a visit to a potential workplace for the career.
- Asample of a job application for this career—real or one you design.
- Alist of 10 questions that an employer might ask during a job interview for this career
- Information on scholarships that are available to students who select this career.
- Alist of 10 ways in which you can get experience related to this career during high school and college.
- An explanation of the types of talents, skills, and interests that would be important for someone to be successful in this career.
- An explanation of how much math, science, technology, writing, and cooperative work might be involved in the career. Discuss what courses you could take in high school to obtain the appropriate background for this career.
- Contact information about two people with this career who would be willing to be guest speakers or conduct a class field trip.
- Report on interviews with three people who have made at least two career changes.
- Report on interviews with ten people in which you ask them to describe what career plans they had in high school and how they arrived at their current career.
- Acreative way of demonstrating that you have developed a real understanding of what it would be like to be a person with the career that you have researched. Be sure to get prior teacher approval.
- Be certain to include a completed *Interview* or *Shadowing Verification Sheet.*

Week 8 - How can you use the community beyond the school develop a deeper understanding of the career?

You should include two of the following additional components:

- Abiography of a biologist with the career.
- Avideotape or multimedia presentation that could be used to recruit individuals for this career in biology.
- Acareer interview report in which you ask the questions that you developed during **Week 3** of this project.
- Acareer interview report in which you ask questions about the amount of math, science, technology, writing, and cooperative work involved in the career.

- Acareer shadowing report in which you describe the workplace and explain the types of work done by the person you are shadowing.
- An explanation of two bioethical dilemmas that people with this career might face.
- Acreative way of demonstrating that you have developed a real understanding of what it would be like to be a person with the career that you have researched. Be sure to get prior teacher approval.
- Be certain to include a completed *Interview* or *Shadowing Verification Sheet*.

Week 9 - Sharing what you have learned with your classmates

Be prepared to participate in a five-minute role-play with your classmates. Your classmates will play the role of people at a party who are asking you about your career. You will play the role of someone with the career that you have researched. You should be able to answer the following questions:

- Where do you work?
- What do you really do in your job?
- What kinds of people do you work with?
- How did you end up in this career?
- What kinds of training did you have to have to get into this career?
- My kid is interested in this career. What advice would you have for him/her?
- Do you enjoy what you do? Why?
- What don't you enjoy about what you do?
- What does it take to be successful in your career?
- If you could change careers, what other careers would you consider?
- How much math is involved in your career?
- How much technology is involved in your career?
- How much writing is involved in your career?
- How much teamwork or working with other people is involved in your career?
- What bioethical dilemmas do you face in your career?
- Do you really use the "scientific method" as part of your job?

Week 10 - Reflecting on what you have learned

Reflect on what you have learned from this project by answering the following essay questions.

1. How has this project helped you:
   - understand the different types of careers in biological sciences
   - understand that knowledge of biology can be important in non biology careers?
2. What are the three most important things that you have learned about each of the following:
   - the process of gathering and interpreting information about potential careers
   - the process of applying for college admission
   - the process of preparing for careers
   - handling long-term projects?
3. What part of this project are you proudest of? Why?
4. What part of this project was most interesting? Why?
5. What part of this project was least interesting or least beneficial? Why?
6. If you could do this project over again, what would you do differently?
7. What advice would you have for future students about how to get the most out of this project?

8. If your teacher revised this project for use with future students, what changes should be made to make it more interesting or relevant for students?
9. Have your parents review your work and answer the following question in writing: “What suggestions do you have for how his/her work on how this project could have been improved?”
10. Have your parents review your work and answer the following question in writing: “What suggestions do you have for your child’s teacher on how the design of this project could have been improved?”

Week 11 - Revision to prepare this project for your portfolio

Revision is an important part of preparing your project for inclusion in your final examination portfolio. Follow the instructions below to complete the revision process.

Organize your notebook. Put the scoring guide first and then arrange the other parts using your scoring guide as a reference. Use labeled dividers to separate the different weeks of the project.

Highlight the things on the the scoring guide for which you did not get full credit.

Make revisions to include all of the missing parts and to follow the recommendations that your teacher and your parents made.

Highlight the right margin of any pages that represent revision work.

Add these revisions to your notebook in the front of the appropriate weekly section.

Make a list of 10 ways that you could improve your work habits to avoid the need for later revisions. Include this in the front section of your notebook.

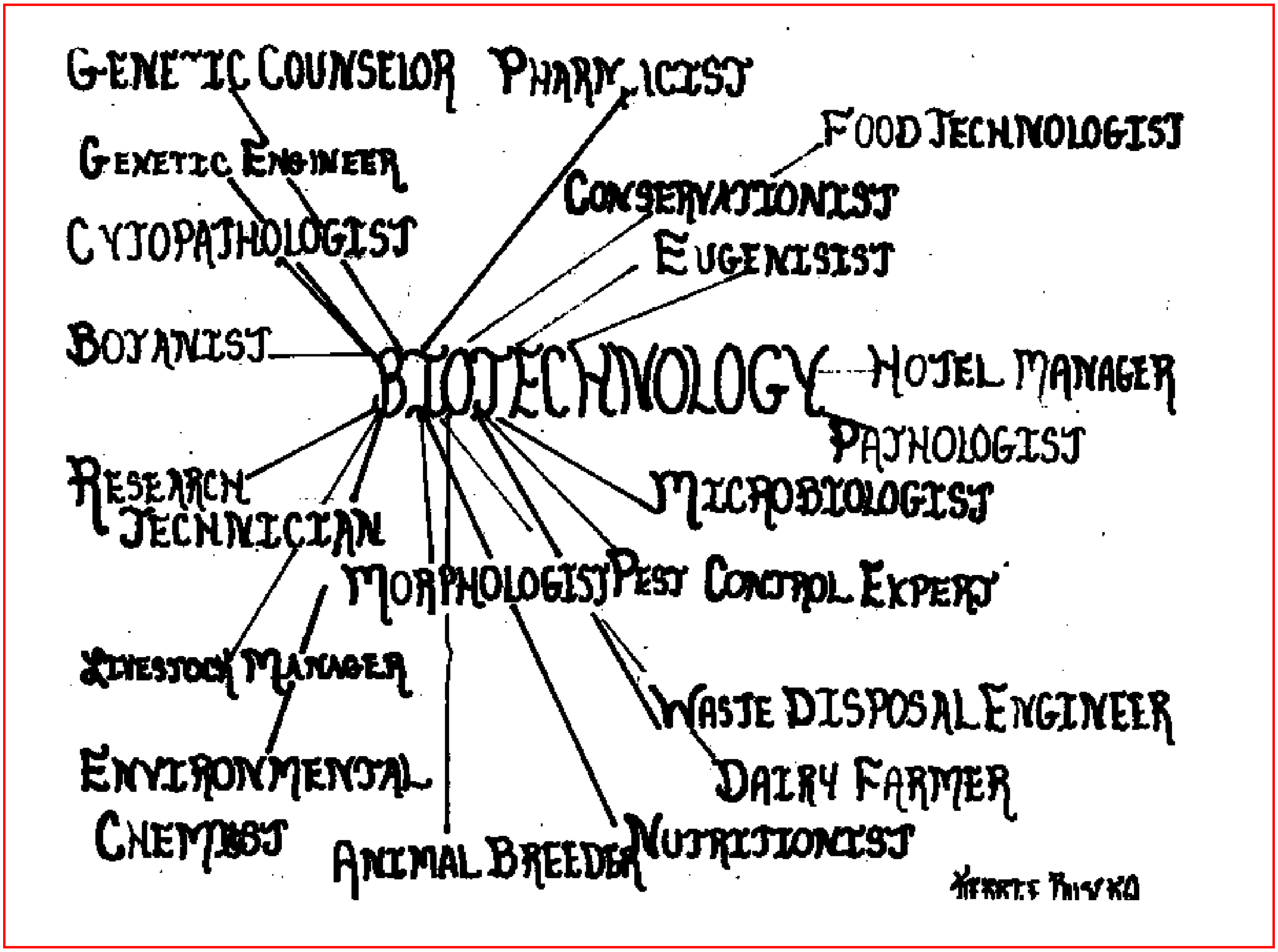
Also, have your parents write a response to the following question: “Do you feel your son’s/daughter’s revised work on this project represents quality work that he/she should be proud of? Why or why not?” Include this in the front section of your notebook.

ASSESSMENT

Since this is my students’ first experience with a long-term project, it is essential that the have access to :

- defined, weekly checkpoints described in the project instructions
- opportunities to seek clarification of instructions or process being used
- grades to evaluate each part of the project
- a grading system that rewards keeping up with the suggested work pace
- a scoring guide that students can use as a checklist to evaluate their progress
- multiple opportunities for analysis, application, and self-reflection that encourage them to go beyond simple copying of information
- a final self-reflection that also provides feedback for the teacher
- an opportunity to revise their work based on their self-reflection and teacher recommendations.

The *Scoring Guide* serves both as an assessment tool for use by both the student and the teacher.



REFLECTION:

REFLECTION

The project:

- Uses an interdisciplinary theme that includes learning standards from other subject areas.
- Shares in task of helping students prepare for their future.
- Brings real world situations into the classroom.
- Allows for student choice to focus on personal interests.
- Uses a *Scoring Guide* that is shared with the students and encourages self-evaluation in monitoring progress throughout the project.
- Incorporates opportunities for analysis, application, and self-reflection and encourage the students to construct knowledge and relate what they have learned to their future.

Scoring Guide for Biology Career Exploration

Student Name ____

Week 1 - What careers are you considering?

2	List of 10 careers	Total points possible = 30
3	Indicates “B” and “I”	Actual points = _______
20	Explains each selection	Recommendations
5	Completes checkpoint when due	

Week 2 - What biology-related careers would you consider?

1	List of 6 biology related careers	Total points possible = 30
12	Explains why considering	Actual points = _______
12	Explains how biology important	Recommendations
5	Completes checkpoint when due	

Week 3 - How can you learn about the careers you have selected?

7	Completes one summary sheet	Total points possible = 50
7	Completes two summary sheets	Actual points = _______
7	Completes three summary sheets	Recommendations
4	In depth work on summary sheets	
6	Three Internet addresses	
6	Three Internet printouts	
5	Business letter requesting information	
3	Stamped addressed envelope	
5	Completes checkpoint when due	

Week 4 - How can you gather more detailed information on a career?

2	Title page with name of career	Total points possible = 100
2	Description of work done	Actual points = _______
2	Typical workday	Recommendations
2	Potential places of employment	
2	Working conditions	
2	Education and training required	
2	Salary range	
10	Related occupations	
2	Job outlook	
4	Addresses to write	
5	Why chose this career	
5	Why eliminated other two	
5	What can do now	
10	Ten questions for interview	
10	Text chapters relevant to career	
10	Summary sheet for one related career	
10	Summary sheet for two related careers	
5	Exploring related careers important	
10	Completes checkpoint when due	

Week 5 - What education is involved in preparing for this career?

5	Identifies appropriate degree program	Total points possible = 50
5	Identifies college	Actual points = _______
5	Copy of general requirements	Recommendations
5	Copy of specific requirements	
5	High school course background	
5	College courses	
5	Education beyond for entry	
5	Education beyond for advancement	
5	Career interview/shadowing form	
5	Completes checkpoint when due	

Week 6 - What should be done to complete a college application?

5	Personal data	Total points possible = 100
5	Educational data	Actual points = _______
5	Test information	Recommendations
5	Family	

5	Academic honors	
5	Activities	
5	Work experience	
10	Personal statement (200 words +)	
10	Fictitious teacher evaluation	
10	Fictitious school report	
10	Senior interview record	
15	List of what can do to improve	
10	Completes checkpoint when due	

Week 7 - How can you apply what you have learned?

10	One completed	Total points possible = 70
10	Two completed	Actual points = _______
10	Three completed	Recommendations
10	Four completed	
10	Five completed	
10	Demonstrates depth of understanding	
10	Completes checkpoint when due	
max of 30	10 bonus points for each additional	

Week 8 - How can you use the community beyond the school?

10	Suggestions for class rubric	Total points possible = 70
20	One completed by due date	Actual points = _______
20	Two completed by due date	Recommendations
20	Score on class developed rubric	
20	Uses feedback to revise work to 20	
10	Completes checkpoint when due	

Week 9 - Sharing what you have learned

5	Thorough, clear answers to question 1	Total points possible = 60
5	Thorough, clear answers to question 2	Actual points = _______
5	Thorough, clear answers to question 3	Recommendations
5	Thorough, clear answers to question 4	
5	Thorough, clear answers to question 5	
5	Obvious preparation for presentation	
5	Uses terminology accurately	
5	Uses clear voice and loud enough	
5	Maintains eye contact	
5	Uses conversational tone	
5	Avoids distracting behaviors	
5	Completes checkpoint when due	

Week 10 - Reflecting on what you have learned

5	1. Understand careers/biology	Total points possible = 60
5	2. Processes of project	Actual points = _______
5	3. Proudest and why	Recommendations
5	4. Most interesting and why	
5	5. Least and why	
5	6. If could do over	
5	7. Advice for future students	
5	8. Suggestions for teacher	
5	9. Parent regarding your work	
5	10. Parent regarding project design	
10	Completes checkpoint when due	

Week 11 - Opportunity for revision

10	Organizes project reorder/dividers	Total points possible = 70
10	Highlights scoring guide	Actual points = _______
10	Includes original work	Recommendations
10	Adds and highlights revised work	
20	Made all necessary revisions	
10	Explains improved work habits	
10	Parent response to revisions	
10	Completes checkpoint when due	

Career Summary Sheet

Student Name ____

Name of Career ____

- Description of the type of work done

- Potential places of employment

- Education and training required

- Salary range

- Job outlook

- Related occupations

- What I think I would like about this career

- What I think I might not like about this career

- Addresses to write away for further information

Interview or Shadowing Verification Sheet

To be completed by student.

Name of interviewer/shadower ____

Date of interview/shadowing ___________ Start time ________ End time ____________________

Location of interview/shadowing ____

____

Name of person interviewed ____

Company ____

Address ____

____

Phone number ___________________ Fax number ______________________________

THANK YOU FOR YOUR COOPERATION IN THIS PROJECT!

To be completed by person being interviewed or shadowed.

Please verify the information above.

Signature ____

Was the student on time for the interview/shadowing? ____________________

Did the interviewer/shadower act in a courteous and prepared manner? _______

What suggestions do you have for **this student** about the interview/shadowing process.

What suggestions about the interviewing/shadowing process would you make for **other students** involved in this project?

What suggestions do you have for **the teachers** involved in the career exploration project?

Please feel free to contact _____________________________at _____________if you have any questions, suggestions, or concerns about this career project.

Essay:

There were two other careers that I was interested in aside from forestry. One was a **"ski resort owner."** I eliminated this idea because it is a seasonal job and you'd have to find a different business for the other three seasons of the year. It also depends on the weather, which can sometimes be very unpredictable. One winter could be cold and snowy and the next could be warm and rainy. Skiing is a very expensive sport and when the economy is poor, this can have a negative effect on whether people go skiing or not.

My other choice was **"architecture."** I do not have any real objections to this career, only that I lost out on a great opportunity which was, not taking architectural courses here at Williamsville East. We have one of the best pre-architectural programs in New York State and I feel that I lost my chance, so I will just move on.

When I am outside in the woods, or in the mountains, or skiing, this great feeling of freedom just rushes through my body. The smell of all the wildlife around me as I hike, is one of the best natural highs there is. Standing on the top of a mountain, being out of breath and looking at the world below you, is mesmerizing. I believe you experience many great things out doors, and if I had the choice I would want to spend my life outdoors. I wouldn't want to live out doors all the time, but when I get older and have to get a job I would like for most of it to be spent outdoors and in the wilderness. I don't see myself (later in life) being confined to sitting in an office doing paper work all day.

This is why I see **"forestry"** as a good career for myself. I am interested in animals and their surroundings. I would like to help provide a beautiful place for them to live. That goes for humans too. We take a lot of our resources for granted. Most of them come from nature, and foresters help save our earth. Conserving our rain forests and forests will make the earth a happier and healthier place to live.

Mathematics, Science & Technology

PART II.4

Energy, Matter, and Organization 2
Bioethics 7

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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COMMENCEMENT

Standards & Performance Indicators

Energy, Matter, and Organization

MST 4

▲ structure and function

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Grade 10

NOTE: The simple story line or task introducing the activity can obviously be made more attractive by the many of you who are much more creative than I am. Have some fun!

This activity is the final assignment in the *Energy, Matter, and Organization* unit, which is one of the six unifying themes covered in the *Regents Biology Program Guide*. Our biology variance is based on this program guide. The students have already studied: Levels of Organization (including cells), Membranes (including diffusion), Enzymes, Photosynthesis, Aerobic Cellular Respiration, Nutrition Gas Exchange Transport. This assignment has the students look at one central area—cellular respiration—and six side areas—human digestion, human circulation, human gas exchange, cells, enzymes, membranes. The students are expected to review each area and make connections between each side area and the central area. It is also expected that during this activity the students will recognize connections between each of the side areas. Requiring students to make connections helps assure construction of knowledge.

Students have one week to complete an essay. Students are expected to review each topic prior to writing the essay. Each student must prepare and submit a concept map or drawing depicting the "connections" among the areas prior to writing the essay. The concept map or drawing is returned to the student with teacher comments. The students are urged to use word processing for the final product. The activity is introduced by reading the short story line, which presents a simple problem to solve or task to do. There is some time following for student questions. The scoring guide is given to the students and explained at the time the activity is introduced. Students have the option of rewriting their essay after it has been graded and returned.

This activity forces students to analyze what has been studied and to make connections among those items studied. The students must take separate areas of study and explain how these areas are integrated for the benefit of the organism. For some classes, this activity may be altered to include as a final result, not an essay, but some artwork depicting the integration of all areas. Acooperative approach to this activity is also an alternative—with the final product expected to be a creative effort. Since we do project work including creative activities (e.g., posters, models, plays, debates, etc.) at other times during the year, the essay is a personal choice for the final product. It is important that students do not lose the opportunities to express themselves through writing.

BIOLOGY 10-R

ENERGY, MATTER & ORGANIZATION UNIT - CULMINATING ACTIVITY

NAME: ______________________ DATE: ______________

CONGRATULATIONS! - Our school has been chosen to take part in a Time Capsule activity to celebrate the beginning of the 21st century. A small box will be buried on school grounds that will contain information about our knowledge of ourselves. This container will not be opened for one thousand years!! Since you are an expert in Biology, you have been selected to take part in this important activity. Your participation in this activity will show future generations of young people how intelligent the 1990's teenager really was!!!

__Your task__ =

"From the cellular to the ecological level, living systems are organized collections of matter. The organization of a living system is maintained by its constant intake, conversion and utilization of matter and energy. Matter provides the building blocks for the structure of life while energy is needed for the metabolic work of assembling and maintaining structure. Metabolic work requires the coupling of energy-producing reactions with energy-consuming reactions. The study of energy relations in biological systems explores the sources of energy available for life processes and the mechanisms by which energy is harnessed to maintain the organization of matter in living systems." With the help of this quote, which was taken from the __Regents Biology Program Guide__, you should be able to answer the following question. Your answer should summarize what you have learned during the __Energy, Matter & Organization__ unit. Your essay should be well-written or typed and include between 300 and 500 words. It is strongly suggested that you look over the notes from this unit and the appropriate textbook chapters before beginning.

How does the process of Aerobic Cellular Respiration in humans involve the integration of the digestive, circulatory and gas exchange systems as well as the involvement of cells, enzymes and membranes?

Your essay should show how each of the following - digestive system, circulatory system, gas exchange system, cells, membranes, and enzymes are involved in aerobic cellular respiration. You should also include how each of these 6 areas depend on each other for proper functioning.

Instructions and a scoring guide for the activity are provided to the students after four or five topics in the unit of study have been covered.

Since students have the opportunity to redo much of their work during the school year, they have the option of rewriting this essay (Last year, over 50 percent opted to rewrite.).

Students share their finished and graded essay with classmates during a cooperative activity in class. This enables students to see how others handled the question. Students also become aware that there is more than one possible answer to this question. Some students are asked how they would evaluate some of their classmate's essays. Self-evaluation and peer evaluation are part of a portfolio assessment later in the year and the sharing of student's essays is good practice for this.

Assessment

ASSESSMENT

Students are assessed according to the scoring guide that follows. For **part b** of the scoring guide, students must clearly indicate how a side area is connected to cellular respiration. For instance, a brief description of carbohydrate digestion resulting in glucose and the use of glucose in the cellular respiration process would satisfy this connection. For **part c** of the scoring guide, students must clearly indicate the connections between the side areas. For instance, a brief explanation of the role of enzymes in the digestion process would satisfy one of these connections.

The concept map or drawing is not graded, but is used as a means of assessing student progress in reaching the goal of the assignment.

SCORING GUIDE

E M C CULMINATING ACTIVITY

NAME: ______________________________ DATE: ____________

a) Correct description of aerobic cellular respiration.	2 points
b) How each of the 6 side areas (digestion, circulation, gas exchange, cells, enzymes and membranes) are connected to cellular respiration. Two points for each correct connection.	12 points
c) How each of the 6 side areas are connected with each other. Allow one point for each correct connection - up to 5 points.	5 points
d) Preliminary concept map/drawing	1 point
e) Correct spelling, grammar, usage (allow up to 4 errors).	3 points
f) Neatness.	1 point
g) On time.	1 point

* Total score multiplied by 4 = percent grade

** For each content mistake in the essay take 3 points off percent grade.

STUDENT ESSAY

AEROBIC RESPIRATION

Aerobic respiration is the process by which an organism gains oxygen and nutrients and rids itself of waste products. Simply, it is the method our bodies use to get the energy needed for survival. It involves breathing, eating, transport, digestion, and cellular respiration. In humans, aerobic respiration is a very complex process that involves many different systems and every cell of the body. The digestive system is needed to provide nutrients and minerals for life processes, and to dispose of wastes. the circulatory system is needed to bring these nutrients, plus the oxygen from the lungs, to all the cells of the body. The gas exchange system is needed to get the oxygen into the body and the carbon dioxide out.

Cells make up all the systems used in aerobic respiration. They also carry out cellular respiration. This is an essential part of aerobic respiration because it breaks down nutrients into the energy needed to carry out life processes. Aerobic respiration requires many chemical reactions, especially during digestion and cellular respiration. All of these reactions require enzymes. Membranes are necessary in several processes. For example, in cellular respiration, oxygen and glucose have to be brought into the cell from the bloodstream. The plasma membrane, which surrounds the cells, is needed to transport the oxygen and glucose into the cell and to keep them there.

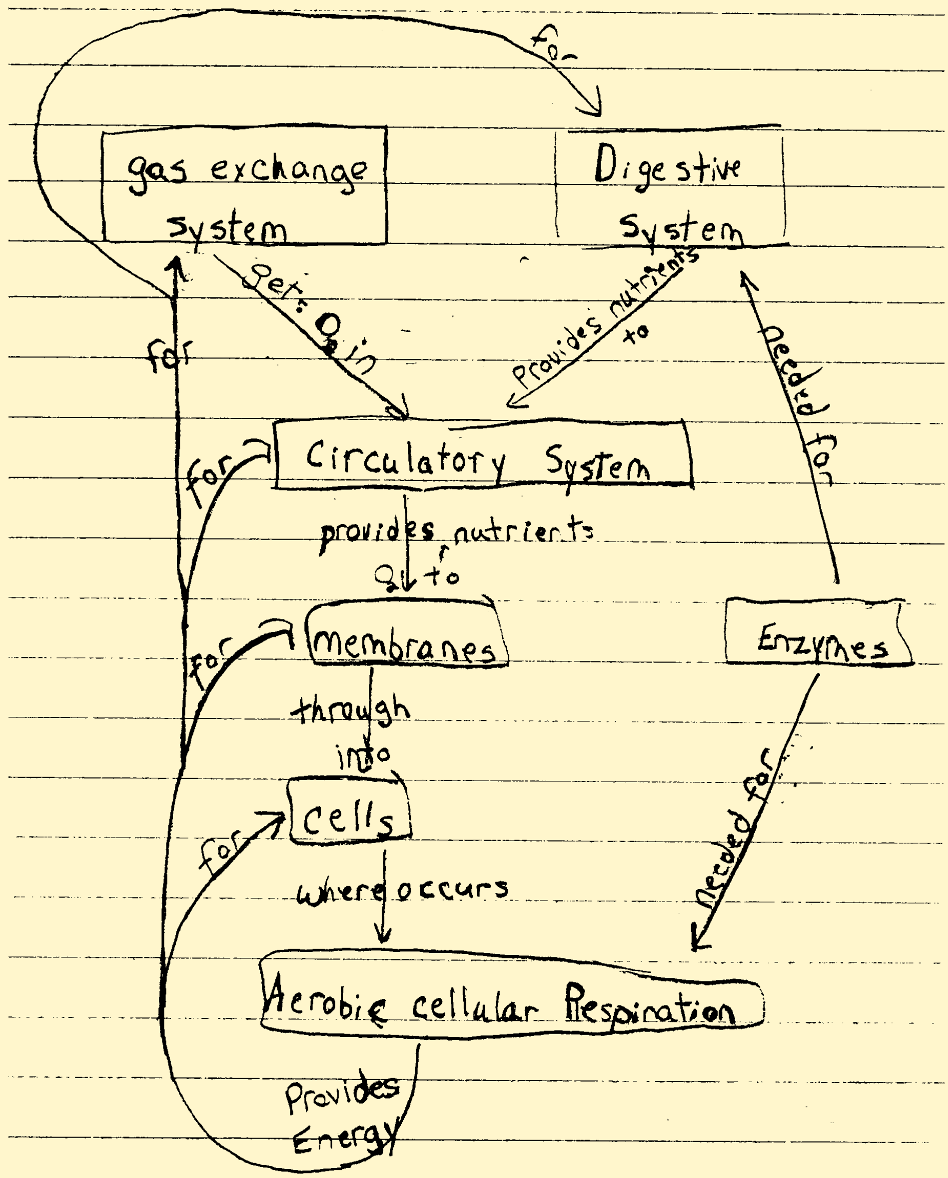
When we eat, the food we take in is broken down in our digestive system. The digestive system uses enzymes to break down the food into substances the body needs to carry out aerobic respiration. These substances are then absorbed into the bloodstream to be taken throughout the body. The substances are also transported back to the digestive system in order to allow it to carry out digestion.

The human circulatory system is made up of the heart, the blood, and the blood vessels. It feeds nutrients and oxygen to cells. It has to get nutrients from the digestive system and oxygen from the lungs through the gas exchange system. All the cells of these systems, however, need the nutrients and oxygen also. They get them from the circulatory system. The circulatory system also carries away the waste of all the cells of these systems, as well as the rest of the body.

The gas exchange system allows oxygen to enter the bloodstream and carbon dioxide to leave. When the blood comes in contact with the membranes of the lungs, it absorbs oxygen and gets rid of carbon dioxide through the membranes. The blood also feeds the lungs and takes away the wastes produced by cellular respiration.

All of these systems are essential to one another. None of the systems could exist without the digestive system breaking down food into the nutrients for survival. Having the nutrients, however, would not do any of the systems any good without the circulatory system to transport them to where they are needed. And even if the nutrients were at the cells that needed them, oxygen from the gas exchange system is needed to use them to produce energy in cellular respiration. Some of this energy is used to keep the heart, digestive system and lungs working. None of these systems could carry out respiration without the others.

STUDENT CONCEPT MAP



REFLECTION

This type of activity is easily adaptable to other subject areas, such as Health; satisfying Standard 3 of the Health, Physical Education, and Home Economics Standards ("students will understand and manage personal ... resources"). Students making an action plan for life can weave in their essay information stressing diet, exercise, etc.

Extensions of this activity would be to have students consider and describe reasons why cellular respiration is not at peak. Is there a problem with one of the six areas? Have students select one of the areas and explain how changes in this area affect cellular respiration (for example; poor nutrition, cardiovascular disease, emphysema, etc.).

COMMENCEMENT

Standards & Performance Indicators

Bio*ethics*

MST 4
- ▲ genetic engineering
- ▲ preserving diversity
- ▲ environments change

MST 7
- ▲ analyze problems/issues
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ present results

In addition to written activities and research, a significant component of this learning experience involves cooperative group work in problem solving and decision making. Thus, it can meet the needs of students with different learning styles and a range of abilities.

BIOETHICAL DECISION-MAKING REFERENCES

- Bioethics Forums. (Student Resource Book, Teacher Resource Book, Laserdisc) Videodiscovery, Inc. Seattle, Washington. 1995.
- DeDecker, Peter F. "Teaching Bioethical Decision-Making in High School," The American Biology Teacher. 49(7): 428-432. 1987.
- Kieffer, G. H. 1979. "Can Bioethics Be Taught?" The American Biology Teacher. 41(3): 1 76.
- McConnell, T. C. 1982. Moral Issues In Health Care: An Introduction To Medical Ethics, Monterey, CA: Wadsworth Health Sciences Division.
- Yashon, Ronnee. Case Studies in Bioethics. 1994.

Objective: To introduce students to some ethical issues in biology and provide them with a model to make decisions.

NOTE TO THE TEACHER: Since some of these issues may be sensitive to students, we suggest that you preview all material and present it with careful attention to students' individual beliefs.

Teacher

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Grades 9 & 10

The use of a constructivist learning model is especially important and appropriate in this experience, as students come to this unit not only with misconceptions about the nature of the issues, but have not yet connected their newly constructed knowledge in biology to their beliefs and values.

This learning experience was designed to introduce students to some of the critical bioethical issues of our modern society and to enable them to begin to identify the values that inform their decisions. Aconstructivist framework is implicit in this experience, with the teachers creating an environment in which their students are encouraged to think and to explore ideas. The bioethical issues that are introduced are of emerging relevance to these students and they become involved in thinking and learning about current societal problems that are real and meaningful to them.

To engage student interest questions are posed to the students, such as:

- What do you value?
- What are ethics?
- When does life begin and end?
- What distinguishes human life from non-human life?
- Who deserves to receive an organ transplant?
- When is it okay to sacrifice an animal?

Students then explore their own values and beliefs by confronting several ethical dilemmas and work in a cooperative group to formulate decisions on critical issues in bioethics. They think about real problems and, with additional insight gained from group discussion, formulate their values and opinions on important societal issues. Finally, they apply their newly constructed knowledge and values to an ethical dilemma of their choice.

The unit on *Bioethics* can be taught near the end of the school year, after students have studied genetics, comparative anatomy (including dissections), ecology, and environmental issues. Therefore, they have constructed knowledge of the major ideas in biology. However, there is flexibility in its placement in the curriculum, for example, it can be taught early in the year as an introduction to ideas in Biology.

One goal of this learning experience is to support student progress toward achieving the learning standard on *Interdisciplinary Problem Solving*:

1. Identification of Values

Students identify and clarify their values by responding to three exercises:

a. personal value statements
b. hammer exercise
c. quick value judgment.

Through class discussion, the teacher helps students identify and prioritize their values, make decisions regarding hypothetical ethical dilemmas, and defend their decisions with value statements, and encourages thinking about the sacrificing of organisms, from simple to complex.

2. Case Studies of Ethical Dilemmas

In cooperative groups, working with case studies, students confront and discuss ethical dilemmas. They must come to consensus regarding their decision on each case, requiring them to communicate effectively within their group.

3. Personal Case Study Analysis

Each student writes an essay about an ethical dilemma of his/her choice, using a worksheet to focus the student on the process of reaching a decision.

DAY ONE

A. Define *ethics* and *bioethics*

Ethics: Asystem of morals or values.
Bioethics: The study of the ethical and moral questions involved in the application of new biological and medical findings, as in the fields of genetic engineering, neurobiology and drug research.

B. Define *value*

Value: Aprinciple, standard, or quality considered worthwhile or desirable. Kieffer's definitions (1979):
Values: 1) indicate what is judged to be "good"
2) imply preference
3) are supported by rational justification
4) evoke strong feelings or intense attitudes
5) specify a course of action.

It is important to impress upon students that values are individual. All responses for the unit will be written on the *Personal Reference Sheet* (PRS). The completed PRS is private and will be read by the teacher only.

Pass out the *Personal Reference Sheet* and turn to the *List of Values*. (NOTE: This list is meant to reflect things important to teenage students in helping them make life choices. This is NOT a final list; teachers and students may wish to add to the list. One possible suggestion is that students brainstorm their own list as a class.) Have students pick the three values most important to them, write them in the space provided and state why these are most important to them.

C. *Quick Value Judgements*

Read the "Quick Value Judgements" to the class. Each student must answer "yes" or "no" within 15 seconds and record their answer on their PRS. Student should then choose from the list of values which item most helped them to make this decision.

Quick Value Judgements

l) Agood friend cheats on a science test, do you tell?
2 You find a wallet with 50 dollars inside and a driver's license. Do you take the money?
3) You (if you are female), or your girlfriend (if you are male) find out that your unborn child is retarded. Do you abort the fetus?

Of particular importance in supporting the assessment of student performance is the depth and thoughtfulness of the student's arguments in support of his /her ethical decisions.

4) Your mother is killed in a car accident by a drunk driver. Would you seek the death penalty for the driver?
5) Your favorite athlete makes racist comments. Do you stop watching him or her?
6) Your best friend really likes a certain boy/girl. This person asks you to go to a movie. Do you go out with him or her?
7) During a group project for science, the teacher mistakenly gives you credit for something someone else did. Do you tell the teacher about the mistake?
8) Your Regents Biology final is the next day, but your friend calls in the morning and asks you to go to Jones Beach for the afternoon. Do you go?
9) Several friends want to feed Alka Seltzer tablets to a sea gull to see if it explodes. Do you try to stop them?
10) Your little sister/brother has been driving you crazy all afternoon. Finally, she/he hits you in the face. Do you hit him/her back?

D. *Hammer Exercise*

This exercise is designed to help students define the value of living things. The class is presented with a list of organisms and are given the imaginary opportunity to "hammer" (kill) each organism. The point at which they stop reveals something about the values of the participant.

List characteristics that distinguish human life from non-human life. Discuss situations in which it may be acceptable to sacrifice a non-human life. Each student should list the last organism to be hammered on their list and give at least one reason.

E. Define *moral problem*

McConnell (1982) defines a moral problem as "... a situation in which there are moral considerations to support one action, say act A, yet there are moral considerations to support another action, act B. Act Aand Act B cannot both be done, but it must be known,which is more important morally—which is the right act."

Name: Anna

Bioethical Decision Making

24.25/25

Personal Reference Sheet

Your three most important values are:

food/warmth/shelter

friendship

truth/wisdom/insight

Quick Value Judgements

		Yes	No
friendship	1. friend cheats on test		✓
honesty	2. lost wallet		✓
empathy	3. retarded child		✓
justice	4. drunk driver		✓
human dignity	5. racist athlete		✓
friendship	6. friend w/ crush		✓
honesty	7. group project in science	✓	
self control leisure/play	8. Jones Beach		✓
animal rights	9. Alka Seltzer	✓	
self control	10. younger sibling	✓	

Hammer Exercise

Which animal is last on your hammer list?

SNAKE RAT

Why?

RAT's are disgusting and dirty. they carry disease

cats + dogs can carry disease - why are rats disgusting?

SNAKEs are poisenous and Slimy - not all are poisonous!

Which characteristics distinguish human life from non-human life? There are many things that are different between humans and non-humans because we can't understand what they think -?

what else?

4.25/5

human: verbal language, reason (developed), know they will die, conciousness, self aware, "manners", dignity, technology

Personal Value Statements

When is it alright for a human being to sacrifice an animal (other than to eat it)? (Support your answer with personal reasons.)

It is ok if you are being attacked (self-defense)

To learn about for medical reasons.

To test for cures for AIDs

5/5

When does life begin? (Support your answer with personal reasons.) Life begins when the egg is fertilized because that is when it will actually become a human 5/5

When does life end? (Support your answer with personal reasons.) Life ends when you die (your brain + heart stop working) It is better to end life how you want it to end. Like it is better to die if you are happy with your life 5/5

Upon what basis should organ recipients be chosen? (Support your answer with personal reasons.) Organ recipients should be chosen by considering their age, who is depending on them, the quality of their life so far + what potential they have. 5/5

The Case Studies

DAY TWO

Case Study #1—Frozen Embryos
The case study may be read outside of class. Students should list their personal decision about this case study and give relevant reasons to justify it. The objective is to have students begin to define in their own words when life begins.

In class, group students and hand out *Bioethical Decision Making Group Worksheet*. Discuss how to use the sheet (perhaps define the problem as a class?). Groups must reach a consensus decision without anyone compromising their personal values.

As a class, discuss the decisions reached by each group and list values and reasons on the board. Brainstorm a list of characteristics that define when life begins. Each student should write a personal definition for their *Personal Reference Sheet*.They must answer the question clearly and coherently. Values that apply to the answer must be justified.

Bioethical Decision Making
Group Worksheet

Part I
Your Name:

Team Members:
1.

2.

3.

Title of Problem:

State the nature of the problem using the word "ought." For example, "Who ought to decide whether HIV testing for marriage licenses be mandatory".

List the facts presented in the case study.

List the stakeholders in the case study.

DAY THREE

Case Study #2A/ #2B—Patient in a Coma / Patient with Alzheimer's
Use the same format and worksheets as **Day Two** with a different case study. Allow cooperative groups to choose one of the two options to discuss within their group. At the end, the students will define when life ends on their *Personal Reference Sheet*.

Bioethical Decision Making

Case Study #2A

On April 14, 1975, Karen Ann Quinlan, a young New Jersey woman, was admitted to a hospital near her home. Doctors decided that she had taken a tranquilizer and then drank a quantity of alcohol. The drug/alcohol combination had caused her to sink into a coma, an unconscious state from which nothing could rouse her. Her brain was irreversibly damaged; it had ceased to function and was no longer working to keep her alive. Doctors had to use machines to force air into her lungs. Her heart continued to beat, but her brain was unlikely ever to function again.

When physicians gave this information to her parents, they requested that her life-support machines be turned off so that she could die. But hospital officials objected, and eventually the matter was placed before the courts.

Ought she be taken off the life-support system?

Case Study #2B

In Florida recently, a seventy-six year old man shot and killed his wife because she was suffering from Alzheimer's disease, a slow, progressive failure of certain nerve cells in the brain that leaves its victims helpless and unable to care for themselves, unaware of who they or their loved ones are.

The husband said he could not watch his wife die in such a manner. The courts in Florida thought otherwise and sentenced him to prison. The governor of Florida later held a hearing about the case but refused to consider pardoning the man.

Ought he be acquitted?

DAY FOUR

Case Study #3—Organ Transplant Recipient Selection
Students choose who will receive the transplant and come to consensus in their group. ***All decisions must be supported with relevant values and reasons.*** As a class, identify which characteristics of those individuals selected for organ transplant are desirable and which characteristics of those not selected are undesirable. Students should list those characteristics that they find desirable on their PRS. These indicate some of their personal values .

Anna
Science

Assisted Suicide Gets Legal Support

Should assisted Suicide be legal? So far, there are only nine states in the United States that have banned Assisted Suicide. They believe that patients were being put to death against there own wishes. They also think that the patient should be able to decide how and when they die.

In my opinion, assisted suicide should be legal. This should be allowed only if the patient is terminally ill and in extreme pain. The patient should have a right to decide whether they should live or die. Most people though, would rather die than continue living while suffering.

page one

Assisted Suicide should only be used to relieve pain and discomfort for terminally ill patients. (Terminally ill means they are going to die of their disease)

Recently, a man named Jack Kevorkian was aquitted of two charges that he helped twenty-seven people commit suicide. He was aquitted because most of the patients were terminally ill. There is a clause in the law that says that you cannot be convicted for assisting a suicide if they had been trying to releve pain and suffering. Kevorkian is going to have a third trial because he was charged in assisting two woman that were not terminally ill. For this charge, he should be put in jail.

As of right now, assisted

page two

suicide is legal in most states. It should remain legal and it should only be used in certain cases. Most patients believe that suffering is even worse than death so the physician will aid them in assisted suicide

page three

Name: ______________________________ Date: _______________

INDIVIDUAL DECISION-MAKING MODEL

Directions: *Choose a case study. Fill in this outline sheet given the information in the case study. Use this outline to write a opinion paper about your case study.*

I. State the Question

____

II. Part II. List the 5 solutions to this question. Then rank them 1-5 with one being your first choice.

_____ A. ____

_____ B. ____

_____ C. ____

_____ D. ____

_____ E. ____

III. Restate the #1 solution. Then from the list of values, list four or more values that you used to choose solution #1.

Solution: ____

Values: ____

____

____

____

____

IV. If the person in your case study choses your #1 solution, what will happen? List three things that might happen. Think about legal problems, psychological, medical, family and government implications.

1. ____

2. ____

3. ____

V. List three reasons someone might not agree with your decision.

1. ____

2. ____

3. ____

DAY FIVE

Students pick a case study that is personally relevant to them* and use the *Individual Worksheet* as an outline. The student is to write a report describing the case and presenting their decision ("I believe that IS right because...") and state the evidence reasons to support their decision. This report is to be turned in with their PRS.

*Acompilation of case studies may be kept on file by teachers for student use. Or the students may use current events, i.e., cloning of mammals.

ASSESSMENT

Assessment

Students are graded on *Personal Value Statements* etc. They are assessed on the group work, including their ability to work effectively in the group. They are assessed on their personal case study analysis. Their opinions must be clearly stated and supported.

RUBRIC

REGENTS OPTION LABORATORY

BIOETHICAL DECISION-MAKING

PART I

PERSONAL VALUE STATEMENTS	GRADING SCALE
List of personal values, quick value judgements, hammer exercise 1 point - all three personal values listed and explained 2 points - quick value judgement table completed 2 points - hammer exercise and explanation provided	= 1 to 5 points

The following four questions are graded using the following criteria:

- 1 point - answer was submitted
- 1 point - value was stated
- 1 point - answer was clear and coherent
- 2 points - explanation clearly showed how value related to the answer

When is it all right to sacrifice an animal other than for food?	= 1 to 5 points
When does human life begin exactly?	= 1 to 5 points
When does human life end?	= 1 to 5 points
What criteria should be used to determine who should receive an organ transplant?	= 1 to 5 points

PART II

CASE STUDIES	GRADING SCALE
Personal case studies analysis and completion of personal case worksheet	1 to 10 points

- 1 point - work was submitted with individual decision-making model
- 1 point - English language used skillfully
- 2 points - work was organized (introduction, body, and conclusion)
- 2 point - work was factually accurate
- 4 points - decision was supported with an explanation of values
  - values were stated
  - solution was stated
  - positive and negative consequences were stated
  - an explanation of values was given

Rubric continued

Ability to work effectively in a group	1 to 5 points

Grade holistically using the following scale:

5 points - effectively worked with lab group as a leader
4 points - effectively contributed to lab group work
3 points - worked as a follower, required reminders to stay on task
2 points - watched lab group work, required reminders to stay on task
1 point - watched lab group work and distracted others during work
0 points - refused to work in lab group

Completion of decision making worksheets	1 to 10 points

Grade holistically according to the following scale:

10/9 points content complete, 95-100% accurate, responses fully explained and well-thought-out, and clear written expression

8/9 points - content complete, 85-95% accurate, clear written expression

6/5 points - content complete, 70-85% accurate, written expression lacked full clarity

4/3 points - content somewhat complete, many inaccuracies, careless reasoning errors, poorly written

2/1 points - mostly incomplete, support lacking, disorganized

0 points - work not submitted

TOTAL POINT VALUE = 50 points

REFLECTION:

REFLECTION

This learning experience could also be taught in conjunction with a Social Studies unit on Law and Constitutional rights and could involve the English department. The students could prepare for and then conduct a debate on the issues they have studied. Students would then have to prepare to defend either side of an issue, giving them a different personal perspective.

Mathematics, Science & Technology

PART II.5

Math, Monarchs, and Metamorphosis.........2

Exploring Transformations...........................9

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).

NEW YORK

THE STATE OF LEARNING

http://www.nysed.gov

ELEMENTARY

Standards & Performance Indicators

Math, Monarchs, and Metamorphosis

MST 1

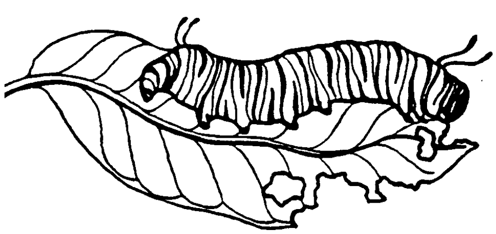
- ▲ ask why
- ▲ clarify and compare
- ▲ interpret observations/measurements
- ▲ adjust explanations

MST 3

- ▲ draw conclusions
- ▲ analyze situations
- ▲ justify answers
- ▲ logical reasoning
- ▲ spatial relationships
- ▲ multiple representations
- ▲ explain ideas
- ▲ recognize/describe/extend
- ▲ solve for unknown
- ▲ manipulatives
- ▲ interpret graphs
- ▲ two/three dimensional

MST 4

- ▲ living/nonliving variations
- ▲ life processes
- ▲ stages of life cycle
- ▲ survival behaviors



Merri Jones Earl
Chenango Forks Central School District
John Harshaw Primary School
6 Patch Road
Binghamton, NY 13901
(607) 648-7580

Grade 1

BUTTERFLY LARVA

Nasco, 901 Jamesville Ave., P.O. Box 901, Fort Atkinson, Wisconsin 53538-0901, 30 Butterfly Larvae, Cat. #FB01929M, $36.40

Connecticut Valley Biological Supply Co., Inc., 82 Valley Road, P. O. Box 326, South Hampton, MA 01073, 30 Larvae, Cat.# AT4851, $38.00

Delta, Dept. CB075, P.O. Box 3000, Nashua, NH 03061-3000, 25 Larvae, Cat. #542701610, $27.20

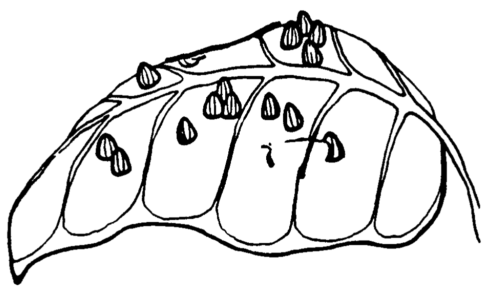
Students are taught to observe and recognize symmetry as it occurs in the natural world. They learn the mutual relation of parts in respect to position such as: limbs on a tree; veins in a leaf; and whorls in a flower. Being able to recognize patterns is a problem-solving tool which can be applied to many real world situations, even at the first grade level. Students are able to predict outcomes and results.

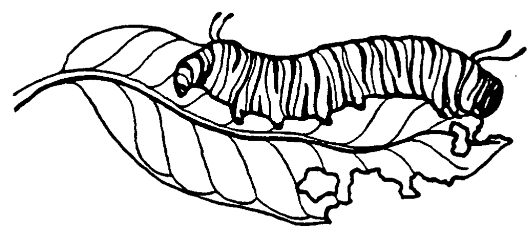
The purpose of this lesson is to give the students an understanding of the mathematical concepts of symmetry and enhance their spatial sense. The concept will be developed as part of an integrated curriculum that will include the study of insects and, specifically, the metamorphosis of the butterfly. Class discussions (characteristics of an insect); hands-on activities (move tiles to change an asymmetrical figure to a symmetric one); readings (*What is a Butterfly?)*; demonstrations (metamorphosis of a butterfly, and questioning: (What can a symmetrical figure do?); problem solving (How can you change a given asymmetrical figure into a symmetrical one?;, and discovery techniques (use mirrors and pattern blocks for discovery of mirror image concept in symmetry) will be integrated. Achart story based on what they have experienced will enable students to strengthen their reading skills as well as review what they have learned.

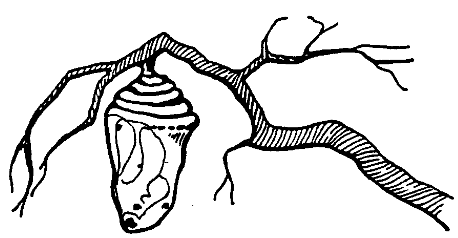
Label and color, please.

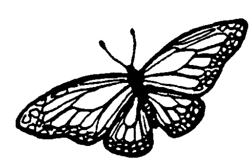
Words to use:

butterfly	egg
caterpillar	chrysalis









DAY 1

Students should be given the opportunity to observe the metamorphosis of butterflies with either a picture or, preferably, a living larva. They can look at a variety of types of butterflies pictured in the classroom and in reference books. After discussion of similarities and differences among butterflies, students will be led to the conclusion that the wings on a butterfly are mirror images of one another. The term "symmetry" will be introduced. On the overhead projector, students will manipulate a variety of acetate "wings" to make symmetric pairs.

Symmetry is a part of the natural world and is a significant concept in a wide range of disciplines. Students may begin to understand elements of it early in their education making this lesson appropriate for grades K, 1, 2, and 3.

Optional Video Segment
To give students a specific responsibility while viewing, the teacher will say, "In this video a girl named Winnie, from Winona, is upset because she doesn't understand something. I think you can help her. When you think you can, raise your hand."

Teacher

Play the tape from the beginning to where Winnie says, "...doesn't sound nice." Pause and ask the student with the raised hand what Winnie doesn't understand. Allow students to express ways to explain "symmetrical." Resume play until arcade game *Symmetrical Polygons* appears on screen. Pause and explain that a polygon is a shape with straight sides. As each polygon is presented Mathman and Mr. Glitch appears; pause tape and encourage students to predict if Mathman will chomp because the figure is symmetrical. This action will occur four times, so pause tape each time. Resume play after students predict. Resume play and pause after Winnie's drawing is "flipped over a line." Ask, "What can a symmetrical figures do?" (Flip over a line.) Stop tape after Winnie from Winona says, "Symmetry can be beautiful."

Students will practice placing a line of symmetry (six inch, thin Stick) on shapes formed on the overhead projector using overhead geometric shapes such as the hexagon and squares.

BUTTERFLIES

Berger, Melvin. A Butterfly is Born. Newbridge Communications, Inc. 1996.
Conklin, Gladys & Lathan, Barbara. I Like Butterflies. Holiday House, USA 1960.
Darby, Gene, What is a Butterfly? Benefic Press, Chicago, IL 1958.
Drew, David. Caterpillar Diary. Rigby, Inc., Crystal Lake, IL 1990.
Gibbons, Gail. Monarch Butterfly. Holiday House, NY 1989.
Mattern, Joanne. Butterflies and Moths. Troll Associates 1993.
Sterling, Dorothy. Caterpillars. Doubleday & Co., Inc. Garden City, NY 1961.
Zoobooks. Butterflies. Volume 7 #9, Wildlife Education, Ltd., San Diego, CA, June 1990.

DAY 2

Containers of paper pattern block shapes and four 9" x 12" white sheets of construction paper will be distributed to each group of four students. Each student will create a symmetrical design and will glue the design on his/her white construction paper. After work has been completed, each student will receive a thin, six-inch stick to be glued on the shape to show the line of symmetry.

DAY 3

Students will sit at desks with one-inch square tiles in small containers and count the tiles to be sure they have 12. After 2 minutes of exploration, direct their attention to the overhead projector. On the overhead, 12 one-inch square tiles will be arranged in an asymmetrical figure. Sheets with that same asymmetrical tile arrangement will be distributed. Students will cover this design with their tiles and be encouraged to explore ways to rearrange the tiles to create symmetrical shapes. Students will share their shapes on the overhead.

The teacher will ask the students to dictate an experience chart story to explain the concept of symmetry.

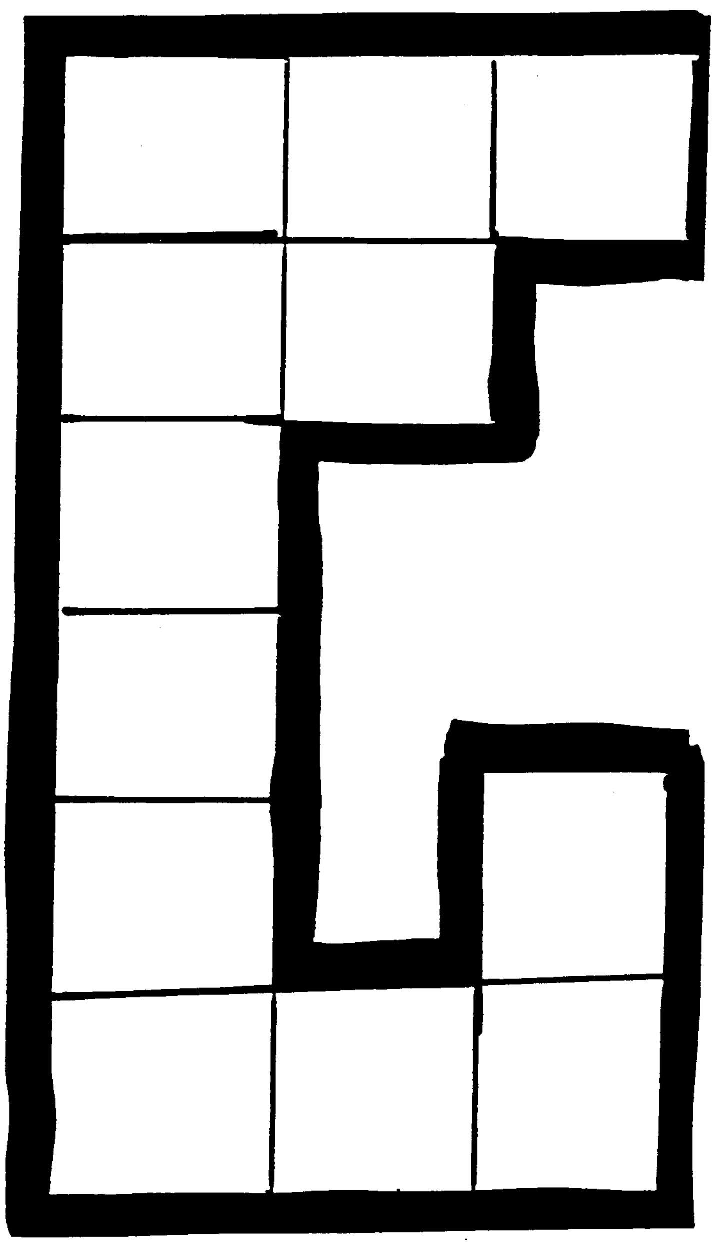
SYMMETRY

Jonas, Ann. Reflections. Greenwillow, New York, NY 1987.

Jonas, Ann. Round Trip. Greenwillow, New York, NY 1983.

McDermott, Gerald. Arrow to the Sun. Viking Penguin, Inc., NY 1974.

Geometry and Spatial Sense. Curriculum and Evaluation Standards for School Mathematics. Addenda Series. National Council of Teachers of Mathematics, Reston, VA 1993.



INSTRUCTIONAL/ENVIRONMENTAL MODIFICATIONS

Desks are arranged in groups of four, allowing students to observe each other and discuss the procedures. Sharing ideas and understandings accommodates the range of abilities and learning styles. The teacher and/or parent volunteer/aide should be available to assist a student who is confused and unable to participate. To further accommodate the students with special needs, puzzles, enlarged illustrations, and computer programs such as *Eduquest* on-line rotations are available.

EACH STUDENT WILL NEED:

- Container holding 12, one-inch square tile pieces
- Paper copy of asymmetrical design from *General Mathpital* (In groups of 4 students)
- 9 x 12 inch white construction paper
- Paper pattern block pieces
- Glue
- One thin stick (or coffee stirrer, straw) about 6 inches long (about the diameter of a toothpick (per student)

ASSESSMENT

The students are observed as they worked with the tiles and a checklist is used to note their individual levels of success. If they were able to reposition the tile pieces to form a symmetrical shape, a check was given. Arubric was designed for evaluating a paper-pattern block design based on the student's understanding of symmetry.

Aworksheet which allowed students to indicate their understanding of metamorphosis was given, collected, reviewed, and evaluated with each student in a conference. Another worksheet distinguishing the differences between a moth and a butterfly was evaluated as above. These worksheets are used to provide feedback.

Students create a booklet illustrating their understandings of the stages of metamorphosis. Self-reflection by students occurs during our daily class meetings.

REFLECTION

Some students could be given additional practice during free time. Ahomework assignment could help some students.

I found that using the *Pattern for Tile Arrangement* worksheet as a visual aid to constructing the asymmetrical figure works better than placing the tiles on top of the worksheet. Studies with square tiles could be expanded to the study of area measurement and other geometric shapes in helping to meet other math standards. The study of butterflies and metamorphosis could be extended to the study of other living creatures, their physical characteristics, and their stages of development. Use the concept to develop a unit on bats. Symmetry could also lead to the study of its uses in construction, engineering design, and art.

These lessons reflect the constructivist philosophy. Students are given opportunities to discover basic principles through hands-on activities and observation. The integrated nature of the unit enables them to make connections among the disciplines and incorporate new concepts into their understandings.

1. Students explore symmetry by manipulating acetate butterfly wings on the overhead.
2. Students construct a symmetrical design.
3. Students create a chart story to explain their understandings of the concept of symmetry.

Rubric for Symmetrical Design Made from Paper Pattern Blocks

Outstanding: The student is able to construct a complex design that is symmetrical and can place the line or lines of symmetry accurately.

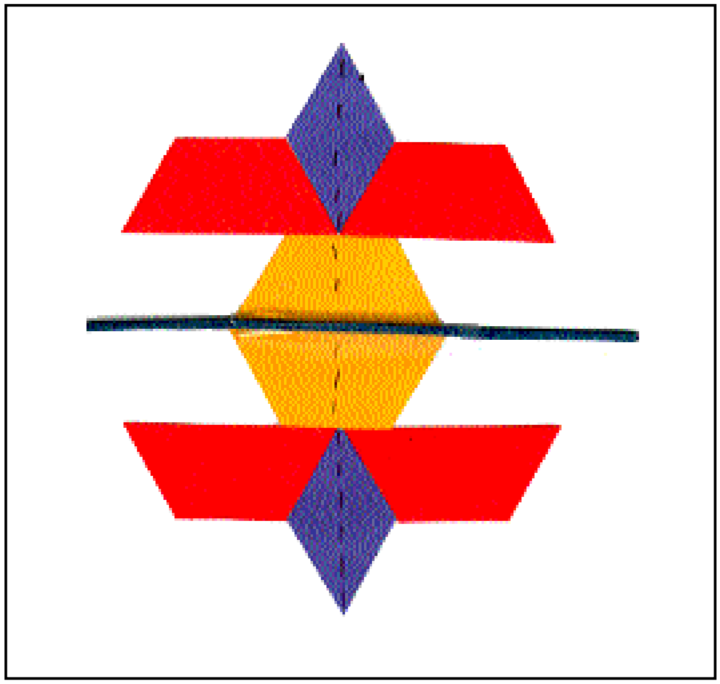
Good: The student is able to construct a simple symmetrical design and correctly place the line of symmetry.

Fair: The student can construct a design that contains some recognizable elements of symmetry but is asymmetrical.

Poor: The student's design is asymmetrical with no elements of symmetry.

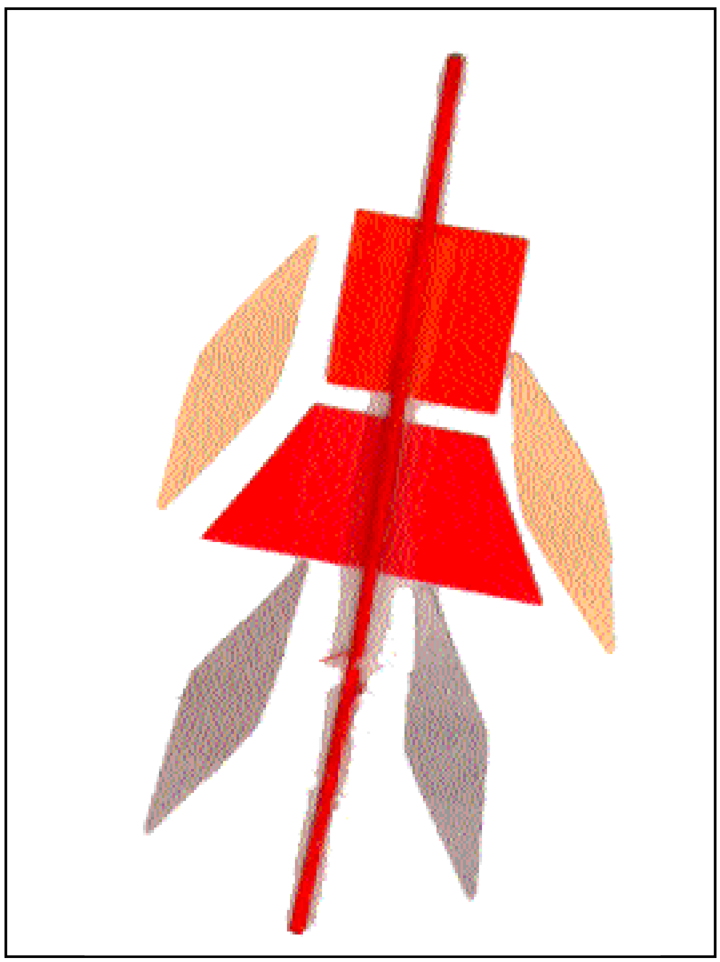
This student excelled in most performance tasks and had no difficulty creating a symmetrical design. The student said he could create a second line of symmetry if he had another stick. The dotted line is where he showed the teacher it would be placed.

SCORE: *Outstanding*



The student was unsure, lacked confidence in his own ability. He copied pattern design of a friend but was able to demonstrate to teacher correct placement of the line of symmetry and explained the shape was that of a person: one leg and one arm on each side of the body.

SCORE: *Good*

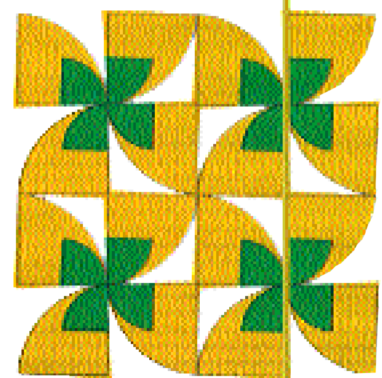


COMMENCEMENT

Standards & Performance Indicators

EXPLORING TRANSFORMATIONS

On The Computer And Using Transformat
On The Computer To Create A Unique De



Generally, the students learn the material faster and better than the traditional way using graph paper and ruler.

Teacher

MST 3

- ▲ transformations
- ▲ learning technologies
- ▲ investigate transformations
- ▲ graphing utilities
- ▲ transformations to functions

MST 7

- ▲ analyze problems/issues
- ▲ design solutions
- ▲ work effectively
- ▲ gather/process information
- ▲ present results

Geometer's Sketchpad 3.0, Key Curriculum Press, Berkeley, CA

This experience was created to integrate computers into the regular Sequential 2 math program and to combine ideas from two disciplines, math and art. All participants were ninth-graders taking Sequential 2 and none of them had previous experience with the software.

Despite the extra work, I have continued to employ the self-teaching concept because I feel strongly that it is the best way for students to learn.

Teacher

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(516) 366-4710

Grade 9

Phase One—Exploration

In the first part, students explore what happens when geometric figures are transformed on the coordinate plane. The teacher uses the first day to review the basic transformations that students learned in *Sequential Math 1*. During the next four class sessions in the computer lab, the students work together in pairs, moving geometric shapes in the plane, measuring the coordinates of the original and image figures, making conjectures regarding rules for each transformation, and testing their hypotheses. They then formalize their rules as functions. Throughout the activity, the students direct their own learning using only their knowledge of the program learned earlier in the year and the tutorial provided by the teacher.

The class was given 2 to 3 successive days in the lab during the first activity, and then a discussion of the results obtained to date was held in the regular classroom. Thus, all students were able to get feedback regarding their work; those who were successful would know that they were, and those who were in error could be steered back in the right direction. In the lab itself, the teacher serves as a facilitator, observing each 2-person team and making suggestions and answering questions, thus keeping the lessons focused.

Phase Two—Design

In the second part, students use their new-found knowledge of transformations to create an original artistic design, such as a tessellation, according to a suggested real-life situation. Students must work together effectively, process information, observe common themes, and present their results. It also serves to acquaint them with an assignment such as they might reasonably expect to encounter in the world of work.

By far the greatest amount of time must be devoted to the teacher's own self-preparation.

Teacher

Students working in teams of two are given the following scenario and instructed to use the computer to create an original drawing which satisfies the criteria.

Imagine the following situation: You are employed by a design firm which creates designs for vendors who manufacture wallpaper, wrapping paper, tile, and fabric. Your supervisor has assigned you to develop a new design which may be sold to one of these vendors.

The design must contain the following elements:

- It must employ at least two types of transformations: line reflections, point reflections, rotations, dilations, and/or translations.
- It must use at least two colors.
- It can be extended to cover at least 75% of the piece of paper.
- It must be relatively easy to reproduce.

In addition, you must write an explanation of how you created your design. This explanation must be clear and easy to read, typed on a word processor, and illustrate your knowledge of transformations. It should be easy to understand so that anyone who reads it can duplicate your design from the instructions.

ASSESSMENT

Phase One—Exploration

Evidence of students' progress is provided in a number of ways. While they are working in the computer lab, the teacher observes their work, answers questions, and asks other questions,which can point them to further discoveries. The tutorial worksheet requires student responses, and students can also record their discoveries in a script box on the sketchpad workpage. Two or three times during the unit the students report to their regular classroom to discuss, compare, and analyze their findings. Homework from the text is assigned as students complete each of their explorations in each type of transformation. At the conclusion of the unit, each student submits a set of four problems using composition of transformations. These are done using a ruler and graph paper (not the computer) and are scored on a scale of 1 to 10 points, exactly as they are on the Sequential Regents' exams. This assignment assesses individual learning. Each student does the work on his/her own, and is given a separate rating.

Phase Two—Design

Assess whether the students understand how to apply transformations to achieve artistic effects.

Design Rubric

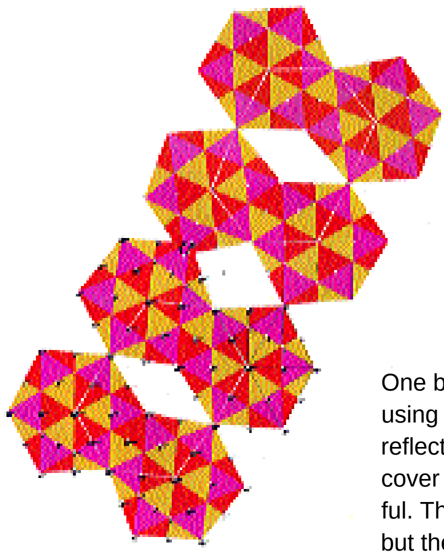
Projects are evaluated according to the following criteria:

THE DESIGN:		
• was created using at least two different transformations.		10
• can be duplicated repeatedly to cover the surface.		5
• uses at least two colors.		5
• is adaptable to a commercial use.		5
• is fairly simple to reproduce.		5
• is pleasing to the eye.		5
Total:	**35 points**	
THE DESIGN DESCRIPTION:		
• can be easily duplicated by the anyone who reads it.		7
• is clear and easy-to-read, with no run-on sentences and no spelling errors.		5
• is typed on a word processor.		3
Total:	**15 points**	
Project Total:	**50 points**	

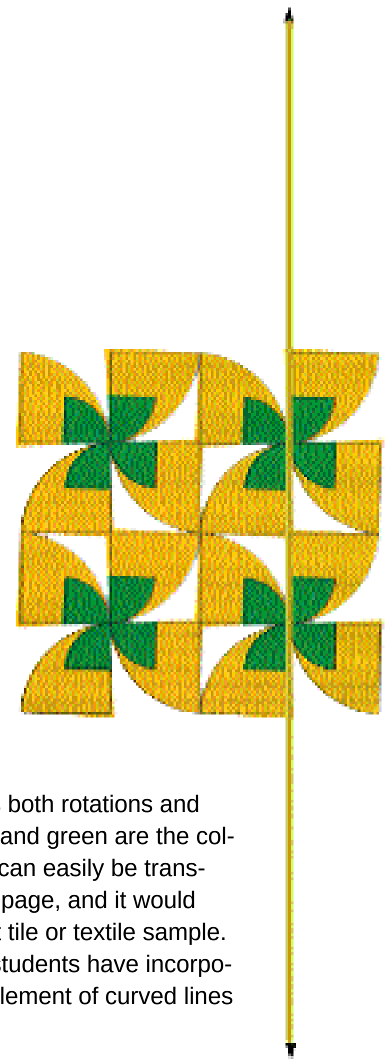
Each team of two people is given the same project score. Individuals are assessed according to the assignment described above, and on subsequent tests.

APPENDIX

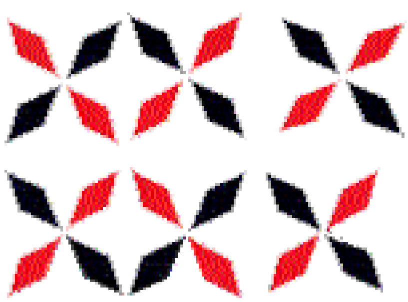
If you are using *Geometer's Sketchpad 3.0* the following **Course 2 Transformations** worksheet is a guide created for this learning experience.



One basic shape has been divided using dilations, then rotated and reflected. It is easily reproduced to cover a surface and commercially useful. The three colors are eye-catching, but the repetitive triangles render it less appealing to the eye.

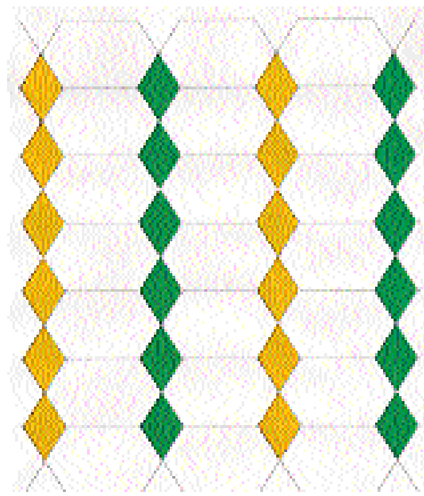


The design uses both rotations and dilations; yellow and green are the colors. The design can easily be translated across the page, and it would make a pleasant tile or textile sample. In addition, the students have incorporated the extra element of curved lines (arcs).



The design is very pleasing to the eye and has nice color contrast. The student has used rotation well, but the translations were done using different directions and distances, resulting in a picture which is not symmetrical. This was probably not intentional, but the unequal white spaces are not only disturbing to view, but render the design difficult to duplicate on the page and therefore not commercially usable. Some minor adjustments, particularly the use of one translation vector, would correct the problems.

This design is deceptively simplistic. The two colored figures are not in fact congruent, but were created by adding and subtracting pieces from congruent squares in the manner of M. C. Escher, then rotated and translated to produce a tessellation. This design is both simple to recreate and infinitely extendible. It is adaptable to many color combinations, making it a useful design for any number fabric items, although a different set of colors would have had more personal appeal, I think.



Two shapes have been created from one basic trapezoid through the use of reflections and translations. The minimal use of two colors keeps the design from looking too cluttered, rendering it pleasant to look at, and useful as a wall tile design. It is easy to recreate and duplicate across the page.

Following is a students' written explanation of how this design was created.

Create an isosceles trapezoid (shorter base = 4.5cm./10nger base = 7cm./ sides = 2.5)

- Keep reflecting the trapezoids until you have the desired length.
- Reflect the trapezoid over the longer base...then the shorter base...then the longer...
- Reflect the column of trapezoids to create to columns...then three...until you have reached the desired length.
- Delete the longer base of each of the trapezoids. Now you should have overlapping hexagons.
- Color in the diamonds created by the overlapping hexagons. All colors are allowable, but we used yellow and green.

This written description received a score of 15 according to the following criteria:

• easily duplicated by the reader	7
• clear and easy-to-read instructions, with no run-on sentences or spelling errors	5
• typed on a word processor.	3
Total:	**15 points**

Mathematics, Science & Technology

PART II.6

Inverse (Indirect) Machines..........................2

Statistics of The M&M Candy......................8

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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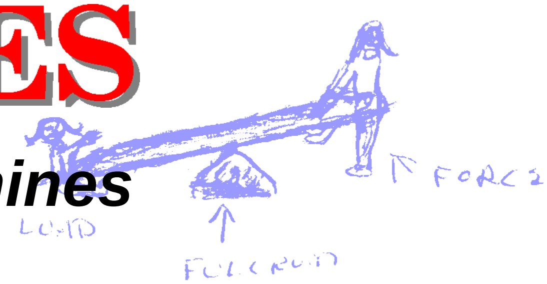
COMMENCEMENT

Standards & Performance Indicators

Inverse (Indirect) MACHINES



Levers: Simple Machines

MST 1
- ▲ compare data
- ▲ evaluate conjectures
- ▲ apply skills to solutions

MST 3
- ▲ ratios/proportions
- ▲ graphing utilities
- ▲ proportions to scale
- ▲ curve fitting

MST 6
- ▲ revise a model
- ▲ collect information
- ▲ mathematical models
- ▲ predictions

MST 7
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ observe common themes
- ▲ realize results
- ▲ present results

Prior Knowledge
Students should be familiar with the solution of proportions and with writing equations and expressions from verbal descriptions.

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Grades 9 & 11

Students need to recognize relationships between quantities. Most relationships studied in the early years of algebra are either direct or inverse (indirect) relationships. Mathematics classes spend a large part of their curriculum learning to manipulate mathematical models of direct relationships. Although listed as part of the *NYS Sequential Mathematics Course 1* curriculum, students do not generally spend very much time with inverse (indirect) relationships and seldom have an opportunity for a hands on investigation of the same. The study of levers as simple machines is no longer contained in the junior high school science curriculum. Thus, the first encounter a student may have with the study and/or use of levers is in a physics course, if (s)he chooses to take such a course.

After a demonstration and discussion of the three different classes of levers, students will be assigned to groups of three or four to complete the following activities:

NAME ______________________________ HR ______ Period _

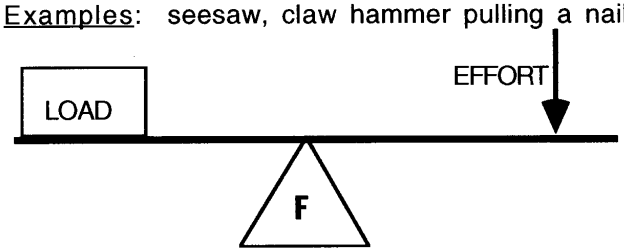
Classes of Levers

There are three (3) classes of levers. You can tell them apart by observing the relative positions of the **fulcrum**, the **load**, and the **effort**.

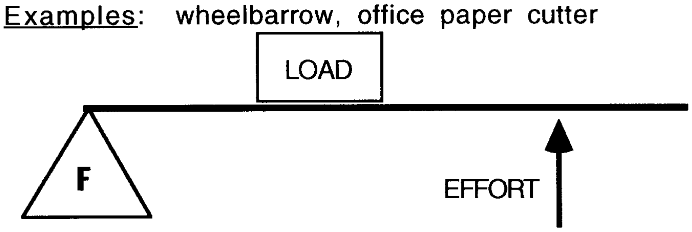
Fulcrum: The pivotal point or hinge about which the lever rotates.
The **Effort:** The force applied to the lever, usually in the form of a push or a pull.
The **Load:** The resistance to be overcome or the weight to be lifted.

Ask the following questions to decide which type of lever you have.

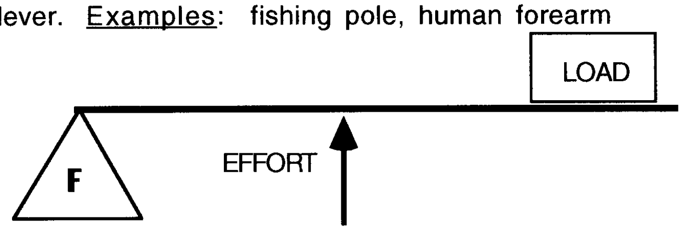
a. Is the fulcrum between the load and the effort?
If YES, then you have a **First Class** lever.
Examples: seesaw, claw hammer pulling a nail



b. Is the load between the fulcrum (F) and the effort (E)?
If YES, then you have a **Second Class** lever.
Examples: wheelbarrow, office paper cutter



c. If NOT EITHER of the above, then you have a **Third Class** lever. Examples: fishing pole, human forearm



Day 1

- With the entire class, introduce the terms: levers, fulcrum, effort, and load.
- In small groups of three or four, have the students build each type of lever and "play" with it. What similarities/differences do the students observe? Record these and use in a full class discussion.
- Have the students identify levers in their daily surroundings and identify each lever's class.

HOMEWORK: Students will draw or cut out a picture as an example of each type of lever. Students will label the appropriate parts of the picture: fulcrum, effort, and load

Day 2

- Complete **Lab A**.
  Using the *Lego dactaTM Technic I* kit, students will build a class one (1) lever and determine the relationship between weights placed on the lever and its distance from the fulcrum. Students will be asked to express the observed relationship in an algebraic form. As part of **Lab A,** students will be making predictions and testing them. They will record only those predictions, regarding the number and position of the *bricks*, which yielded a balance between the load and the effort.

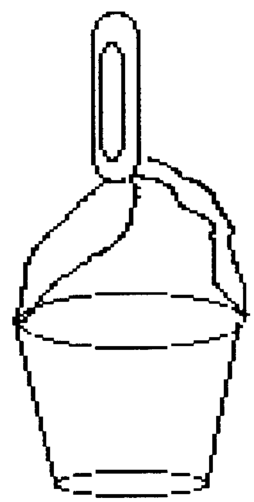
<u>HOMEWORK</u>: Students will complete the *Conclusions* section of **Lab A**.

Day 3

- The full class will report and discuss the results of **Lab A**.
- The class will determine, from among the group responses and further discussions, an appropriate algebraic representation for the relationship between weight (load) and distance from the fulcrum for a First Class lever.

<u>HOMEWORK</u>: Students will make corrections and adjustments to their work on **Lab A**.

Day 4



- Complete **Lab B**.
  Using the *Lego dactaTM Technic I* kit, adjust your lever so that the fulcrum is placed at the third hole from one end of the lever. Aspecified weight, a brick from the *Lego dactaTM Technic I* kit, should be placed on the short end of the lever. Construct a *bucket* utilizing two rubber bands joined together for the handle and attached to a small paper cup. The *bucket* will be suspended from the opposite end of the lever by hanging it from a paper clip through the last hole (#10) of the lever. Predictions should be made regarding the number of paper clips needed to cause the lever to change orientation (from raised to dropped).
- Test your observation using the knowledge of relations and algebraic expressions developed in **Lab A** by adding paper clips to the bucket until the lever changes orientation. Were your predictions correct? If not, why?
- By averaging the results of several groups, or several trials, you will obtain data which you should graph.

<u>HOMEWORK</u>: Graph the data and determine a line of best fit with the equation for that line. (Uncooked spaghetti can be used to help find the line of best fit.) Use that equation to determine the weight of the *brick*.

Day 5

- Full class reporting and discussion of the results of **Lab B**.
- What were the limitations of this experiment? How could the results of the experiment be made more exact? What modifications to the **Labs** could be made to yield “better” data? Can you think of other situations/experiments which would also illustrate inverse (indirect) variation?
- Complete *Pair Practice Sheet* identifying direct and inverse (indirect) variation relationships.

<u>HOMEWORK</u>: Review information regarding direct and inverse (indirect) variation in preparation for a quiz.

Day 6

- Traditional pencil and paper assessment, identifying direct and inverse (indirect) variation relations.

One Week Later

- Students will be randomly divided into groups of four as they arrive in the classroom. They will be given the following situation and asked to propose a workable solution.

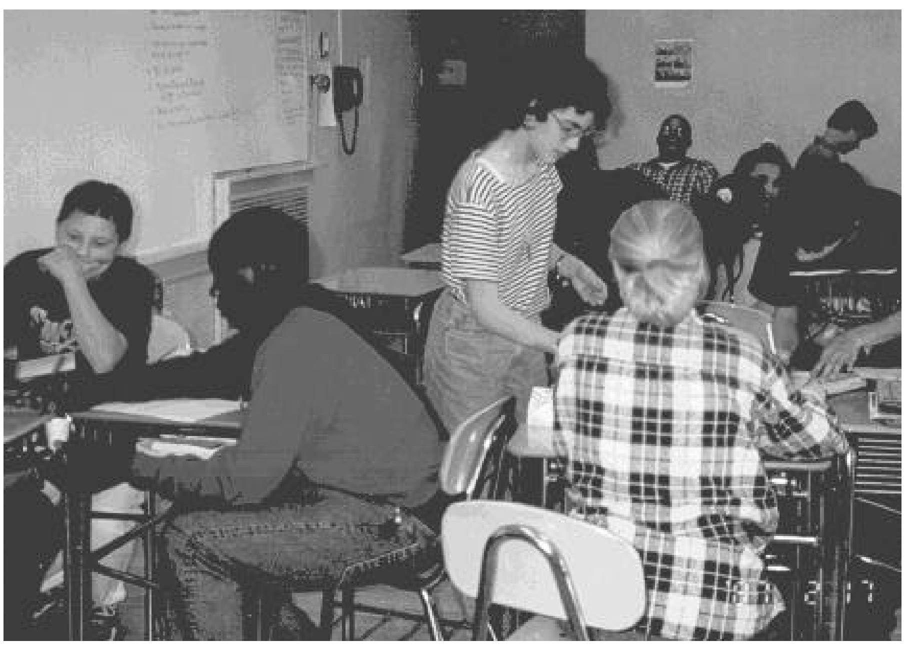
> A school bus has taken a group of students on an outing to a remote pond for the purpose of collecting science data. The bus acquires a flat tire, and the substitute bus driver discovers that the company has forgotten to include a jack for the bus in the tool compartment. He does have all the other necessary tools and a spare tire. How can the students help the bus driver?

Note: The class will first have to determine an approximate weight of the bus. This could be done by estimation based upon the comparative weights of other large objects, i.e., cars [In this case students would be working with direct proportions to obtain an estimate of the bus's weight.], or by contacting a local school bus company.

- Each group must write up a viable solution which will include a diagram, a list of necessary tools and/or materials, and step-by-step instructions for solving the bus driver's dilemma. Solutions will be holistically ranked and the better solutions will be presented to the class the following day.

Cooperative Learning

- The teacher will organize groups of three to four students each.
- Groups will reflect gender and ethnic balances.
- Each group member will have a specific role in the group.
- Social skills, such as explaining ideas, encouraging team members, asking for clarification, giving constructive criticism, and keeping an open mind will be encouraged.
- Peer review and responsibility for the group's success will be emphasized .



Gender and Equity Issues

- Gender equity will be considered when forming the groups.
- Activities will be both gender-free and bias-free.
- All students will be expected to know how to use the materials and will have an opportunity to do so.
- Through the cooperative groups, students with different skill levels will be able to get help from their peers in addition to assistance from the teacher.

Lab A:

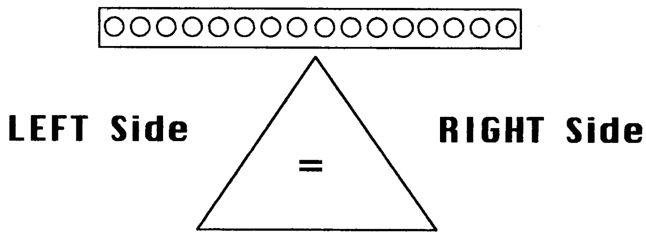
Using the *Lego dactaTM Technic I* kit students will build a class one(1) lever and determine the relationship between weights placed on the lever and its distance from the fulcrum. Students will be asked to express the observed relationship in an algebraic form.

NAME Jessica HR _______ PERIOD____

Course 1 Lab A
Variation

DISTANCE: Count the number of "pegs"from the center, including the "peg" on which the stack of "bricks" rests

WEIGHT: Count the number of "bricks" in the stack



	Weight (W_L)	Distance (D_L)	Weight (W_R)	Distance (D_R)
1.	1	7	3	2
2.	3	1	1	4
3.	3	4	~~1~~ 2	6
4.	2	5	3	3
5.	1	5	3	1

What do you notice about the relationship between the Distance and the Weight?

I noticed that a majority of the distance [the distance or weight on] between is 3. The product of both sides is close to equal

Using W_L, D_L, W_R, and D_R, write an algebraic expression which shows that relationship.

$W_L * D_L = W_R * D_R$ $\quad \frac{W_L}{D_R} = \frac{W_R}{D_L}$

INDIRECT OR INVERSE VARIATION

Lab B:

Using the *Lego dactaTM Technic I* kit, students will adjust their lever so that the fulcrum is placed at the third hole from one end of the lever. Aspecified weight, a *brick* from the *Lego dactaTM Technic I* kit, will be placed on the short end of the lever. The students will construct a *bucket* utilizing two rubber bands joined together for the handle and attached to a small paper cup. The *bucket* will be suspended from the opposite end of the lever by hanging it from a paper clip through the last hole (#10) of the lever. Students will test their observations and algebraic expressions developed in **Lab A** by adding paper clips to the *bucket* until the lever changes orientation. By averaging the results of several groups, or several trials, students will obtain data which should be graphed. Aline of best fit should be determined and the equation for that line written. Students should recognize that the equation can be used to determine the weight of the *brick*.

ASSESSMENT

- Written work in student portfolio
- Student-generated graph
- Student-generated algebraic expressions and equation for the student generated data
- Rationale for observed patterns (collected orally by teacher while circulating among groups)
- Teacher observed data, actions, and interactions.

NAME ______Jessica______ ________________ HR ______ Period ___

Scoring Rubric for Inverse Variation

Assessment Scale:

1 **Unacceptable or Missing** - Your work is either incomplete or requires major revisions.

2 **Minimally Acceptable** - Your work is acceptable, but needs minor reviosions or improvements.

3 **Acceptable** - Your work fulfills all of the objectives of this portion of the activity.

35/36

Part I: Lab A

1.	Have the 5 trials been completed?	1	2	**3**
2.	Is the described relationship correct & accurate?	1	2	**3**
3.	Is the algebraic expression a correct interpretation of the description?	1	2	**3**

Part II: Lab B

4.	Is the data chart complete?	1	2	**3**
5.	Are the computed averages correct?	1	2	**3**
6.	Is the hole # vs. # of paper clips graphed correctly?	1	2	**3**
7.	Is the algebraic expression for completing the brick's weight accurate?	1	2	**3**
8.	Is the estimate for the brick's weight reasonable?	1	2	**3**
9.*	Is the estimate for the brick's weight accurate? (within 10 grams)	1	**2**	3

Part III: Pictures/Drawings of Classes of Levers

Accurate drawing and correct labeling for:

Class 1 Lever-				
10.	Fulcrum, Effort, Weight (Load)	1	2	**3**
Class 2 Lever-				
11.	Fulcrum, Effort, Weight (Load)	1	2	**3**
Class 3 Lever-				
12.	Fulcrum, Effort, Weight (Load)	1	2	**3**

* extra credit for computing the brick's weight within 5 grams

INTERMEDIATE

Standards & Performance Indicators

Statistics of The M&M Candy

MST 1

- ▲ inductive reasoning
- ▲ solve problems

MST 3

- ▲ reasoning strategies
- ▲ conjectures/arguments
- ▲ conclusions using inductive
- ▲ simple/compound statements
- ▲ equivalent forms
- ▲ ratios/proportions/percents
- ▲ order relations
- ▲ estimate/make/use
- ▲ standard/nonstandard measurements
- ▲ display/describe/compare
- ▲ critical judgement
- ▲ check reasonableness
- ▲ solve problems
- ▲ estimate probability
- ▲ simulation techniques
- ▲ determine probabilities

I didn't know there was this much math in a bag of M&M's.

Student

Materials:

- rulers and/or Vernier calibrators (one for each pair of students)
- triple beam balance (one for each group of four)
- three 1-pound bags on M & M candies - two plain and one peanut; Note: One bag of the plain candies is used in estimating and then as simple rewards. The second bag is used in calculating the mass.
- a small package of M & M candies (one for each individual student)

Basically, this unit introduces the students to estimation, measurement (linear and mass), and experimental and theoretical probability using a bag of M&M candies. The students conduct surveys in each class to determine the team's favorite color and compare their results to the company's research using various charts and graphs on the computer. They are also informally introduced to ratio, proportion, and percentage.

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Grade 7

The concluding activities focus on statistics and their experiences during the activity. In social studies, their research skills will be augmented by studying the history of chocolate, the production of chocolate, and the Hershey Company. Students will be encouraged to design their own magazine advertisement or create a script for a commercial. Using their imagination they will be given the opportunity to create a candy super hero, report on being a "presidential M&M", or describe their feelings on being the new blue M&M in "the bag."

It is expected that the students have some knowledge of measurement, statistics, and simple probability in order to succeed with this learning experience.

In all the activities the teacher is primarily a facilitator. The activities are set up so that the students can work independently or question a member of their cooperative group.

For this project, the accelerated and self-contained students were integrated with the Regents math students. Each group had a minimum of one accelerated math student and one exceptionally bright Regents student. The self-contained students were placed with students who had demonstrated to the teacher their ability to explain themselves well and had patience. Both of these skills are vital for the group to be successful. English as a second language (ESL) students are also part of our team. They also were integrated into the mainstream.

STUDENT NAME Lisa

ESTIMATION AND PREDICTIONS

1. OBSERVATION

You have had several days to observe (but not eat!) a one pound bag of plain M & M's. Based on your observations, fill in the chart below:

COLOR	NUMBER
Red	95
Orange	55
Green	25
Yellow	50
Brown	150
Blue	30

TOTAL NUMBER OF M&M'S: 405

If you were given a one pound bag of PEANUT M&M's, how many candies do you think would be in the bag? 300 Would you expect to have more or less candies than in the plain M&M bag? less Why? peanut m&m's weigh more

2. Based on your results answer the following questions:

a) Which color appeared the most? brown

b) Which color appeared the least? green

c) Did any colors appear approximately the same number of times? no If yes, which colors? ______

ACTIVITY 1: ESTIMATION AND PREDICTIONS

The students had the opportunity to observe for several days a 1-pound bag of plain M&M's displayed in a clear container and a 1-pound bag of peanut candies in a solid container. After a brief discussion about how many candies are in the clear container, a discussion of how many candies are in the solid container ensues.

Each student is expected to complete the worksheets. The candies in the containers are used as rewards in class and each student is required to place tally marks on charts set up in the classroom to record the results. When all the candies are given out, the frequency of each color is tallied and recorded.

ACTIVITY 2: SURVEY, TALLY, AND FREQUENCY

Aquick discussion, led by the teacher, is held about which color(s) appeared to be the most frequent in the clear container.

good, but confusing at bottom. I can't figure out which were crossed out or were the #'s that you wanted to put down

STUDENT NAME Lisa

SURVEY, TALLY AND FREQUENCY

The M&M company will be conducting a survey to determine which color M&M is the favorite choice. To help them out we will conduct a survey in the classroom to see the favorite color of the class.

COLOR	TALLY	FREQUENCY
Red	~~IIII~~ II	7
Orange	I	1
Green	III	3
Yellow	II	2
Brown	III	3
Blue	~~IIII~~ ~~IIII~~ ~~IIII~~ II	17
		(33)

1. Based on our survey results answer the following questions:

a) Which color was picked the most? blue

b) Which color was picked the least? orange

c) Were any colors picked approximately the same number of times? yes If yes, which colors? green and brown

2. If you owned the company, how many of each color would you put in a bag? (Assume you have 100 M & M's)

Red 25 [illegible]

Orange 10 [illegible]

Green 15 [illegible]

Yellow 10 [illegible]

Brown 15 [illegible]

Blue 25 [illegible]

confusing

Asurvey of the students, and any adults, regarding their favorite M&M color is then conducted by the teacher. The teacher can have a transparency of the chart, modeling for the class how to deal with the tally marks. These results are then compared to their observation of the clear container.

Questions that can be addressed:

- Are the results similar? How?
- Who was included in the sample surveyed?
- How would this compare to a survey of adults?
- What would be the favorite color of the entire team? Why?

Each student is expected to complete the worksheets.

Note: Activities 3 and 4 can be done independently in science and mathematics or combined in a double science/mathematics period.

ACTIVITY 3: MEASURING M&M CANDIES

In science class (or during a double period) each student will work with a partner to measure the diameter of one M&M candy using a metric ruler or Vernier calibrator. The students repeat the process using 20 candies laid in a straight line. They compute the average and compare it to their first measurement.

The second part of the activity deals with mass measurement and the students use a triple beam balance to compute the mass of one candy and then 20 candies. The students receive 20 candies in a sandwich bag. An average mass is then calculated.

Using this information, the student is expected to calculate how many candies are in a 1-pound bag. Each student will then review their observation estimate and their measurement estimate and write their conclusions.

measure graphic

STUDENT NAME: Lisa

MEASURING M&M CANDIES

1. LINEAR MEASUREMENT

What is the approximate diameter of a plain M&M to the nearest tenths? Be sure to include the unit of measure.
1/2 in

What tool did you use? ruler Do you feel the measurement is accurate? Why? we lined up the m+m with the ruler.

Lay 20 plain M&M candies in a straight line. Measure this distance to the nearest tenths? Include the unit of measure. 10 in

What tool did you use? ruler

Find the average diameter of one plain M&M candy. 1/2 in

Compare the measures of the two diameters. Are they equal? Which measurement do you feel is more accurate? Explain.
they are equal.

paper 2

2. MASS MEASUREMENT

What is the mass of one M&M candy to the nearest tenths? Be sure to include the unit of measure. 1g

What tool did you use? TBB scale Do you feel that this measurement is accurate? yes Why? because we used the TBB scale.

Find the mass of 20 M&M candies to the nearest tenths. 20g Include the unit of measure.

What tool did you use? TBBS Do you feel that this measurement is accurate? yes Why? becaus we used the TBB scale.

Find the average mass of one M&M candy. 1 g

Compare the two masses. Are they equal? yes Which measure do you feel is the most accurate? yes
Why? because we used the TBB scale for both

ACTIVITY 4: STATISTICAL PROBABILITY OF M&M CANDIES

In mathematics class (or as part of a double period) each student is given a small bag of M&M candies. Each student records how many of each color of the candies is in the bag. The students are now informally introduced to writing a ratio. Adiscussion is led by the teacher to see how many of each color the students had. Since each student's bag is different, the need for percent is introduced and the students are instructed on how to do the conversion on a calculator.

4. Place all of your M&M's (**NO CHEATING!**) back in the bag. Pick an M&M from the bag and note its color in the chart below using tally marks. Place the M&M back in the bag. Repeat this procedure ***twenty*** times. Then compute the frequency, probability, and rate of percent.

EXPERIMENTAL PROBABILITY

COLOR	TALLY	FREQUENCY	PROBABILITY	PERCENT
RED	~~IIII~~ II	7	7/59	11%
ORANGE	III	3	3/39	5%
GREEN	I	1	1/59	1%
YELLOW	I	1	1/59	1%
BROWN	~~IIII~~ III	8	8/59	13%
BLUE	0	0	0/59	0%

5. Compare your theoretical percents and your experimental percents. Are they different? Are they equal? How does the number of each color affect its probability? If the two rates of percent are relatively close then your experiment worked the way it was supposed to work. Explain your results. **(Write a minimum of 5 complete sentences.)**

The Colors (Red + Brown) that had the most showed up the most the ~~ones~~ Colors that had the least Showed up the least

STUDENT NAME Lisa

STATISTICAL PROBABILITY OF M&M CANDIES

1. What is the mass of one M&M candy? 1g
What is the mass of your bag of M&M candies? 46.5
Using the space below estimate how many M&M candies are in your bag of M&M's.

65

2. Using your bag of M & M's, fill in the tally of each color in the chart below. Compute the frequency of each color, its simple probability and rate of percent.

THEORETICAL PROBABILILITY

COLOR	TALLY	FREQUENCY	PROBABILITY	PERCENT
Red	𝍸 𝍸 𝍸	15	15/65	23%
Orange	𝍸	5	5/65	07%
Green	𝍸 I	6	6/65	09%
Yellow	III	3	3/65	04%
Brown	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	30	30/65	46%
Blue	0	0	0/65	0%

TOTAL NUMBER OF M & M'S

3. Compare your prediction in question #1 to the actual number of M&M's you have in your bag. Did you overestimate or underestimate? Would you consider your estimate to be "good"? Explain.

good over esimate
the axtual is 59

The second part of the activity is the experiment. Each student places the candy back in the bag or some other container, retrieves one candy, records its color, returns it to the bag and repeats this procedure 20 times.

The final activity requires students to compare their two results and draw conclusions.

ACTIVITY 5: M&M CONCLUSIONS

The concluding worksheets were designed to allow the students to summarize some of the data and to draw some conclusions from this data. The concepts of range, median, mode, and mean are also reinforced in this activity.

M&M BONUS ACTIVITIES:

These are extended activities for the student to explore. Achoice is given and students are encouraged to come up with their own ideas. These activities are optional and count as extra credit.

M & M CONCLUSIONS

1. The first activity of the M & M Performance Task was to estimate how many candies were in a one pound bag. Your estimate was 560. Based on all the activities do you feel you estimated exactly, overestimated or underestimated? Explain why. (Write a least three complete sentences.)

2. In the second activity a survey was conducted in each class to determine which color each student preferred. In your class the color with the highest frequency was Blue and the color with the smallest frequency was orange

Complete the table below based on the overall team's opinion.

nice Chart

COLOR	FREQUENCY OF EACH CLASS PERIODS 3	4	5	7	8	TOTAL	PERCENT
Red	6	7	1	5	7	26	21%
Orange	1	1	0	0	0	2	1%
Green	3	3	2	4	4	16	13%
Yellow	2	2	5	0	0	9	7%
Brown	1	3	0	1	1	6	5%
Blue	12	17	9	10	12	60	50%
TOTALS	25	33	17	20	24	119	→

3. Based on the results of the entire team survey, answer the following questions.
a) Which color was picked the most? ____________
b) Which color was picked the least? ____________

incomplete

ASSESSMENT

Assessment

Many group discussions are held as the project evolves. All of the questions are designed to further their critical thinking skills. Since the students sit in cooperative learning groups they are able to further clarify any discussions that take place.

The worksheets themselves are graded by the student, another student, and the teacher according to a scoring rubric. These scores are averaged and a grade is assigned. The grade is counted as a project.

Students are also encouraged to do an extra credit task from bonus activities which are suggested. However, student-generated ideas are readily accepted. New additions this year were designing an M&M pillow and a wood candy dispenser as well as other ideas for surveys.

M & M Candy Rubric

A+

1. All measurements and calculations are correct.
2. Clear, logical reasoning is demonstrated.
3. All procedures are clearly described.
4. All information is given.

A

1. There is a minor error in the calculations ***or*** minor information is missing.
2. Clear, logical reasoning is demonstrated.
3. All procedures are clearly described.

B

1. There are several computational mistakes ***or*** some information is missing.
2. Clear logical reasoning is demonstrated.
3. All procedures are clearly described.

C

1. Some major information is missing.
2. There are minor flaws in reasoning.
3. An explanation of reasoning is attempted but lacks development.

D

1. There are many flaws in the reasoning process that impede a logical process.
2. There is little explanation.
3. There is lack of completion.

F

1. Answers can not be found.
2. No explanations of reasoning are given.

EVALUATION AND REFLECTION: What grade should you get on this project? Explain why you should receive this grade. What did you enjoy most about this project? What was the most difficult part of this project? What did you learn?

Lisa
Good job

Checked by: Jessica Mui

Comments inside

M & M CANDY RUBRIC

SCORING GUIDELINES

	STUDENT	GRADER	TEACHER
	Assign 0, 1, 2 or 3		
1. ESTIMATION AND PREDICTIONS • The observation table is filled in completely. • All questions are answered. • In question 3 the sum of their results equals 100. • The ratio and percent is calculated for each color. • The computations are correct.	3	3	
2. SURVEY, TALLY AND FREQUENCY • The survey table is filled in completely. • All questions are answered. • In questions 2, 3 and 4 the sum of their results equals 100. • A clear explanation (at least one sentence) is written in question 4. • In question 5 one type of graph is indicated. • A clear explanation (at least one sentence) is written in question 5.	2	2	
3. MEASURING M & M CANDIES • All the questions in the linear and mass measurement sections are completed. • All measures are to the nearest tenths. • Units of measure are included. • Each explanation is a clear, complete sentence. • In question 3 all work is shown clearly and neatly. • The computations are correct. • The student understood what they were doing. • The conclusions are complete. • Words like equal, greater or less are used in the written explanation. • One prediction is picked and a clear explanation (at least one sentence) is written.	2	2	
4. STATISTICAL PROBABILITY OF M & M CANDIES • In question 1 all answers are complete and all work is shown clearly. • The theoretical probability chart is complete. • The computations are correct. • It is clearly stated that the estimate is an overestimate or an underestimate. • A clear explanation (at least one sentence) is written. • The experimental probability chart is complete. • The computations are correct. • In question 5 a clear explanation is written.	2	2	
5. M & M CONCLUSIONS • Each question is answered completely. • All tables are complete • The computations are correct. • Explanations are written in clear, complete sentences. • Knowledge about probability and statistics is demonstrated.	$1\frac{1}{2}$	2	

REFLECTION:

I have found that almost all learners are able to successfully complete these activities to some degree. With the lowest functioning students, a lesson in simple probability might prove useful. These students also require more involvement from the teacher whereas the other students work independently.

Mathematics, Science & Technology

Part II.7

How Gear Systems Work...............................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).

NEW YORK

THE STATE OF LEARNING

http://www.nysed.gov

ELEMENTARY

Standards & Performance Indicators

How Gear Systems Work:

A Research Project

Bradford J. Helmer, Jr., Richard T. Davis

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http://www.massapequa.k12.ny.us/msd/techdept/4thgr/fairnew.htm

Grade 4

MST 1
- ▲ generate ideas/solutions
- ▲ plan and build

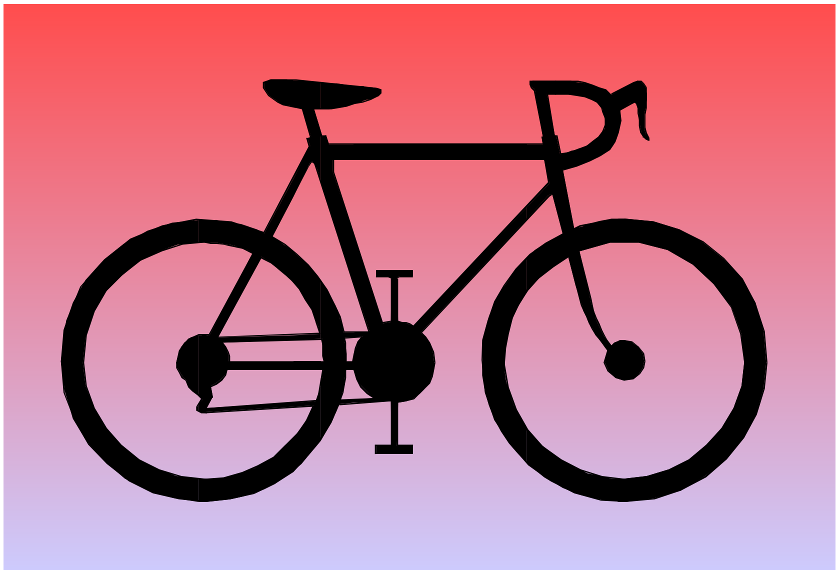
MST 5
- ▲ possible solutions
- ▲ plan and build
- ▲ test solution
- ▲ design/construct

MST 6
- ▲ analyze/construct/operate models
- ▲ different than real thing
- ▲ represent aspects of real world
- ▲ simple instruments

MST 7
- ▲ design solutions
- ▲ observe phenomena
- ▲ work effectively
- ▲ generate/analyze ideas
- ▲ realize results

Curriculum Connections

This learning experience has been developed to introduce fourth grade students to the major concepts contained within Technology Education curricula. Among these concepts are: mastering of curriculum by means of directed, hands-on learning; the manipulation of mathematics concepts and science theory to demonstrate real-world applications of their school curriculums; and the introduction of a structured method of brainstorming and problem solving, by which students can forward their own designs and solutions to real-world type problems.



Capsela Learning Systems

These learning systems contain all the gear systems, wiring, switches, wheels, and everything mentioned in our experiments. For a typical class of twenty two students, we use 12 of the *Capsela 1000* kits. We try to keep student teams limited to only two students, with one additional kit for instructor demonstrations, as well as emergency replacement parts. The kits, at a cost to us of $55.00, have provided good service at a reasonable cost.

There were several reasons for our selection of the *Capsela Learning Systems*. First and foremost was the usability issue with the fourth grade student population. All of the Capsela equipment is quick and simple to assemble, requiring no special hand tools since it has plastic connectors and plug-in type wiring connections. Another feature that made the *Capsela Learning Systems* attractive was how the motor, batteries, and all gear systems are contained in clear plastic, allowing the students the opportunity to see the various gear systems in operation. The final reason for the *Capsela Learning Systems* selection was the issue of expanding our curriculum with the vast number of different activities that could be supported by these relatively inexpensive systems.

Our *A Research Project: How Gear Systems Work* challenges the students to apply information regarding simple machines introduced as part of their regular science curriculum along with a new mathematics concept for fourth grade students: ratios. The teacher introduces the concept that technology is, by definition, the application of scientific knowledge and mathematics concepts to solve a problem, resulting in an improvement in the human condition.

Students are introduced to the technology of the wheel and axle, and learn that by applying a new technology, the gear tooth, designers and planners were able to construct systems that could transfer a great deal of torque (*twisting force*—fourth grade term) without slippage. Next the students review, directly from their current science curriculum, how machines can alter a force, whether the source of the power be a gasoline engine, an electric motor, or the leg muscle of a bike rider. At this point, utilizing a 10-speed bike mounted on a platform, with wheel and pedal components marked to allow easy counting of their rotation, the concept of different gear ratios will be shown in a format the students can relate to their daily lives. Students respond to questions regarding why bikes have all these speeds, and what happens when you select different speeds. Many of the students demonstrate a sound understanding of the effects of different speeds on a bike's gear system. By the end of our lesson, they realize they really understand the mathematics concept of ratios.

At this point we introduce the students to our five planned experiments. We discuss why experiments are an important part of understanding how something works. This Technology Education activity is likely the first school-based research any of the students have ever attempted, and they approach these experiments with serious determination. They are instructed to double check all the data they collect, as wrong data can only yield incorrect conclusions. They are required by experiment questions to apply the mathematics we have reviewed concerning ratios. Finally, they are reminded to base their answers on the scientific concepts regarding machines they have learned about during their science lessons, and which we have reviewed recently during our introduction to simple machines.

The experiments require the students to produce written explanations of their impressions of data collected. This now brings additional curricula and their related skills into this *AResearch* http://www.massapequa.k12.ny.us/msd/techdept/4thgr/fairnew m

Fairfield Schools Technology Newsletter

Spring 1996

News from
Fairfield's Discovery Room - *TECHNOLOGY*

Educating Today's Students for the 21st Century

Technology is Learning Through Doing!

Our technology class is fun. We learn a lot with Mr. Helmer as our teacher. The Capsela kits are cool, we learn how to hook up motors, wheels, lights and more.

This class is only for fourth graders in Fairfield School. We think it would be a good idea to use it in all schools. The classes are forty minutes long and in the Discovery Room. We learn a lot by hearing, seeing, practice, and with our teacher's help.

Sometimes we feel like scientists when we do things with the gears in the Capsela kit. Mr. Helmer is funny and nice. -*Written by Mr. Hludzinski's Class*

> *As a point of interest, our web page was seen by a children's education magazine in China. The editors thought enough of our fourth grade Technology Education Program to write an entire magazine article, complete with our web page graphics, explaining to their young readers how you can understand difficult concepts if you reduce them to simple terms you understand.*

Project: How Gear Systems Work. Their creative writing, spelling, and ability to express their viewpoints by written word are all being called upon during this activity. In addition, the classroom teachers have used this Technology Education Program (two units of study in our case), as an opportunity to utilize the computer writing lab, have students express their reactions to this new program on a word processor, and then edit their opinions into a *Fairfield Technology Newsletter*.

The Technology Education Department has also taken this opportunity to introduce the students to the power of the Internet. Their newsletter was added to the Technology Education's Department's web page, showing the students that people from all over the world can now read of their opinions concerning this program, or anything they wish to write about in the future.

If this were to be the first unit of a program, the teacher, who would be totally new to these fourth graders, would begin the first class meeting by having the students complete a short, *What Do You Know About Technology Worksheet*. This worksheet was designed to be enjoyable, allowing the students to have a good time trying to answer the questions. At the same time, the teacher is given some feedback as to the student's background knowledge. Once completed, the teacher collects the papers and talks about what really is technology. The class period ends with the promise of showing the students a very important technology and something they all have seen, but perhaps not really understood.

What Do You Know About Technology?

Complete this questionnaire by answering each of the following questions to the best of your ability.   This questionnaire is to see how much you already know about technology. Good luck and may the Force be with you!

1. What does the word technology mean to you?
2. In the movie, "Snow White," how many dwarves lived in the cottage with her?
3. What is the fastest speed on a mountain bike? Why is it the fastest speed?
4. Can plants grow without soil? Why or why not?
5. What is your favorite electric toy and how many batteries does it use?
6. How is your home heated? (Examples: oil, gas, wood, solar)
7.. Name the things that a plant needs to grow.
8.. In the cartoon "X-Men" what is the name of the man in the wheelchair?
9. What color was added to the M&M candies last year?
10.. How does electricity work?

At the next class, the technology teacher begins by asking students many questions related to mountain bikes:

- Why do they have so many speeds?
- What do the speeds do? How do the speeds change?
- What does the speed change do for the rider?
- If the bike is a machine, what is the rider?
- How else could we power the bike?
- The bike chain and sprocket resemble what simple machines?

The teacher then brings out a bike mounted upon a platform and demonstrates to the class, with a great deal of student assistance, what happens as speeds are changed. The students are introduced to a new term: gear ratio. The term in this case is related to a bike' s gear system: the number of tire rotations for each rotation of the pedal crank. The class also discusses other applications of the ratio concept; mixing glues, canned fruit juices, etc. The teacher ends the class by asking the students to try and find out what a research project is before their next class meeting.

At the third meeting, the students are presented with the paperwork for the *Research Project: How Gear Systems Work*. Students talk about what a research project means to them, and how it might help them in understanding technologies.

After this discussion period, the students are grouped in teams of two or three students and given a container filled with Capsela components. (Aword of explanation: this is our second unit of study. During the first unit of *Electrical Circuits*, the students are introduced to the Capsela Learning System and spend time developing different circuits. Had this not been already accomplished, the teacher would have to invest a class period to allow the students an opportunity to investigate how the Capsela components hook together.) Having experience working with the Capsela, the students are eager to begin working on these experiments. At this point, both the regular classroom and technology teacher assume the role of mentors. They move about the classroom checking student progress, lending assistance as needed, providing direction as the teams complete each experiment, and completing the scoring rubrics for each team. The number of experiments the students complete (There is a total of five.) will depend upon the ability of each team. Two additional class periods are allotted to this activity, with a solid majority of the students completing all five experiments in this time.

Upon the completion of the research project, the students are given a performance task to complete. This last phase challenges the students to apply everything they have learned from the two units of study: *Electrical Circuit Design* and *Research Project: How Gear Systems Work* to solve a real world type problem, working with the Capsela system. The students are presented with a *Performance Task: Construction Warning Light*. The technology teacher reviews the performance task with the students, answering questions, clarifying the problem statement requirements, until the students consider themselves ready. Before the class meeting, the technology teacher assembles a large assortment of Capsela components, enough to provide each group with many possible solutions to the problem statement. Once the students begin work, the two teachers again assume the role of mentors, offering suggestions and confirming student understandings.

As part of the programs activities, the students write their reactions to the activities and the impact of the teacher's approach to the subject matter. During the Spring 1996 Pilot Program, the teachers took their classes to the computer lab, where the students worked to develop a *Fairfield Technology Newsletter*.

This activity was designed to be conducted in a "laboratory room" setting. For our pilot program we selected a seldom utilize "general-purpose" room. To that classroom we added six work tables (36" x 60"), chairs and a storage cabinet for the Capsela components

Introduction

This activity has been designed to challenge your group's ability to solve real world type problems. Over the past few weeks you have been working with electrical circuit designs and wiring layouts. Recently you have explored how different gear systems are used to increase the power or speed of an electric motor. This activity will demonstrate your group's skill at applying this new information and technology in developing a solution to a problem.

Problem Statement:

A construction company has come to you with a problem they would like you to solve. The workers are fixing a bridge on the Long Island Expressway. The work is very dangerous because of the traffic. The company needs your team, specialists in technology, to construct a model of a warning light they might place on the roadway to warn traffic, and protect their workers. This device must meet several design requirements:

- **It must have a flashing light to warn motorists that there is construction work ahead.**
- **The device must be able to stand on its own.**
- **The device must be easily movable from one job site to another.**
- **The light must be able to turn on and off with a switch.**
- **The light and motor must be on different power sources.**

Experiment #1 System Power / Twisting Force

INFORMATION

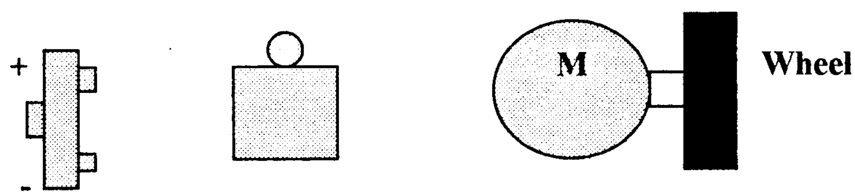
In this part of the research project we will look at the Capsela motor unit. The motor rotates at 9,600 rpm and uses only 3 volts of electricity. This means that the motor has a limited amount of power or twisting force.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count. ***May the Force be with you!***

Step 1:

Connect the motor capsule to the large wheel. Connect the electrical circuit as shown below.



Note : Make sure that the batteries are placed into the power pack correctly.
Ensure that the teeth of the motor and the teeth of the wheel are interlock firmly.

Step 2:

Start the motor and watch the wheel. Record its motion (fast or slow).

____

Use your fingers to cause enough friction to stop the wheel. Does it stop easily or do you have some difficulty?

____

Step 3:

In terms of power or the ability to turn, how would you rate this system's performance? (very good, good, okay, bad, or very bad)

____

4th Grade Technology Program- Massapequa Schools

Experiment #2 Gear Reduction

INFORMATION

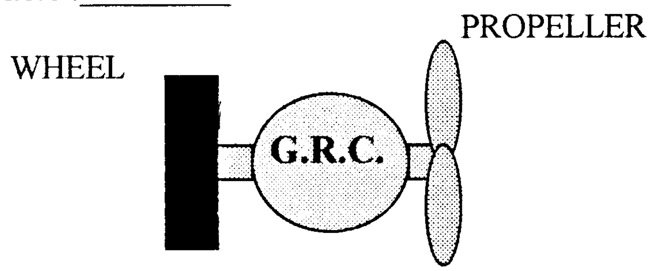
In this experiment you will look at the Gear Reduction Capsule and how it changes the force of the motor. Engineers and designers use different size gears (number of teeth) to allow them to change the speed and twisting force of their motor or engine.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the gear reduction capsule. Place the green propeller on the gray shaft connector and the large wheel on the white shaft connector. Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your answer here :_________

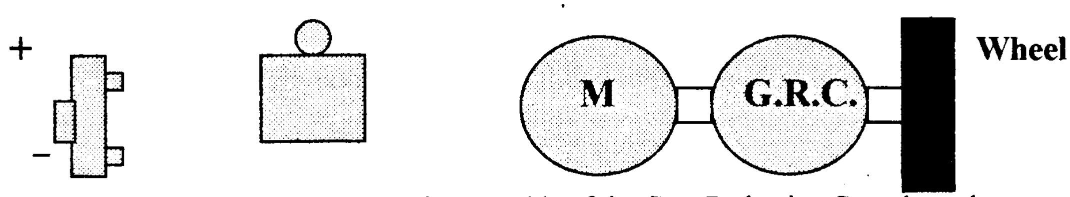


Using your information, how many times does the motor have to turn to make the wheel turn 9 times? (Show your math calculations below.)

Answer:____________________

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Note : You must always connect the gray side of the Gear Reduction Capsule to the motor or the motor will not be able to twist the shaft.

Experiment #3 Worm Gear Capsule

INFORMATION

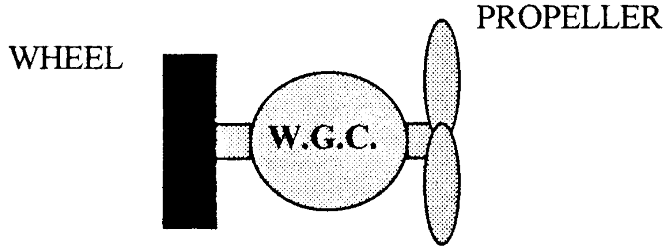
In this experiment you will look at the Worm Gear Capsule and how it changes the force of the motor. This capsule is very special because it uses a screw to move other gears. Pay close attention to how the screw is used inside the capsule.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.
"Transformers! More than meets the eye!"

Step 1:

Locate the worm gear capsule. Notice that the capsule has two gray shafts and two white shafts. Place the green propeller on one of the gray shaft connectors and the large wheel on one of the white shaft connectors. Rotate the propeller and count the number of turns it takes to rotate the wheel one time.
Place your answer here :_________

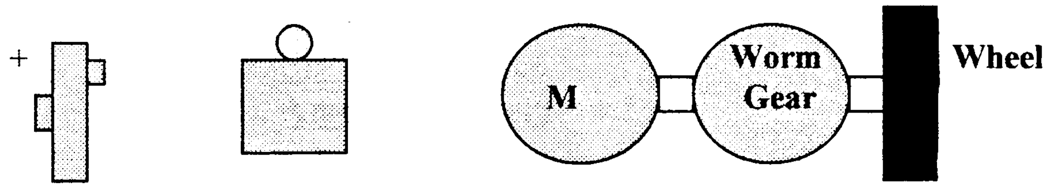


Using your information, how many times does the motor have to turn to make the wheel turn 3 times? (Show your math calculations below.)

Answer:______________________

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment #4 Crown Gear

INFORMATION

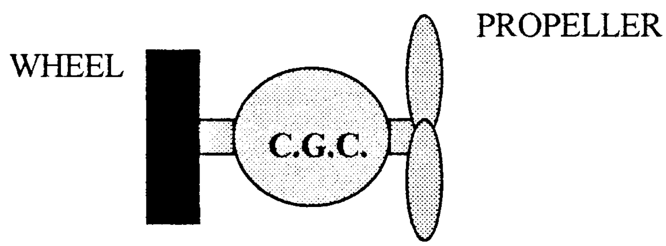
In this experiment you will look at the Crown Gear Capsule and how it changes the force of the motor. Notice that the teeth on the crown gear (the largest gear in the capsule) are on the side of the gear.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the crown gear capsule. Place the green propeller on the shaft connector with the crown gear (largest gear in the capsule) and the wheel on the shaft connector with the small *follower* gears. Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your answer here :_________

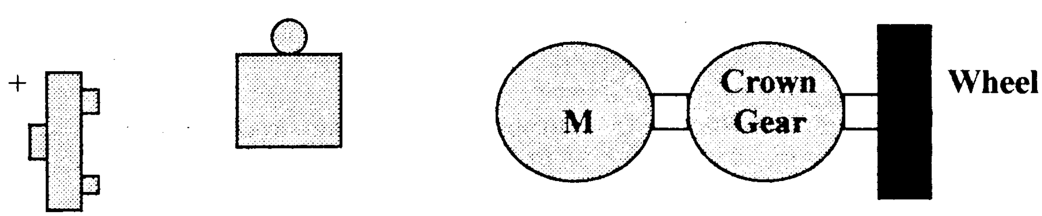


Using your information, how many times does the motor have to turn to make the wheel turn 17 times? (Show your math calculations below.)

Answer:______________________

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment #5 Internal Gear

INFORMATION

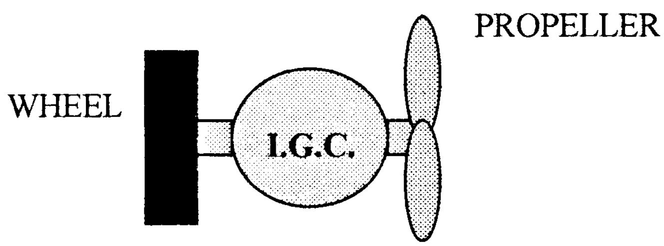
In this experiment you will look at the Internal Gear Capsule and how it changes the force of the motor. Notice that the teeth on the internal gear are on the inside.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the internal gear capsule. Place the green propeller on the shaft connector with the driver gear (smallest gear in the capsule) and the wheel on the shaft connector with the internal gear (large gear with the teeth inside). Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your
answer here :_________

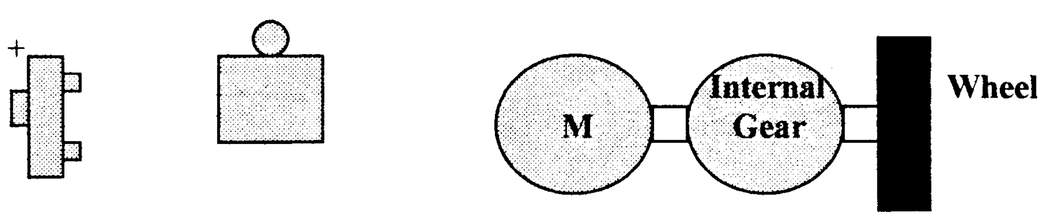


Using your information, how many times does the motor have to turn to make the wheel turn 11 times? (Show your math calculations below.)

Answer:______________________

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment # Gear Reduction Continued

How has the speed been changed? ______________________________

____

Using your finger, is it harder or easier to stop the wheel? How has the amount of the force been changed? ______________________________

____

How has the direction of the force been changed? ____________________

____

____

ASSESSMENT

Assessment

This activity contains two very distinct components: research project and performance task. During the research project experiments, student progress is assessed by their responses as they precede through each of the five experiments. Another opportunity to assess student progress is by the total number of the experiments completed during the time provided. The final assessment is provided by the attached MST Scoring Rubric, completed by the classroom and technology teachers as the students work.

The performance task requires students to develop a drawing of their design layout, followed by a *Design Review* of their completed warning light system. The task finishes with the students completing a *Student Response* form.

Design Review

How well has your design team met the following performance task requirements?

1. Does the device have a flashing warning light?

2. How often does the light blink every minute?

3. What changes could your team make in your design to change the number of blinks per minute?
   - Explain how it would change blinking speed.

4. Does the device stand on its own?

5. Can the device be moved easily from one job site to another?

Student Response Form

1.. Did you have enough time to complete the design tasks?

2. What did you like most about this task and why?

3. What did you like least about this task?

4. Did you think this task was easy?

5. Did you think this task was hard?

6. Do you like science?

7. Do you think this was a fair test of your science ability?

8. Did you like this new unit of Technology Education you have had for eight weeks?
   - **a)** What did you enjoy the most?
   - **b)** Do you think this task was a fair test of your technology ability?

In addition to the written evaluations, the technology and regular classroom teachers each evaluate the students' progress during the class periods for: construction quality, the accuracy of data collection, and the final responses to questions.

At the conclusion of the three-unit program, the students take a comprehensive test of the information and concepts presented. This test includes multiple choice, completion, and fill-in questions. Student success with this testing instrument has been extremely positive and reflective of student success with the program's activities.

GEAR SYSTEMS : RESEARCH PROJECT

MST Scoring Rubric

Name:__________________________ Class:___________________

ACTIVITY	SCORE ACHIEVED			
RESEARCH EXPERIMENTS				
1 - ADDRESSES PROCEDURE STATEMENTS	1	2	3	4
2 - CORRECTLY SELECTS GEAR SYSTEM COMPONENTS	1	2	3	4
3 - CORRECTLY COMPLETES WIRING DIAGRAM	1	2	3	4
GEAR SYSTEM CONSTRUCTION				
1 - ACCURATELY REPRESENTS DIAGRAM	1	2	3	4
2 - COMPONENTS CORRECTLY PLACED INTO ASSEMBLY	1	2	3	4
3 - COMPONENTS CORRECTLY WIRED FOR TESTING	1	2	3	4
4 - CIRCUIT PERFORMS AS DESCRIBED ON DIAGRAM	1	2	3	4
WRITE - UP OF ACTIVITY				
1 - WORK CLEARLY LABELED	1	2	3	4
2 - CORRECT CONCLUSIONS	1	2	3	4
3 - RESPONSES DEMONSTRATE UNDERSTANDING OF CONCEPTS	1	2	3	4

RUBRIC SCORING KEY

1 - REQUIRED EXTENSIVE TEACHER ASSISTANCE - WORK QUALITY FAIR

2 - REQUIRED MODERATE ASSISTANCE - WORK QUALITY GOOD

3 - MOSTLY INDEPENDENT WORK - VERY GOOD WORK QUALITY

4 - INDEPENDENT STUDENT WORK - SUPERIOR WORK QUALITY

REFLECTION:

REFLECTIONS

Our observations of the fourth grade student's ability to solve problems and carry out our experiments lead us to believe that we must take advantage of the opportunity we have to develop an early appreciation for technology education and the lifelong skills it instills.

I cannot stress enough the importance of bringing the fourth grade elementary teachers into the planning stages of this program as early as is practical. They should view this program as an enhancement of their curricula, not a new pull-out program, or just another invasion of their classroom time with their students. Our elementary teachers have been fully supportive, both with assisting during our activities, and by offering constructive suggestions to improve the quality of our activity worksheets.

Mathematics, Science & Technology

PART II.8

Introduction to Flight....................................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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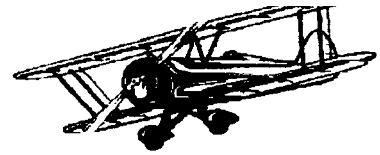
INTERMEDIATE

Standards & Performance Indicators

Introduction to Flight



MST 1
- ▲ identify technical solutions
- ▲ alternative solutions
- ▲ construct model solution
- ▲ test solution

MST 2
- ▲ spreadsheets and data base

MST 5
- ▲ technical solutions
- ▲ develop plans
- ▲ test solutions
- ▲ thorough investigation
- ▲ information resources
- ▲ work schedules/plans
- ▲ modeling tool
- ▲ system control

MST 6
- ▲ answers or solutions

MST 7
- ▲ design solutions
- ▲ observe phenomena
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ observe common themes
- ▲ realize results
- ▲ present results

Ernest R. Ruiz, Tom Salemi,
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Smithtown Central School District
Smithtown Middle School
10 School street
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(516) 361-2500

Grade 7

SUPPLIES

The following is a list of supplies and equipment that are required to carry out this activity, but may not be commonly available in many middle schools.

1. One - Basic Wind I tunnel, Kelvin Catalog #840580 - $345.00
2. One - Strain Gauge and Data Acquisition Interface (IBM), Kelvin Catalog #840471
3. Two - Analog Wind Speed Meter, Kelvin Catalog #720101 - $59.00 each
4. Twenty - French Curves, various suppliers - $4.00 each
S. Supply of balsa wood for wing spars and ribs
6. Digital scale, various suppliers (Prices vary according to kind, quality and accuracy.)
7. Flight stanchion (can be made by staff or purchased through Kelvin Electronics)

A Math, Science and Technology Integrated Project

The airplane has had a profound effect on world history. Look at how wars have been fought since the invention of the flying machine. The world has shrunk and communications are instant, thanks to airplanes and aerospace developments. What does the future have in store? Could *Star Trek* become a reality? These are fertile areas for investigation along with ecological and social issues. Topics like these, and others, could be studied in a broad school curriculum.

To succeed in this activity, students should be able to do the following:

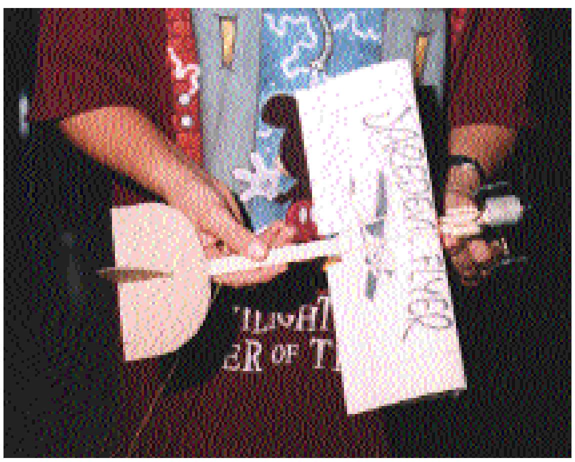
1. Measure using both the English and metric systems.
2. Carry out appropriate math computations.
3. Graph coordinates.
4. Prepare and enter data into a computer spread sheet.

S. Follow directions.

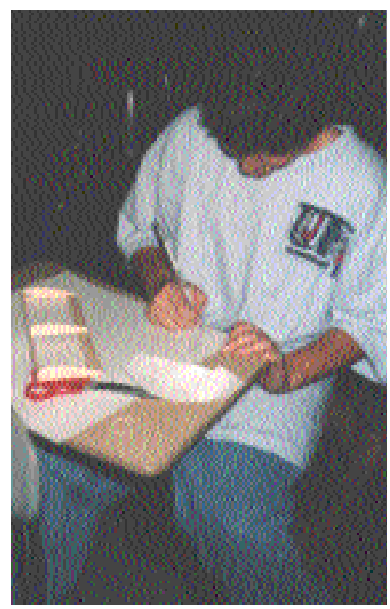
6. Work with scientific apparatus.
7. Use appropriate tools and machines.
8. Communicate ideas.
9. Work cooperatively.
10. Work independently.
11. Work safely.

Integrated activities allow students to understand that subjects are not isolated and that math, science, and reading and writing skills are as important in technology as technology is, directly or indirectly, in those areas.

Teacher



To initiate the program, the students are given the problem statement which clearly defines the problem and states the parameters that the students must consider in seeking a solution. To help them understand the task, the steps in problem solving are reviewed. These activities can be presented in either, or all, of the subject areas.



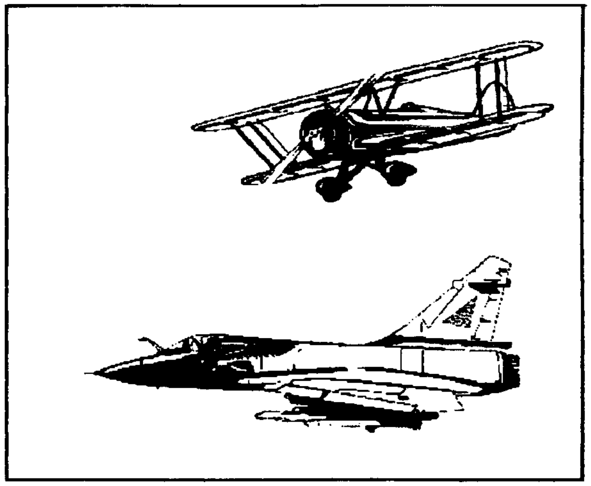
Under the tutelage of the math instructor, the students go over graphing procedures and the locating of points using x and y coordinates. This information is then used to plot the profiles of various airfoils using coordinates given by the instructor. Using French curves, students connect the points in order and the end result is a wing or airfoil profile. Coordinates for the wing profiles are prepared beforehand. They are designed to show relative lift possibilities and in some cases negative lift or no lift at all. The next step, again under the tutelage of the math instructor, is to calculate the areas of the top and bottom surfaces of the airfoil (In most instances they are not symmetrical.) for a wing cross-section three inches in length. At this point, a paper mock-up of the three-inch cross section could be made to show in three dimensions the surfaces of the wings, or to help calculate the surface areas. Students need to keep a record of the information they have gathered relating to the shape and surface areas of the wings. This data will be useful later in understanding lift and Bernoulli's principle.

Smithtown Middle School

Math, Science and Technology Integrated Activity

Introduction to Flight

Problem Statement



BACKGROUND

Around the turn of the century, Wilbur and Orville Wright were experimenting with kites and gliders with the hope of developing a powered, heavier than air, craft that could fly. Today we take flight, by craft heavier than air, for granted, but back then it almost seemed impossible. The Wright Brothers were successful, not because of luck, but because of their willingness to work on a task until completion and their application of Math, Science and Technological concepts. In this project we will incorporate these same skills and concepts to design, test, redesign and construct model planes that we will fly in class.

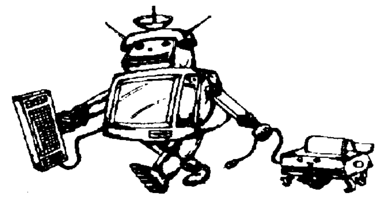
PROBLEM

In teams of two you will plot out the profile for an airfoil from prescribed coordinates. Working with this shape you will determine the surface area for a portion of a wing three inches long. You will then construct a model of the airfoil and test it to determine its lift capabilities. After analyzing the results of the test for your wing section and those of your classmates you will determine what makes for an effective airfoil and design your own. This airfoil will be attached to a fuselage with stabilizers that you will build in the Technology Lab. Your goal will be to design, test and construct the most efficient airplane, that is, the one that will fly the highest and/or fastest.

RELEVANT INFORMATION

1. In Math, Science and Technology classes you will be asked to perform different activities related to this problem. These activities must be done in a timely fashion to allow for integration between the subject areas.
2. You might find yourselves doing things in a fashion that is different from what you are used to. Be flexible and allow the teachers to assist you in this activity.
3. You might find yourselves working with people that you do not know. This happens in the real world. It is imperative that you learn to work with others. That, too, is required in the real world.
4. Computers will be used to record and analyze data.
5. A contest may be held at the end of this activity. The winners will be the team that produces the plane that flies the highest and/or fastest.
6. Any problems that arise which require a judgement to be made, will be solved by the teacher(s) and that decision will be final.

SMITHTOWN SCHOOL DISTRICT
TECHNOLOGY EDUCATION DEPARTMENT



DESIGN / PROBLEM SOLVING BRIEF

Name(s) Marcia

Activity Title Flight

Date

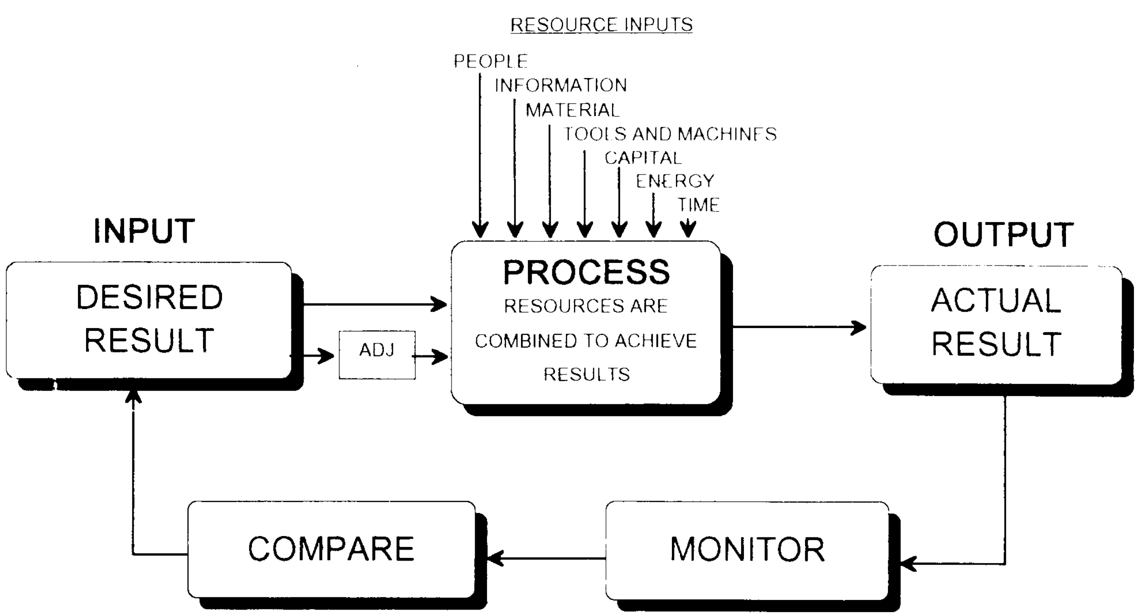
Period 2

Grade Level 7

WRITE A DESCRIPTION OF THE PROBLEM YOU ARE TO SOLVE.

Design a plane with an air foil that will fly using the class equipment.

USE THE SYSTEMS DIAGRAM TO HELP PLAN YOUR SOLUTION



STEPS IN PROBLEM SOLVING

1. Define the problem
2. Gather resources
3. Develop alternative solutions
4. Select the best solution
5. Implement the best solution
6. Evaluate the results and make necessary changes

THINK ABOUT YOUR ASSIGNMENT AND LIST THE CRITERIA THAT YOUR SOLUTION MUST SATISFY IN ORDER TO SOLVE THE PROBLEM

	satisfies yes or no
1. The plane must ~~fly~~ fit ~~using~~ the lab stanchion and power supply.	yes
2. The wing design should be aerodynamic to supply lift.	yes
3. The tabs must be properly adjusted for the most efficient flight.	yes

WHAT RESOURCES WILL I NEED TO SOLVE THIS PROBLEM?

1. HOW CAN PEOPLE HELP ME WITH THIS PROBLEM?

People can give me advice on how to get my plane to fly higher.

2. WHAT TOOLS AND MACHINES WILL I USE TO EXTEND MY ABILITIES?

To extend my abilities I will use the ban saw, a ruler, wood, sandpaper, hot glue, paper, colored pencils, staples, drills, an eyelit and apparatus used to fly plane.

3. WHERE WILL I FIND INFORMATION TO REACH MY GOALS?

I will find information to reach my goals from my Tech. Ed. teacher, other people, books, and notes

4. WHAT MATERIALS ARE AVAILABLE TO USE ON THIS PROJECT?

The materials that are available to use are the ban saw, wood, sandpaper, hot glue, paper staples, drills, an eyelit ,and apparatus used to fly planes.

5. WHAT FORM(S) OF ENERGY WILL I USE?

I will use human energy to make the plane. I will use electrical energy for the machines and to fly my plane.

6. HOW WILL I USE CAPITAL TO COMPLETE THIS PROJECT?

I will use capital by using the bought building, bought machines, bought tools, bought wood and other supplies.

7. WHAT TIME LIMITATION(S) AM I FACING?

I had a limit of about fifteen (15) forty(40) minute periods for construction and testing.

FEEDBACK

1. EXPLAIN WHY YOU WERE, OR WERE NOT, SUCCESSFUL IN SOLVING YOUR PROBLEM.

I was successful in solving my problem because my plane took off and flew to the height of 9 on the measuring board. A 9 is on A.

2. DESCRIBE SOME OF THE DIFFICULTIES THAT YOU HAD TO OVERCOME IN SOLVING THIS PROBLEM.

One difficulty I had was that my plane's front was pointing up so that my plane did not fly very high. To overcome this problem I cut a small square of wood and glued it to the front of my plane so that the weight is balanced.

SELF ASSESSMENT

DARKEN IN THE THERMOMETER FOR YOUR RATING

Design Brief	Workmanship	Success in solving the problem
EXCELLENT 4	EXCELLENT 4	EXCELLENT 4
GOOD 3	GOOD 3	GOOD 3
AVERAGE 2	AVERAGE 2	AVERAGE 2
FAIR 1	FAIR 1	FAIR 1

In technology, the students construct a test model of the airfoil that they had planned earlier. In preparation for this portion of the activity, safety information and the use of appropriate tools must be presented. After the airfoil models are completed, they are tested for lift and air flow properties in a wind tunnel. The data collected from these tests is used to study and reinforce Bernoulli's Principle. Further, this data is studied by students to determine what qualities they would consider in designing wings for their model plane. Science and technology teachers guide students through these steps.

After testing, students can use spreadsheets to analyze and chart the results. With this data they design and plot the airfoil for the model airplane. The new airfoil design and model airplane are constructed in the technology lab. After construction is completed, the models are tested and modified to achieve the best possible flight.

As an additional highlight, the models, after final modifications have been made, are entered in a fly-off. The goal is to fly the highest and/or fastest using the flight stanchion. As closure, the activity is analyzed and reviewed in the various subject areas to have the students explain what they have learned, their reactions to the activity, and suggestions for the future.

PLOTTING COORDINATES – WING DESIGN

EXCELLENT (4-5)	FAIR (2-3)	POOR (0-1)
1) Sets appppropriate scale	1) Sets a scale	1) Sets inappropriate scale
2) Plots all points correctly	2) plots most points correctly	2) Does not plot points correctly
3) Makes smooth curve to complete points	3) Makes reasonable curves to connect points	3) Connected points do not generate appropriate curve
4) Does all work neatly and accurately	4) Work is reasonably neat and accurate	4) Work is not neat and accurate

FINDING THE SURFACE AREA OF THE WING – AVERAGING METHOD

EXCELLENT (4-5)	FAIR (2-3)	POOR (0-1)
1) Accurately places sheet of graph paper over airfoil	1) Places graph paper over airfoil	1) Places sheet of graph paper randomly over airfoil
2) Accurately finds the surface area of the foil by averaging interior and exterior squares	2) Finds the surface area only by estimating squares inside the airfoil	2) Only counts full squares to estimate the interior area of the airfoil
3) Work is neatly done, ideas are clearly shown	3) Work is neat and well organized	3) Work is unorganized, ideas not clearly thought out

TECHNOLOGY ASSESSMENT
FLIGHT

Problem Solving

ABILITY TO RECOGNIZE A PROBLEM **1.** **Rarely notices any sort of problem**	**2.** **Notices obvious problems**	**3.** **Maintains questioning attitude, intelligently curious**	**4.** **Consistently identifies problems**
TENDENCY TO STICK TO A PROBLEM **1.** **No capacity for sustained attack on most problems**	**2.** **Solves simple problems efficiently**	**3.** **Is reluctant to leave a problem without completing it**	**4.** **Is unusually persistent in all problem solving**

Work Skills and Habits

SAFETY **1.** **Frequently needs to be reminded about proper safety procedures**	**2.** **Usually uses proper safety procedures**	**3.** **Regularly uses proper safety procedures**	**4.** **Consistently uses proper safety procedures**
ORGANIZATION **1.** **Poorly organized, loses or misplaces supplies**	**2.** **Usually organized**	**3.** **Organized almost all of the time**	**4.** **Consistently has supplies and materials organized**
ACCURACY **1.** **Shows no concern for measuring and working accurately**	**2.** **Works accurately on easy tasks**	**3.** **Works accurately on most tasks**	**4.** **Works accurately on all tasks**
SELECTION OF TOOLS AND/OR MACHINES **1.** **Uses any tool or machine without concern for appropriateness**	**2.** **Usually selects appropriate tools/machines**	**3.** **Uses appropriate tools and machines regularly**	**4.** **Always uses appropriate tools/machines**
COOPERATION **1.** **Difficulty working with others**	**2.** **Works with others under teacher supervision**	**3.** **Works well with others**	**4.** **Works well both as a leader and a follower**

REFLECTION

As with all learning activities, this one will benefit from modification through practice and development. The needs of all learners will be better met if they are taken through the activity in an organized fashion, allowing the faster students to do tasks at their own pace and yet not pulling too far ahead of slower students. Keeping the students on task can prevent boredom on the one hand and feelings of inferiority on the other.

This activity utilizes integration and has students apply theory to practice and do hands-on work as they solve problems and construct a working model.

Students enjoy this activity and have an opportunity to apply, in a practical manner, what they learn in school. They employ skills from various subject areas and use technical and engineering concepts to reinforce or prove principles and theories that they learn about, rather than just accept them as being true.

Rich

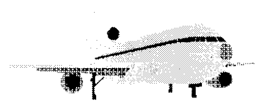
Flight

This year in Tech Ed. my favorite project was about flight..My teacher ,Mr.Ruiz ,taught us about it .The first thing he told us about was Bernoulli's Principle. He taught us about how the wind goes under the wing slower ,which makes more pressure.The wind going over the top curved part of the wing has to go faster because it has a farther way to go.This causes less pressure over the wing which creates lift.This is how planes are able to fly.

Knowing this important information ,we were told to design a plane of our own.We had to make two wing tips exactly alike.We also had to make a fuselage with two two inch pieces of wood which hold the engine given to us.We had to make a trailing edge .We took that and a split dowel rod.We attached all of that together with hot glue in the shape of a wing.We then covered that with a sheet of paper.The next thing we had to build was a horizontal and vertical stabilizer.Mr. Ruiz gave us a pattern and we cut it out of cardboard.Every thing we built was attached the way he showed us .

When we were done building our planes ,we were able to see if they flyed and how high.Mr. Ruiz had previously made a system that would make our planes fly.He had a radio transformer which was hooked up to a post.At the top of the post was a device which would turn with the moving plane atached to the wire.

This was a great project Mr.Ruiz.Thank



you.

Mathematics, Science & Technology

PART II.9

Bill and Ted's Eggsellent Adventure............2

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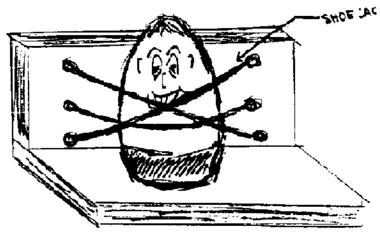
COMMENCEMENT

Standards & Performance Indicators



Bill and Ted's **Egg**sellent *Adventure*

MST 1
- ▲ investigation/technological invention
- ▲ creative solutions
- ▲ work schedules/plans
- ▲ perform test

MST 2
- ▲ prepare multimedia
- ▲ model solutions

MST 5
- ▲ thorough investigation
- ▲ creative solutions
- ▲ work schedules/plans
- ▲ devise test solutions
- ▲ use equipment correctly
- ▲ CADD
- ▲ selecting systems

MST 6
- ▲ mathematical models
- ▲ predictions

MST 7
- ▲ design solutions
- ▲ work effectively
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ observe common themes
- ▲ realize results
- ▲ present results

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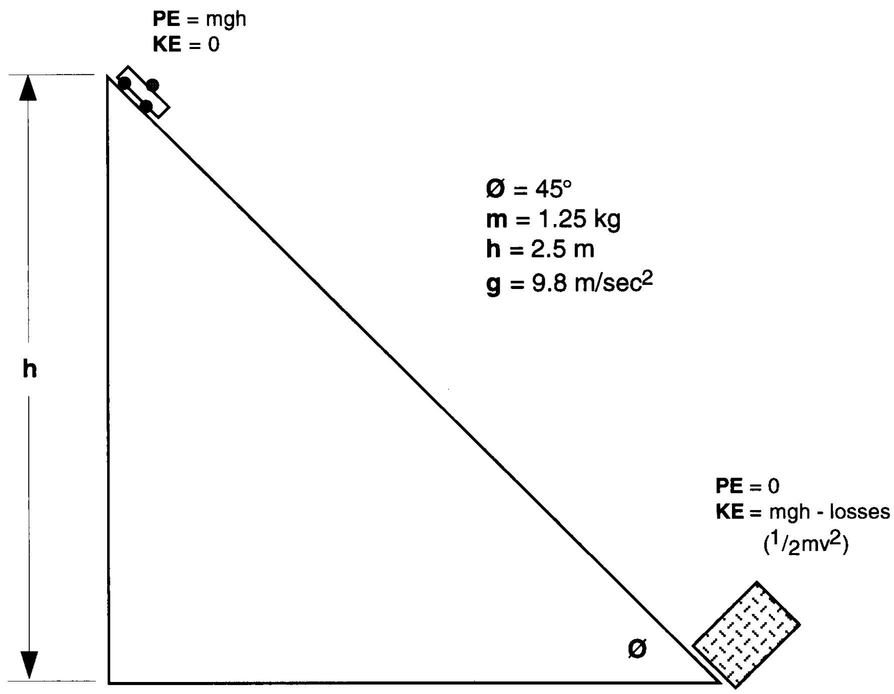
Grades 11&12

Engineers have to go through many designs in order to optimize their solution. To design a crumple zone isn't as easy as it seems. It took me maybe five tries just to get a design decent enough to optimize. By the time I had finished making my crumple zone, it wasn't fancy anymore, but it was very efficient.

Student

Introduction to the Design Activity

In this problem solving and design activity you will use elements of physics, mathematics, and technology to design safety systems that will protect the *occupants* of a vehicle. The vehicle will be a standard dynamics cart (purchased from Frey Scientific). The occupants will be two eggs (Bill and Ted). The vehicles will be tested by sending them down a ramp and allowing them to slam into a concrete block at the bottom.



Each team of students will design the following systems: a restraint system, a crumple zone system, an ergonomics system, and a car body system. The design solutions will be modeled and tested. This activity will utilize the ***energy model*** to determine whether or not the safety systems designed (restraint and crumple zone) will allow the occupants to survive a crash test.

When each vehicle is placed on the top of the ramp, it will have a certain amount of stored, or **potential** energy (*PE*) that is a function of the mass of the vehicle (*m*), the height of the ramp (*h*) and the acceleration due to gravity (*g*). This can be expressed as:

$$PE = mgh$$

PE is the potential energy in joules;
m is the mass in kilograms;
h is the height in meters;
g is the acceleration due to gravity (a constant 9.8 meters/second^2).

Energy is defined as the ability to do work, or the ability to put an object into motion. **Work** is defined as the amount of force exerted on an object to move it a specified distance. Work and energy are both measured in foot-pounds in US units, and in newton-meters in SI (International) units. The *joule* is an SI unit that is equivalent to one newton-meter. ***Joules*** will be used in all calculations of work and energy in this activity.

The PE of the vehicle can also be referred to as its GPE, or gravitational potential energy. The vehicle will have a certain number of joules of PE at the top of the ramp. The energy in motion, or **kinetic** energy (KE) at the top of the ramp will be zero, until the vehicle is released. The car will accelerate as it travels down the ramp. The increase in the velocity of the car will relate to an increased KE, and a decreased PE. At the bottom of the ramp, the velocity of the vehicle will be maximum, as will its kinetic energy. The potential energy at the bottom will be zero, indicating that all of the PE has been converted into KE.

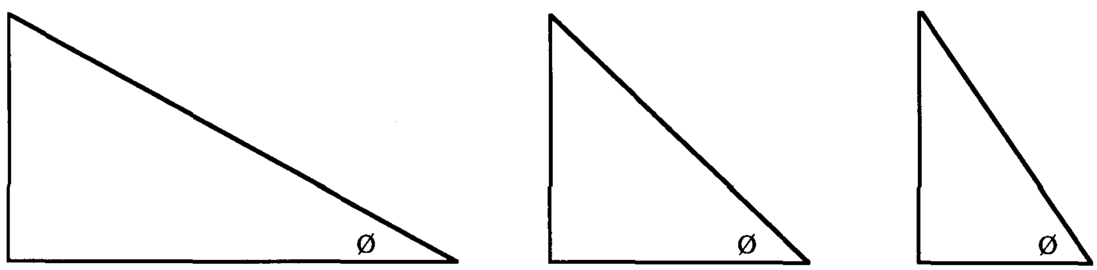
The kinetic energy can be expressed as:

$$\mathbf{KE = 1/2\ mv^2}$$

KE is the kinetic energy in joules;
m is the mass in kilograms;
v is the velocity on meters per second.

This is of course theoretical; all of the potential energy will be not converted into kinetic energy of the vehicle ($1/2\ mv^2$) at the bottom of the ramp. Energy will be lost due to friction (between the road surface and the wheels, and between the axles and wheels). Rotational losses will also be a factor (the energy used to turn the wheels) in the final velocity at the bottom of the ramp. These frictional and rotational losses can be significant, and must therefore be considered.

Another important consideration is the angle of the ramp. Although the acceleration due to gravity is a constant ($9.8\ m/s^2$), the angle of the ramp will control the actual acceleration of the vehicle. The vehicle acceleration will be higher as the ramp is made steeper. We can relate this to the "thrill" of accelerating down a steep section on a roller coaster. The illustration below shows three ramps at different angles; the height is held constant for each ramp. The ramp at 30˚ will accelerate the vehicle the least, and the 60˚ ramp will accelerate the vehicle the most.



Ø=30˚ **Ø=45˚** **Ø=60˚**

If the same vehicle was placed at the top of all three ramps, it would have the same amount of potential energy (***mgh***) which would be converted into kinetic energy as it travels down the ramp (including losses). The actual distance traveled along the ramp will differ for each angle; as the ramp steepens, the distance the vehicle travels becomes less. Using the relationships for ***work*** and ***force***, it can be shown that when the vehicle travels a shorter distance (on the 60° ramp), the force of the vehicle upon impact will be higher than it would be on the 30° or 45° ramp. This is evidenced by the greater magnitude of impacts that occur at steeper angles. The acceleration of the vehicle varies proportionally as the angle of the ramp is changed.

The actual acceleration of the vehicle is proportional to the **sine** of the angle of the ramp. The acceleration of the vehicle down the ramp equals the product of the acceleration due to gravity and the sine of the angle:

$$\mathbf{a = g\ sin Ø}$$

The **g sinØ** values for each of the three angles above is:

30˚ ramp: $9.8\ (.500) = \mathbf{4.90}\ m/s^2$
45˚ ramp: $9.8\ (.707) = \mathbf{6.93}\ m/s^2$
60˚ ramp: $9.8\ (.866) = \mathbf{8.49}\ m/s^2$

The above example illustrates the significant differences in acceleration that occur as the angle of the ramp is varied. These differences in acceleration will translate into proportionally different forces at impact.

Inquiry, Analysis and Design

Since the energy model is used in this case study, an analysis of the forces exerted on either the vehicle or the occupants is unnecessary. Resolving the forces (using vectors) requires a much more involved analysis. Since the acceleration due to gravity is a constant (9.8 m/s^2), tests will be performed by determining the amount of PE (mgh) each safety system can absorb.

Asuggested apparatus to test the restraint and crumple zone safety systems is described below. The apparatus consists of guides fabricated from 1" PVC pipe, sleeves fabricated from 1 1/4" PVC pipe, a wooden base (5/4x6) and platen (2x6), and a variety of pipe flanges, elbows, and couplings. The PVC guides are 1-meter long, and spaced approximately 0.5 meters apart. The specimen is tested by allowing the platen to drop a specified distance. With the weight of the platen known, the distance that the platen falls (including the compressed portion of the specimen) can be used to calculate the potential energy (mgh) absorbed by the specimen. Weights can be added to the platen to increase the mgh without increasing the height of the apparatus. Tests on each of the safety systems can be analyzed, and the results used to optimize the design solution.

Eleven members of each design team are expected to actively participate in all of the facets of this design and problem solving activity. Although all responsibilities will be shared, each team member will be placed in charge of a specific subsystem. The ***Chief Engineer*** for each subsystem will be held accountable for the operation and final success of that subsystem.

Subsystem Chief Engineers:

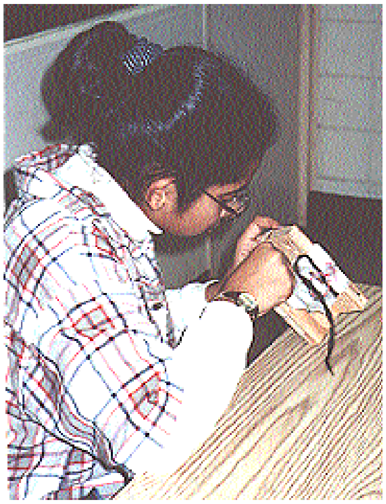
- **Restraint Subsystem Chief Engineer**: Responsible for "occupants" being held in a safe/secure position during and after the collision.
- **Crumple Zone Chief Engineer**: Responsible for the modeling of the subsystem to insure that the design is adequate for the predictable forces and energy transfers at impact.
- **Car Body Design Chief Engineer:** Responsible for the design and construction of a realistic looking car body.
- **Ergonomics Chief Engineer**: Responsible for the ***human factors*** considerations which include: entry/exit, visibility, and space considerations.

Design teams will determine the forces and energy transfers for their vehicle. They will then determine the resulting energy that will be absorbed by their safety systems.

Assessment of Work by Design Teams

- Portfolio documenting and describing the design: Research, investigations, report, drawings
- Optimization of design solutions
- ***Eggonomics*** of the design
- Realistic component of the car body design
- Presentation/justification of design to class
- Survival of the occupants *(Bill and Ted)*
- Student Journal/Log Book
- Class participation.

Each Design Team must submit a portfolio which documents their work on this case study.
The portfolio must contain each of the following materials:



Restraint Subsystem

- Sketches of all preliminary designs
- Materials chosen and rejected (analysis)
- Test results (mgh) for each trial
- Reasons for failure: observations, causes/effects
- Methods of optimization and results
- Final optimized solution: drawings/description.

Crumple Zone Subsystem

- Sketches of all preliminary designs
- Materials chosen and rejected (analysis)
- Test results (mgh, mgΔh) for each trial as a function of height and/or angle
- Reasons for failure: observations, causes/effects
- Methods of optimization and results
- Final optimized solution: drawings/description.

Car Body Design Subsystem

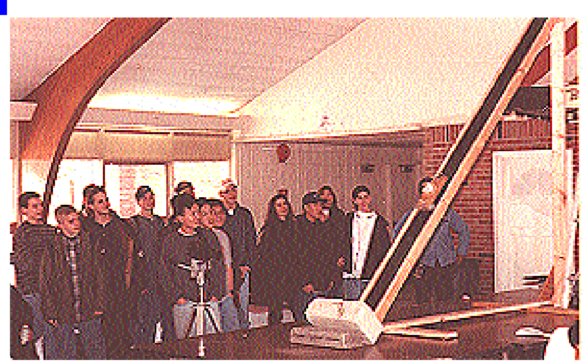
- Sketches of all preliminary designs
- Materials chosen and rejected (analysis)
- Design goals stated: appearance, aerodynamics, ergonomics, weight, and crash-worthiness.

Ergonomics Subsystem

- Measurements and investigations on human factors engineering
- Methods used to apply ergonomics to final design
- Evidence of ergonomics in car body design.

Restraint Subsystem Book

Crumple Zone	**Chief Engineer, Andy**
Restraint Subsystem	**Chief Engineer, Pat**
Car Body	**Chief Engineer, Eric**
Ergonomics	**Chief Engineer, Eric**



Crumple Zone Design
Group#5

Throughout the process of designing an efficent crumple zone, there was a key factor that was always kept in mind. Good absorbtion was the goal for the crumple zone.

The desired crumple zone had to absorb enough kinetic energy from reaching the rest of the car so that the remaining energy could be easily dissapated with the restraint systems. Many materials were tested, and their "behavior" was recorded. From these preliminary testings, the actual shape and forms of the crumple zone we formed.

Cardboard had a tendency to spring back no matter what shape it was made into. It was made into cylinders, tubes, cubes, pyramids, "I" bar shapes or even combinations tended to bounce, a lot.

Paper a distant cousin of cardboard has less tendency to bounce, but still springs. The most efficent absorbing shape is the cylinder, or unsealed box. The sealed air tight box bounced the highest.

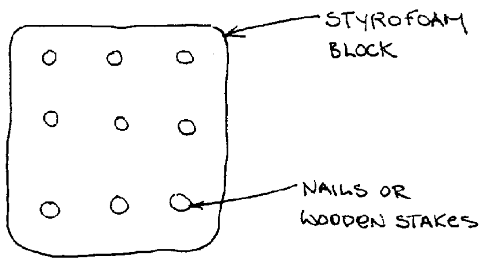
Plastic tendency bounce is comparable to paper in that it springs, but less than cardboard. All shapes srung back up. Tubes, cylinders, and frustum shaped cut outs. The truncated cone shape worked the best.

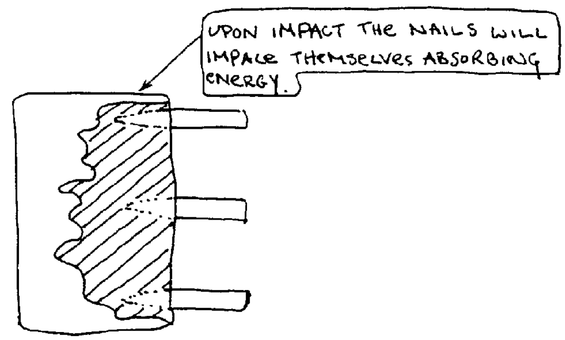
Metal which was the best material for its "unbounceability". No bounce was seen with any shape for the foil or can. The soda can did bounce without slits which had let air out. It actuall. The soda can did bounce without slits which had let air out. It actually took effort fo a bounce to appear such as using paper with metal. A pure metal crumple zone would probably not bounce. (The final design was of pure metal materials, soda can and foil.) Yet it can be noted that a pure metal crumple zone may not be very efficent in an actual collision with only the 3 inch thick dimensions.

From the sketches on the following pages, the solutions are ordered in preliminary, immediate and preliminary solutions.

NAILS AND STYROFOAM

DESIGN #1





USING 14 NAILS AND TESTING IT:

TESTED TWICE WITH SIMILAR RESULT. →

$J = MGH$

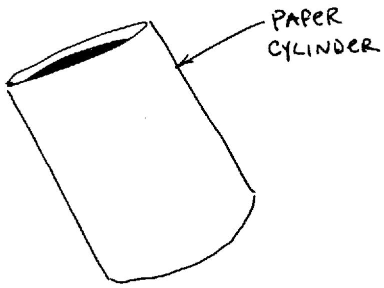
$J = (.745)(9.8)(2\,Kg)$ (m) (m/sec²)

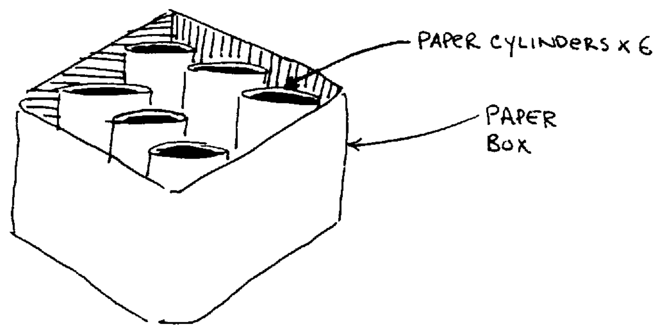
$J = 14.602$

– NO BOUNCE, BUT NAILS WENT COMPLETELY THROUGH TO THE ANVIL.

DESIGN #2

PAPER CYLINDERS





TEST:

$J = MGH$

$J = (2kg)(9.8 \, m/sec^2)(.792 \, m)$

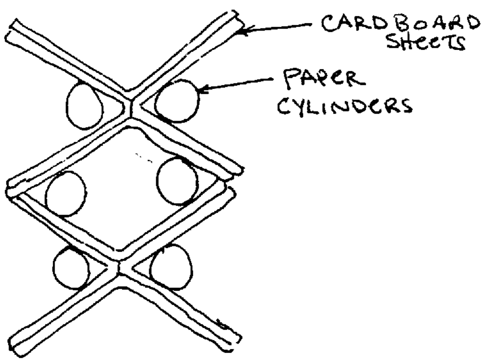
$J = 15.5$

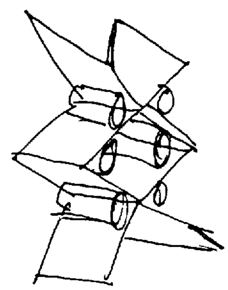
BETTER RESULTS THAN NAILS AND STYROFOAM.

– SLIGHT BOUNCE NOTED
THE BOX TRAPPED AIR.

NO NAME

DESIGN #3





TEST:

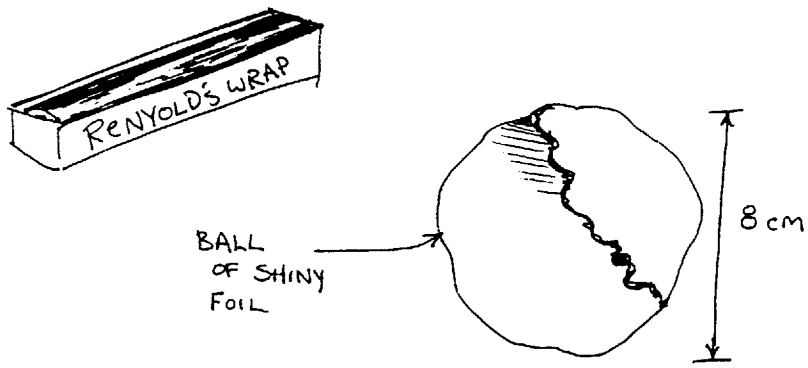
$$Pe = MGH$$

$$Pe = (9.8)_{m/sec^2}(4.)_{kg}(.775)_{m} = 30.38$$

- GOOD ABSORBTION, BUT IT BOUNCED.

ALUMINUM BALL

DESIGN #4



– TEST:

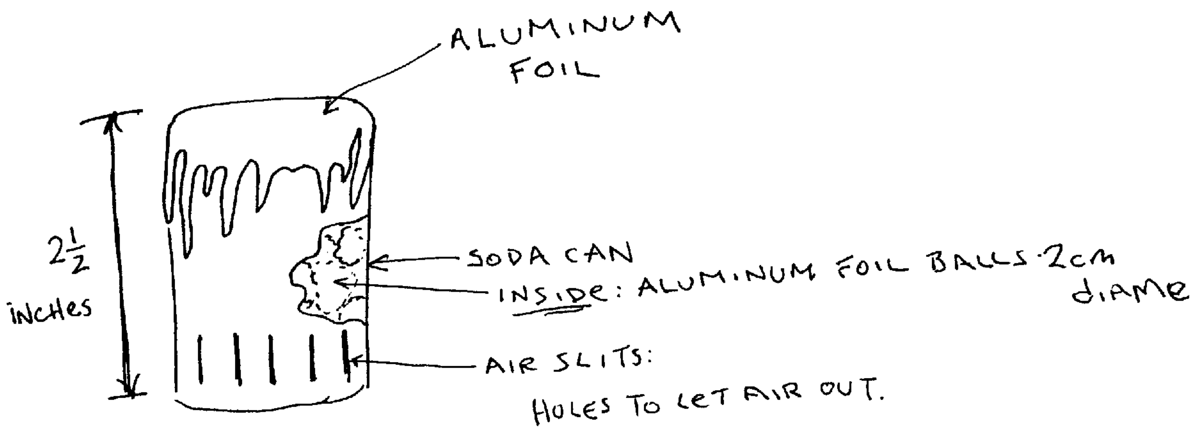
$Pe = MGH$

$(.745\ m)(2\ kg)(9.8\ m/sec^2) = 14.6\ J$

– NO NOTICEABLE BOUNCE.

FINAL

Kenetic Killer



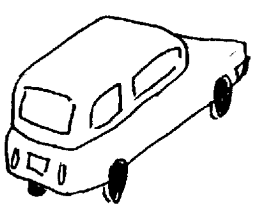
TEST:

$$Pe = MGH$$

$$Pe = (.765\,\text{m})(4\,\text{kg})(9.8\,\text{m/sec}^2)$$

$$= 30.1\ \text{J}$$

- NO BOUNCE



Restraint Subsystem

AS THE RESTRAINT SUBSYSTEM CHIEF ENGINEER, I WAS RESPONSIBLE FOR THE "OCCUPANTS" BEING HELD IN A SAFE / SECURE POSITION DURING AND AFTER THE COLLISION, OVER THE LAST COUPLE OF WEEKS WE HAVE TESTED OVER 5 DIFFERENT RESTRAINT SYSTEMS, USING ALL TYPES OF MATERIALS; EVERYTHING FROM RUBBER BANDS TO COTTON AND GUAZE.

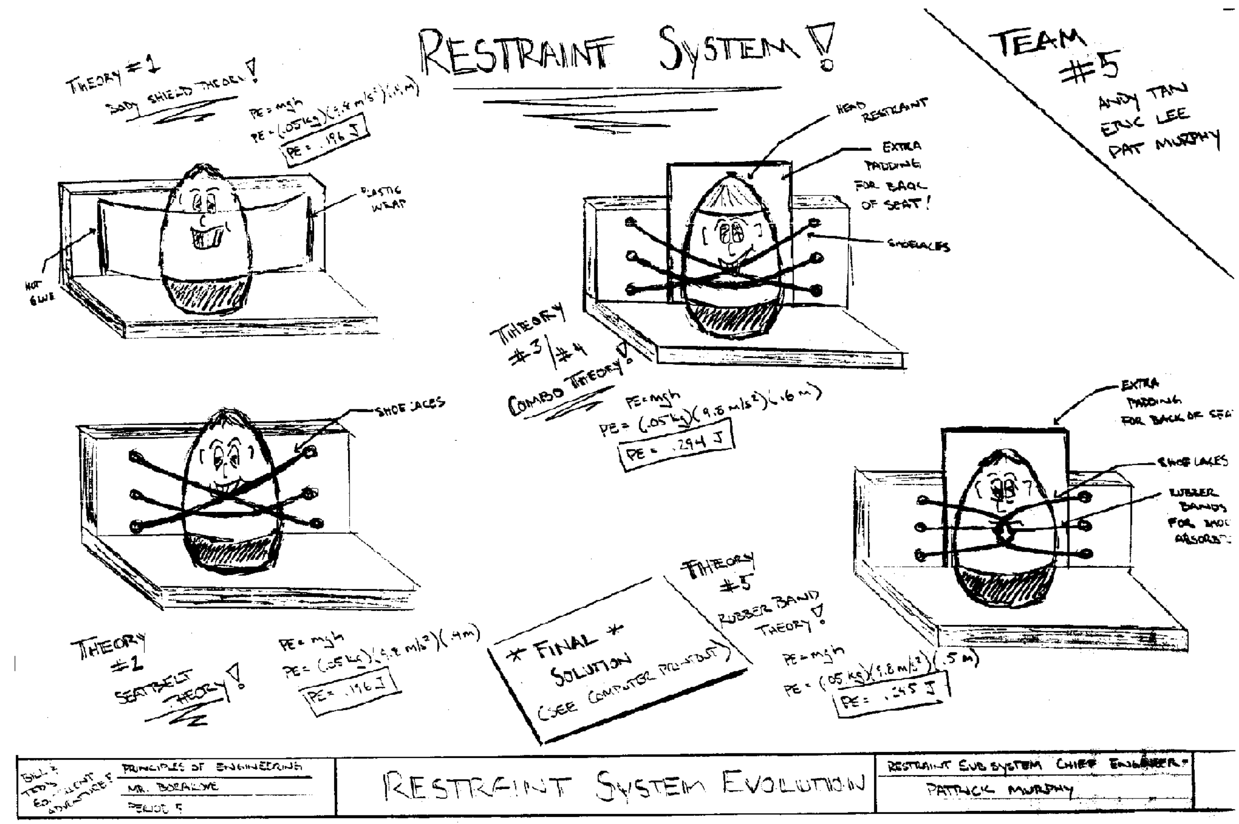
WE FOUND THAT CERTAIN MATERIALS SUCH AS RUBBER BANDS AND PLASTIC WRAP DID NOT WORK PROPERLY. AND MATERIALS LIKE SHOE LACES AND GUAZE DID NOT WORK ON THEIR OWN, BUT WHEN WE INCORPORATED THEM TOGETHER IN ONE SUBSYSTEM, WE GOT A WORKING, EFFIECIENT, FUNCTIONAL RESTRAINING DEVICE.

THE PROBLEM WITH THE SHOE LACES ALONE, WAS THAT THEY WERE TO NARROW AND DID NOT HAVE ENOUGH SURFACE AREA IN CONTACT WITH THE OCCUPANTS. THERE FORE, WHEN A COLLISION OCCURED, THE SHOE LACES ACTED LIKE A KNIFE AND SLICED THROUGH THE OCCUPANTS. IN ORDER TO IMPROVE OUR DESIGN, WE INCREASED THE SURFACE AREA OF OUR RESTRAINING DEVICE BY GLUEING THE SHOE LACES TO FORM BOARD STRIPS OR CARD BOARD STRIPS. WE THEN WRAPPED THEM IN COTTON AND GUAZE TO CUSHION THE OCCUPANTS DURING THE COLLISION. WE ALSO ADDED PADDING TO THE BACK OF THE SEAT BY USING FOAM BOARD AND GUAZE, TO PROTECT THE OCCUPANTS WHEN THEY ARE "WHIP LASHED" BACK INTO THE SEAT AFTER THE INITIAL IMPACT. BY ADDING COTTON IN AND BEHIND THE EGG CARTON SEAT, WE ALSO LESSONED THE BLOW OF THE CRASH.

OUR ORIGINAL DESIGN HAS COME A LONG WAY TO THE FINISHED PRODUCT. IN THE BEGINNING OUR PRODUCT BOARDERD ON OUR ERGONOMIC LIMITS, BUT IN THE FINAL PRODUCT, WE FOUND THAT WE DID NOT NEED ALL THE COTTON AND GUAZE. WE CUT BACK ON THE EXTRA PADDING AND WE HELPED OUR ERGONOMIC STATUS.

I THINK THAT WE ALL PUT A GOOD EFFORT INTO OUR DESIGN, AND AFTER TESTING IT WE KNOW IT WILL BE SUCESSFUL. WE ALL ENJOYED WORKING ON OUR CAR, AND ARE PROUD OF OUR FINAL PRODUCT.

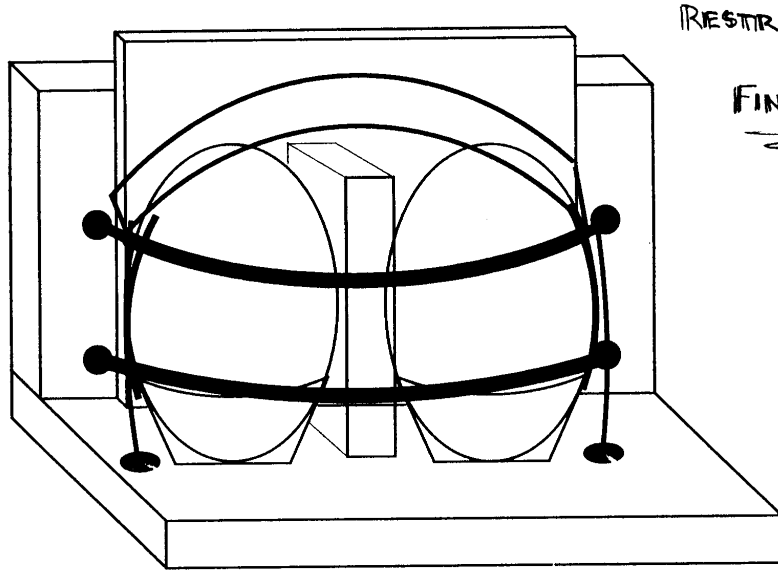
Restraint Subsystem

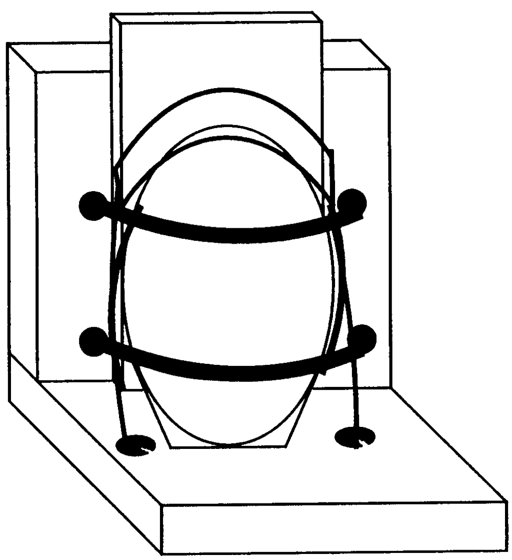


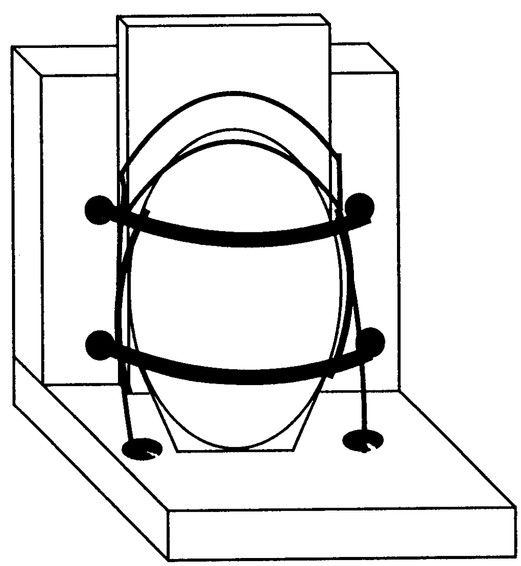
Restraint Subsystem

RESTRAINT SYSTEM

FINAL DESIGN!







FINAL CALCULATIONS!

$P.E. = mgh$

$P.E._0 = (.65\ kg)(9.8\ m/s^2)(.9\ m)$

$P.E._0 = .441\ J$ (MAX.)!

Car Body

Our car body designs were made up in order to have less gravity but weighs heavier then others, so that it will increase the speed of the car which will be dropped from the wooden rail. I chose to make the car heavier then anybody else in the class because I had a complete trust in Andy's crumple zone, Pat's restrain system, and wanted extra points added to our grades.

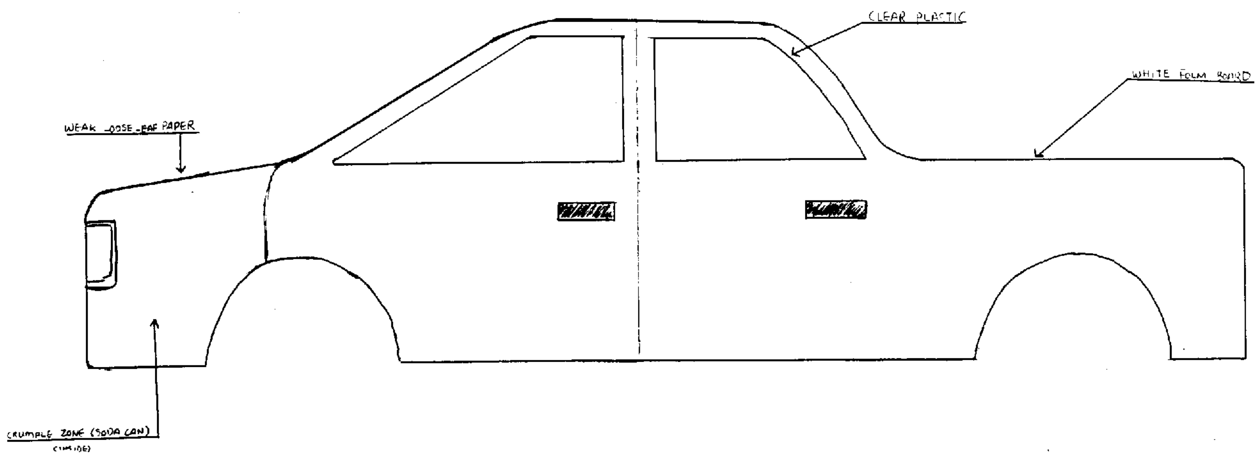
Our car body is made from a white form board which was painted black in order to bring out the style of the car. We agreed on the black color and went with it. I put clear plastics on the windows to stop the air from coming in and slowing down the car. Before I came up with the pick up truck idea I was going to make our design a mini van or a 4 by 4. We had to throw this ideas away because it was not suitable for our crumple zone and our restrain system. Besides our idea was an original, not like all the other groups who built a mini van.

As I mentioned at the presentation our main focus was at the crumple zone and at the restrain system. The car body had nothing to do with the protection of the eggs. This car body is only used for it's figure.

Bill and Ted will survive if they choose to ride in our car. I'm pretty sure that other groups will survive but I guarantee that our car will be most efficient.

Car Body

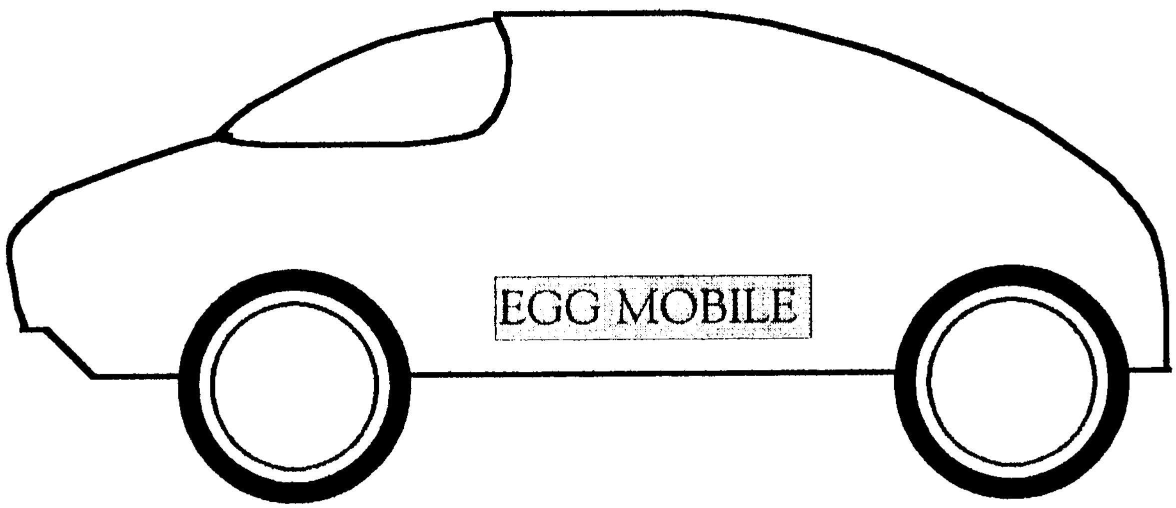
Final Carbody Drawing



Car Body

Pliminary Drawing #1

too round, it slows down. This led to an idea that we should make a sharper edged cars.



Auto Safety Case Study

Log Book Assessment

"Bill and Ted's Eggsellent Adventure"

Student: ____

Assessment Scale:

- **4: Mastery:** Your work demonstrates excellence in this portion of the activity.
- **3: Accomplished:** Your work fulfills all of the objectives of this portion of the activity.
- **2: Acceptable:** Your work is acceptable, but needs minor revisions.
- **1: Unacceptable:** Your work is either incomplete, or requires major revisions.

1. Entries are made on a daily basis to document student's work. ____________
2. Entries are thorough and complete containing all relevant material. ____________
3. Entries contain data, observations and an analysis of the investigations. ____________
4. Entries indicate use of problem solving and design techniques. ____________
5. Illustrations are included where appropriate, and they enhance the clarity of the logbook entries. ____________
6. Entries demonstrate student's contribution to the group effort in this activity. ____________

Total: ____________

Auto Safety Case Study

Assessment of Activity

"Bill and Ted's Eggsellent Adventure"

Design Team # ____ Subsystem Chief Engineers:

Restraint Subsystem: ________________________ Crumple Zone Subsystem:________________________

Car Body Subsystem:________________________ Ergonomic Subsystem: ___________________________

Assessment Scale:

4: Mastery: Your work demonstrates excellence in this portion of the activity.

3: Accomplished: Your work fulfills all of the objectives of this portion of the activity.

2: Acceptable: Your work is acceptable, but needs minor revisions.

1: Unacceptable: Your work is either incomplete, or requires major revisions.

A. Restraint Subsystem

a) Preliminary designs are clearly identified with sketches. ________

b) All data collected for preliminary designs, calculations (analysis of data), and observations are clearly documented for each trial. ________

c) Design shows evidence of optimization. ________

d) Final solution is provided with suitable drawings. ________

e) Aconcise, written description documents your work. ________

B. Crumple Zone Subsystem

a) Preliminary designs are clearly identified with sketches. ________

b) All data collected for preliminary designs, calculations (analysis of data), and observations are clearly documented for each trial. ________

c) Design shows evidence of optimization. ________

d) Final solution is provided with suitable drawings. ________

e) Aconcise, written description documents your work. ________

C. Car Body Design Subsystem and Ergonomics Subsystem

a) Preliminary designs are clearly identified with sketches. ________

b) Safety systems are incorporated into a realistic car-body design. ________

c) Car body illustrates quality workmanship, and good utilization of both materials and equipment. ________

d) Effective use of ergonomics in restraint system design. ________

e) Visible indications that human factors engineering is incorporated into the vehicle design. ________

D . Survival of the Occupants **(Bill & Ted)**

Bill and Ted survive the crash unharmed (no cracks):	(4)	________
Either Bill or Ted is injured (shell cracked) in the crash:	(3)	________
Bill and Ted are both injured in the crash:	(2)	________
Either Bill or Ted *eggspires* (cracks with leakage) in the crash:	(1)	________

E. Presentation of Design to Class

a) Presentation was organized and well-planned. ________

b) Presentation was thorough and included all relevant content material. ________

c) Responses to questions were clear and appropriate. ________

d) Design was justified to class in presentation. ________

e) All design team members actively participated in presentation. ________

f) Presenters handled themselves in a professional manner. ________

g) Presentation included a variety of audiovisual media and visual aids. ________

F. Classwork/Groupwork

a) Student shows consistent effort. ________

b) Work started in a businesslike manner at bell. ________

c) Willingness to help other students. ________

d) Suitable class conduct displayed. ________

e) Student actively contributes to the group effort. ________

f) Student actively participates in the peer review process. ________

g) Student completes work in a timely fashion (at specified deadlines). ________

h) Student worked responsibly as a subsystem Chief Engineer, and was supportive to the other members of the design team. ________

Student's Name: ____

Mathematics, Science & Technology

PART II.10

Boat Hull Design..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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COMMENCEMENT

Standards & Performance Indicators

Boat Hull Design

MST 1
- ▲ investigation/technological invention
- ▲ creative solutions
- ▲ work schedules/plans

MST 2
- ▲ advanced features of software

MST 5
- ▲ creative solutions
- ▲ devise test solutions
- ▲ use equipment correctly
- ▲ explain tradeoffs

MST 6
- ▲ revise a model
- ▲ collect information
- ▲ mathematical models
- ▲ subjective decision making

MST 7
- ▲ analyze problems/issues
- ▲ design solutions
- ▲ observe phenomena
- ▲ gather/process information
- ▲ generate/analyze ideas
- ▲ realize results
- ▲ present results

BUILDING THE TEST TANK
There are a variety of materials available and suitable for this activity: balsa wood—hard wood—closed cell foam—cloth battery-operated motor—propeller—shaft—discarded wheel balancing weights wire—steel washers—clay—petroleum jelly—aluminum flashing

Working in teams of two to four, the students will develop at least three alternative boat designs. Included in the development process is: a rationale for selecting the type of hull, propeller, location of ballast, and type of building material used in the design; a selection and improvement on the most promising design; and a scale drawing of the most promising hull design with two or three views that include basic details and dimensions.

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Grades 9&12

There was a carnival atmosphere to this activity and a lot of excitement was generated among adults and students.
Teacher

In this activity the students will be required to demonstrate certain prior knowledge. Students should be familiar with the following: working in cooperative learning groups; researching information; using the design loop process to generate solutions to problems; brainstorming and developing concept maps; being familiar with 3-view and isometric drawings (CAD and CADD is optional); understanding mathematical modeling, concurrent engineering, material processing, and the use of computers.

MATH CONCEPTS:

- volume
- area (surface area)
- basic trig relationships
- basic geometry relationships
- decimal multiplication rules

SCIENCE CONCEPTS:

- Archimedes' principle
- Newton's laws
- mass and weight
- work and energy
- equilibrium
- stability
- speed and acceleration
- lift and drag

TECHNOLOGY CONCEPTS:

- Basic marine terminology
- propulsion
- what a mechanical drawing is
- design optimization
- tool usage
- center of gravity and buoyancy
- good craftsmanship
- decision making
- functionality of product
- design loop

Need To Know

Principles:
Archimedes Principles
Newton's Laws of Motion
Hydrodynamics
Flotation

Overviews:
History and development of marine transportation systems
Marine terminology
Types of boats
Importance of craftsmanship

Need To Do:

Design:
Construct prototypes
Test models
Evaluate results
Consider hull design, propulsion systems, keel, ballast, and rudder

Presentation:
Prepare analysis of collected data (speed, stability, and design variations) and report conclusions.
Present multimedia program to describe the solution to the problem.

Assessment

ASSESSMENT

I TECHNOLOGICAL DESIGN:

The Design Process:

A) Research material contained in design portfolio
B) Multiple design solutions presented in sufficient detail
C) Alternative designs evaluated against established design criteria (design brief)
D) Optimal/final design explained in sufficient detail

The Design Solution:

A) Functionality of design meets established design criteria
B) Craftsmanship of final product (material process)
C) Scaled drawing of design (two views minimum, with dimensions)

II SCIENCE INQUIRY

A) Established task-related questions (scientific and experimental investigations)
B) Conducted investigations to answer questions (resources identified)
C) Conclusions reached are expressed in scientific terms
D) Use of conclusions to improve design (optimization)

III MATHEMATICAL ANALYSIS

A) Used measurements correctly as necessary
B) Collected data in a systematic organization
C) Organized data into charts and/or graphs
D) Prepared and analyzed charts/graphs and established conclusions

IV WORK HABITS

A) Used tools and materials safely and correctly
B) Shows evidence of collaborative efforts
C) Completed assigned tasks in a timely fashion

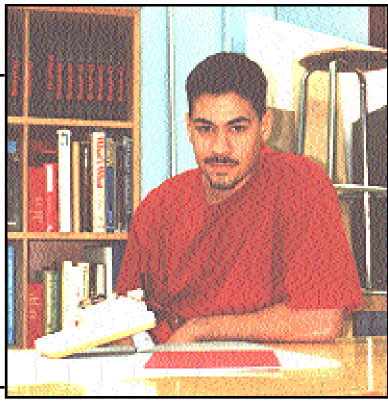
V COMMUNICATIONS AND PRESENTATIONS [optional]

A) Participates in an assigned role during group presentations of results
B) Demonstrates understanding of key concepts and ideas
C) Identifies problems and explains the solutions and how they were achieved
D) Uses charts, graphs, models, etc. to present results

Assessment is done using a Boat Hull Matrix. *There are three grading levels to the assessment.*

2.0	*Acceptable:*	Demonstrates that this portion of the activity fulfills the objectives of the constraints.
1.0	*Minimally Acceptable:*	Falls short of meeting the objectives of the constraints, needs revisions and more investigation.
0.0	*Unacceptable:*	Is incomplete or requires major revisions and additional investigation.

NOTE: An additional assessment is made using some form of an MST test.



I added a rudder to the craft to have it go in a straight line. I put the battery on the top front of the upper deck, so it can make-up for the wright in the back and I can be able to put the payload in the front deck.

Students with little or no experience with cooperative learning demonstrated tremendous cohesiveness and cooperative skills. They asked for more activities such as this.

Teacher

DESIGN CRITERIA & SPECIFICATIONS

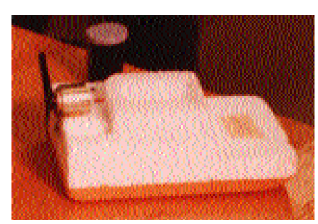
State the specifications which you will design your boat hull to meet or exceed. *(These specifications should be as clear and direct as possible.)*

- I want to build a light weight hull.
- I want the craft to look like a hovercraft
- I want the craft to have a lot of speed.
- I want the craft to use one airpropeller.
- I want the craft geometry to be 8in. length and 4in. beam (width).
- I want the motor to be in the back of the craft and the propeller to be as close to the water as possible.

INVESTIGATIONS:

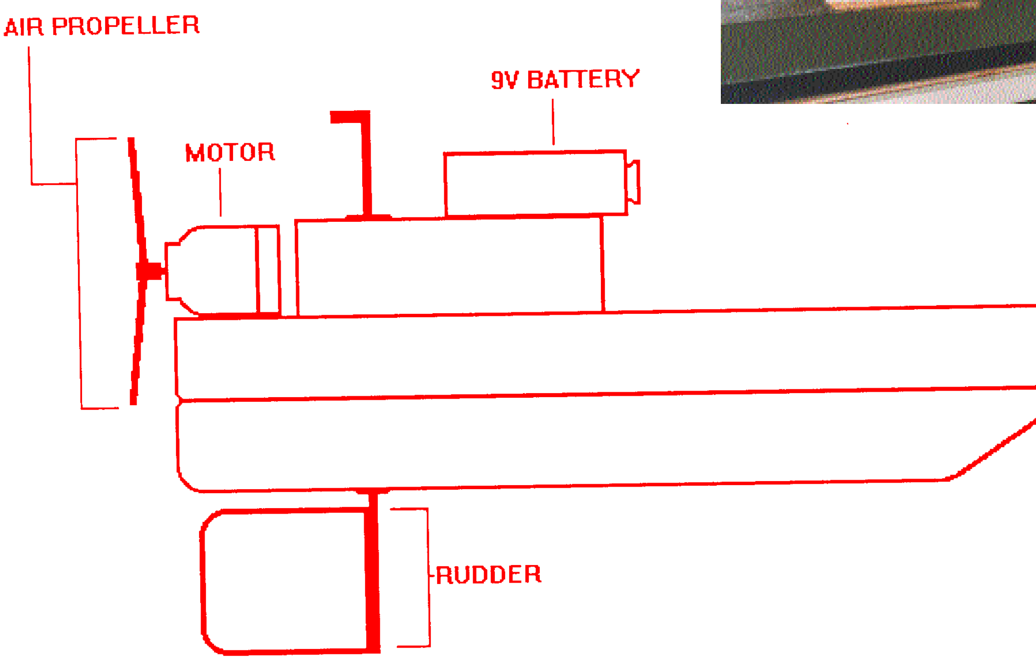
- List all of the questions that you believe must be answered to achieve a successful design.
- List the resources used to research the math, science, technology concepts and answer these questions.
- Describe what you learned by conducting the above investigations.

- will the design of the craft float?
- will the craft be light weight?
- will it go fast?
- will it go straight?
- How much weight it can carry?



Possible solutions

- I added a rudder so the craft can go in a straight line.
- I put the motor in the back of the craft and the propeller as close to the water as possible to give it more stability and more speed.
- I will distribute the weight all round, the craft, specially in the front so the craft can carry the maximum possible pay-load.



Craft Geometry

Lenght- 8 in.
Width- 4 in.
Weight- 141 mg.
Payload- 84 mg.
Total weight- 225 mg.
Speed- 9.5 sec. on a 10 ft. tank.

TESTING / OPTIMIZATION

- I put the rudder furthest to the back so the craft can have the best direction control. I also put the rudder in the back because thats where the air propeller's propulsion is and it gives the craft a more sensitive point of direction.

EVALUATION / SUMMARY

my primery objective was to built a light weight craft that would go fast. I was succeful in that the craft had excellent speed for its size. The craft wasn't able to carry a lot of payload but it was the fastest of all the air propeller in the class and one of the fastest against the marine propeller craft. to be able to carry more payload, I have to improve the design of the hull, I think I should make the beam (width) longer.

Mathematics, Science & Technology

PART III.1

Assessment Models 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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Proposed State Assessments for Mathematics Science, Technology

As a new assessment system for mathematics, science, technology comes closer to reality in New York State, the following proposals for revising existing assessments are being discussed. Your participation in this dialogue is encouraged. Please use the response form at the end of this Teacher Resource Guide to share your comments with the New York State Education Department.

Common Understandings

Assessments will:

- be mapped directly to the science standards with attention to mathematics and technology and especially to inquiry, information systems, the interconnectedness of common themes, and interdisciplinary problem-solving
- assess a broader range of skills than is assessed by the present State tests
- test content matter and require that students construct meaning given unique situations
- all include both an on-demand test (administered to all students during a common time period) and an extended task (a standardized task or set of tasks completed over a longer period of time)
- all have a laboratory requirement as a prerequisite at the commencement level
- be scored by New York State teachers using scoring guides that describe students' work at different levels of performance

The following descriptions of the new assessments are based on the results of pilot tests and the recommendations of several groups including teachers, administrators, and mentors. They represent current thinking and suggest the direction of the assessments, but exact specifications for each test will continue to evolve as teachers and test developers contribute to further refinement.

Descriptions:

Proposed Elementary Science Assessment

The Elementary Science Program Evaluation Test (ESPET) will continue to consist of both an on-demand component and a performance component made up of several stations. At each of these stations students will be asked to use inquiry methods to answer questions and/or address problems posed to them.

School districts will continue to be encouraged to use the results of this test to evaluate their science program by identifying areas which are particularly effective and those which are in need of strengthening.

There will be a mathematics, science, and technology curriculum-embedded task at the elementary level which will require students to apply their knowledge in those three areas to design a solution to a given situation. This task is intended to be a long-range problem in which students work together in groups to develop a solution.

Proposed Intermediate Science Assessment

The proposal for the intermediate assessment includes an exam offered at grade eight comprised of an on-demand component assessing content, skills, and application and a laboratory task.

There may be a mathematics, science, and technology curriculum-embedded task at the intermediate level which will require students to apply their knowledge in those three areas to design a solution to a given situation. This task will be a long-range problem in which the students work together in groups to develop a solution.

Proposed Commencement Science Assessment

The current proposal for commencement level includes Regents exams in Earth science, biology, chemistry, and physics. These exams will be revised and aligned to reflect the learning standards. They will be comprised of an on-demand portion assessing content, skills, and applications to real-world situations; a laboratory practical to occur before the exam; and a long-range project which incorporates all the mathematics, science, and technology standards.

MST

1 2 3 4
5 6 7

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

Assessment System Overview

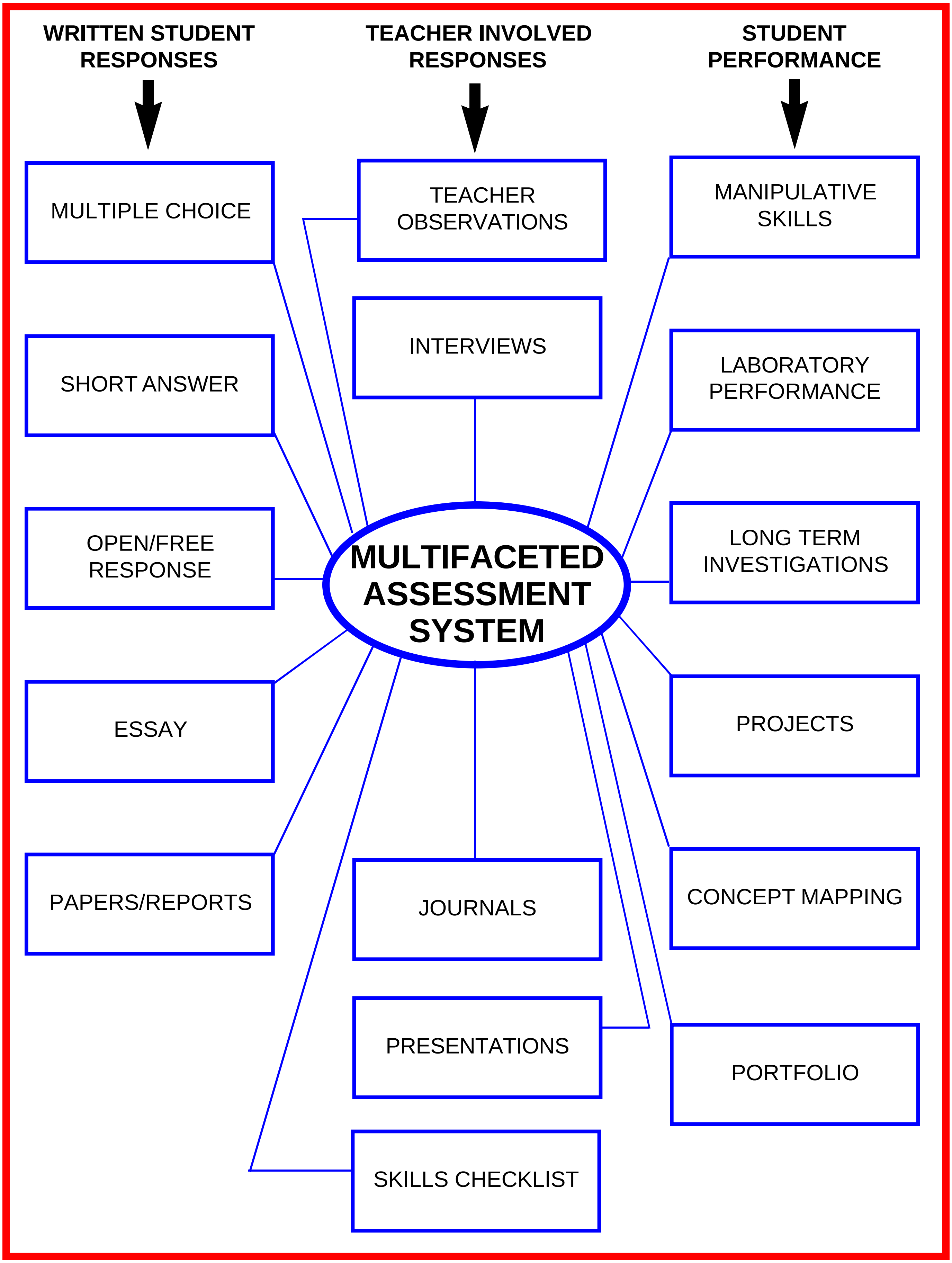
The following two charts provide an overview of the kinds of activities that can be used as assessments. In planning an assessment for a particular purpose, teachers should consider various options and how they might enhance student learning. Examples of many of these assessment types can be found in Part II of this teacher resource guide.

The chart showing a Multifaceted Assessment System suggests the kind of assessment system that we hope to develop in New York State. It includes short answers and performance-based questions; it provides opportunities for student and teacher reflection; it reminds teachers that both on-demand and extended task components will be included.

Some Assessment Options

True-False Item			
Multiple-Choice Item	**Responses**	**Objectively**	**Conventional**
Matching	**Selected**	**Scored**	**Assessments**
Modified Objective			
Completion			
Short Answer			
Essay			
Papers			
Lab Reports			
Observations	**Constructed**	**Subjectively**	**Alternative**
Discussion	**Responses**	**Scored**	**Assessments**
Interviews	**• open**		
Skills Check-List	**• free**		
Performance Testing			
Lab/Field Practicals			
Projects			
Poster-Board Session			
Portfolios			
Self Rating			
Peer Rating			

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


WRITTEN STUDENT RESPONSES
TEACHER INVOLVED RESPONSES
STUDENT PERFORMANCE
MULTIPLE CHOICE
TEACHER OBSERVATIONS
MANIPULATIVE SKILLS
INTERVIEWS
SHORT ANSWER
LABORATORY PERFORMANCE
OPEN/FREE RESPONSE
MULTIFACETED ASSESSMENT SYSTEM
LONG TERM INVESTIGATIONS
ESSAY
PROJECTS
PAPERS/REPORTS
JOURNALS
CONCEPT MAPPING
PRESENTATIONS
PORTFOLIO
SKILLS CHECKLIST

MST

3

ELEMENTARY
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Designing Equitable Assessments

Although this statement was written in light of changing mathematics assessments, it is valid for assessments in all disciplines. Those who design assessments for student use will want to be conscious of the Principle of Equity.

The Principle of Equity asserts that all students—not only a talented few—can learn mathematics to the extent required to live and work effectively in the 21st century. Assessments must be designed with this principle in mind and will:

Determine:

- what students have learned
- what students still need to learn
- further educational opportunities for all students.

Require:

- rethinking of what and how to assess
- reflecting on how individuals and groups are affected by assessment design and procedures
- designing flexible tasks that challenge students and allow them to demonstrate accomplishment.

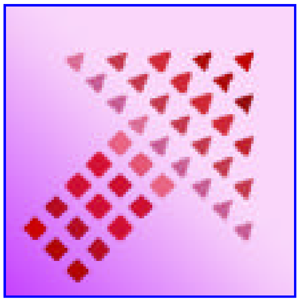
Contribute to:

- opportunities for students to learn
- higher expectations for all students
- better instructional practices
- increased effort on the part of students to achieve at higher levels.

Curriculum, Instruction, and Assessment in Mathematics:

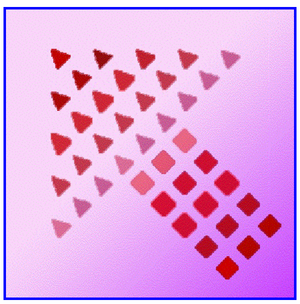
Changes Necessary to Reflect New York State Learning Standards and Assessment

MST
3
ELEMENTARY
INTERMEDIATE
COMMENCEMENT



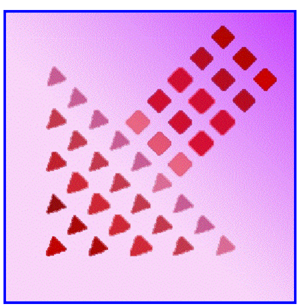
Curriculum:

Mathematics content is closely aligned to both national and State standards. Little substantive change in content is anticipated.



Instruction:

Teachers will need to help students make connections of mathematics to science, technology, and other disciplines. They will teach students how to write effective explanations for their responses and how to work collaboratively with other students to accomplish projects. Teachers will guide students in real-world explorations of a mathematical nature.



Assessments:

Revised assessments at all levels will include extended tasks or projects performed individually, in small groups, or as a whole class to accomplish the tasks. Students will individually communicate their results to the teacher. The number of student constructed responses of various lengths, as well as short multiple-choice items, will be increased. Students will be expected to show how they arrived at their answers by writing sentences which explain their reasoning. Such questions will be phrased in the context of a real-life application of the skill or concept being assessed. Skill in writing effective explanations will thus be demonstrated on the extended task as well as in the greater number of student constructed items on tests.

MST

3

COMMENCEMENT

Mathematics A Regents Assessment Specifications

To conduct a meaningful assessment of mathematics proficiency, it is necessary to measure a student's proficiencies for the seven key ideas for as described in the *Learning Standards for Mathematics, Science, and Technology.* These key ideas are: mathematical reasoning, number and numeration, operations, modeling / multiple representations, measurement, uncertainty, and patterns / functions. Classification of mathematical topics into these key ideas may not be exact and inevitably involves some overlap. In addition, many of the key ideas can be assessed by tasks which involve students in synthesizing knowledge across mathematical topics.

The seven key ideas mentioned above will be only one of three dimensions considered in the construction of the assessment. The other two dimensions will include three process or cognitive levels, and three categories of questions and tasks.

and Tasks					
Aspect	**Range***	**Aspect**	**Range***	**Aspect**	**Range***
Mathematical Reasoning	5-10%	Procedural Knowledge	25-40%	Multiple Choice	20-35%
Number and Numeration	10-15%	Conceptual Understanding	25-35%	Short Constructed Response	20-35%
Operations	10-15%	Problem Solving		Extended Constructed Response	30-45%
Modeling /Multiple Representations	20-30% 15-20%				
Measurement	5-10%				
Uncertainly	15-20%				
Patterns/ Functions					

*The percents indicated are in terms of the total number of points available on the test.

The ranges for each dimension were established by a panel of consultants composed of New York State high school mathematics teachers. In addition to the dimensions listed above, the panel also decided on a range for the amount of questions that are to be in context. Apreliminary estimate for the percentage of the assessment that will either be an application or be given in a contextual setting is 50-60 percent.

The tentative architecture of the assessment will include a Part I, which will contain multiple choice questions that are scored either correct or incorrect with a value of two points each; a Part II, where students will be required to display their solutions and will be scored with a two or three point rubric; and a Part III, where students will be expected to show, demonstrate, or explain their responses to more complex problems and applications that will be scored with a four point rubric. Students may have a choice on Part III of the assessment.

One possible design for the Mathematics ARegents Test is:

Part I	20 questions	(2 points each)	Total 40 points
Part II	8 questions	(2 points each)	Total 16 points
	8 questions	(3 points each)	Total 24 points
Part III	10 questions*	(4 points each)	Total 40 points
	* Possible choice of 10 out of 14 questions for Part III		
			Total Test - 120 points

In addition to the Mathematics ARegents Test described above, students may be given an extended task or project as part of their course work. Some of the questions contained in the on-demand portion of the assessment would be based on what the students are expected to learn from performing the extended task. Details of the extended task or project are still under discussion.

The mathematics content included in these specifications constitutes a subset of the commencement level performance indicators published in standard 3 - Mathematics of the *Learning Standards For Mathematics, Science, and Technology* (MST - March 1996 edition). In some cases, the performance indicators have been clarified by the use of more specific examples of content.

Although the goal of the Regents is to eventually have every student accomplish all of the commencement performance indicators listed in the MST document, it was felt that it was unreasonable to expect that level of performance at this time. The transition to an all Regents curriculum and the institution of MST standards-based assessments in grades four and eight will take several years to affect all of our students.

The Regents' commitment is to review the specifications often and amend them, as appropriate, in order to continue to raise the performance expectation for all students until the commencement level goal is reached.

Mathematical Reasoning

1. Students use mathematical reasoning to analyze mathematical situations, make conjectures, gather evidence, and construct an argument.

Students should be able to:

* construct simple valid arguments

* follow and judge the validity of arguments.

Note: Formal Euclidean proof is not required.

Numbers and Numeration

2. Students use number sense and numeration to develop an understanding of the multiple uses of numbers in the real world, the use of numbers to communicate mathematically, and the use of numbers in the development of mathematical ideas.

Students should be able to:

- understand and use rational and irrational numbers
- recognize the order of the real numbers
- apply the properties of real numbers to various subsets of numbers; in particular the use of closure, commutativity, associativity, distributivity, identity element, and inverses.

Operations

3. Students use mathematical operations and relationships among them to understand mathematics.

Students should be able to:

- use addition, subtraction, multiplication, division, and exponentiation with real numbers and algebraic expressions
- use integral exponents on integers and algebraic expressions
- recognize and identify symmetry and transformations on figures
- use field properties to justify mathematical procedures.

Modeling/Multiple Representation

4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.

Students should be able to:

- represent problem situations symbolically by using algebraic expressions, sequences, tree diagrams, geometric figures, and graphs; in particular the classification of triangles and quadrilaterals (parallelogram, rectangle, rhombus, square, and trapezoid), polygons of 5, 6, 8, 10, and 12 sides, congruence and similarity, and solids (prism, rectangular solid, pyramid, right circular cylinder, cone, and sphere)
- justify the procedures for basic geometric constructions
- use transformations in the coordinate plane
- develop and apply the concept of basic loci to compound loci
- model real-world problems with systems of equations and inequalities.

Measurement

5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.

Students should be able to:

- apply formulas to find measures such as length, area, volume, weight, time, and angle in real-world contexts
- choose and apply appropriate units and tools in measurement situations
- use dimensional analysis techniques

- use statistical methods including the measures of central tendency to describe and compare data; in particular the use of histograms, bar graphs, circle graphs, line graphs, stem and leaf plots, box and whisker plots, scatter plots
- use trigonometry as a method to measure indirectly in particular the use of sine, cosine, and tangent
- apply proportions to scale drawings and direct variation
- relate absolute value, distance between two points, and the slope of a line to the coordinate plane
- explain the role of error in measurement and its consequence on subsequent calculations
- use geometric relationships in relevant measurement problems involving geometric concepts; in particular the use of ratios of perimeters and areas in similar polygons and with circle circumference and area, angle classification and measurement (acute, right, obtuse, straight, supplementary, complementary, vertical, corresponding, alternate interior, or exterior) and sum of the interior and exterior angles of polygons.

Uncertainty

6. Students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations.

Students should be able to:

- judge the reasonableness of results obtained from applications in algebra, geometry, trigonometry, probability, and statistics
- use experimental and theoretical probability to represent and solve problems involving uncertainty
- use the concept of random variable in computing probabilities
- determine probabilities using permutations and combinations.

Patterns/ Functions

7. Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.

Students should be able to:

- represent and analyze functions using verbal descriptions, tables, equations, and graphs
- apply linear and quadratic functions in the solution of problems
- translate among the verbal descriptions, tables, equations, and graphic forms of functions
- model real-world situations with the appropriate function.

Note: Use of the quadratic formula is not required.

MST 3

COMMENCEMENT

Old Paradigm/New Paradigm

Dr. Courtney Young of the Nanuet Union Free School District, took questions from old Regents exams and re-wrote them to embody the new standards. The new versions require students to explain their mathematical manipulations in real-world contexts.

Original

The frequency table below shows the distribution of time, in minutes, in which 36 students finished the 5K Firecracker Run.

Interval (minutes)	Frequency
14-16	2
17-19	6
20-22	9
23-25	8
26-28	7
29-31	4

a How many students finished the race in less than 23 minutes? [2]

b Based on the frequency table, which interval contains the median? [2]

c On your answer paper, copy and complete the cumulative frequency table below. [2]

Interval	Cumulative Frequency
14-16	2
14-19	
14-22	
14-25	
14-28	
14-31	

d On graph paper, using the cumulative frequency table completed in part c, construct a cumulative frequency histogram. [4]

Alternative

a) Who won? Who needs to train more and perhaps lose weight?

b) Were there good times? (Assume a level course and good weather) Discuss your conclusion.

c) Calculate the number of miles in the 5000 meter course. Estimate the number of football fields (100 yds) that would equal.

d) Which interval contains the median? What is the range of times?

e) Complete this table and compute the average time.

Mid Point	Frequencies	Totals
15	2	30
18	6	‘
21	9	‘
‘	‘	‘
‘	‘	‘
‘	‘	‘
30	4	120

f) Describe which is the best indicator of performance and why you think so: the mean, median or mode.

g) Complete the cumulative frequency table.

h) What percent of the runners finished in less than 23 minutes?

i) Construct a cumulative frequency histogram.

j) Plot the mean, median, and mode on the vertical axis.

k) Discuss the general shape of your histogram.

Source: Young, Dr. Courtney D. Jr. Nanuet High School., Nanuet Union Free Schools.

Original

Let p represent: "The stove is hot."
Let q represent: "The water is boiling."
Let r represent: "The food is cooking."

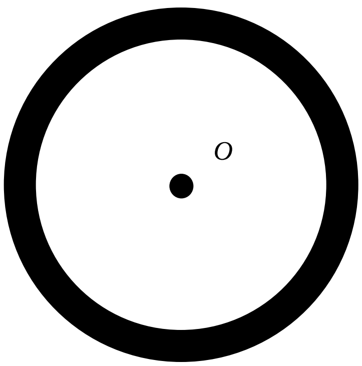
a Write in symbolic form the converse of the statement: "If the stove is not hot, then the water is not boiling." [2]

b Write in sentence form: $\sim r \rightarrow \sim q$ [2]

c Write in sentence form: $p \vee \sim r$ [2]

d *On your answer paper*, construct a truth table for the statement $p \wedge \sim q$. [4]

In the accompanying diagram, both circles have the same center



The radii of the circles are 3 and 5.

a Find, in terms of π, the area of the shaded region. [4]

b What percent of the diagram is unshaded? [2]

c A dart is thrown and lands on the diagram. Find the probability that the dart will land on the

(l) shaded area [2]

(2) unshaded area [2]

Alternative

p: The "Series" is close!
q: The 'Fans' are cheering!
r: The "Yankees" are scoring!

a) Converse of: If the series is not close, then the Fans are not cheering.

b) Sentence form: $\sim r \rightarrow \sim q$ Write an equivalent sentence. Prove they are equivalent.

c) Sentence form: $p \vee \sim r$ Translate to an If-then sentence. Prove they are equivalent.

Asmall Spruce tree is centered at 

Its branches spread out to a 3 ft. radius.
The surrounding mulch has a 5 ft. radius.
The mulch is surrounded by concrete.

a) Find the area of the shaded region (the mulch).

b) What percent of the total area is covered by the tree?

c) If the tree needs a rain gathering area of mulch equal to 300 percent of the area covered by the tree in order to survive, will this tree live? Explain. If not, by how much should the radius of the mulch be increased?

d) Assuming rain falls vertically, find the probability that rain will land on.

i) the mulch (shaded) area.

ii) the branches of the Spruce.

Original

The ages of three children in a family can be expressed as consecutive integers. The square of the age of the youngest child is 4 more than 8 times the age of the oldest child. Find the ages of the three children. [l0]

Alternative

Three teachers plan to retire this year: Mr. A, Mrs. B, and Ms. C. Mrs. B's class decides to have a party for them, and during their planning they invent a math problem to give all three teachers in a contest setting. Are they going to get even or what! Here is the contest problem:

* The ages of 3 retiring teachers are 3 consecutive integers. Mr. Ais younger than Mrs. B who is younger that Ms. C. The square of the age of the youngest is 400 years more than 48 times the age of Mrs. B. Find all 3 ages.

a) Show how the problem can be solved.
b) "Extra credit" will be awarded to the teacher who can find a second method of solution. Prepare an answer "key" for a second method.

Original

Solve the following system of equations algebraically or graphically and check:

$$3y = 2x - 6$$
$$x + y = 8$$

[8.2]

Alternative

The Graphing Calculator Club is small, (only 8 members) but they have big plans. In order to earn money for a "T192" the members of one group managed to raise $20.00 each. The rest of the members purchased reference material to use with the new machine; they spent $30.00 a piece. Overall they still had a surplus of $60.00 to apply toward the new calculator.

How many members were in the money raising group?

a) Set up a table to analyze the situation. Use expressions for "total members" and for "money surplus" in your table's heading. Identify the "solution" row of your table.
b) Write and solve a pair of equations to verify your work.
c) Graph your pair of equations and identify the "solution."

Original	Alternative

Original

In ΔABC, AB is $\frac{3}{5}$ of the length of $\overline{BC}$, and AC is $\frac{4}{5}$ of the length of $\overline{BC}$. If the perimeter of ΔABC is 24, find the lengths of $\overline{AB}$, $\overline{AC}$, and $\overline{BC}$. [*Only an algebraic solution will be accepted*.] [5.5]

Alternative

Al, Bill, and Carla live near Albany, Buffalo, and Canton respectively. They use ham radios to communicate. Let triangle ABC represent the situation. A storm is centered in upstate New York on Monday (the interior of triangle ABC) and they are just barely able to make contact with each other. The maximum effective ranges are as follows. From Al to Bill is 3/5 the range from Bill to Carla, and from Al to Carla is 4/5 the range from Bill to Carla.

a) Label your triangle (A,B,C,) and use expressions to label the effective ranges AB, AC, BC.
b) Suppose the minimum perimeter for effective communication between the three is 1200 miles. Study some possible range values by completing this table:
c) Represent the distances in terms of one variable and find the ranges given the minimum perimeter of 1200 miles
d) Compute the area of Monday's communication triangle. The storm passes by Wednesday and this area doubles. What are the dimensions of the new triangle? **Explain your work.** Can Al now reach Chicago? Discuss!

AB	AC	BC	Perimeter
120	160	200	480
		250	
		300	
		350	
		400	
		450	
		500	
		550	
		600	

Original

a) On graph paper draw the graph of the equation $y = x^2 - 6x + 8$ for all values of x in the interval $0 \le x \le 6$.
b) On the same set of axes draw the image of the graph drawn in part a after a translation of $(x - 3, y + 1)$ and label it b.
c) Write an equation of the graph drawn in part b.

Alternative

An olympic diver leaves an 8 meter platform at time 0, enters the water at time = 2 seconds, reaches the bottom of her arc at time = 3 seconds, and emerges at the surface at time = 4 sec.

a) Develop a quadratic model of her path based on a y - intercept of 8 (meters) and t intercept of 2 and 4 (seconds). Draw the graph for $0 \le t \le 6$ (seconds).
b) Use the same set of axes to draw the image after a translation of $(t - 3, y + 1)$ and write its equation.
c) Interpret this change in terms of a diving situation.

Original

The length of a rectangle is 4 less than twice its width. If the area of the rectangle is 20, find the width of the rectangle to the nearest tenth.

In the accompanying diagrams of parallelogram MATH, $\overline{AH}$ is a diagonal, altitude $\overline{AV}$ is drawn to side $\overline{MH}$, AT = 18, VH = 10, and m M = 42.

a) Find AV to the nearest tenth.
b) Find the area of parallelogram MATH to the nearest integer.
c) Find the perimeter of parallelogram MATH to the nearest integer.

Solve the following system of equations algebraically and check:

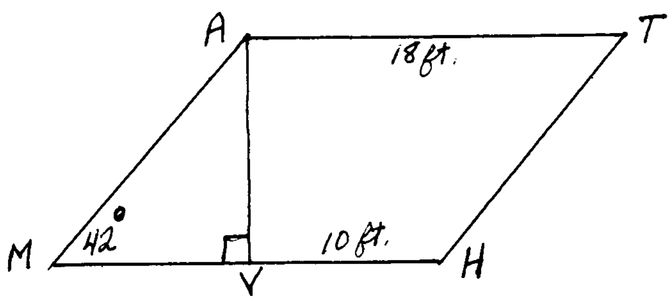
$$x^2 + y = 100$$
$$y = x - 2$$

Alternative

We need 20 square yards to store our new Bass Boat! The shape of our garage is about twice as long as wide and we want the storage space approximately in that proportion. If we can "save" 4 yards in front of the boat, we can store the motor and other accessories also. How can we determine the dimension of the storage area?

---

a) The Math Club is allocated space at the school fair as shown in the diagram:
b) Find the maximum allowable width for a display table.
c) Find the length of rope needed to cordon off the entire space while the floor is being painted.



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a) Assume that Jupiter has a circular orbit and lies 10 astronomical units from the Sun. Place the Sun at the origin of your coordinate system and write an equation modeling Jupiter's path. Draw the graph.
b) The "Floater" species on Jupiter (very intelligent) has discovered that an alien ship has entered the solar system and is traveling the path modeled by $y = x - 2$. Graph their path on your coordinate system.
c) Find, in quadrant one, the coordinates of the point where the alien ship will intersect Jupiter's orbit.
d) Assume Jupiter is located at (10,0) when the alien ship crosses its orbit. If the floater species sends a signal to the aliens, how far will the signal travel?
e) If the alien computer takes 3 minutes to decode the message and encode a reply, how long will the Floaters wait? Explain your reasoning.

Original

Given: △EAD, $\overline{ABCD}$, $\overline{AB} \cong \overline{DC}$ and ∠EBC ≅ ∠ECB.

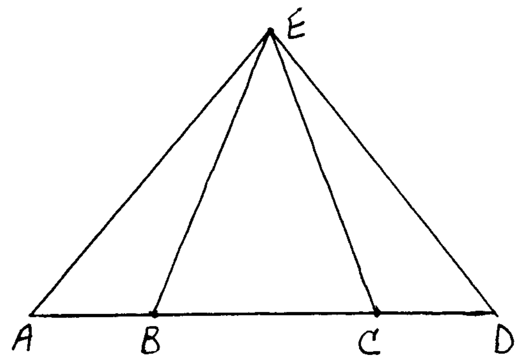
Prove: △EAD is isosceles.

Quadrilateral ABCD has vertices A(-8,2), B(0,6), C(8,0) and D(-8,-8). Prove that quadrilateral ABCD is an isosceles trapezoid.

Alternative

Our Family tent has enough headroom but we need more sleeping area. My little brother suggested that we use the floor material to expand the size. (We can sew in a new floor later.)

In our tent currently ∠EBC ≅ ∠ECB and we want to make the new sleeping spaces $\overline{AB} \cong \overline{CD}$. Will our “new” tent be isosceles? Write out a discussion proof.



Four “Sport” fishing boats are spying on a renegade whaler. The whaler is located at W(0,0). The “Fishing” boats ABLE, BAKER, CHARLIE, and DELTAare located at (8,-2), (0,6), (8,0) and (-8,-8) respectively.

a) If ABLE sends a visual signal to BAKER, can DELTA use the same direction to send a signal to CHARLIE? Why or Why not?

b) ABLE and DELTAare towing a sonar rig. BAKER and CHARLIE tow one also. Each team must maintain a fixed distance so as to avoid damage to the sonar equipment. Are they? (the rigs are the same size). What is the current distance (AD, BC)?

c) What is the current shape of the array ABCD? Discuss how you know this.

Mathematics, Science & Technology

Part III.2

Assessment Models 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).

NEW YORK
THE STATE OF LEARNING

http://www.nysed.gov

MST 3

ELEMENTARY
INTERMEDIATE
COMMENCEMENT

Sample Questions from New York State Pilot Math Assessments

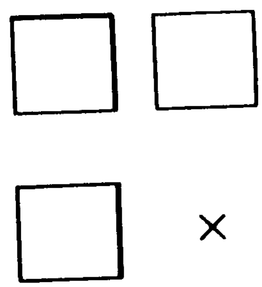
Questions from fourth-grade, eighth-grade and commencement level pilots provide examples of the sorts of thinking expected of students in new assessments.

Assessment

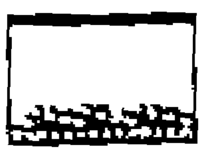
4th grade

Fourth-grade:

1. Using the digits 3, 4, 5, place each digit in a box in order to get the largest possible answer (product). No digit may be used more than once.



2. Jerry has gumballs in a plastic box. Right now there are 58 gumballs in the box shown below:



Estimate how many gumballs will be in the box if Jerry fills it up to the lid.

Explain how you got your estimate.

8th grade

Eighth-grade:

1. Jason went to the grocery store and bought a package of 10 hot dogs and a package of 8 rolls. Jason noticed he would have two hot dogs without rolls. He wondered, “What is the least number of packages of hot dogs and rolls I would have to buy in order to have hot dogs and rolls come out even?”
   Solve Jason’s problem. Show your work.

2. Melita has an average of 87 on the four tests she has taken in English class so far this marking period. She could make the honor roll if she gets her average up to 90. There will be only one more test before the end of the marking period.

What score will Melita need on the last test to give her an average of 90 for the marking period? Show your work.

Extended Task

The following task assesses your ability to integrate and use your mathematical understanding to gather data and communicate your conclusions.

The Acme Bubble Gum Company is introducing a new series of Olympic Star Trading Cards. The collection includes pictures of six gold-medal winners. There is one card in each pack of gum. The probability of getting any one of the stars is equal.

In order to answer this problem, you will work in groups to simulate the purchase of gum packs in different ways.

Before you begin these experiments, answer the following questions to predict what the actual outcomes will be:

1. What do you think would be a reasonable number of packs of gum that you would need to purchase to collect all six stars?
2. Is it possible to get all six stars by purchasing only six packs of gum?
3. Is it possible **not** to get all six stars if you purchased 100 packs of gum?

Group Data Collection

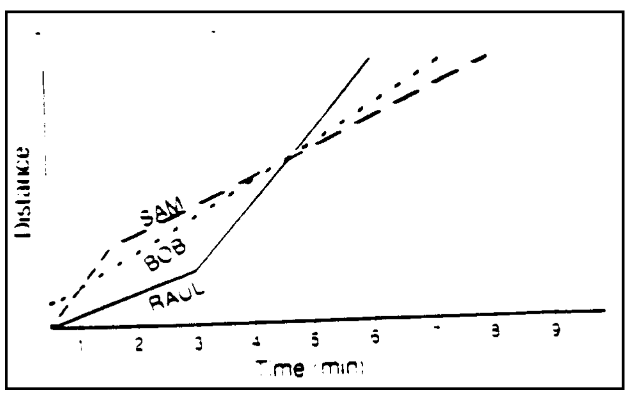
Each group will simulate the purchase of gum packs in three different ways.

1. Use a spinner divided into six equal regions, with the regions numbered 1, 2, 3, 4, 5, and 6. Each spin will represent the purchase of a pack of gum. Spin and record your results and the number of spins until you have landed on each number at least once.
2. Using a cube numbered from one to six, perform a similar experiment. Keep track of your rolls until you have rolled each number at least once.
3. Place six chips numbered from 1 to 6 into a container. Remove one chip and record your pick each time. [Remember to replace the chip drawn each time before drawing again.] Continue to draw until each number has been drawn at least once.

When your group has completed the three simulations, record your results on the class chart as directed by your teacher.

COMMENCEMENT:

1. Three notebooks and two pens cost $6.90. At the same time, two notebooks and one pen cost $4.35. Find the cost of a notebook and the cost of a pen.
2. The graph below shows the relative positions of three runners in a race. Write a paragraph describing the entire race.



MST

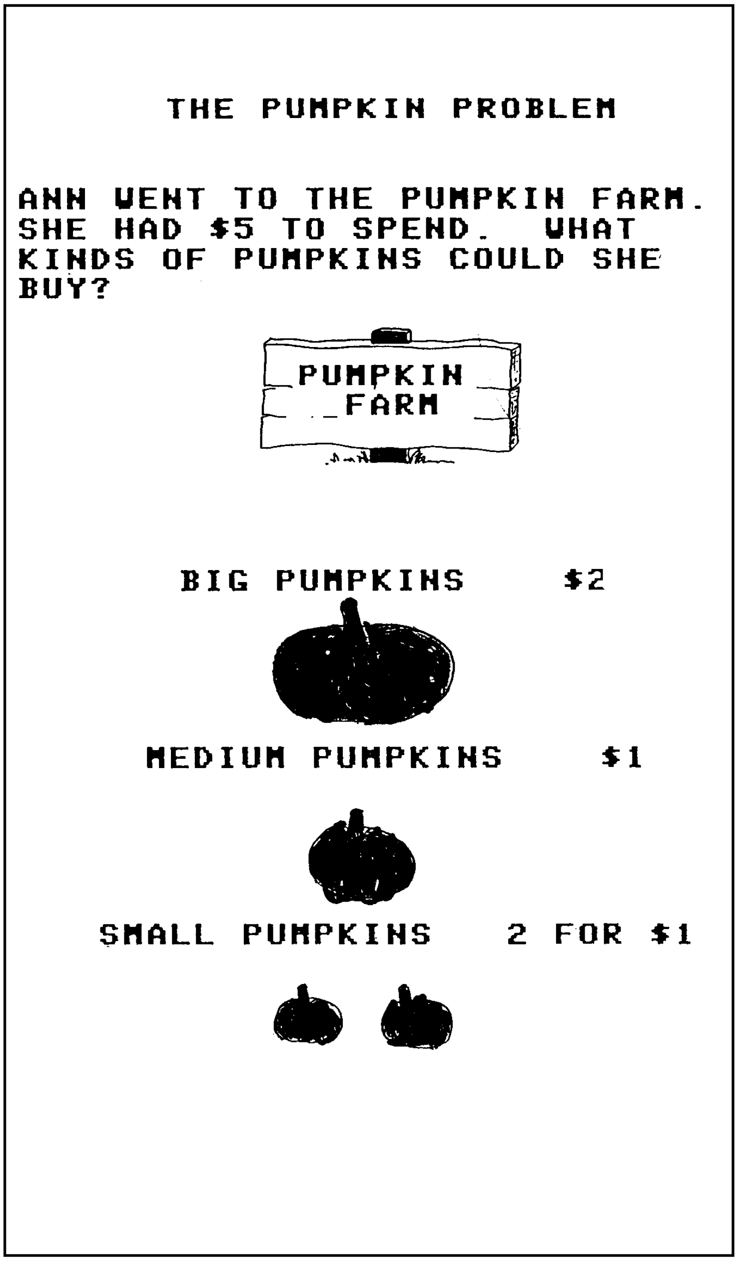
1 3 7

ELEMENTARY

Harvest Halloween

Context

First-grade students are asked to work with a partner to solve a problem about buying pumpkins. The problem could be made easier or more difficult by changing the total amount of money the pumpkins cost, or by asking each pair or group of students to find as many solutions as possible.



Objectives

1. to solve a ‘’real” problem that is connected to students’ interests (and is integrated with other curriculum areas, i.e., science, social studies, health)
2. to relate mathematics to things students do outside of school (with their families) and thus to see that mathematics is present and useful (both inside and outside the classroom)
3. to see that a problem can have more than one solution
4. to develop students’ ability to communicate mathematically through writing and / or drawing and to share their thinking (with others) through class discussion
5. (to foster curiosity about mathematics) and to make connections between mathematics and other subject areas.

Materials needed

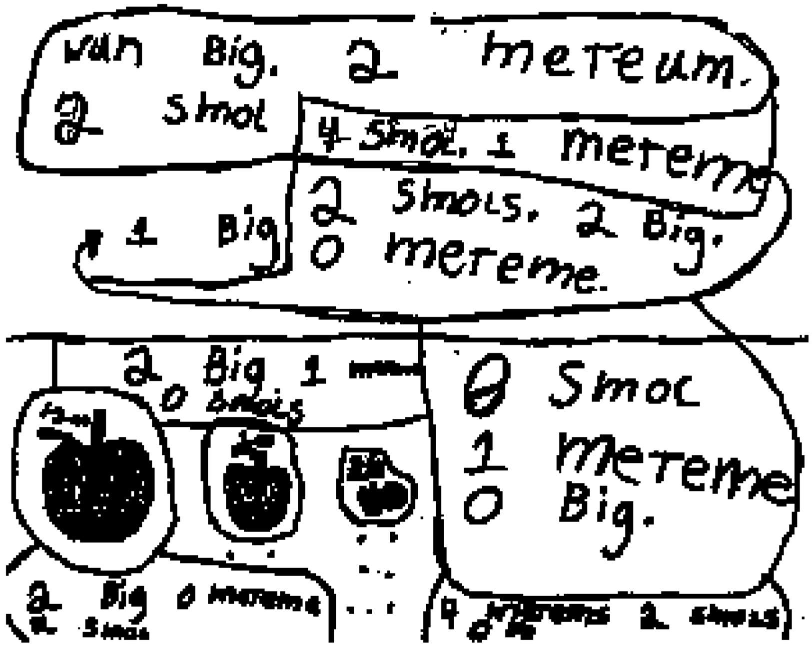
1. at least 4 pumpkins—1 large, 1 medium, and 2 small (if real pumpkins are not available, you could use paper cut-outs of pumpkins)
2. a variety of mathematic manipulatives and collections for the students to use to “stand for” the pumpkins as they work out their solution(s)
3. paper (white & orange), pencils, crayons / markers
4. large chart paper to record the brainstorming and the multiple solutions during the class discussion.

Adapted from: Caren, Ann, Beverly J. Martin School, Ithaca City Schools.

Procedures

1. Present the following problem to the students:

   I went to the pumpkin farm with $5.00 to spend. Big pumpkins were $2.00. Medium pumpkins were $1.00. Small pumpkins were 2 for $1.00. I spent all of my money. What kind of pumpkins could I buy?



2. Place the pumpkins on a table with a sign showing the prices of each kind of pumpkin. Refer to them as you describe the problem.
3. Explain that students may use any materials in the room, or draw, to help them solve this problem. Brainstorm a list of mathematic manipulatives that they use to stand for the pumpkins as they work on solving this problem.
4. After students have solved the problem, they should write and / or draw to explain how they solved it. Give them an opportunity to share their solution(s) with the class.
5. The students then work in pairs or small groups. The teacher should circulate throughout the room to observe them and to conference where needed.
6. As students finish, they should share their solutions. The teacher should record the various solutions on chart paper so that they can see the multiple solutions and check to see if their solution has been mentioned.

Assessment Techniques

Assessment

1. Observe and record student participation in class discussion by audio-taping and making written notes during and / or after the lesson regarding:

   -ability to explain reasoning
   -willingness to take risks
   -level of involvement and interest in the assignment
   -inventiveness in thinking about how to solve the problem.

2. Observe and record information about the student's work with a partner by taking brief notes during the work session and talking to groups as they work through the problems regarding:

   -grasp of numerical relationships
   -ability to represent numerical relationships with words and symbols
   -process of working with others
   -choice of materials and how they were used to solve the problem
   -level of involvement in the process.

3. Review the written work done by the students, making notes on the information gained and using the process of analyzing the work to plan the next steps in the instructional process, in terms of individual students and of the class as a whole.

MST 2

INTERMEDIATE

Creating Data Bases: Computer Class Assessment

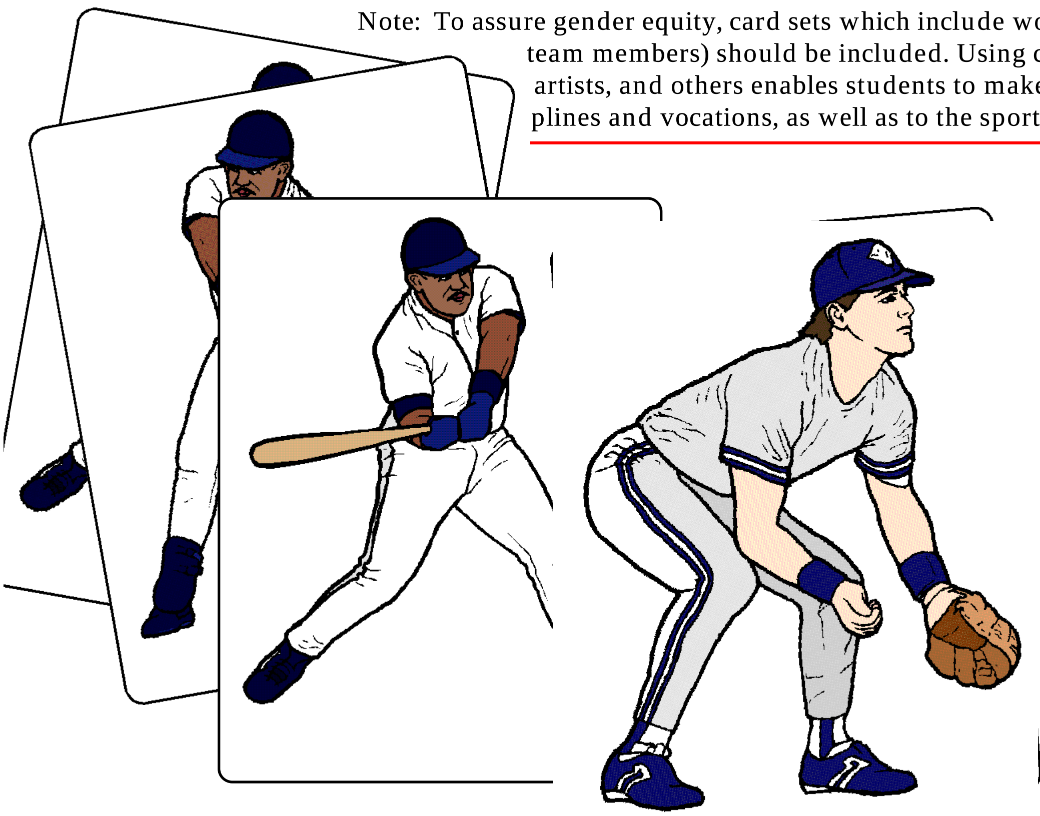
Context:

Students have been working on creating database files from papers which have everything labeled for them.

For this assessment, each student will be given a series of fifteen baseball cards. From these cards they will have to decide which categories are the most important, type in field names, decide what length would be appropriate for each line, and gather the correct information from the back of each of the baseball cards.

After all the information is filed, each student will choose any one of the players and prepare a one-page composition about the player, based on information contained in the database. They will use any computerized word processing programs with which they feel comfortable.

Note: To assure gender equity, card sets which include women athletes (e.g., Olympic team members) should be included. Using cards that portray authors, artists, and others enables students to make connections to other disciplines and vocations, as well as to the sports field.



Source: Lewis, Shiela and Guski, Patricia. Eighth-grade computer teachers, Emerson Junior High, Yonkers City Schools.

MST

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INTERMEDIATE

Jungle Explorer Assessment

Context

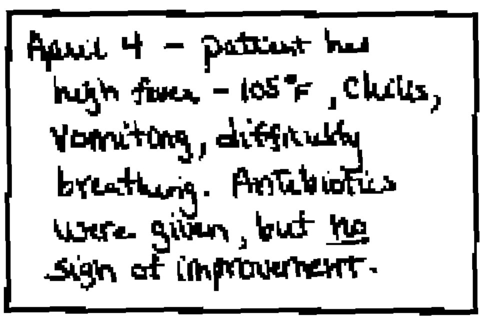
The following assessment was designed to be given after studying units on bacteria, viruses, and on the immune system. Students are expected to finish the task in a 43 minute class period, without notes. Their answers may be fictional, but must be supported by facts / content discussed in class.

Directions

Read all of the following information **and** the questions before you begin to write your essay. Answer the problem as completely as you can; you must use at least **fifteen** vocabulary words from these last two units.

You are a staff member of the Center for Disease Control in Atlanta, Georgia. You have just been flown into Zaire, Africa to investigate a newly found outbreak of a disease. You have to move as quickly as possible because thousands of people are dying from an unknown disease, and you must stop it before it spreads to the city 75 miles away. Your only sources of information are local doctors, the dead bodies, family members, and the homes of the dying or the dead.

The following notes are from a diary of a doctor who treated the first victims. He is now also deceased.


April 4 – patient has high fever – 105°F, chills, vomiting, difficulty breathing. Antibiotics were given, but no sign of improvement.

1. How would you proceed? What would you do to get started?
2. What information would you want to look for?
3. How could you tell if this disease is caused by a virus or bacterium? (at least 3 ways)
4. Draw a picture of the microorganism as it looks under the microscope and label its parts.
5. Name the organism.
6. Describe what is happening to the victims' bodies.
7. Why can't the victims fight off this disease?
8. What precautions need to be taken so that you do not catch this disease?
9. How do we keep this disease from spreading? (at least 2 ways)

Source: Wood, Lisa, Seventh-grade life science teacher, Bethlehem Central Middle School, Bethlehem Central Schools.

MST

1 2 3 4
5 6 7

COMMENCEMENT

River Watch Program

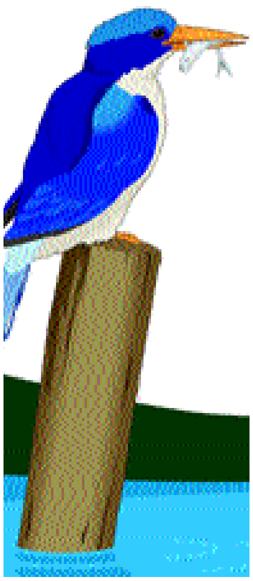
Context

Glens Falls High School students monitor the water quality of the Hudson River with teachers and others to investigate the health of local aquatic systems in their communities. Using laboratory equipment, they measure:

- nitrate concentration
- phosphate concentration
- alkalinity
- pH
- water temperature.

Data is then evaluated to:

- detect potential pollution problems
- determine river's fitness for swimming, fishing, and other public uses
- devise cleanup strategies in event of pollution.



River Watch is a demonstration of applied science in education, for students are required to use their knowledge of chemistry, biology Earth science, mathematics, and English through hands-on science. They collect and analyze data which is computerized and processed in a regional data bank. Students also present their findings publicly at a full day session of the regional student-sponsored Clean Water Congress held in November. These science students are both enlightened and excited by the River Watch exercise. They have a vested interest in the results of their work because the Hudson River is their own local waterway, and data they collect is accurate, reliable, and can be used by decision-makers to address local concerns.

RIVER WATCH ESSAY SCORING RUBRIC

1. DEVELOPS BASELINE STUDY

Full development of ideas 1
Articulate; concise 1
Appropriate terminology used 1
Specific chemical concepts addressed.............2

Four parameters identified................................4
Three parameters identified..............................3
Two parameters identified 2
One parameter identified..................................1
No parameters identified 0

Excellent selection of sample sites...................1
Poor selection of sample sites..........................0

2. SEWAGE TREATMENT

Full development of ideas 1
Articulate; concise 1
Appropriate terminology used 1
Specific chemical concepts addressed.............2

3. DEVELOPMENT

Full development of ideas 1
Articulate; concise 1
Appropriate terminology used 1
Specific chemical concepts addressed.............2

4. FARMERS

Full development of ideas 1
Articulate; concise 1
Appropriate terminology used 1
Specific chemical concepts addressed.............2

Source: Danna, Steve and Pamela Parrott, Glens Falls High School, Glens Falls City Schools.

Applied Biology: Portfolios and Self-Assessment

MST 4

COMMENCEMENT

Context

Teachers from Glens Falls and Brighton High Schools developed this Applied Biology Portfolio Project as a self-assessment that commencement level students could use to assess their proficiency at Standard 4.

Artists, business people, scientists, and others use portfolios when seeking jobs to demonstrate their skills and accomplishments. Aportfolio is a collection of a person's best work. In June, you will prepare a portfolio of your ten best pieces of work done in this class. During the year, you will keep a work folder which will be checked at the end of each quarter. In January and June, you will place your best work with a written evaluation of each item in the portfolio for review by you, your parents, peers, and teacher.

1. Purchase two folders or portfolios (one for the work folder, and one for the official portfolio)
2. Decorate your folders—especially the portfolio (show your creativity)
3. In June, your portfolio must contain:
   a. table of contents
   b. a description and self evaluation of each item
   c. use of computer graphics (ex. graphs, charts)
   d. use of artwork (ex. sketches of cells)
   e. Ten works including:
      - two-written lab reports (one from September and one from later in the year to illustrate progress in scientific writing)
      - one-short report and the assessment sheet for a major project (River Watch, Mentorship, Exploravision)
      - two-concept maps
      - one-personal contribution to a cooperative learning activity
      - one-piece that shows the interdisciplinary use of science in another subject taken at Glens Falls High School
      - one-journal article analysis or critique that covers a controversial issue (ex. bioengineering, laboratory animals, acid rain)
      - two-works of your choice done during the year.

Your portfolio will change through the year as you complete new work and develop better skills. Upon completion of this class, you will keep your portfolio to use someday at a college or job interview. Remember, the portfolio represents your finest work in this applied program.

Portfolio Element Self-Evaluation Criteria

Following is a list of criteria to use in evaluating your portfolio:

1) selection of a topic that is of interest;

2) ability to describe the strengths of the portfolio element;

3) ability to describe ways in which the portfolio element could be improved;

4) ability to select important ideas from independent learning;

5) ability to seek constructive suggestions regarding improvement of work.

You will receive one point for each portfolio evaluation form which shows the five criteria. Since there are ten portfolio evaluation forms, you may earn a total of ten points for your portfolio self-evaluations.

Adapted from: Giglio, Kathy, McKain, Mike, and Nicandri, Steve. Brighton High School, Brighton Central Schools. With Danna, Steve and Parrott, Pamela. Glens Falls High School, Glens Falls City Schools.

Self-Evaluation of Portfolio Element

Name ____

Type of portfolio element ____

Title/Subject ____

Why did you select this portfolio element?

What did you like most about doing this portfolio element?

What did you like least about doing this portfolio element?

What is good about the work that you have done for this portfolio element?

What could be improved in the work that you have done for this portfolio element?

What are the ten most important things you learned about biology from doing this portfolio element?

Share your work with two of your classmates. What did they like about your portfolio element?

Share your work with two of your classmates. What suggestions did they have for improving your portfolio element?

What advice should your teacher give to future students who might select a portfolio element similar to this one?

Checklist: Writing Skills for Laboratory Reports

MST

1 2 3 4
5 6 7

COMMENCEMENT

Context

The writing that students do in science class is different from the writing they complete in their English language arts classes. The following chart suggests skills and techniques that students will need to master to write effectively in the science classes.

	Acceptable	*Not acceptable*	*Does Not Apply*
WRITING SKILLS			
I. Mechanical Skills			
1. spells correctly			
2. punctuates correctly			
3. capitalizes correctly			
4. writes legibly			
II. Word Choice			
1. uses words correctly			
2. uses appropriate vocabulary			
3. uses clear, concrete language (without slang)			
III. Sentence Structure and Syntax			
1. varies sentence structure			
2. uses complete sentences (without fragments or run-ons)			
3. keeps subject/verb in agreement			
4. appropriately uses conjunctions			
IV. Graphic Techniques (for Diagrams, Tables, Charts and Graphs)			
1. draws accurately			
2. adapts constructions to fit conventions			
3. labels correctly			
4. presents visually effective data			
5. matches captions to data			
V. Organization of the Lab Report			
1. composes internally consistent paragraphs			
2. reorganizes paragraphs into sections			
3. forms transitions between ideas			
4. summarizes and concludes major ideas			
5. articulates and coordinates a coherent model			
VI. Communicating the Lab Activity			
1. follows format directions			
2. focuses upon topic			
3. excludes irrelevant material			
4. supports generalizations with appropriate examples and details			
5. demonstrates understanding of the objective			

Adapted from: *Reflections on Writing in Science*, New York State Education Department, 1984.

MST

1 2 3 4
5 6 7

COMMENCEMENT

Checklist: Inquiry and Writing Skills for Revision and Evaluation of the Written Report

Context

The writing that students do in science class is different from the writing they complete in their English language arts classes. The following chart suggests skills and techniques that students will need to master to write effectively in the science classes.

	Acceptable	*Not acceptable*	*Does Not Apply*
INQUIRY SKILLS			
I. Planning			
1. identifies a problem or question to investigate			
2. formulates hypothesis			
3. explains or refers to experimental design			
4. plans appropriate controls			
II. Performance			
1. demonstrates knowledge of technique			
2. describes and observes accurately and completely			
3. demonstrates quantitative measurement			
4. identifies dependent and independent variables			
III. Analysis and Interpretation			
1. appropriately transforms raw data			
2. correctly interprets observed data			
3. shows qualitative relationships			
4. shows quantitative relationships			
5. analyzes accuracy of data			
6. suggests limitations or assumptions affecting data			
7. proposes a generalization or model			
8. draws conclusions			
IV. Application			
1. integrates prior knowledge			
2. suggests original hypothesis			
3. suggests contemporary application			

Adapted from: *Reflections on Writing in Science*, New York State Education Department, 1984.

Mathematics, Science & Technology

APPENDICES

A: Guidelines for The Use of Animals
in Elementary and Secondary Schools......2

B: Laboratory Requirements 5

C: Mentor Networks.......................................6

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

Appendix A

Guidelines for The Use of Animals in Elementary and Secondary Schools

The Science Teachers Association of New York State (STANYS) recommends these guidelines for use by science educators and students. They apply primarily to the use of non-human animals in instructional activities planned and supervised by teachers at the pre-college level.

STANYS believes that the study of living organisms and their life processes is essential to effective and meaningful instruction in the life sciences. STANYS also believes that students learn best through active participation in the learning process. Hence, if students are not given the opportunity to directly study living organisms, they will be deprived of experiences necessary to comprehend and appreciate life and life processes. Therefore, STANYS recommends the prudent and responsible use of animals in the classroom as a means of:

- fostering a respect for life, both human and non-human
- teaching the proper care and handling of animals
- providing a realistic framework upon which to organize biological knowledge
- observing the similarities and differences that exist between species
- understanding the relationship between biological form and function
- experiencing personal discovery.

Classroom experiences involving animals range from observation to dissection. Opportunities to observe live animals and to examine preserved specimens provide active learning situations with immediate feedback. STANYS supports these activities as long as they manifest sound educational objectives, convey substantive knowledge of biology and are conducted in compliance with appropriate guidelines established by the scientific community and Section 809 of New York State Education Law. Classroom teachers are in the best position to determine the appropriateness and educational value of such activities.

STANYS also takes the position that no alternative can fully substitute for the appropriate use of live animals and the dissection of animal specimens in the classroom. In every instance, these specimens should be obtained from a reputable source such as a science supply company, a university, or a grocery store. Educators should be aware of the educational limitations of computer simulations and other alternatives presently being marketed. STANYS supports the use of these materials as enhancements to the educational process but not as exclusive replacements for the use of actual organisms. At the same time, life science educators must be sensitive to student objections and respond to them in accordance with Section 809 of New York State Education Law.

The abuse of any living organism for experimentation or other purpose is intolerable in any segment of society. Because biology deals specifically with living organisms, life science educators must be especially aware of their responsibility to prevent the inhumane treatment of any living organism in the name of science teaching and research. This responsibility should extend beyond the confines of the teacher's classroom to the rest of the school and community. Therefore the care of any live animal in the classroom should not only be overseen by the teacher but, in the case of vertebrates, a veterinary professional should be consulted when appropriate.

The following are guidelines recommended by the National Science Teachers Association (NSTA) concerning the responsible use of animals in a school classroom / laboratory. They are endorsed by STANYS as well.

Source: Science Teachers Association of New York State (STANYS), Newsletter, Spring 1997.

The guidelines follow.

- Acquisition and care of animals must be appropriate to the species.
- Student classwork and science projects involving animals must be under the supervision of a science teacher or other trained professional.
- Teachers sponsoring or supervising the use of animals in instructional activities, including acquisition, care, and disposition, will adhere to local, State, and national laws, policies, and regulations regarding species of organisms.
- Teachers must instruct students on safety precautions for handling live animals or animal specimens.
- Plans for the future care or disposition of animals at the conclusion of the study must be developed and implemented.
- Laboratory and dissection activities must be conducted with consideration / appreciation for the organism.
- Laboratory and dissection activities must be conducted in a clean and organized work space with care and laboratory precision.
- Laboratory dissection objectives must be appropriate to the maturity level of the student.
- Student views and beliefs sensitive to dissection must be considered; the teacher will respond appropriately.

Adopted by NSTA Board of Directors, in July, 1991.

Education Law §809

§809. Instruction in the humane treatment of animals and birds (Eff. until July 1, 1995. See also §809 post.)

Historical and Statutory Notes

§809. Instruction in the humane treatment of animals {Eff. July 1, 1995, as amended by L.1994, c. 542. See also §809 ante.}

1. The officer, board or commission authorized or required to prescribe courses of instruction shall cause instruction in every elementary school under state control or supported wholly or partly by public money of the state, in the humane treatment and protection of animals and the importance of the part they play in the economy of nature as well as the necessity of controlling the proliferation of animals which are subsequently abandoned and caused to suffer extreme cruelty. Such instruction shall be for such period of time during each school year as the Board of Regents may prescribe and may be joined with work in literature, reading, language, nature study or ethnology. Such weekly instruction may be divided into two or more periods. Aschool district shall not be entitled to participate in the public school money on account of any school or the attendance at any school subject to the provisions of this section, if the instruction required hereby is not given therein.

2. Study and care of live animals. Any school which cares for or uses animals for study shall ensure that each animal in such school is afforded the following: appropriate quarters; sufficient space for normal behavior and postural requirements of the species; proper ventilation, lighting, and temperature control; adequate food and clean drinking water; and quarters which shall be cleaned on a regular basis and located in all areas where undue stress and disturbance are minimized.

3. Application. The provisions of this section shall not be construed to prohibit or constrain vocational instruction in the normal practices of animal husbandry, or prohibit or constrain instruction in environmental education activities as established by the Department of Environmental Conservation.

4. Dissection of animals. Any student expressing a moral or religious objection to the performance or witnessing of the dissection of animals, either wholly or in part, shall be provided the opportunity to undertake and complete an alternative project that shall be approved by such student's teacher; provided, however, that such objection is sub-

stantiated in writing by the student's parent or legal guardian. Students who perform alternative projects who do not perform or witness the dissection of animals shall not be penalized.

5. Treatment of live vertebrate animals.

a) Except as provided for in this subdivision, no school district, school principal, administrator, or teacher shall require or permit the performance of a lesson or experimental study on a live vertebrate animal in any such school or during any activity conducted under the auspices of such school whether or not the activity takes place on the premises of such school where such lesson or experimental study employs:

(i) microorganisms which cause disease in humans or animals

(ii) ionizing radiation

(iii) known cancer producing agents

(iv) chemicals at toxic levels

(v) drugs producing pain or deformity

(vi) severe extremes of temperature

(vii) electric or other shock

(viii) excessive noise

(ix) noxious fumes

(x) exercise to exhaustion

(xi) overcrowding

(xii) paralysis by muscle relaxants or other means

(xiii) deprivation or excess food, water or other essential nutrients

(xiv) surgery or other invasive procedures

(xv) other extreme stimuli

(xvi) termination of life.

b. Notwithstanding any inconsistent provision of this section, the commissioner may, upon the submission of a written program plan, issue to such school a written waiver of such restrictions for students subject to the following provisions:

(i) the student shall be in grade ten, eleven, or twelve

(ii) the students shall be under the supervision of one or more teachers certified in science

(iii) the student shall be pursuing an accelerated course of study in the sciences as defined by the commissioner in preparation for taking a state or national advanced placement examination.

The commissioner shall issue a waiver of such restrictions for any teacher certified in science instructing such student. The written program plan shall include, but not be limited to:

(i) the educational basis for requesting a waiver

(ii) the objective of the lesson or experiment

(iii) the methods and techniques to be used

(iv) any other information required by the commissioner.

6. Report. On or before the first day of January next succeeding the effective date of this amended section, the commissioner shall annually submit a report to the governor and the legislature which shall include, but not be limited to, the number of written program plan proposals submitted by schools and the number of such proposals subsequently approved by the commissioner. In those cases where a program plan proposal has been approved by the commissioner, such plan shall be appended to become a part of the commissioner's annual report.

(As amended L.1994, e. 542 §1)

Appendix B

Laboratory Requirements

For Regents level coursework, students must complete a laboratory requirement. The following may be useful in addressing concerns regarding the laboratory requirement:

- All students in a Regents science course must complete the laboratory requirement of 1200 minutes of hands-on laboratory experiences, with satisfactory laboratory reports **prior** to entry into a Regents examination in science. (Teachers may wish to publicize a date when all labs must be completed.)

- The minimum laboratory requirement for each Regents science course is 1200 minutes. This may be found in statement form in each New York State Regents Syllabus in science , as well as the Commissioner's Regulations. Districts may set a higher time requirement, but it should be stated in school policy; students and parents should be informed of the school's requirements.

- The requirement is often stated as "thirty 40 minute sessions." This represents a **time** requirement, not a quantity requirement of thirty labs with thirty laboratory reports.

- All laboratories completed by students should be **hands-on**. Students should be actively engaged in laboratory work. While computers, library research papers, and worksheets may be a part of the laboratory experience, they should not comprise the sole experience. Teacher demonstrations, followed by student reports are also not considered to be a hands-on experience.

- Satisfactory laboratory reports must be completed by all students. The laboratory report format is set at the local level.

- By Commissioner's Regulation, laboratory reports must be kept on file for a minimum of six months. For students who transfer into a district, copies of labs completed by the student or a letter from the student's teacher or principal stating completion of labs to the date of transfer are acceptable and should also be kept on file for six months.

Teachers of science may wish to keep a log of labs with the date completed, minutes to complete, etc. Logs can be used to easily ascertain the time requirement for all students, including those who may transfer to other schools.

Some students, including those with disabilities, may require modifications, comparative laboratories, or replacement laboratories. For further information consult with your local special educators, the Special Education Training and Resource Center, or the New York State Education Department at (518) 473-9471.

Appendix C

Mentor Networks

New York mentors work through their local Board of Cooperative Educational Services (BOCES) to provide professional development for their peers in the areas of each discipline. Descriptions of the various mentor networks follow.

Biology Mentor Network

The Biology Mentor Network is an established, state-wide resource group organized to assist local science teachers, BOCES affiliates, large urban districts, and non-public schools in their efforts to implement the New York State mathematics, science, and technology learning standards for all students.

The Network has trained mentors to do the following:

- provide local districts with staff development workshops on the mathematics, science, and technology framework
- provide local districts with new instruction and assessment strategies for biology
- participate on national, State, and local committees
- serve as liaisons to mathematics, technology, and other networks
- serve as consultants for districts pursuing science variances
- facilitate in the establishment of consortiums
- present workshops at local, State, and national conferences
- act as contact persons for local resources
- solicit learning experiences from local district teachers to be submitted to MST Science Consultant, Sandy Latourelle (Email: latoursm@together.net)
- facilitate local peer review
- act as consultants in the writing of grant proposals which would generate improvements in science education.

The network has developed the following resource materials that can be used for local program development:

- **Regents Biology Program Guide** (an alternative biology program organized around six unifying themes that can be used in the development of a biology variance or in the modification of an existing program)
- **Regents Biology Assessment Guide** (provides guidelines for development of variance assessments or to design/improve local alternative assessments)
- **Regents Biology Program Improvement Process Guide** (outlines a process which integrates program evaluation with on-going program improvement)
- **Cornell Institute of Regional Bio Mentors Lab Manuals I and II** (open-ended laboratory experiences that develop student inquiry and science process skills)
- sample materials that provide models for planning and implementing diverse instructional and assessment strategies (portfolios, rubric design, performance assessment, concept mapping, cooperative learning, learning styles)
- instructional modules (themes include Structure and Function, and The Continuity of Life, Evolution, and Ecology).

For further information or assistance, contact: Linda Hobart , Finger Lakes Community College, Canandaigua, NY l4424 , Phone:716-394-3500 X326, Fax:716-394-5005 or Lee Drake, e-mail: drakela@snyflcaa.fingerlakes.edu or LeeADrake@aol.com

Earth Science, Chemistry, and Physics Mentor Network

Science Mentors at the high school level serve as a support network for fellow teachers. They promote Earth science, chemistry, and physics education by:

- developing workshops on curriculum related topics to assist in the teaching of an up-to-date science curriculum which addresses student needs as well as State mandates and requirements
- providing a personal contact for teachers who have individual curriculum concerns and needs
- sharing the knowledge of useful reference material based on teacher's expressed needs
- providing school districts, BOCES, and professional organizations with current and relevant information on Earth science, chemistry, and physics teaching, and assisting in the dissemination of information to teachers in the field
- modeling leadership in the field which promotes excellence in science education in the classroom and in the community
- serving as a liaison with the State Education Department so that Department staff receives feedback from the field on curriculum development and related issues, and so that teachers are informed of important issues as they occur.

Mathematics Mentor Network

The Mathematics Mentor Network provides collaborative staff development to experienced elementary teachers to help them change their classroom practices to better support their students in meeting the higher mathematics, science, and technology standards. In working with one another and with teachers in their home communities, mentors facilitate improved learning throughout the State. Mentors:

- engage teachers, supervisors, and others as appropriate in ongoing staff development that focuses on teaching and learning in mathematics education
- assist teachers to translate the State standards into projects, problem-solving activities, and extended tasks
- enable teachers to create learning environments conducive to a constructivist learning orientation and to use inquiry, manipulative hands-on-experiences, and the integration of calculators in learning mathematics.
- integrate other topics and real world situations, problem-solving, mathematical reasoning, and commmunication
- promote equity
- support local efforts in systemic change for good practice
- generate enthusiasm for new directions in mathematics teaching, focusing on both pedagogy and content
- communicate/disseminate information about mathematics, science, and technology frameworks, standards, and assessments; professional literature; and professional opportunities
- encourage the integration of mathematics, science, and technology with other subject areas
- attend network institutes and meetings.

Science Assessment Liaison (SAL) Network

The statewide network of regional science assessment liaison (SAL) professionals was created to provide technical assistance activities in alternative assessment and evaluation techniques. SAL members work with public and nonpublic classroom teachers of science at elementary, middle, and secondary levels, and their administrators, as well as with college faculty of preservice teachers.

Each BOCES and large city district will have one SALfor each level. The elementary portion of the network, trained during the 1996-97 school year, is available to provide assistance to districts beginning in the spring of 1997. Middle level SALs will be trained during the 1997-98 school year, and the secondary level SALs will be trained during the 1998-99 school year.

Assessment tasks developed by the State Education Department and through an NSF grant will be used as models for dissemination by the SALs to their regional clientele. SALs will share information with teachers and administrators on administering and scoring these tasks and using student performance data to improve local instructional programs.

Source: Steele, Rosanna M. Science Assessment Liaison Network.

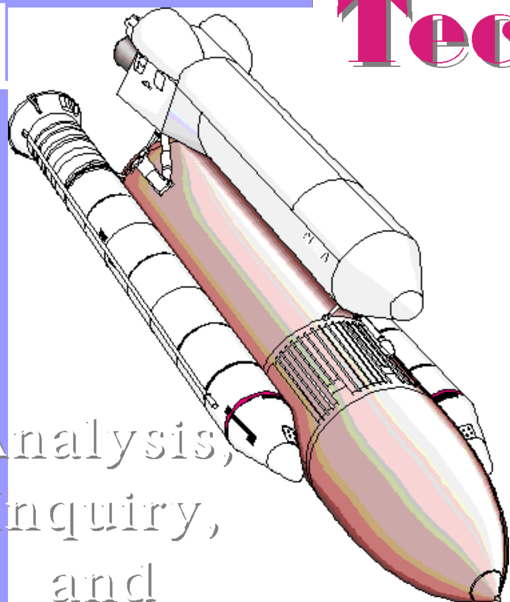
Mathematics, Science & Technology

Standard 1..........2
Standard 2..........8
Standard 3..........10
Standard 4..........21
Standard 5..........27
Standard 6..........36
Standard 7..........40

Mathematics, Science & Technology

STANDARD 1

Analysis, Inquiry, and Design



Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Elementary Students:

MATHEMATICAL ANALYSIS

1 *Abstraction and symbolic representation are used to communicate mathematically.*

- use special mathematical notation and symbolism to communicate in mathematics and to compare and describe quantities, express relationships, and relate mathematics to their immediate environments

2 *Deductive and inductive reasoning are used to reach mathematical conclusions.*

- use simple logical reasoning to develop conclusions, recognizing that patterns and relationships present in the environment assist them in reaching these conclusions

3 *Critical thinking skills are used in the solution of mathematical problems.*

SCIENTIFIC INQUIRY

1 *The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.*

- ask "why" questions in attempts to seek greater understanding concerning objects and events they have observed and heard about
- question the explanations they hear from others and read about, seeking clarification and comparing them with their own observations and understandings
- develop relationships among observations to construct descriptions of objects and events and to form their own tentative explanations of what they have observed use of what they have observed

2 *Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the conventional*

ENGINEERING DESIGN

1 *Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.*

- describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved
- investigate prior solutions and ideas from books, magazines, family, friends, neighbors, and community members
- generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathematics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices

Continued.

STANDARD 1

Elementary Students:

MATHEMATICAL ANALYSIS

- explore and solve problems generated from school, home, and community situations, using concrete objects or manipulative materials when possible

SCIENTIFIC INQUIRY

conventionaltechniques and procedures and usually requiring considerable ingenuity.

- develop written plans for exploring phenomena or for evaluating explanations guided by questions or proposed explanations they have helped formulate
- share their research plans with others and revise them based on their suggestions
- carry out their plans for exploring phenomena through direct observation and through the use of simple instruments that permit measurements of quantities (e.g., length, mass, volume, temperature, and time)

3 *The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.*

- organize observations and measurements of objects and events through classification and the preparation of simple charts and tables
- interpret organized observations and measurements, recognizing simple patterns, sequences, and relationships
- share their findings with others and actively seek their interpretations and ideas
- adjust their explanations and understandings of objects and events based on their findings and new ideas

ENGINEERING DESIGN

- plan and build, under supervision, a model of the solution using familiar materials, processes, and hand tools
- discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better

STANDARD 1

Intemediate Students:

MATHEMATICAL ANALYSIS

1 *Abstraction and symbolic representation are used to communicate mathematically.*

- extend mathematical notation and symbolism to include variables and algebraic expressions in order to describe and compare quantities and express mathematical relationships

2 *Deductive and inductive reasoning are used to reach mathematical conclusions.*

- use inductive reasoning to construct, evaluate, and validate conjectures and arguments, recognizing that patterns and relationships can assist in explaining and extending mathematical phenomena

3 *Critical thinking skills are used in the solution of mathematical problems.*

- apply mathematical knowledge to solve real-world problems and problems that arise from the investigation of mathematical ideas, using representations such as pictures, charts, and tables

SCIENTIFIC INQUIRY

1 *The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.*

- formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations
- construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena
- represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others
- seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists

2 *Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.*

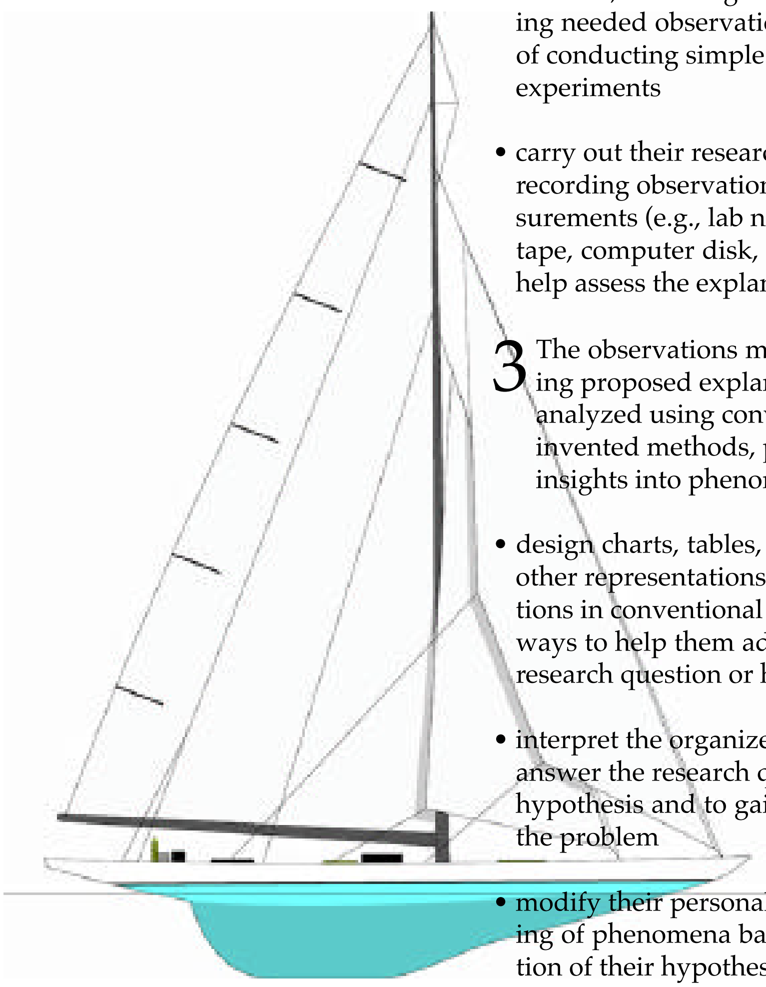
ENGINEERING DESIGN

1 *Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.*

- identify needs and opportunities for technical solutions from an investigation of situations of general or social interest
- locate and utilize a range of printed, electronic, and human information resources to obtain ideas
- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal
- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship

Continued.

Standard 1



Intermediate Students:

Scientific Inquiry

- use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information
- develop, present, and defend formal research proposals for testing their own explanations of common phenomena, including ways of obtaining needed observations and ways of conducting simple controlled experiments
- carry out their research proposals, recording observations and measurements (e.g., lab notes, audio tape, computer disk, video tape) to help assess the explanation

3 The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

- design charts, tables, graphs and other representations of observations in conventional and creative ways to help them address their research question or hypothesis
- interpret the organized data to answer the research question or hypothesis and to gain insight into the problem
- modify their personal understanding of phenomena based on evaluation of their hypothesis

Engineering Design

- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made

Analysis, Inquiry, and Design

STANDARD 1

Commencement Students:

MATHEMATICAL ANALYSIS

1 *Abstraction and symbolic representation are used to communicate mathematically.*

- use algebraic and geometric representations to describe and compare data

2 *Deductive and inductive reasoning are used to reach mathematical conclusions.*

- use deductive reasoning to construct and evaluate conjectures and arguments, recognizing that patterns and relationships in mathematics assist them in arriving at these conjectures and arguments

3 *Critical thinking skills are used in the solution of mathematical problems.*

- apply algebraic and geometric concepts and skills to the solution of problems

SCIENTIFIC INQUIRY

1 *The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.*

- elaborate on basic scientific and personal explanations of natural phenomena, and develop extended visual models and mathematical formulations to represent their thinking
- hone ideas through reasoning, library research, and discussion with others, including experts
- work toward reconciling competing explanations; clarifying points of agreement and disagreement
- coordinate explanations at different levels of scale, points of focus, and degrees of complexity and specificity and recognize the need for such alternative representations of the natural world

2 *Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.*

- devise ways of making observations to test proposed explanations.
- refine their research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion

ENGINEERING DESIGN

1 *Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.*

- initiate and carry out a thorough investigation of an unfamiliar situation and identify needs and opportunities for technological invention or innovation
- identify, locate, and use a wide range of information resources, and document through notes and sketches how findings relate to the problem
- generate creative solutions, break ideas into significant functional elements, and explore possible refinements; predict possible outcomes using mathematical and functional modeling techniques; choose the optimal solution to the problem, clearly documenting ideas against design criteria and constraints; and explain how human understands, economics, ergonomics, and environmental considerations have influenced the solution

Continued.

Analysis, Inquiry, and Design

STANDARD 1

Commencement Students:

SCIENTIFIC INQUIRY

- develop and present proposals including formal hypotheses to test their explanations, i.e., they predict what should be observed under specified conditions if the explanation is true

- carry out their research plan for testing explanations, including selecting and developing techniques, acquiring and building apparatus, and recording observations as necessary

3 *The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.*

- use various means of representing and organizing observations (e.g., diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data

- apply statistical analysis techniques when appropriate to test if chance alone explains the result

- assess correspondence between the predicted result contained in the hypothesis and the actual result and reach a conclusion as to whether or not the explanation on which the prediction was based is supported

- based on the results of the test and through public discussion, they revise the explanation and contemplate additional research

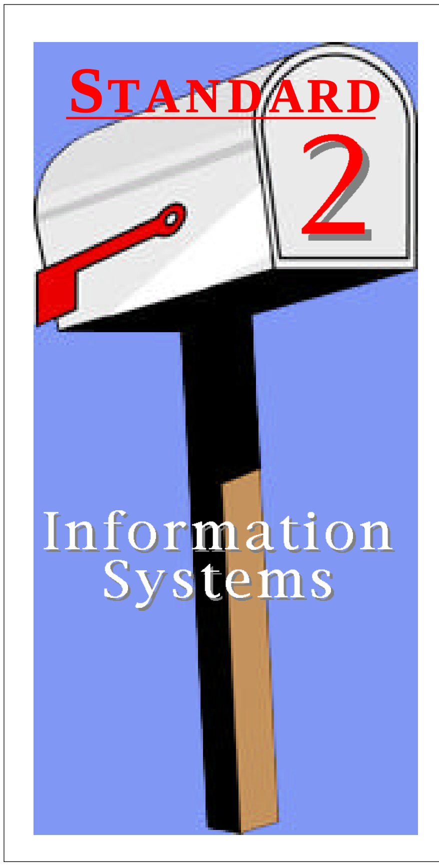
- develop a written report for public scrutiny that describes their proposed explanation, including a literature review, the research they carried out, its result, and suggestions for further research

ENGINEERING DESIGN

- develop work schedules and working plans which include optimal use and cost of materials, processes, time, and expertise; construct a model of the solution, incorporating developmental modifications while working to a high degree of quality (craftsmanship)

- devise a test of the solution according to the design criteria and perform the test; record, portray, and logically evaluate performance test results through quantitative, graphic, and verbal means. Use a variety of creative verbal and graphic techniques effectively and persuasively to present conclusions, predict impacts and new problems, and suggest and pursue modifications

Analysis, Inquiry, and Design



Mathematics, Science & Technology

Students will access, generate, process, and transfer information using appropriate technologies.

ELEMENTARY

1 *Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.*

- use a variety of equipment and software packages to enter, process, display, and communicate information in different forms using text, tables, pictures, and sound
- telecommunicate a message to a distant location with teacher help
- access needed information from printed media, electronic data bases, and community resources

2 *Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.*

- describe the uses of information systems in homes, schools, and businesses

INTERMEDIATE

1 *Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.*

- use a range of equipment and software to integrate several forms of information in order to create good quality audio, video, graphic, and text-based presentations
- use spreadsheets and data-base software to collect, process, display, and analyze information. Students access needed information from electronic data bases and on-line telecommunication services
- systematically obtain accurate and relevant information pertaining to a particular topic from a range of sources, including local and national media, libraries, museums, governmental agencies, industries, and individuals

COMMENCEMENT

1 *Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.*

- understand and use the more advanced features of word processing, spreadsheets, and data-base software
- prepare multimedia presentations demonstrating a clear sense of audience and purpose
- access, select, collate, and analyze information obtained from a wide range of sources such as research data bases, foundations, organizations, national libraries, and electronic communication networks, including the Internet
- students receive news reports from abroad and work in groups to produce newspapers reflecting the perspectives of different countries

Continued.

STANDARD 2

Information Systems

ELEMENTARY

- understand that computers are used to store personal information
- demonstrate ability to evaluate information

3 *Information technology can have positive and negative impacts on society, depending upon how it is used.*

- describe the uses of information systems in homes and schools
- demonstrate ability to evaluate information critically

INTERMEDIATE

- collect data from probes to measure events and phenomena
- use simple modeling programs to make predictions

2 *Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.*

- understand the need to question the accuracy of information displayed on a computer because the results produced by a computer may be affected by incorrect data entry
- identify advantages and limitations of data-handling programs and graphics programs
- understand why electronically stored personal information has greater potential for misuse than records kept in conventional form

3 *Information technology can have positive and negative impacts on society, depending upon how it is used.*

- use graphical, statistical, and presentation software to presents project to fellow classmates
- describe applications of information technology in mathematics, science, and other technologies that address needs and solve problems in the community
- explain the impact of the use and abuse of electronically generated information on individuals and families

COMMENCEMENT

- utilize electronic networks to share information
- model solutions to a range of problems in mathematics, science, and technology using computer simulation software

2 *Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.*

- explain the impact of the use and abuse of electronically generated information on individuals and families
- evaluate software packages relative to their suitability to a particular application and their ease of use
- discuss the ethical and social issues raised by the use and abuse of information systems

3 *Information technology can have positive and negative impacts on society, depending upon how it is used.*

- work with a virtual community to conduct a project or solve a problem using the network
- discuss how applications of information technology can address some major global problems and issues
- discuss the environmental, ethical, moral, and social issues raised by the use and abuse of information technology

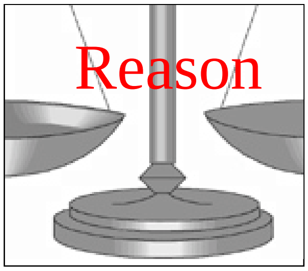
STANDARD

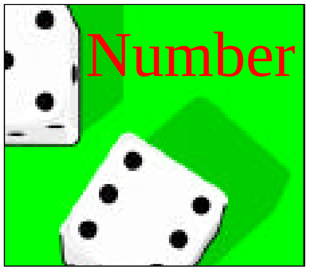
3

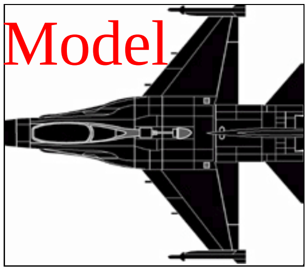
Mathematics

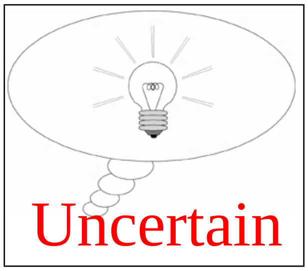
Mathematics, Science & Technology

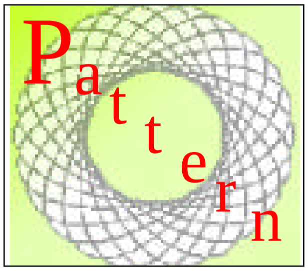
Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

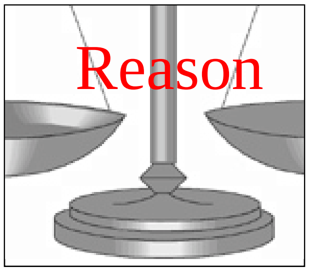












MATHEMATICAL REASONING

Students use mathematical reasoning to analyze mathematical situations, make conjectures, gather evidence, and construct an argument. **Students will:**

ELEMENTARY

- use models, facts, and relationships to draw conclusions about mathematics and explain their thinking
- use patterns and relationships to analyze mathematical situations
- justify their answers and solution processes
- use logical reasoning to reach simple conclusions

INTERMEDIATE

- apply a variety of reasoning strategies
- make and evaluate conjectures and arguments using appropriate language
- make conclusions based on inductive reasoning
- justify conclusions involving simple and compound (i.e., and/or) statements

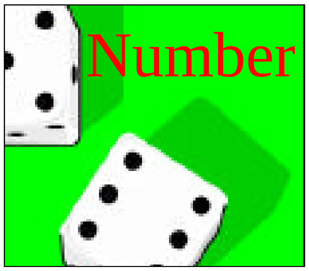
COMMENCEMENT

- derive and apply formulas to find measures such as length, area, volume, weight, time, and angle in real-world contexts
- choose the appropriate tools for measurement
- use dimensional analysis techniques
- use statistical methods including measures of central tendency to describe and compare data
- use trigonometry as a method to measure indirectly
- apply proportions to scale drawings, computer-assisted design blueprints, and direct variation in order to compute indirect measurements
- relate absolute value, distance between two points, and the slope of a line to the coordinate plane
- understand error in measurement and its consequence on subsequent calculations
- use geometric relationships in relevant measurement problems involving geometric concepts

FOUR-YEAR SEQUENCE

- construct indirect proofs or proofs using mathematical induction
- investigate and compare the axiomatic structures of various geometries

STANDARD 3



NUMBER & NUMERATION

Students use number sense and numeration to develop an understanding of multiple uses of numbers in the real world, use of numbers to communicate mathematically, and use of numbers in the development of mathematical ideas.

Students will:

ELEMENTARY

- use whole numbers and fractions to identify locations, quantify groups of objects, and measure distances
- use concrete materials to model numbers and number relationships for whole numbers and common fractions, including decimal fractions
- relate counting to grouping and to place-value
- recognize the order of whole numbers and commonly used fractions and decimals
- demonstrate the concept of percent through problems related to actual situations

INTERMEDIATE

- understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential, expanded and scientific notation)
- understand and apply ratios, proportions, and percents through a wide variety of hands-on explorations
- develop an understanding of number theory (primes, factors, and multiples)
- recognize order relations for decimals, integers, and rational numbers

COMMENCEMENT

- judge the reasonableness of results obtained from applications in algebra, geometry, trigonometry, probability, and statistics
- judge the reasonableness of a graph produced by a calculator or computer
- use experimental or theoretical probability to represent and solve problems involving uncertainty
- use the concept of random variable in computing probabilities
- determine probabilities using permutations and combinations

FOUR-YEAR SEQUENCE

- understand the concept of infinity.
- recognize the hierarchy of the complex number system.
- model the structure of the complex number system.
- recognize when to use and how to apply the field properties.

STANDARD 3

OPERATION

Students use mathematical operations and relationships among them to understand mathematics. **Students will:**

ELEMENTARY

- add, subtract, multiply, and divide whole numbers
- develop strategies for selecting the appropriate computational and operational method in problem-solving situations
- know single digit addition, subtraction, multiplication, and division facts
- understand the commutative and associative properties

INTERMEDIATE

- add, subtract, multiply, and divide fractions, decimals, and integers
- explore and use the operations dealing with roots and powers
- use grouping symbols (parentheses) to clarify the intended order of operations
- apply the associative, commutative, distributive, inverse, and identity properties
- demonstrate an understanding of operational algorithms (procedures for adding, subtracting, etc.)
- develop appropriate proficiency with facts and algorithms
- apply concepts of ratio and proportion to solve problems

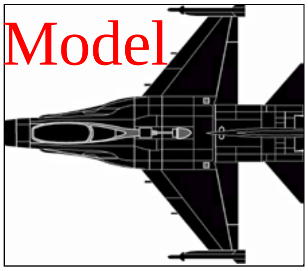
COMMENCEMENT

- use function vocabulary and notation
- represent and analyze functions using verbal descriptions, tables, equations, and graphs
- translate among the verbal descriptions, tables, equations and graphic forms of functions
- analyze the effect of parametric changes on the graphs of functions.
- apply linear, exponential, and quadratic functions in the solution of problems
- apply and interpret transformations to functions
- model real-world situations with the appropriate function
- apply axiomatic structure to algebra and geometry
- use computers and graphing calculators to analyze mathematical phenomena

FOUR-YEAR SEQUENCE

- use appropriate techniques, including graphing utilities, to perform basic operations on matrices.
- use rational exponents on real numbers and all operations on complex numbers.
- combine functions using the basic operations and the composition of two functions.

STANDARD 3



MODELING/MULTIPLE REPRESENTATION

Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.
Students will:

ELEMENTARY

- use concrete materials to model spatial relationships
- construct tables, charts, and graphs to display and analyze real-world data
- use multiple representations (simulations, manipulative materials, pictures, and diagrams) as tools to explain the operation of everyday procedures
- use variables such as height, weight, and hand size to predict changes over time
- use physical materials, pictures, and diagrams to explain mathematical ideas and processes and to demonstrate geometric concepts

INTERMEDIATE

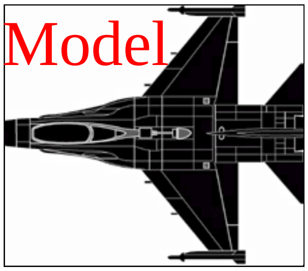
- visualize, represent, and transform two- and three-dimensional shapes
- use maps and scale drawings to represent real objects or places
- use the coordinate plane to explore geometric ideas
- represent numerical relationships in one- and two-dimensional graphs
- use variables to represent relationships
- use concrete materials and diagrams to describe the operation of real world processes and systems
- develop and explore models that do and do not rely on chance
- investigate both two- and three-dimensional transformations
- use appropriate tools to construct and verify geometric relationships
- develop procedures for basic geometric constructions

COMMENCEMENT

- represent problem situations symbolically by using algebraic expressions, sequences, tree diagrams, geometric figures, and graphs
- manipulate symbolic representations to explore concepts at an abstract level
- choose appropriate representations to facilitate the solving of a problem
- use learning technologies to make and verify geometric conjectures
- justify the procedures for basic geometric constructions
- investigate transformations in the coordinate plane
- develop meaning for basic conic sections
- develop and apply the concept of basic loci to compound loci
- use graphing utilities to create and explore geometric and algebraic models
- model real-world problems with systems of equations and inequalities

Continued.

STANDARD 3



MODELING/MULTIPLE REPRESENTATION

FOUR-YEAR SEQUENCE

- model vector quantities both algebraically and geometrically
- represent graphically the sum and difference of two complex numbers
- model and solve problems that involve absolute value, vectors, and matrices
- model quadratic inequalities both algebraically and graphically
- model the composition of transformations
- determine the effects of changing parameters of the graphs of functions
- use polynomial, rational, trigonometric, and exponential functions to model real-world relationships
- use algebraic relationships to analyze the conic sections
- use circular functions to study and model periodic real-world phenomena
- illustrate spatial relationships using perspective, projec-tions, and maps
- represent problem situations using discrete structures such as finite graphs, matrices, sequences, and recurrence relations
- analyze spatial relationships using the Cartesian coordinate system in three dimensions

STANDARD 3

MEASUREMENT

Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.. **Students will:**

ELEMENTARY

- understand that measurement is approximate, never exact
- select appropriate standard and nonstandard measurement tools in measurement activities
- understand the attributes of area, length, capacity, weight, volume, time, temperature, and angle
- estimate and find measures such as length, perimeter, area, and volume using both nonstandard and standard units
- collect and display data
- use statistical methods such as graphs, tables, and charts to interpret data

INTERMEDIATE

- estimate, make, and use measurements in real-world situations
- select appropriate standard and nonstandard measurement units and tools to measure to a desired degree of accuracy
- develop measurement skills and informally derive and apply formulas in direct measurement activities
- use statistical methods and measures of central tendencies to display, describe, and compare data
- explore and produce graphic representations of data using calculators/computers
- develop critical judgment for the reasonableness of measurement

COMMENCEMENT

- derive and apply formulas to find measures such as length, area, volume, weight, time, and angle in real-world contexts
- the appropriate tools for measurement
- use dimensional analysis techniques
- use statistical methods including measures of central tendency to describe and compare data
- use trigonometry as a method to measure indirectly
- apply proportions to scale drawings, computer-assisted design blueprints, and direct variation in order to compute indirect measurements
- relate absolute value, distance between two points, and the slope of a line to the coordinate plane
- understand error in measurement and its consequence on subsequent calculations
- use geometric relationships in relevant measurement problems involving geometric concepts

Continued.

STANDARD 3

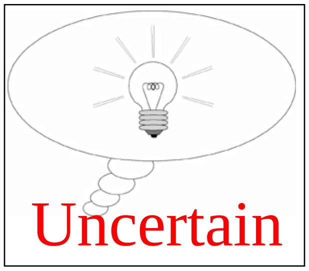
MEASUREMENT

FOUR-YEAR SEQUENCE

- derive and apply formulas relating angle measure and arc degree measure in a circle
- prove and apply theorems related to lengths of segments in a circle
- define the trigonometric functions in terms of the unit circle
- relate trigonometric relationships to the area of a triangle and to the general solutions of triangles
- apply the normal curve and its properties to familiar contexts
- design a statistical experiment to study a problem and communicate the outcomes, including dispersion
- use statistical methods, including scatter plots and lines of best fit, to make predictions
- apply the conceptual foundation of limits, infinite sequences and series, the area under a curve, rate of change, inverse variation, and the slope of a tangent line to authentic problems in mathematics and other disciplines
- determine optimization points on a graph
- use derivatives to find maximum, minimum, and inflection points of a function

STANDARD 3

Mathematics



UNCERTAINTY

Students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations. **Students will:**

ELEMENTARY

- make estimates to compare to actual results of both formal and informal measurement
- make estimates to compare to actual results of computations
- recognize situations where only an estimate is required
- develop a wide variety of estimation skills and strategies
- determine the reasonableness of results
- predict experimental probabilities
- make predictions using unbiased random samples
- determine probabilities of simple events

INTERMEDIATE

- use estimation to check the reasonableness of results obtained by computation, algorithms, or the use of technology
- use estimation to solve problems for which exact answers are inappropriate
- estimate the probability of events
- use simulation techniques to estimate probabilities
- determine probabilities of independent and mutually exclusive events

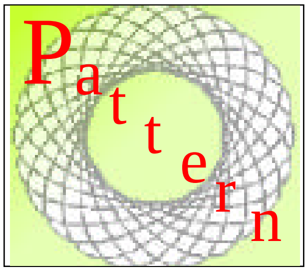
COMMENCEMENT

- judge the reasonableness of a graph produced by a calculator or computer
- use experimental or theoretical probability to represent and solve problems involving uncertainty
- use the concept of random variable in computing probabilities
- determine probabilities using permutations and combinations

FOUR -YEAR SEQUENCE

- interpret probabilities in real-world situations
- use a Bernoulli experiment to determine probabilities for experiments with exactly two outcomes
- use curve fitting to predict from data
- apply the concept of random variable to generate and interpret probability distributions
- create and interpret applications of discrete and continuous probability distributions
- make predictions based on interpolations and extrapolations from data
- obtain confidence intervals and test hypotheses using appropriate statistical methods
- approximate the roots of polynomial equations

STANDARD 3



PATTERNS/FUNCTIONS

Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently
Students will: .

ELEMENTARY

- recognize, describe, extend, and create a wide variety of patterns
- represent and describe mathematical relationships
- explore and express relationships using variables and open sentences
- solve for an unknown using manipulative materials
- use a variety of manipulative materials and technologies to explore patterns
- interpret graphs
- explore and develop relationships among two- and three-dimensional geometric shapes
- discover patterns in nature, art, music, and literature

INTERMEDIATE

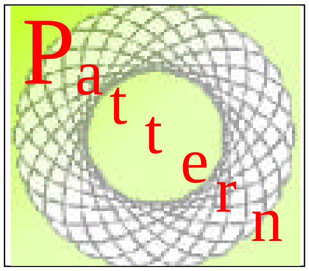
- recognize, describe, and generalize a wide variety of patterns and functions
- describe and represent patterns and functional relationships using tables, charts and graphs, algebraic expressions, rules, and verbal descriptions
- develop methods to solve basic linear and quadratic equations
- develop an understanding of functions and functional relationships: that a change in one quantity (variable) results in change in another
- verify results of substituting variables
- apply the concept of similarity in relevant situations
- use properties of polygons to classify them
- explore relationships involving points, lines, angles, and planes
- develop and apply the Pythagorean principle in the solution of problems
- explore and develop basic concepts of right triangle trigonometry
- use patterns and functions to represent and solve problems

COMMENCEMENT

- use function vocabulary and notation
- represent and analyze functions using verbal descriptions, tables, equations, and graphs
- translate among the verbal descriptions, tables, equations and graphic forms of functions
- analyze the effect of parametric changes on the graphs of functions
- apply linear, exponential, and quadratic functions in the solution of problems
- apply and interpret transformations to functions
- model real-world situations with the appropriate function
- apply axiomatic structure to algebra and geometry
- use computers and graphing calculators to analyze mathematical phenomena

Continued.

STANDARD 3



PATTERNS/FUNCTIONS

FOUR-YEAR SEQUENCE

- solve equations with complex roots using a variety of algebraic and graphical methods with appropriate tools
- understand and apply the relationship between rectangular form and polar form of a complex number
- evaluate and form the composition of functions
- use the definition of a derivative to examine properties of a function
- solve equations involving fractions, absolute values, and radicals
- use basic transformations to demonstrate similarity and congruence of figures
- identify and differentiate between direct and indirect isometries
- analyze inverse functions using transformations
- apply ideas of symmetries in sketching and analyzing graphs of functions
- use the normal curve to answer questions about data
- develop methods to solve trigonometric equations and verify trigonometric functions
- describe patterns produced by processes of geometric change, formally connecting iteration, approximations, limits, and fractals
- extend pattern and compute the nth term in numerical and geometric sequences
- use the limiting process to analyze infinite sequences and series
- use algebraic and geometric iteration to explore patterns and solve problems
- solve optimization problems
- use linear programming and difference equations in the solution of problems

Mathematics, Science & Technology

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Elementary Students:

PHYSICAL SETTING

1 *The Earth and celestial phenomena can be described by principles of relative motion and perspective.*

- describe patterns of daily, monthly, and seasonal changes in their environment

2 *Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.*

- describe the relationships among air, water, and land on Earth

3 *Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.*

- observe and describe properties of materials using appropriate tools
- describe chemical and physical changes, including changes in states of matter

4 *Energy exists in many forms, and when these forms change energy is conserved.*

- describe a variety of forms of energy (e.g., heat, chemical, light) and the changes that occur in objects when they interact with those forms of energy
- observe the way one form of energy can be transformed into another form of energy present in common situations (e.g., mechanical to heat energy, mechanical to electrical energy, chemical to heat energy)

5 *Energy and matter interact through forces that result in changes in motion.*

- describe the effects of common forces (pushes and pulls) on objects, such as those caused by gravity, magnetism, and mechanical forces
- describe how forces can operate across distances

Continued.

STANDARD 4

Elementary Students:

THE LIVING ENVIRONMENT

1 *Living things are both similar to and different from each other and nonliving things.*

- describe the characteristics of and variations between living and non-living things
- describe the life processes common to all living things

2 *Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.*

- recognize that traits of living things are both inherited and acquired or learned
- recognize that for humans and other living things there is genetic continuity between generations

3 *Individual organisms and species change over time.*

- describe how the structures of plants and animals complement the environment of the plant or animal
- observe that differences within a species may give individuals an advantage in surviving and reproducing

4 *The continuity of life is sustained through reproduction and development.*

- describe the major stages in the life cycles of selected plants and animals
- describe evidence of growth, repair, and maintenance, such as nails, hair, and bone, and the healing of cuts and bruises

5 *Organisms maintain a dynamic equilibrium that sustains life.*

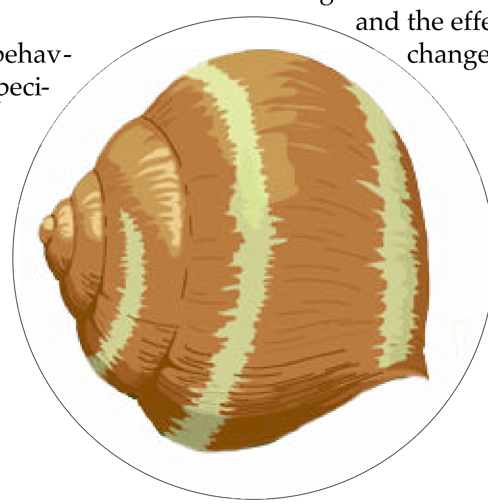
- describe basic life functions of common living specimens (guppy, meal-worm, gerbil)
- describe some survival behaviors of common living specimens
- describe the factors that help promote good health and growth in humans

6 *Plants and animals depend on each other and their physical environment.*

- describe how plants and animals, including humans, depend upon each other and the nonliving environment
- describe the relationship of the sun as an energy source for living and nonliving cycles

7 *Human decisions and activities have had a profound impact on the physical and living environment.*

- identify ways in which humans have changed their environment and the effects of those changes



STANDARD 4

Intermediate Students:

PHYSICAL SETTING

1 *The Earth and celestial phenomena can be described by principles of relative motion and perspective.*

- explain daily, monthly, and seasonal changes on earth

2 *Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.*

- explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change
- describe volcano and earthquake patterns, the rock cycle, and weather and climate changes

3 *Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.*

- observe and describe properties of materials, such as density, conductivity, and solubility
- distinguish between chemical and physical changes
- develop their own mental models to explain common chemical reactions and changes in states of matter

4 *Energy exists in many forms, and when these forms change energy is conserved.*

- describe the sources and identify the transformations of energy observed in everyday life
- observe and describe heating and cooling events
- observe and describe energy changes as related to chemical reactions
- observe and describe the properties of sound, light, magnetism, and electricity
- describe situations that support the principle of conservation of energy

5 *Energy and matter interact through forces that result in changes in motion.*

- describe different patterns of motion of objects
- observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects

Continued.

Intermediate Students:

THE LIVING ENVIRONMENT

1 *Living things are both similar to and different from each other and nonliving things.*

- compare and contrast the parts of plants, animals, and one-celled organisms
- explain the functioning of the major human organ systems and their interactions

2 *Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.*

- describe sexual and asexual mechanisms for passing genetic materials from generation to generation
- describe simple mechanisms related to the inheritance of some physical traits in offspring

3 *Individual organisms and species change over time.*

- describe sources of variation in organisms and their structures and relate the variations to survival
- describe factors responsible for competition within species and the significance of that competition

4 *The continuity of life is sustained through reproduction and development.*

- observe and describe the variations in reproductive patterns of organisms, including asexual and sexual reproduction
- explain the role of sperm and egg cells in sexual reproduction
- observe and describe developmental patterns in selected plants and animals (e.g., insects, frogs, humans, seed-bearing plants)
- observe and describe cell division at the microscopic level and its macroscopic effects

5 *Organisms maintain a dynamic equilibrium that sustains life.*

- compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium
- describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms

6 *Plants and animals depend on each other and their physical environment.*

- describe the flow of energy and matter through food chains and food webs
- provide evidence that green plants make food and explain the significance of this process to other organisms

7 *Human decisions and activities have had a profound impact on the physical and living environment.*

- describe how living things, including humans, depend upon the living and nonliving environment for their survival
- describe the effects of environmental changes on humans and other populations

STANDARD 4

Commencement Students:

PHYSICAL SETTING

1 *The Earth and celestial phenomena can be described by principles of relative motion and perspective.*

- explain complex phenomena, such as tides, variations in day length, solar insolation, apparent motion of the planets, and annual traverse of the constellations
- describe current theories about the origin of the universe and solar system

2 *Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.*

- use the concepts of density and heat energy to explain observations of weather patterns, seasonal changes, and the movements of the Earth's plates
- explain how incoming solar radiations, ocean currents, and land masses affect weather and climate

3 *Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.*

- explain the properties of materials in terms of the arrangement and properties of the atoms that compose them
- use atomic and molecular models to explain common chemical reactions
- apply the principle of conservation of mass to chemical reactions
- use kinetic molecular theory to explain rates of reactions and the relationships among temperature, pressure, and volume of a substance

4 *Energy exists in many forms, and when these forms change energy is conserved.*

- observe and describe transmission of various forms of energy
- explain heat in terms of kinetic molecular theory
- explain variations in wavelength and frequency in terms of the source of the vibrations that produce them, e.g., molecules, electrons, and nuclear particles
- explain the uses and hazards of radioactivity

5 *Energy and matter interact through forces that result in changes in motion.*

- explain and predict different patterns of motion of objects (e.g., linear and angular motion, velocity and acceleration, momentum and inertia)
- explain chemical bonding in terms of the motion of electrons
- compare energy relationships within an atom's nucleus to those outside the nucleus

Continued.

Commencement Students:

THE LIVING ENVIRONMENT

1 *Living things are both similar to and different from each other and nonliving things.*

- explain how diversity of populations within ecosystems relates to the stability of ecosystems
- describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)
- explain how a one-celled organism is able to function despite lacking the levels of organization present in more complex organisms

2 *Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.*

- explain how the structure and replication of genetic material result in offspring that resemble their parents
- explain how the technology of genetic engineering allows humans to alter the genetic makeup of organisms

3 *Individual organisms and species change over time.*

- explain the mechanisms and patterns of evolution

4 *The continuity of life is sustained through reproduction and development.*

- explain how organisms, including humans, reproduce their own kind

5 *Organisms maintain a dynamic equilibrium that sustains life.*

- explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium
- explain disease as a failure of homeostasis
- relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms

6 *Plants and animals depend on each other and their physical environment.*

- explain factors that limit growth of individuals and populations
- explain the importance of preserving diversity of species and habitats
- explain how the living and nonliving environments change over time and respond to disturbances

7 *Human decisions and activities have had a profound impact on the physical and living environment.*

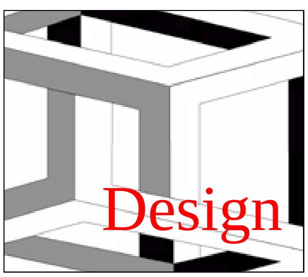
- describe the range of interrelationships of humans with the living and nonliving environment
- explain the impact of technological development and growth in the human population on the living and non-living environment
- explain how individual choices and societal actions can contribute to improving the environment

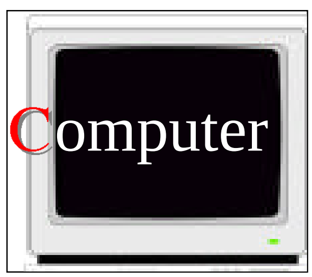
STANDARD 5

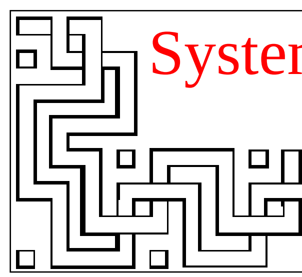
Technology

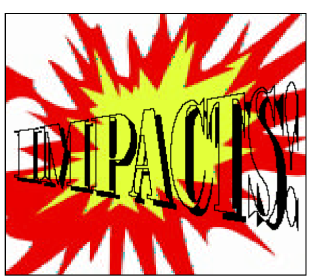
Mathematics, Science & Technology

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

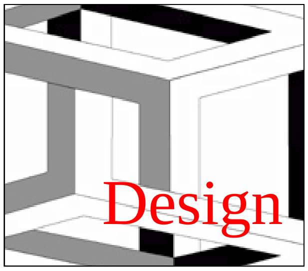








STANDARD 5



ENGINEERING DESIGN

Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints. **Students will:**

ELEMENTARY

- describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved
- investigate prior solutions and ideas from books, magazines, family, friends, neighbors, and community members
- generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathemat-ics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices
- plan and build, under supervision, a model of the solution using familiar materials, processes, and hand tools
- discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better

INTERMEDIATE

- identify needs and opportunities for technical solutions from an investigation of situations of general or social interest
- locate and utilize a range of printed, electronic, and human information resources to obtain ideas
- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal
- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship
- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made

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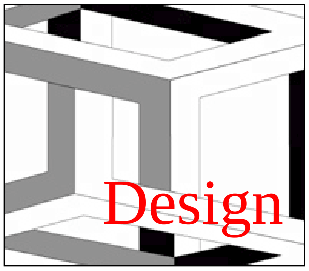


COMMENCEMENT

- initiate and carry out a thorough investigation of an unfamiliar situation and identify needs and opportunities for technological invention or innovation

- identify, locate, and use a wide range of information resources including subject experts, library references, magazines, videotapes, films, electronic data bases and on-line services, and discuss and document through notes and sketches how findings relate to the problem

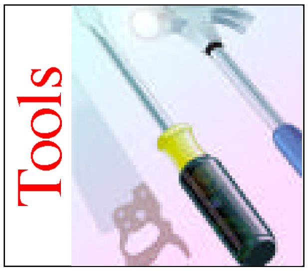
- generate creative solution ideas, break ideas into the significant functional elements, and explore possible refinements; predict possible outcomes using mathematical and functional modeling techniques; choose the optimal solution to the problem, clearly documenting ideas against design criteria and constraints; and explain how human values, economics, ergonomics, and environmental considerations have influenced the solution

- develop work schedules and plans which include optimal use and cost of materials, processes, time, and expertise; construct a model of the solution, incorporating developmental modifications while working to a high degree of quality (craftsmanship)

- in a group setting, devise a test of the solution relative to the design criteria and perform the test; record, portray, and logically evaluate performance test results through quantitative, graphic, and verbal means; and use a variety of creative verbal and graphic techniques effectively and persuasively to present conclusions, predict impacts and new problems, and suggest and pursue modifications

STANDARD 5

Technology



TOOLS, RESOURCES & TECHNOLOGICAL PROCESSES

Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms. **Students will:**

ELEMENTARY

- explore, use, and process a variety of materials and energy sources to design and construct things
- understand the importance of safety, cost, ease of use, and availability in selecting tools and resources for a specific purpose
- develop basic skill in the use of hand tools
- use simple manufacturing processes (e.g., assembly, mul-tiple stages of production, quality control) to produce a product
- use appropriate graphic and electronic tools and techniques to process information

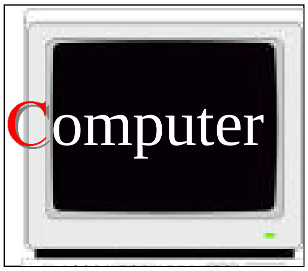
INTERMEDIATE

- choose and use resources for a particular purpose based upon an analysis and understanding of their properties, costs, availability, and environmental impact
- use a variety of hand tools and machines to change materials into new forms through forming, separating, and combining processes, and processes which cause internal change to occur
- combine manufacturing processes with other technological processes to produce, market, and distribute a product
- process energy into other forms and information into more meaningful information

COMMENCEMENT

- test, use, and describe the attributes of a range of material (including synthetic and composite materials), information, and energy resources
- select appropriate tools, instruments, and equipment and use them correctly to process materials, energy, and information
- explain tradeoffs made in selecting alternative resources in terms of safety, cost, properties, availability, ease of processing, and disposability
- describe and model methods (including computer-based methods) to control system processes and monitor system outputs

Standard 5



Computer Technology

Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge. **Students will:**

Elementary

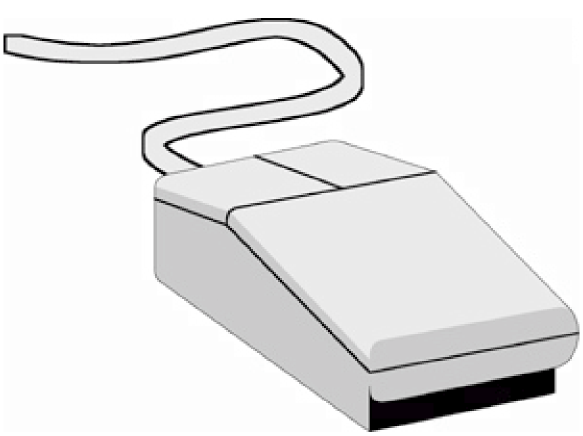
- identify and describe the function of the major components of a computer system
- use the computer as a tool for generating and drawing ideas
- control computerized devices and systems through programming
- model and simulate the design of a complex environment by giving direct commands

Intermediate

- assemble a computer system including keyboard, central processing unit and disc drives, mouse, modem, printer, and monitor
- use a computer system to connect to and access needed information from various Internet sites
- use computer hardware and software to draw and dimension prototypical designs
- use a computer as a modeling tool
- use a computer system to monitor and control external events and/or systems

Commencement

- understand basic computer architecture and describe the function of computer subsystems and peripheral devices
- select a computer system that meets personal needs
- attach a modem to a computer system and telephone line, set up and use communications software, connect to various on-line networks, including the Internet, and access needed information using e-mail, telnet, gopher, ftp, and web searches
- use computer-aided drawing and design (CADD) software to model realistic solutions to design problems
- develop an understanding of computer programming and attain some facility in writing computer programs



STANDARD 5

Systems

TECHNOLOGICAL SYSTEMS

Technological systems are designed to achieve spe-cific results and produce outputs, such as products, structures, services, energy, or other systems. **Students will:**

ELEMENTARY

- identify familiar examples of technological systems that are used to satisfy human needs and wants, and select them on the basis of safety, cost, and function
- assemble and operate simple technological systems, including those with interconnecting mechanisms to achieve different kinds of movement
- understand that larger systems are made up of smaller component subsystems

INTERMEDIATE

- select appropriate technological systems on the basis of safety, function, cost, ease of operation, and quality of post-purchase support
- assemble, operate, and explain the operation of simple open- and closed-loop electrical, electronic, mechanical, and pneumatic systems
- describe how subsystems and system elements (inputs, processes, outputs) interact within systems
- describe how system control requires sensing information, processing it, and making changes

COMMENCEMENT

- explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes
- model, explain, and analyze the performance of a feedback control system
- explain how complex technological systems involve the confluence of numerous other systems

HISTORY & EVOLUTION OF TECHNOLOGY

Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base. **Students will:**

ELEMENTARY

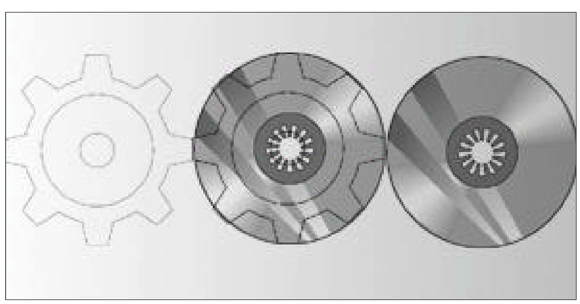
- identify technological developments that have significantly accelerated human progress

INTERMEDIATE

- describe how the evolution of technology led to the shift in society from an agricultural base to an industrial base to an information base
- understand the contributions of people of different genders, races, and ethnic groups to technological development
- describe how new technologies have evolved as a result of combining existing technologies (e.g., photography combined optics and chemistry; the airplane combined kite and glider technology with a lightweight gasoline engine)

COMMENCEMENT

- explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete



STANDARD 5

IMPACTS OF TECHNOLOGY

Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development. **Students will:**

ELEMENTARY

- describe how technology can have positive and negative effects on the environment and on the way people live and work

INTERMEDIATE

- describe how outputs of a technological system can be desired, undesired, expected, or unexpected
- describe through examples how modern technology reduces manufacturing and construction costs and produces more uniform products

COMMENCEMENT

- explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology.
- explain how computers and automation have changed the nature of work
- explain how national security is dependent upon both military and nonmilitary applications of technology

STANDARD 5

Manage

MANAGEMENT OF TECHNOLOGY

Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. **Students will:**

ELEMENTARY

- participate in small group projects and in structured group tasks requiring planning, financing, production, quality control, and follow-up
- speculate on and model possible technological solutions that can improve the safety and quality of the school or community environment

INTERMEDIATE

- manage time and financial resources in a technological project
- provide examples of products that are well (and poorly) designed and made, describe their positive and negative attributes, and suggest measures that can be implemented to monitor quality during production
- assume leadership responsibilities within a structured group activity

COMMENCEMENT

- develop and use computer-based scheduling and project tracking tools, such as flow charts and graphs
- explain how statistical process control helps to assure high quality output
- discuss the role technology has played in the operation of successful U.S. businesses and under what circumstances they are competitive with other countries
- explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand
- describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to- manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction
- help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics

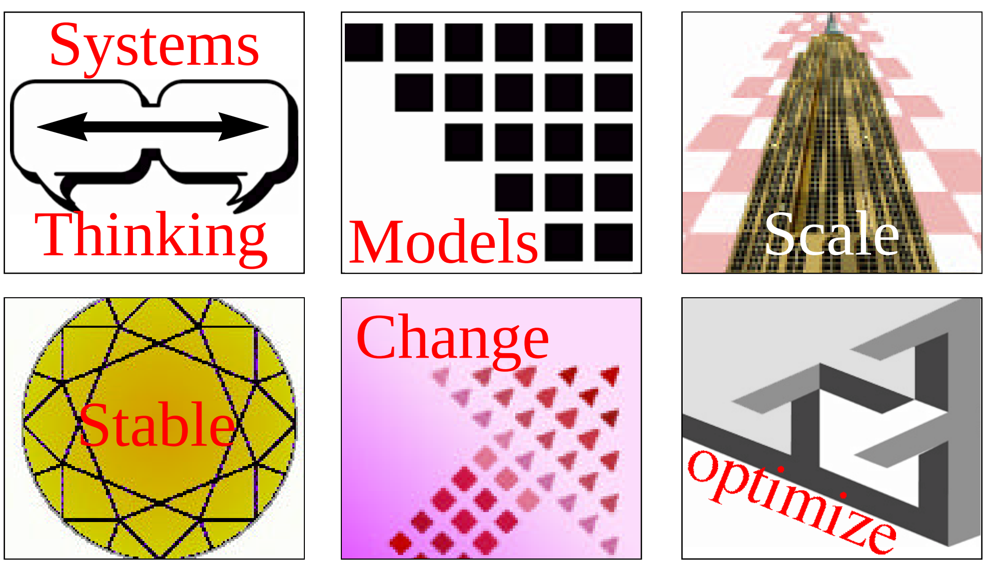
STANDARD

6

Interconnectedness: Common Themes

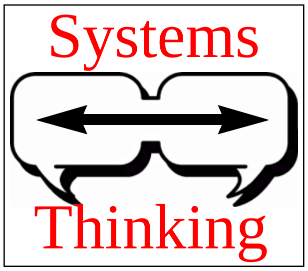
Mathematics, Science & Technology

<u>Students will</u> understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.



STANDARD 6

Common Themes



SYSTEM THINKING

Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.
Students will:

ELEMENTARY

- observe and describe interactions among components of simple systems
- identify common things that can be considered to be systems (e.g., a plant population, a subway system, human beings)

INTERMEDIATE

- describe the differences between dynamic systems and organizational systems
- describe the differences and similarities between engineering systems, natural systems, and social systems
- describe the differences between open- and closed-loop systems
- describe how the output from one part of a system (which can include material, energy, or information) can become the input to other parts

COMMENCEMENT

- explain how positive feedback and negative feedback have opposite effects on system outputs
- use an input-process-output-feedback diagram to model and compare the behavior of natural and engineered systems
- define boundary conditions when doing systems analysis to determine what influences a system and how it behaves

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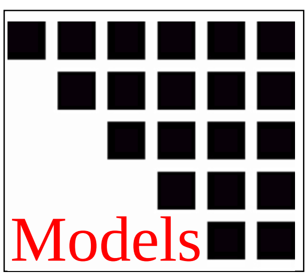


MODELS

Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.
Students will:

ELEMENTARY

- analyze, construct, and operate models in order to discover attributes of the real thing
- discover that a model of something is different from the real thing but can be used to study the real thing
- use different types of models, such as graphs, sketches, diagrams, and maps, to represent various aspects of the real world

INTERMEDIATE

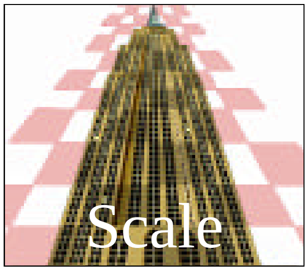
- select an appropriate model to begin the search for answers or solutions to a question or problem
- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation)
- demonstrate the effectiveness of different models to represent the same thing and the same model to represent different things

COMMENCEMENT

- revise a model to create a more complete or improved representation of the system
- collect information about the behavior of a system and use modeling tools to represent the operation of the system
- find and use mathematical models that behave in the same manner as the processes under investigation
- compare predictions to actual observations using test models

STANDARD 6

Common Themes



MAGNITUDE & SCALE

The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Students will:**

ELEMENTARY

- provide examples of natural and manufactured things that belong to the same category yet have very different sizes, weights, ages, speeds, and other measurements
- identify the biggest and the smallest values as well as the average value of a system when given information about its characteristics and behavior

INTERMEDIATE

- cite examples of how different aspects of natural and designed systems change at different rates with changes in scale
- use powers of ten notation to represent very small and very large numbers

COMMENCEMENT

- describe the effects of changes in scale on the functioning of physical, biological, or designed systems
- extend their use of powers of ten notation to understanding the exponential function and performing operations with exponential factors

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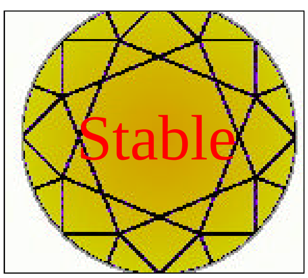


EQUILIBRIUM & STABILITY

Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Students will:**

ELEMENTARY

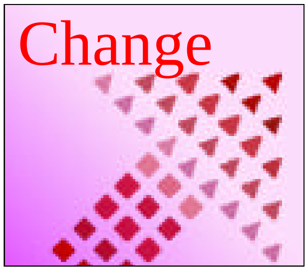
- cite examples of systems in which some features stay the same while other features change
- distinguish between reasons for stability—from lack of changes to changes that counterbalance one another to changes within cycles

INTERMEDIATE

- describe how feedback mechanisms are used in both designed and natural systems to keep changes within desired limits
- describe changes within equilibrium cycles in terms of frequency or cycle length and determine the highest and lowest values and when they occur

COMMENCEMENT

- describe specific instances of how disturbances might affect a system's equilibrium, from small disturbances that do not upset the equilibrium to larger disturbances (threshold level) that cause the system to become unstable
- cite specific examples of how dynamic equilibrium is achieved by equality of change in opposing directions



PATTERNS OF CHANGE

Identifying patterns of change is necessary for making predictions about future behavior and conditions. **Students will:**

ELEMENTARY

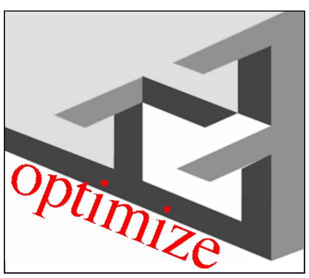
- use simple instruments to measure such quantities as distance, size, and weight and look for patterns in the data
- analyze data by making tables and graphs and looking for patterns of change

INTERMEDIATE

- use simple linear equations to represent how a parameter changes with time
- observe patterns of change in trends or cycles and make predictions on what might happen in the future

COMMENCEMENT

- use sophisticated mathematical models, such as graphs and equations of various algebraic or trigonometric functions
- search for multiple trends when analyzing data for patterns, and identify data that do not fit the trends



OPTIMIZATION

In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.
Students will:

ELEMENTARY

- determine the criteria and constraints of a simple decision making problem
- use simple quantitative methods, such as ratios, to compare costs to benefits of a decision problem

INTERMEDIATE

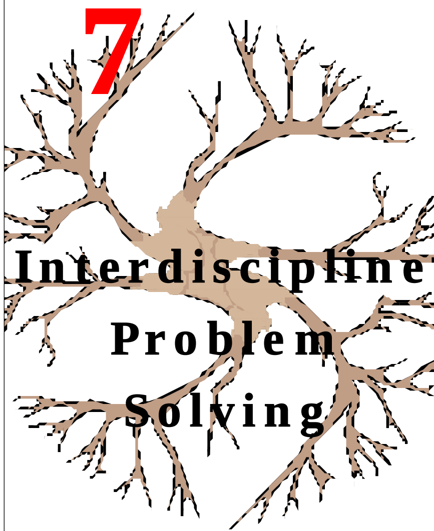
- determine the criteria and constraints and make trade-offs to determine the best decision
- use graphs of information for a decision making problem to determine the optimum solution

COMMENCEMENT

- use optimization techniques, such as linear programming, to determine optimum solutions to problems that can be solved using quantitative methods
- analyze subjective decision making problems to explain the trade-offs that can be made to arrive at the best solution

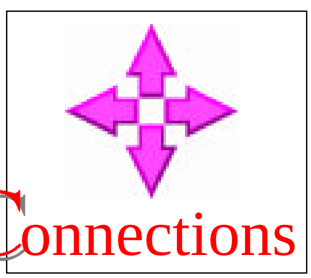
Mathematics, Science & Technology

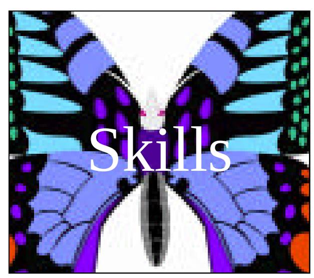
STANDARD 7



Interdiscipline Problem Solving

__Students will__ apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.





STANDARD 7 Interdisciplinary Problem Solving

Connections

CONNECTIONS

The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomen. **Students will:**

ELEMENTARY

- analyze science/technology/society problems and issues that affect their home, school, orcommunity, and carry out a remedial course of action
- make informed consumer decisions by applying knowledge about the attributes of particular products and making cost/benefit tradeoffs to arrive at an optimal choice
- design solutions to problems involving a familiar and real context, investigate related science concepts to inform the solution, and use mathematics to model, quantify, measure, and compute
- observe phenomena and evaluate them scientifically and mathematically by conducting a fair test of the effect of variables and using mathematical knowledge and technological tools to collect, analyze, and present data and conclusions.

INTERMEDIATE

- analyze science/technology/society problems and issues at the local level and plan and carry out a remedial course of action
- make informed consumer decisions by seeking answers to appropriate questions about products, services, and systems; determining the cost/benefit and risk/benefit tradeoffs; and applying this knowledge to a potential purchase
- design solutions to real-world problems of general social interest related to home, school, or community using scientific experimentation to inform the solution and applying mathematical concepts and reasoning to assist in developing a solution
- describe and explain phenomena by designing and conducting investigations involving systematic observations, accurate measurements, and the identification and control of variables; by inquiring into relevant mathematical ideas; and by using mathematical and technological tools and procedures to assist in the investigation

COMMENCEMENT

- analyze science/technology/society problems and issues on a community, national, or global scale and plan and carry out a remedial course of action
- analyze and quantify consumer product data, understand environmental and economic impacts, develop a method for judging the value and efficacy of competing products, and discuss cost/benefit and risk/benefit tradeoffs made in arriving at the optimal choice
- design solutions to real-world problems on a community, national, or global scale using a technological design process that integrates scientific investigation and rigorous mathematical analysis of the problem and of the solution
- explain and evaluate phenomena mathematically and scientifically by formulating a testable hypothesis, demonstrating the logical connections between the scientific concepts guiding the hypothesis and the design of an experiment, applying and inquiring into the mathematical ideas relating to investigation of phenomena, and using (and if needed, designing) technological tools and procedures to assist in the investigation and in the communication of results

STANDARD 7 Interdisciplinary Problem Solving

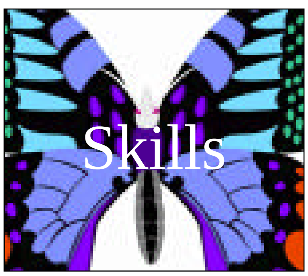
STRATEGIES

and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena. **Students will:**

ELEMENTARY—INTERMEDIATE—COMMENCEMENT

Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to:

- work effectively
- gather and process information
- generate and analyze ideas
- observe common themes
- realize ideas
- present results



SKILLS & STRATEGIES FOR INTERDISCIPLINARY PROBLEM SOLVING

ELEMENTARY—INTERMEDIATE—COMMENCEMENT

Working Effectively: Contributing to the work of a brainstorming group, laboratory partnership, cooperative learning group, or project team; planning procedures; identify and managing responsibilities of team members; and staying on task, whether working alone or as part of a group

Gathering and Processing Information: Accessing information from printed media, electronic data bases, and community resources and using the information to develop a definition of the problem and to research possible solutions

Generating and Analyzing Ideas: Developing ideas for proposed solutions, investigating ideas, collecting data, and showing relationships and patterns in the data

Common Themes: Observing examples of common unifying themes, applying them to the problem, and using them to better understand the dimensions of the problem

Realizing Ideas: Constructing components or models, arriving at a solution, and evaluating the result

Presenting Results: Using a variety of media to present the solution and to communicate the results

Mathematics, Science & Technology

REVIEW AND COMMENTS

Reaction Form 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).

http://www.nysed.gov

Mathematics, Science, and Technology
Resource Guide

R E A C T I O N   F O R M

Your response to this questionnaire will assist the Education Department in preparing the revised *Mathematics, Science, and Technology Resource Guide*. Thank you for taking the time to send us your comments. Please feel free to duplicate this form for other individuals.

Demographic Information: I am a(an):

☐ Teacher (Grade________)   ☐ Parent

☐ Administrator: ○ Principal   ○ Assistant Principal   ○ Curriculum Specialist

☐ Other____

****

1. How did you hear about the *The Mathematics, Science, and Technology Curriculum Resource Guide*?
   - ☐ colleague
   - ☐ administrator
   - ☐ teleconference
   - ☐ workshop
   - ☐ electronic notice
   - ☐ BOCES/CSD
   - ☐ other

2. What specifically is most helpful about:

   Part I? ____

   Part II? ____

   Part III? ____

3. What other materials would you like to see in the guide?

   ____

4. What changes would you suggest to make the document more user-friendly?

   ____

   ____

5. Overall, to what extent do you feel the information in this guide will influence teaching and learning in your classroom?

5	4	3	2	1
To a Great Extent				Not at All

6. Overall, to what extent do you feel the guide illuminates the *Learning Standards for Mathematics, Science,and Technology*?

5	4	3	2	1
To a Great Extent				Not at All

Additional Comments:

FOLD

Please return this form by June 30, 1997 to the following address:

The Mathematics, Science and Technology Resource Guide
New York State Education Department
Office of Curriculum and Instruction
681 EBA
Albany, New York 12234

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